time history analyisis

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CHAPTER 1

INTRODUCTION

1.1. GENERAL

As the population grows, there is less available land, leading to the need for high-rise buildings. These tall buildings are often affected by natural events, especially earthquakes, which can seriously damage their structure. Earthquakes are unpredictable and can't be controlled, but building codes are updated over time to improve safety. These updates often increase the base shear (seismic force) requirements for buildings.
To reduce the risk of building collapse during earthquakes, several factors must be considered in the design. Most buildings include key structural elements like beams, columns, braces, shear walls, and floor slabs. In multi-storey buildings, floor slabs not only support gravity loads but also help transfer lateral (sideways) forces during an earthquake.

Earthquakes can damage structures and disrupt everyday life. Because of their global impact, it is important to study and analyze how buildings behave during these events, so we can design them to stay safe for longer periods. Thanks to advances in technology, we now have better ways to deal with natural disasters—like early warning systems, stronger construction methods, and faster emergency response. Still, not all disasters can be predicted or fully prevented.
Seismic hazard maps, like those in **IS 1893:2016**, show different earthquake zones and help guide safer building designs.

Earthquake-prone areas need to be carefully designed to withstand ground shakes and prevent damage, saving both money and lives. Nowadays, architects often create buildings with unusual or irregular shapes, which tend to be more vulnerable during earthquakes. Because of this, it's important to study how these irregularly shaped buildings behave when subjected to seismic forces, especially depending on the type of soil they are built on.

1.2. DIFFERENT SEISMIC ZONES

In India, earthquakes are grouped into five different categories called seismic zones, based on how strong the ground shaking can be and how much damage might happen. These zones are spread out across various parts of the country according to how risky they are. Zone 1 is the safest, where only minor issues or repairs might be needed after a quake. Zone 2 is a bit more active, with slightly more damage likely. Zone 3 is where buildings could face moderate damage. Zone 4 areas are more vulnerable and could experience a lot of destruction during an earthquake. Finally, Zone 5 is the most dangerous, with the highest chance of severe and widespread damage. This classification is made by looking at past earthquake events, the geology of the area, and the potential risks for the future.

1.3. SEISMIC ANALYSIS

Seismic analysis is like giving a building a thorough health check-up, especially if it's in an area where earthquakes are common. It's a way for engineers to figure out how the building would behave if the ground suddenly started shaking. By understanding how the structure might respond, they can design it to stay strong and protect the people inside. It's all about anticipating how the building might sway or bend during a quake, so we can make it safer, smarter, and more prepared for whatever nature throws its way.
Seismic analysis is categorized further as static seismic analysis and dynamic seismic analysis.

1.4. METHODS OF SEISMIC ANALYSIS

1. Equivalent Lateral Force Method: With SSI Seismic analysis works on the idea that lateral force or we can say that sideways forces an earthquake can be estimated and used for design. As per IS 1893 (Part 1): 2016, the **linear static method** is a simpler approach that's suitable for regular buildings up to 15 meters tall in seismic Zone II, or for buildings with a natural vibration period of less than 0.4 seconds. This method is less complex and quicker to use because it doesn't take into account the effects of higher vibration modes.

Response Spectrum Analysis (RSA): This approach is best suited for buildings where higher vibration modes have a noticeable effect on how the structure behaves during an earthquake. It's commonly used to study the dynamic response of irregular buildings or those with breaks or changes in their structural layout. In particular, it helps evaluate the forces and movements that tall buildings go through when hit by moderate earthquake vibrations. These vibrations usually cause the building to respond in a mostly linear way, but with movements and forces that are still significant enough to need careful analysis. This method works by analyzing how a building responds in each of its natural vibration modes separately, taking into account a specific level of damping (which represents energy loss during movement). Once each mode's response is calculated, they are combined to get the overall behavior of the structure during an earthquake. According to IS 1893 – 2016 (Part 1), this approach is suitable for all types of buildings, except for regular low-rise buildings under 15 meters tall located in seismic Zone II, where simpler methods are usually enough.

2. Pushover Analysis (PoA): It is a type of static analysis that allows to understand how a building behaves when pushed beyond its elastic range. Unlike simpler method, it considersthat actual non-linear behaviour of material and structural elements, making it useful for studying how a building will deform and where it might fail during a strong earthquake. This approach helps reveal how much strength and flexibility structure has, how loads are distributed, and which part are most vulnerable. By identifyingthese weak spots early on, engineers can improve the design and detailing of the building to make it safer. In case of existing buildings, pushover analysis is especially valuable for seismic retrofitting helping bring older structures up to current safety standards or strengthen areas that lack the needed earthquake resistance. However, while it provides helpful insights , the method does have its limitations like it doesn't fully capture the complex effects of real time ground shaking or changes in vibration modes as the structure yields.

3. Time History Analysis (THA):
   Time history analysis, a type of non-linear dynamic analysis, is considered one of the most accurate ways to understand how a building truly performs during an earthquake. It works by calculating the structure's response at many small time intervals throughout the duration of the ground motion, giving a detailed picture of how it moves and reacts. However because it requires a lot of computing power and expert knowledge to interpret the results correctly, it's usually reserved for more complex or special types of structures where precision is critical.

1.5. OBJECTIVE OF STUDY

- To create 3D model of Reinforced concrete structure and perform time history analysis in Etabs software.
- To determine the displacement of structure that is subjected to seismic loading **or ground motion past records**.
- To examine and compare different structural responses, including storey displacement, storey drift, **time history plots** and base shear.
- To determine which configuration is the most susceptible to damage.
- The analysis of structure under **El Centro 1940 and Bhuj 2001 Earthquake**.

1.6. STRUCTURE OF THIS DISSERTATION WORK

- Introduction
- Objectives
- Literature review
- Finding
- Research Gap
- Methodology
- Results and Discussion
- Conclusion
- Future scope of the work
- References

CHAPTER 2

LITERATURE REVIEW

2.1. PAST STUDY

Mahmood Hosseini (2017): The research investigates the building of 16 stories, designed as per IBC 2009 and ACI 318-2014 codes. The focus is on Life Safety (LS) Performance level in reinforced multi-level building with special moment-resisting frame. This building is situated in Tehran's highest seismic hazard zone. The author evaluated the performance using nonlinear time history analysis (NLTHA). These records were scaled according to code recommendations. The models included elastoplastic behavior for beam and column sections, allowing for the formation of plastic hinges.

Key parameters such as roof displacement and acceleration, base shear forces, and plastic hinge patterns were closely analyzed to gauge structural performance.

In several cases, the buildings did not meet the expected Life Safety performance level during the simulated earthquakes. In fact, some even approached collapse, likely due to the high intensity and vertical component of the near-source ground motions. The distribution of plastic hinges varied with building height and earthquake characteristics but often showed concentrated damage at certain levels.

The result suggest that current seismic design codes may not fully account for the effects of strong vertical ground motions typical of near-source earthquakes. To ensure buildings can reliably achieve the intended Life Safety level, code provisions especially those addressing vertical ground motions should be revisited and improved.

V. Munni et-al. (2022): In this study seismic performance of a plan-irregular building located in Seismic Zone V, assessed under three different soil conditions using the Response Spectrum Method in ETABS software. To enhance earthquake resistance, the structure incorporates steel fibers, high strength steel, and high-performance concrete.

Dynamic response parameters such as base shear, displacement, and stiffness were compared between a regular and an L shaped building model. The analysis focused on how different soil conditions influence the seismic behavior of both structural configurations. Factors such as soil texture, density, and consistency play a significant role in determining how seismic energy is transmitted to a building.

Due to increasing trend towards architectural creativity has led to the construction of the buildings with irregularities. The author considered irregular building of L-shaped configurations, which is more vulnerable during seismic events.

