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SEISMIC ANALYSIS OF BASE ISOLATED BUILDING UNDER NEAR FIELD AND FAR FIELD EARTHQUAKE

A Dissertation Submitted
in Partial Fulfillment of the Requirement for the Award of the Degree of

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by

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CANDIDATE'S DECLARATION

I, **Monal Kumar**, hereby declare that the work which is being presented in dissertation entitled "**Seismic Analysis of Base isolated building under near field and far field earthquake**" which is submitted by me to thein partial fulfillment of the requirement for the award of the degree of **Master of Technology**, submitted in the Department of Civil Engineering, Delhi Technological University, Delhi is an authenticate record of my own work carried out during the period from 2023 to 2024 under the supervision of **Shri Gokaran Prasad Awadhiya**.

The matter presented in the dissertation has not been submitted by me for the award of any other degree or any other institute.

Monal Kumar

Candidate's Signature

This is to certify that the student has incorporated all the corrections suggested by the examiners in the thesis and the statement made by the candidate is correct to the best of our knowledge.

30.05.2024

Signature of Supervisor (S) **Signature of Examiner**

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CERTIFICATE

Certified that **Monal Kumar (2K22/STE/08)** has carried out their research work presented in this dissertation entitled **"Seismic Analysis of Base isolated building under near field and far field earthquake"** for the award of **Master of Technology** from the Department of Civil Engineering, Delhi Technological University, Delhi; under the my supervision. The dissertation embodies results of original work, and studies are carried out by the student himself and the contents of the dissertation do not form the basis for the award of any other degree to the candidate or to anybody else from this or any other University.

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ABSTRACT

A comprehensive seismic study of a base-isolated structure susceptible to both near-field and far-field seismic situations has been provided in this work. The focus of the study is to determine how well base isolation methods work to improve a structure's seismic resiliency and reduce its response in various seismic conditions. Using complex computational techniques, an ordinary structure with a base isolation system is analyzed, considering realistic material attributes, geometrical designs, and boundary situations. Gathering and analyzing ground motion data that represents near-field and far-field seismic conditions allows us to replicate the dynamic excitations that a structure could face. The structural reaction, which includes accelerations, displacements, inter-storey drifts, and floor response spectra, is assessed using nonlinear dynamic analysis.

Across near-field and far-field earthquakes, the efficacy of the base isolation system in lowering transmission loads and displacements is determined and compared. Studies additionally take place regarding the comfort and safety of the structure's citizens, as well as the impact of important factors including structural features and isolator qualities. The purpose of the study is to improve design techniques and the resilience of structures in earthquake-prone areas by offering analytical data regarding the seismic response of base-isolated buildings under various seismic conditions.

In this research work prepare four different cases in ETABS. Base isolation devices are typically installed between a building's foundation and superstructure. They serve as a flexible interface, depending, in the case of a seismic event, on the structure's ability to move regardless of its position on the ground itself.

Keyword: Base Isolator, Seismic Load, Time history, Epicenter, Deformation etc.

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LIST OF ABBREVIATION

ETABS	:	Extended Three-Dimensional Analysis of Building System
FVD	:	Fluid Viscous Dampers
HDRB	:	High Damping Rubber-Bearing Isolator
LRB	:	Lead Rubber Bearing
MRE	:	Magnetorheological elastomers
RCC	:	Reinforced Cement Concrete
TMDs	:	Tuned Mass Dampers

CHAPTER 1

INTRODUCTION

1.1. GENERAL

Buildings that are earthquake-resistant correspond to those that have been designed to resist seismic forces. For buildings, seismic isolation provides a really passive seismic system. The most significant concern is earthquakes. Even greater impacts are experienced by constructed structures since these shocks have the potential to cause severe damage to both human property and their lives. Both architects and engineers were required to make several modifications to the architecture of existing buildings in order to mitigate the risks associated with earthquakes.

A natural earthquake occurs when the earth's crust trembles or moves abruptly A natural earthquake excludes vibrations from fake explosions, nuclear tests, etc. We live on a planet made up of plates. A fault is a junction between two plates. According to the Indian context, this fault extends from Himachal Pradesh through Uttaranchal, Bihar, Assam, and Burma. In Indonesia, that plate descends through the Andaman-Nicobar Islands and the Bay of Bengal. Earthquakes occur when the rocks are subjected to stress due to the movement of the plate.

People don't die in earthquakes, but buildings do. In designing a safe structure, it is up to a structural engineer to determine the parameters based on past experiences and to plan for potential hazards in the future. Engineers have developed methods through finite element computer technology/software to improve the performance of structures subjected to earthquakes by modeling, analyzing, and meticulously displaying the results. One would never have imagined that Civil Engineering research had reached such far-reaching horizons. Computer science and technology developed in the last few decades have saved a lot of human effort and time for structural engineers.

A method to improve structural efficiency based on alternatives for reducing demand is structural segmentation. In order to reduce the seismic response of a particular portion during seismic encouragement, it can be used to remove all or part of a ground structure or other structural characteristic. By focusing the displacement on a separate plane, this method separates the structure from the horizontal aspect of the ground vibration. In this case, a system is developed where the seismic energy-affected period and the primary vibration duration remain separated. Buildings have become needed because of population growth and the lack of available residential land. These structures have been designed to withstand lateral loads from things like earthquakes and wind. Because of this, creating anti-seismic structures is crucial, and it heavily relies on the structural layout, building material, and construction method considerations used. However, this depends on particular components like site boundaries, area terrain, and contract ability