The author applied guidelines of Indian Standard IS 1893 for seismic loading to a ten story building and analysis is done using Response Spectrum Method. Three types of soil representing different site conditions were considered in the analysis to observe their impact on seismic performance. The research help us to understand how load is applied to the building as per configurations and which method suitable for analyses of structure.

Also, this study aims to understand how plan irregularities and varying soil conditions affect a building's seismic performance, using a comparative analysis of regular and irregular RC structures. The results offer useful information for enhancing the performance and design of irregular structures. The work add much to the structural engineering.

Adiya Kumar Tiwary et-al. (2022): This study examines 10-storey building with composite columns, viscous dampers and base isolation methods to evaluate how well these techniques help in reducing the building response. The author used ETABS v19 to design 3D models with composite columns, viscous dampers, and base isolation. Several models were created for the research out of which three were standard rcc columns, three were composite column and one is combined both types. The earthquake analysis is done with respect to response spectrum method. This analysis is based on linear dynamic response analysis. The use of composite columns and viscous dampers adds weight and stiffness to the structure, resulting in greater overall rigidity. This increased the stiffness helps in reducing story displacement during seismic events, enhancing structural stability. However, the added seismic weight leads to an increase in story shear forces as more force is transmitted through the building during ground shaking. On the other hand, the base isolation technique proves to be highly effective in managing seismic response. It significantly reduces both displacement and base shear, while also increasing the fundamental time period of the structure. This shift in dynamic behavior helps the building respond more flexibly to earthquake forces, making base isolation a particularly efficient strategy for seismic protection.

A combination of composite columns, viscous dampers, and a base isolation mechanism is highly helpful in controlling the seismic response of the structure.

A. S Elnashai et-al. (2001): The study compares inelastic static pushover analysis with dynamic collapse analysis using earthquake records on 12 RC buildings to assess the technique's validity. These 12 RC buildings were split into three groups: 8-story irregular frame, 12-story regular frame, and 8-stroey dual frame wall structures. Detailed models were created, considering geometric and strength characteristics of columns, beams and beams-columns connections. Buildings were designed and detailed in accordance with Eurocode 8 with different design ground accelerations and ductility classes. The research confirms that static pushover analysis an easier and less resource-intensive method can reliably estimate the seismic capacity and potential failure points of reinforced concrete buildings. Static pushover analysis is more appropriate for low rise and short period frame structures. This study provides valuable insight how structures with irregularities or flexible systems behave during earthquakes informs engineers on when and how to adjust their models or safety factors, leading to more resilient designs.

Harpreet Singh et al. (2024): The recent research explored the effectiveness of different structural systems in resisting dynamic loads in high-rise reinforced concrete buildings. Their study compared five structural configurations using a 16-storey building model and carried out a dynamic analysis through the response spectrum method in ETABS software. The systems evaluated included a conventional moment-resisting frame, a shear wall system, a braced frame, an outrigger system, and a diagrid system. The analysis focused on several critical performance indicators, such as base shear, storey displacement, inter-storey drift, lateral stiffness, and the building's fundamental time period. The diagrid system showed the most promising results. It offered substantial reductions in overall displacement, improved stiffness, and significantly decreased in the period of vibration indicates better resistance to dynamic forces. The shear wall system also performed well on the other hand, the braced frame and outrigger systems showed moderate improvements. This research compares multiple systems like framed, shear wall, braced frame, outrigger, and diagrid—under the same conditions, this helps us to get clear, data-driven insights into which system performs best under dynamic loads like earthquakes or strong winds. The study emphasizes the importance of dynamic analysis (response spectrum method) over static analysis for tall buildings. The outcome of research helps us to understand how different systems affect displacement, drift, and stiffness helps engineers optimize structural elements (like beams, walls, or braces) to improve performance.

Kushal Vijay Rathode (2020): The study addresses the necessity of probabilistic approaches in assessing the seismic performance of base isolated structures under varying seismic hazard scenar This presents how a ten-story reinforced concrete (RCC) building responds to earthquake forces through time history analysis, highlighting the critical role of structural strength in earthquake-resistant design. Using ETABS software, a nonlinear time history analysis is carried out with the 1940 El Centro earthquake record as a reference. The study focuses on key factors that influence a building's seismic performance—such as load-carrying capacity, ductility, stiffness, damping, and mass. Important response parameters like base shear, story drift, and lateral displacements are measured and evaluated. These results are then compared with the limits and recommendations provided in the IS 1893:2002 seismic design code to assess the building's compliance and overall performance. This paper helps in understanding the elastic and inelastic behaviour of reinforced concrete structure during earthquake. By using advanced methods such as Fast Nonlinear Modal Analysis along with real earthquake ground motion records, this study shows how modern computational tools can be effectively applied to understand complex seismic behaviour. These techniques helps to perform more accurate and efficient assessments, encouraging the use of innovative analysis methods in practical study design.

Ahmed S. Brwa and Twana Ahmed Hussein (2020): The authors introduce a different way called the "state space representation" (SSR), which lets them run detailed earthquake simulations in MATLAB a popular, flexible computer program. They created a model of a five-story building and tested it with real earthquake data from the 1940 El-Centro quake. Then, they compared their MATLAB results with those from ETABS to see if they match. The results from MATLAB matched closely with ETABS, showing that this method is accurate. This means civil engineers now have a cheaper, customizable, and powerful tool to analyze how buildings behave during earthquakes giving them better insight into designing safer buildings without always needing expensive software. Time history analysis gives the full response of the structure during and after dynamic loads, unlike response spectrum analysis. A mathematical model of a five-story one-bay shear frame was created to conduct a linear time history analysis and investigate the structural response. This helps for better insight into designing safer buildings without always needing expensive software.

Nikos D. Lagaros, Chara Ch. Mitropoulou (2015): The author study the behaviour of buildings during earthquakes using time history analysis. The study discusses several important values (called intensity measures) used to understand ground shaking such as Peak Ground Acceleration (PGA) which tell us about how strong the shaking is also Arias Intensity, Characteristic Intensity, and Cumulative Absolute Velocity also discussed which helps to predict how much damage might occur. The study also looks at how the angle at which the earthquake hits a building affects its performance. Changing the angle of incoming ground motion can significantly change the results. Fragility curve also obtained which tell us about the probability that a building will exceed certain damage levels under different levels of shaking. They help engineers and decision-makers understand and manage earthquake risk. This study shows us how to simulate a building with realistic earthquake scenarios and helps in designing structures that are safer, more efficient, and and safety of structures, ultimately leading to more robust and reliable built environments.

Nikesh B. Lothe and Sanjay K. Bhadke (2024): This study presents a comparative evaluation of high-rise buildings with both uniform and varying storey heights, focusing on their seismic performance. The main goal is to optimize structural design for improved safety, functionality, and cost-efficiency. An eleven-storey residential building is modeled and analyzed using ETABS software, in compliance with Indian standards for reinforced concrete and seismic design. Special attention is given to **time history analysis**, which is shown to be highly effective in capturing the complex, nonlinear behavior of irregular structures during earthquakes. The research compares different analysis methods and demonstrates that time history analysis provides a more accurate understanding of the dynamic response of high-rise buildings. Key aspects such as mass irregularity, soft storeys, and the presence of shear walls are examined to assess their impact on seismic parameters like base shear, storey displacement, and inter-storey drift. The study also emphasizes the role of plan irregularities and the need for appropriate distribution of lateral inertia forces, particularly in low-rise buildings. Overall, the findings enhance the understanding of seismic analysis and design, offering practical insights for developing safer and more resilient structure.

Jeong and Seung Yong (2020): The study addresses how well a high-rise building with a core wall system can handle earthquakes. Core walls are vertical structural elements that help resist sideways forces from wind or earthquakes. These walls often have openings for elevators or staircases, so they're usually connected by horizontal coupling beams. These beams are designed to be weaker than the walls, which means they bend and absorb energy first during an earthquake. This behavior is important because it helps the building dissipate energy and stay standing. The researchers used a software program called ETABS 2016 to run two types of advanced analysis namely Nonlinear static analysis which checks how the building behaves as loads are slowly increased. Nonlinear time history analysis simulates how the building responds over time during actual earthquake shaking. this research helps civil engineers make more informed decisions during the seismic design of high-rise buildings. It promotes the use of realistic modeling and analysis techniques that lead to safer, more reliable, and code-compliant structures. the time history analysis gives a more detailed and realistic picture of how the building would behave in an actual earthquake, especially for complex or tall structures with basements.

K.Sugamya and K Jaya Prakash (2023): The author focuses on multi-story buildings with open ground floors commonly known as soft story buildings which are known to be more likely to collapse during earthquakes. Despite this risk, they are still widely constructed in developing countries, mainly to provide ground-level parking. Unfortunately, this need often outweighs the safety concerns raised by engineers. In this study, a 3D model of a multi-story building is created and analyzed using the ETABS software. The goal is to study how the presence of a soft ground floor and infill walls affects the building's behavior during an earthquake. The seismic analysis includes Linear static analysis (using the response spectrum method), Linear dynamic analysis (time history method) and nonlinear static analysis (pushover method). The building model includes all critical elements that affect its mass, stiffness, and strength. The displacement (deflection) at each story is measured and compared across the different analysis methods. Time history analysis is also used to evaluate the building's capacity, seismic demand, and overall performance level. The study also considers how the structure behaves inelastically and evaluates ductility that is how much deformation building can handle before failing.

Sara Honarparast et al. (2019): The paper This study focuses on two main goals is to evaluate how older CSWs behave during earthquakes and compare their performance with CSWs designed to modern standards. And to assess how effective carbon fiber-reinforced polymer (CFRP) retrofitting is in improving the seismic performance of deficient CSWs. For the analysis, two 20-story CSW buildings located in a seismically active zone of Western Canada were studied. One was designed according to the 1941 National Building Code of Canada (NBCC), and the other followed the 2015 NBCC along with CSA A23.3-14 standards. Using nonlinear time history analysis in the RUAUMOKO software, the study simulated earthquake responses for both original and CFRP-retrofitted CSWs. The results clearly showed that CFRP retrofitting significantly improved seismic performance, especially in reducing story displacement, inter-story drift, rotation of coupling beams, and curvature of the walls.

S. Ghosh and S Chakraborty (2017): This study evaluates the seismic risk of a reinforced concrete building frame located in Guwahati City, in northeast India an area known for its seismic activity. The first step involves conducting a site-specific probabilistic seismic hazard analysis, which helps to develop a hazard curve and select appropriate ground motion records for use in nonlinear time history analysis (NLTHA). Due to the limited availability of real earthquake recordings in the region, the study also includes synthetic and artificial ground motions to ensure a comprehensive and reliable data set. The building's response is particularly its drift demand under different earthquake intensities is then evaluated using NLTHA. To understand how much seismic stress the building can handle, a series of random pushover analyses are carried out. These help to estimate the structural capacity at different performance limit states. Using the data on seismic demand, capacity, and hazard, the study develops fragility curves, which show the probability of the building reaching or exceeding certain damage levels during an earthquake. Finally, the annual probability of failure for the example building is calculated. The findings suggest that medium-rise RC buildings with moderate natural periods, like the one analyzed, are likely to experience nonlinear (inelastic) behavior during strong earthquakes. However, the study also indicates that buildings designed according to current Indian codes should be sufficiently safe to prevent major structural failure or life-threatening collapse, even under severe seismic events.

Prof. N Murali Krishna and Md Masihuddin Siddiqui (2020): This study focuses on how asymmetric buildings respond to earthquakes and explores ways to control their seismic behavior using two key techniques: shear walls and base isolation systems. The structural system used is a reinforced concrete (RCC) moment-resisting frame, and the seismic behavior is analyzed through nonlinear time history analysis (NLTHA) using ETAB version 16. To improve the seismic performance of such asymmetric buildings, it's important to apply seismic control techniques that help reduce these torsional effects. Key response parameters such as storey drift, base shear, storey displacement, and torsional moments were closely examined. The results show that base isolation significantly reduces these seismic effects in low-rise asymmetric buildings, while shear walls prove to be more effective in high-rise asymmetric buildings. This highlights the importance of selecting the right seismic control strategy based on the height and configuration of the structure.

Gowthami H N et al. (2019): The author in this project focuses on analyzing how a 40-storey vertically irregular building performs under lateral seismic loads, particularly when different structural systems—such as rigid frames, core systems, and outrigger systems—are used. The study is conducted for conditions representing Seismic Zone V with soft soil, which is one of the most critical scenarios for earthquake-resistant design. A key aspect considered in this study is mass irregularity, which refers to having significantly heavier floors at certain levels in the building. In this case, extra mass is added to the 5th, 15th, and 25th floors to simulate this irregularity. The structural model is developed and analyzed using ETABS software, following the guidelines of IS 1893 (Part 1): 2016. To evaluate the effectiveness of each structural system, the study examines parameters such as top storey displacement, natural time period, and base shear. The results help compare how each system is particularly core and outrigger configurations responds to seismic forces at different heights, providing valuable insights for the design of tall buildings in high-risk earthquake zones.

2.2. FINDING

- Several papers focuses on the seismic performance of different structural systems, including multi-storied steel buildings, RCC buildings, and nuclear island buildings, under various ground motion scenarios.
- Many studies emphasized on response spectrum method the effectiveness of response spectrum graphs based on storey displacement, story drift and base reaction.
- The findings suggest that for buildings in high seismic zones or with irregular configurations, NLTHA should be integrated into the design and evaluation process, as it provides a realistic picture of structural performance beyond what linear methods can offer.
- Many papers suggest that in all seismic zones, displacement tends to be highest at the top floors and gradually decreases toward the base. This trend is more prominent in soft soil conditions and taller structures.
- As per several studies buildings with irregular shapes (e.g., L-shaped) show higher **story** drift and displacement, making them more susceptible to damage during earthquakes compared to regular buildings.
- Certain papers investigated regularly shaped buildings tend to have greater base shear values, indicating they absorb and transfer seismic forces more uniformly compared to irregular buildings.
- As per past study Response Spectrum and Time History Analyses offer more realistic and reliable results than static methods, especially for multi-story RCC buildings. These methods capture the effects of ground motion frequency, direction, and duration more effectively.

2.3. RESEARCH GAPS

- While nonlinear time history analysis (NLTHA) is one of the most accurate ways to study a building's response to earthquakes, it is not widely used in practical design due to its complexity and time-consuming nature. Many existing studies and real-world designs still rely on simplified linear methods that may not fully capture real seismic behavior
- There is limited research focused on mid-rise RCC buildings using real ground motion data like the El Centro 1940 earthquake, especially in the context of Indian standards (IS 1893:2016). Most studies overlook how base shear, storey drift, and displacement vary with

time during real seismic events.

- IS 1893:2016 specifies the criteria for seismic performance, many previous studies have not directly compared NLTHA results with code-defined limits, such as storey drift limits, which is critical for understanding code compliance.
- Several papers have basic 3D model design also past research rely heavily on simplified assumptions. There is a need for realistic 3D modeling using advanced tools like ETABS, especially to assess the full effects of seismic and wind loads on high-rise buildings.
- Several studies have explored how buildings respond to seismic forces, very few have examined and compared their behavior across multiple seismic zones—Zone III, IV, and V—using a single consistent model.
- Most of the past research focuses on seismic behavior on a single type of soil. There is limited study on how different soils (hard, medium, and soft) affect the seismic performance of both regular and irregular buildings.
- There is limited research on plan irregularity although it is known to increase seismic vulnerability, comparative results between regular and L-shaped buildings under the same conditions are rarely explored in depth.

CHAPTER 3

METHODOLOGY

For performing Nonlinear time history analysis in ETABS first we have to define structural model than assign material property, mass source after that apply gravity load and static loads. Also check model stability by running linear static analysis. Then import and define ground motion record after this we have to define nonlinear time history load cases. Now we have to run nonlinear time history analysis.

Here two cases is being considered as per ground motion record. Case 1 Bhuj earthquake 2001 is taken and in Case 2 El Centro 1940 earthquake is considered. There is no change in model configurations.

3.1 GEOMETRICAL ANALYSIS OF MODEL

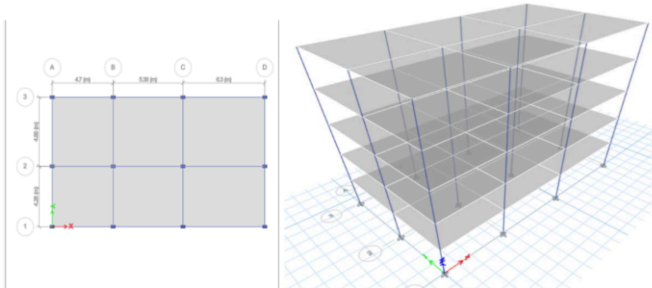

Fig. 3.1 Top & Elevation view of G+4 Structure

Table 3.1. Model Specifications

S. No.	Data	Value
1	Grade of Reinforcement	HYSD 500
2	Grade Of Concrete	M25
3	No. of stories	G+4
4	No. of bay along X-direction	3
5	No. of bay along Y-direction	2
6	Length along X-direction	16.38m
7	Length along Y-direction	9.14m
8	Floor height	3m
9	Column Size	360*230 mm
10	Beam Size	300*230 mm
11	Depth of Slab	150mm
12	Wall Load	13.8 KN/m
13	Live load	3kn/m2

14	Software	CSI ETABS
15	Earthquake method	Time History
Earthquake as per BHUJH 2001		
16	seismic zone	5
17	soil type	2
18	Importance factor	1
19	Response Reduction factor	5

3.2 MATERIAL PROPERTY

3.2.1 Property data for Material M25

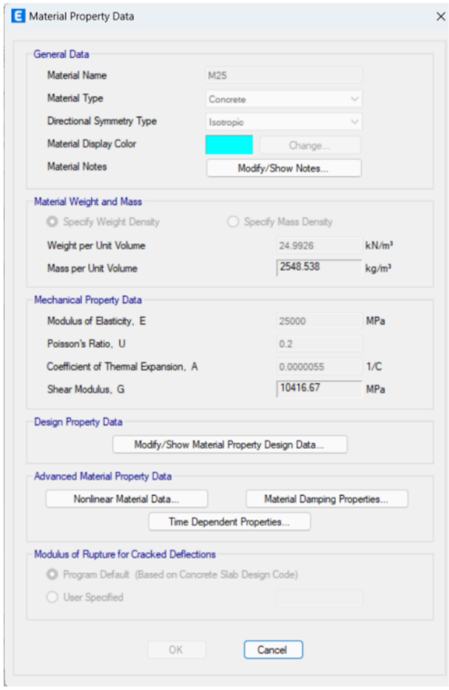

Fig. 3.3 Property of Concrete M25

3.2.2 Property data for Material HYSD500

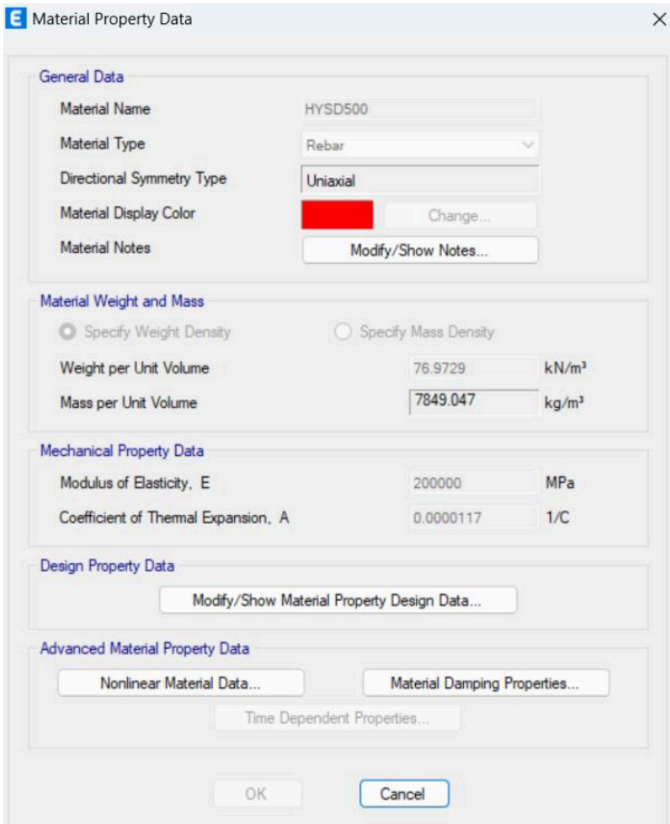

Fig. 3.5. **Property data of Material HYSD500**

3.3 SECTION PROPERTY

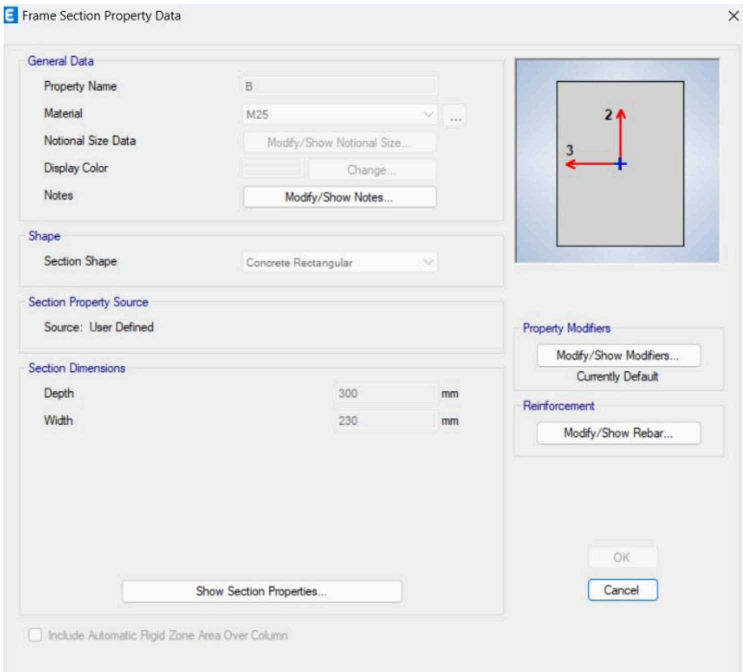

Fig. 3.7. Property Assign for Beam 300*230

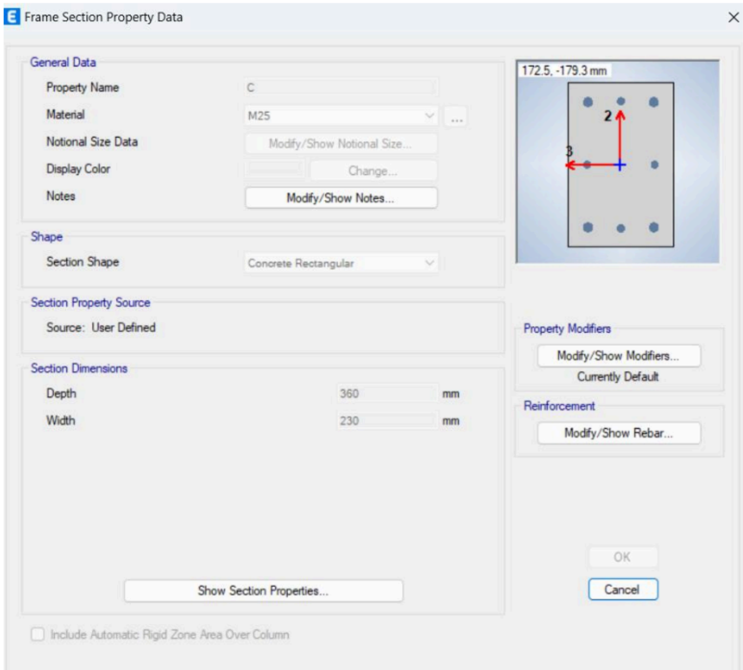

Fig. 3.8. Property Assign for Column 360*230

3.4 SLAB PROPERTY

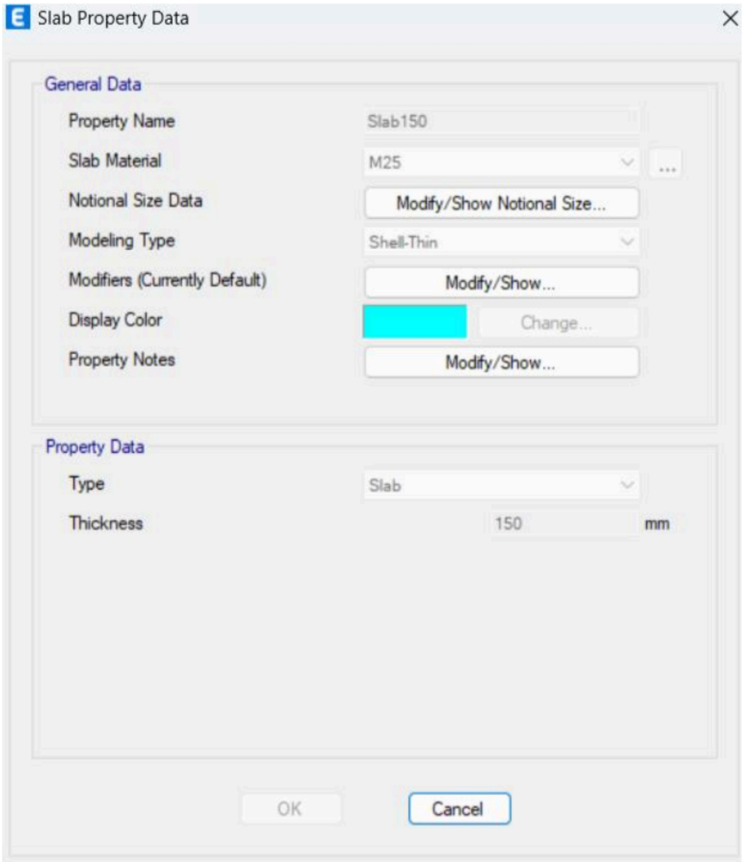

Fig. 3.9. Slab Property

3.5 DEFINE LOAD PATTERNS

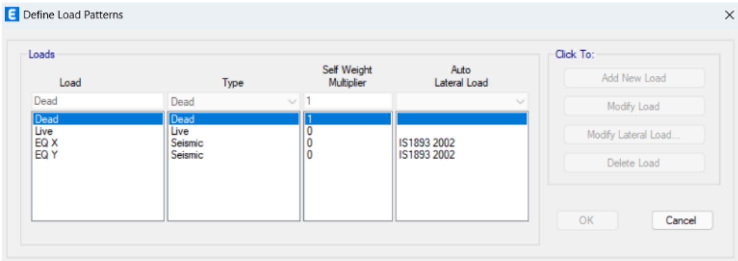

Fig. Load Patterns

3.6 DEFINE TIME HISTORY FUNCTIONS (Case 1: Bhuj EQ)

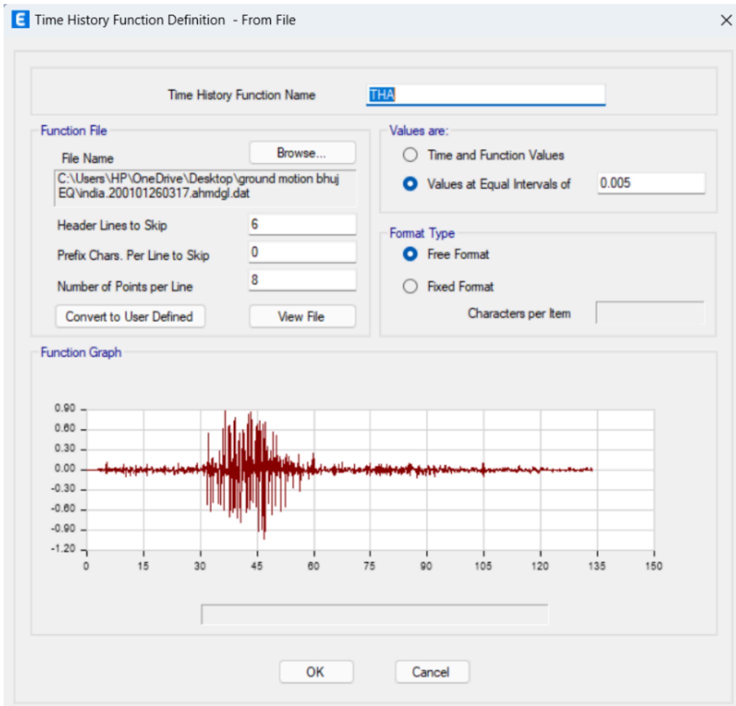

Fig. Time history function bhuj, India 2001

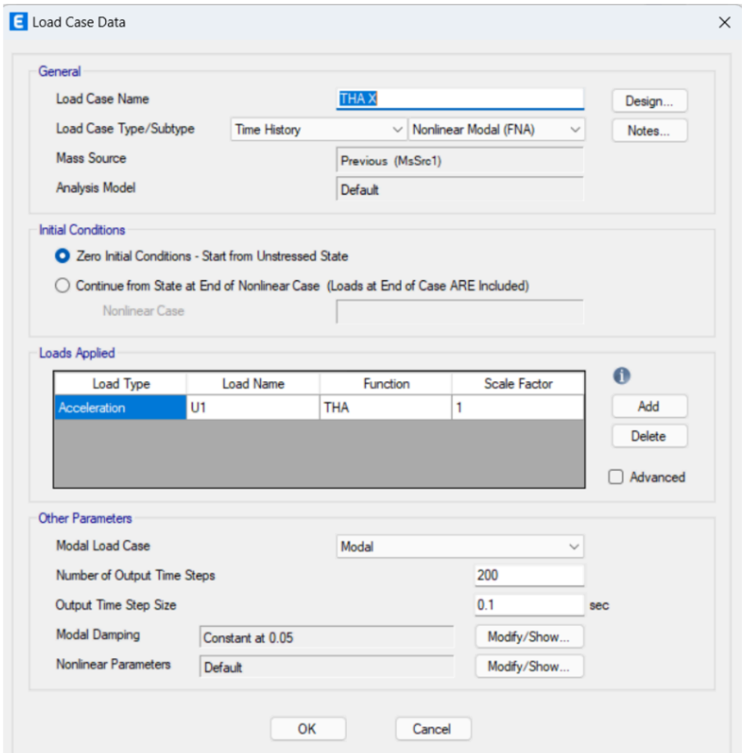

Fig. load case data in X direction

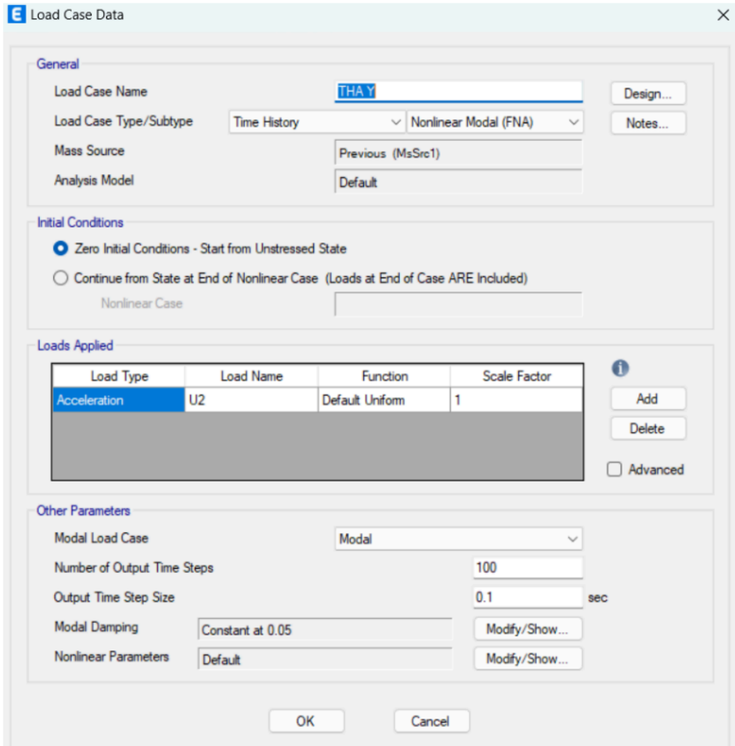

Fig. load case data in Y- direction

3.7 DEFINE TIME HISTORY FUNCTIONS (Case 2: El Centro EQ)

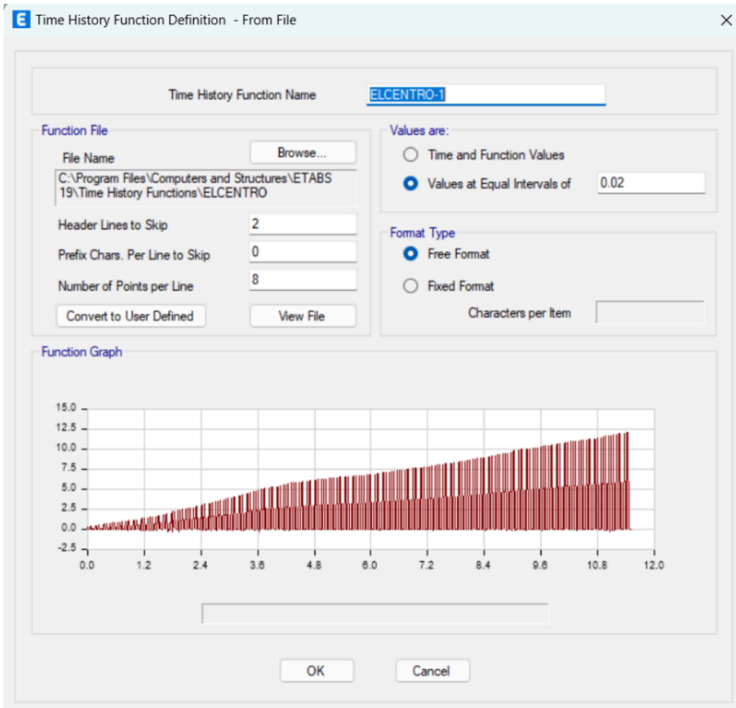

Fig. Time history function El Centro

CHAPTER 4

RESULT AND DISCUSSION

In this section, we conduct the design of a G+4 floor structure, and analysis is done for both El Centro and Bhuj earthquake ground motion record. We analyze the results obtained for different parameters and present them in graphical or tabular form. Additionally, we generate deformed shapes for these cases under varying load combinations.

4.1. TIME HISTORY PLOT

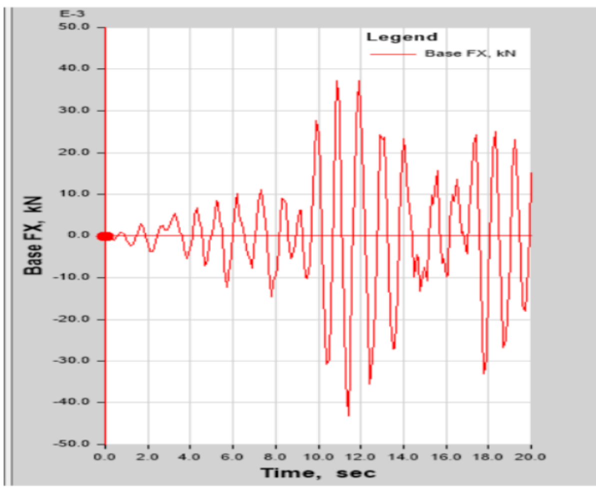

Fig. Time vs base reaction in X-dir. (Bhuj EQ)

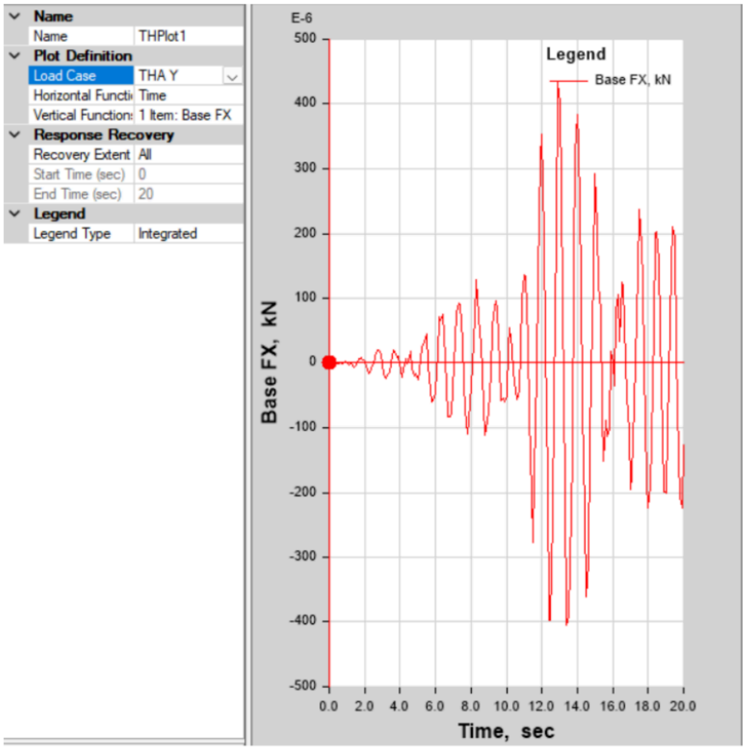

Fig. Time vs base reaction in Y-dir. (Bhuj EQ)

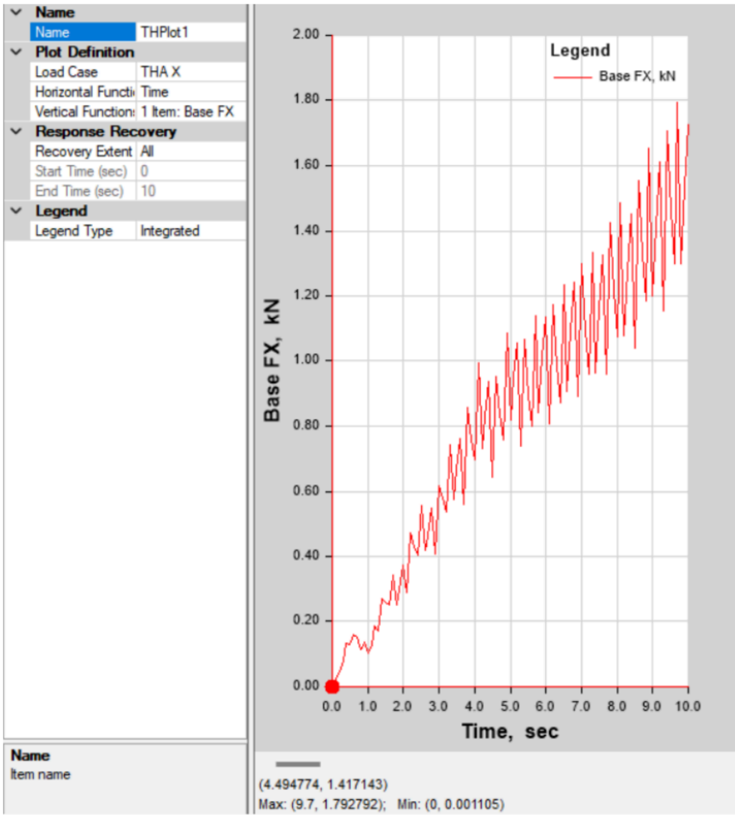

Fig. Time vs base reaction in X-dir. (El Centro EQ)

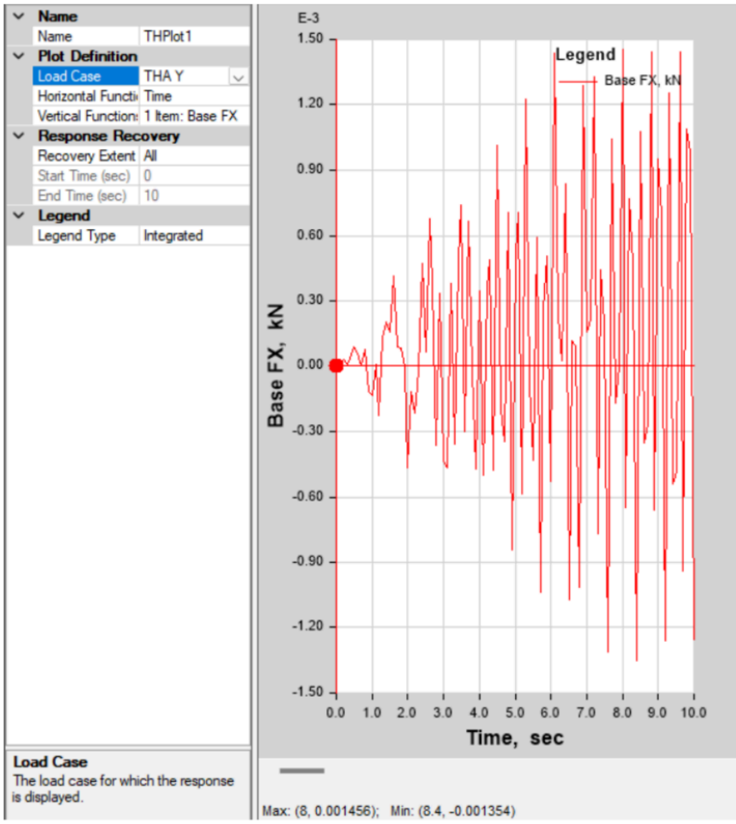

Fig. Time vs base reaction in Y-dir. (El Centro EQ)

4.2. STORY DISPLACEMENT

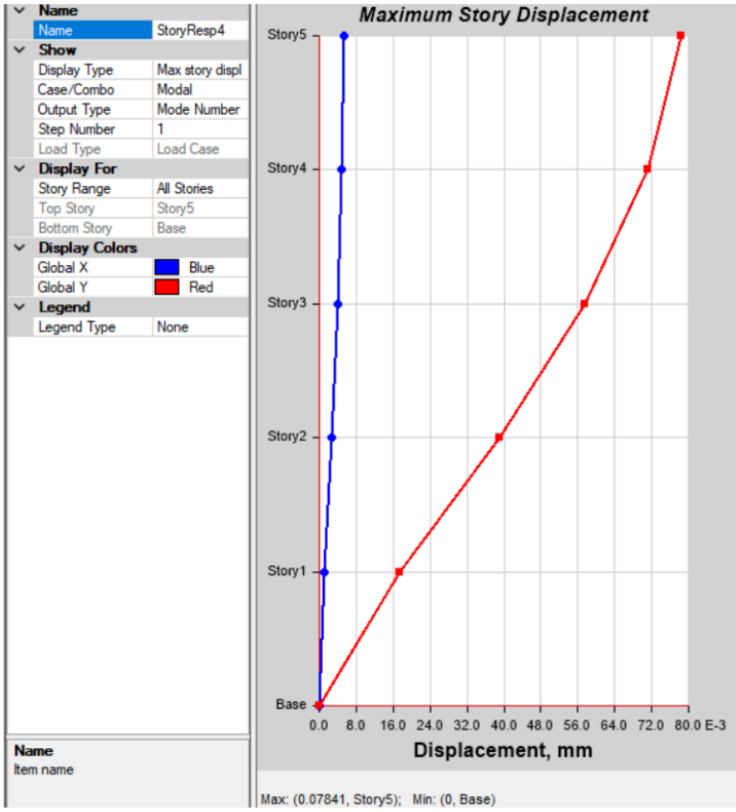

Fig. Storey height vs Displacement Case 1 (Bhuj EQ)

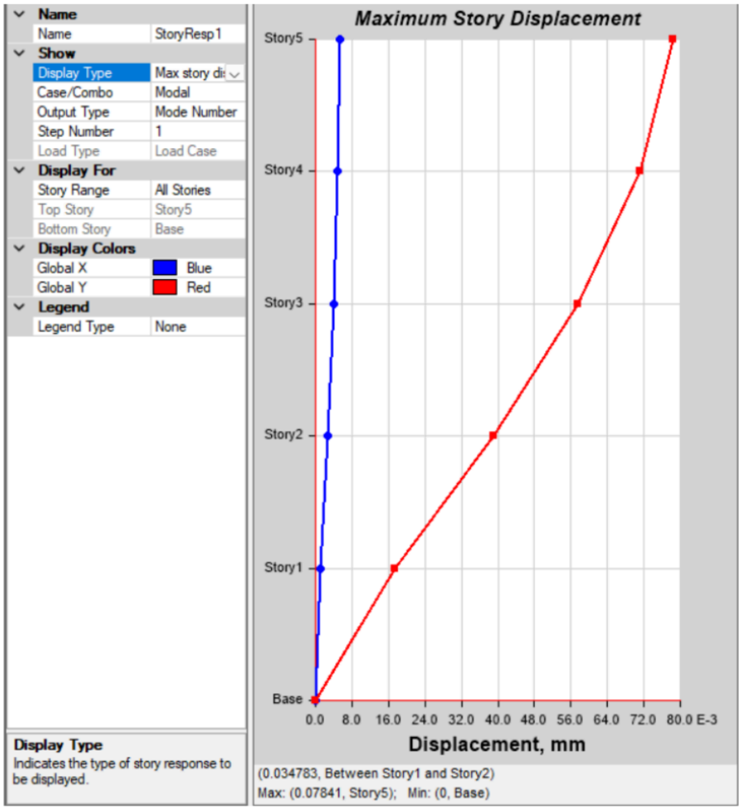

Fig. Storey height vs Displacement Case 2 (El Centro EQ)

4.3. STORY DRIFT

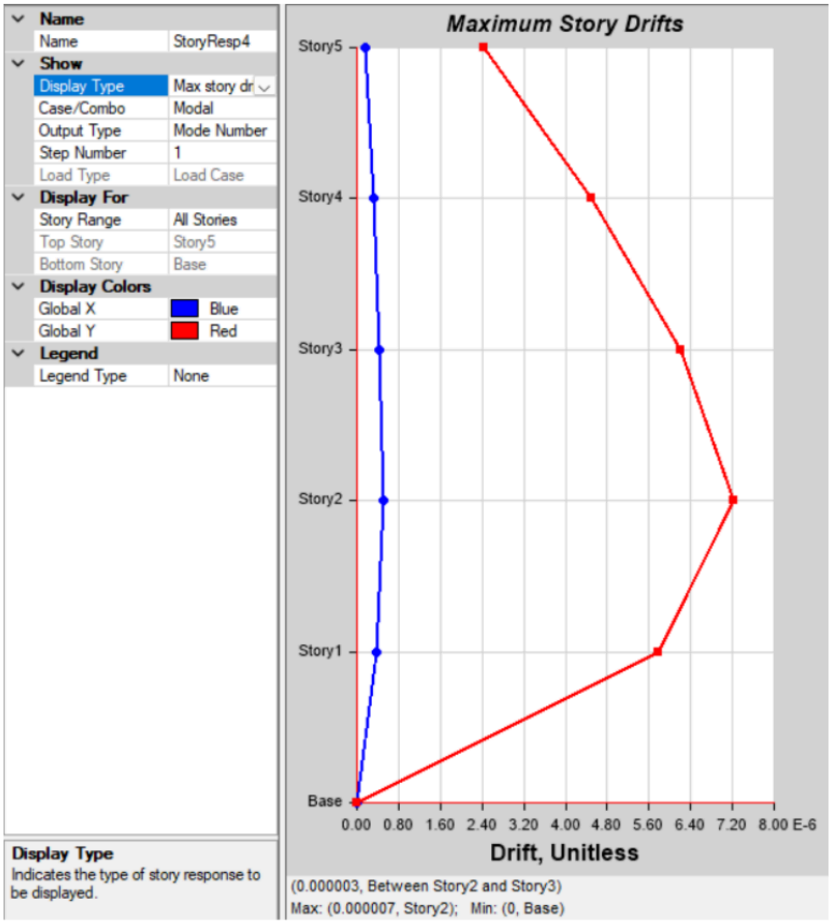

Fig. Storey height vs Drift Case 1 (Bhuj EQ)

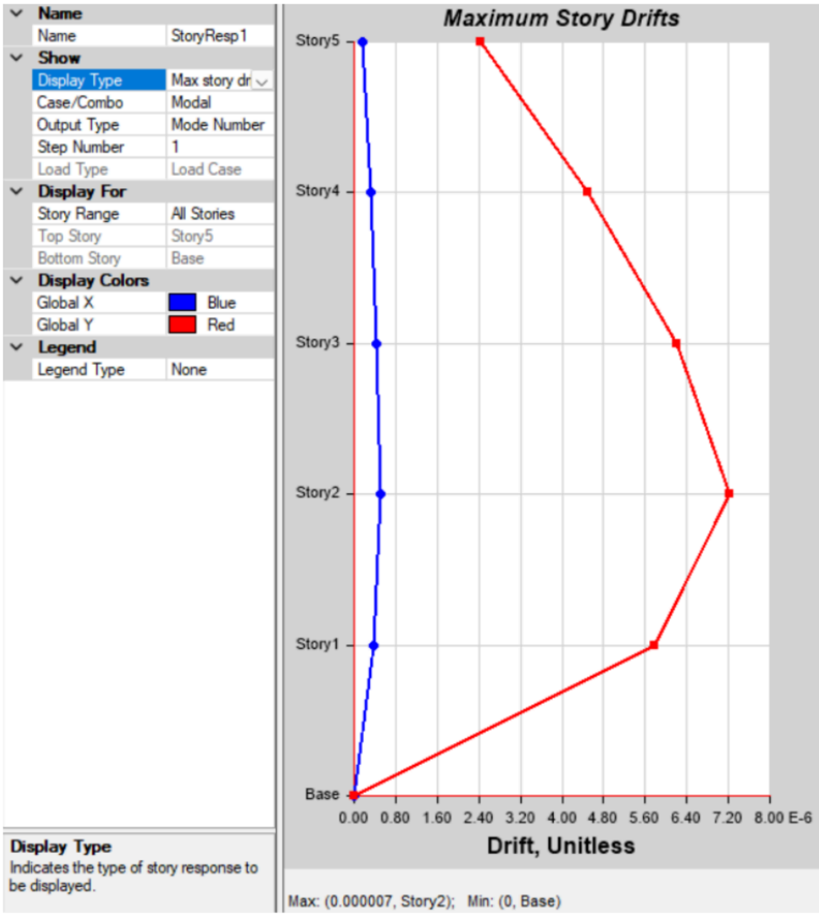

Fig. Storey height vs Drift Case 2 (El Centro EQ)

4.4. BASE REACTION

Table: Base Reactions (El Centro EQ)

Output Case	Step Type	FX (kN)	FY (kN)	FZ (kN)	MX (kN-m)	MY (kN-m)	MZ (kN-m)
THA X	Max	1.7928	0.0015	0	0.0063	14.3915	-0.0049
THA X	Min	0.0011	-0.0014	0	-0.0061	0	-8.0707
THA Y	Max	0.0015	1.6744	0	0	0.0063	13.6161
THA Y	Min	-0.0014	0.0011	0	-13.8973	-0.0062	0.0086

Table: Base Reactions (Bhuj EQ)

Output Case	Step Type	FX (kN)	FY (kN)	FZ (kN)	MX (kN-m)	MY (kN-m)	MZ (kN-m)
THA X	Max	0.0373	0.0004	0	0.0046	0.4145	0.1973
THA X	Min	-0.0432	-0.0004	0	-0.0045	-0.427	-0.1744
THA Y	Max	0.0004	0.0504	0	0.5489	0.0046	0.4382
THA Y	Min	-0.0004	-0.0509	0	-0.5239	-0.0046	-0.4345

4.5. DISCUSSION

- The analysis revealed that base shear and overturning moments changed noticeably depending on the direction and strength of the earthquake forces. This variation shows how different ground motion characteristics impact the overall stability of the structure.
- It was found that the highest horizontal displacements occurred at the upper floors, while the lower storeys experienced relatively less lateral movement, which is typical in tall buildings subjected to seismic activity.
- In some cases, the inter-storey drift exceeded the allowable limits specified in IS 1893:2016, particularly during stronger earthquakes. This highlights the importance of improving the design or applying retrofitting measures to ensure safety in structurally weak zones.
- Buildings with a regular and symmetrical layout showed lower story drift compared to those with irregular shapes. This reinforces the idea that symmetry plays a key role in improving a building's stability and overall performance during an earthquake.

CHAPTER 5

CONCLUSION

- From the obtained graph of base reaction we can conclude that the base reaction increases with time in sec from the time history plot. The base reaction is maximum at 9.7 sec with 1792 Kn at x-direction where as the maximum values in y direction is 14.56 KN at 8 sec. these values are as per El Centro EQ ground motion.
- The variation of base shear in X and Y direction are plotted as El Centro EQ ground motion.
- The graph of storey drift with respect to height of building is obtained and maximum drift is 0.007 mm at storey 2 in El Centro EQ ground motion.
- Similarly, the storey drift with respect to height of building is obtained and maximum drift is 0.007 mm at storey 2 in Bhuj EQ ground motion.
- Maximum displacement of storey 5 is 0.07481mm in El Centro EQ ground motion.
- Similarly in Bhuj EQ ground motion case the value of maximum displacement of storey 5 is 0.07481mm.
- The max. value of base shear in x direction is 370.37KN at 10.9 sec where as the max. value of base shear in y direction is 4.37KN at 12.9 sec. These values is of ground motion Bhuj EQ.

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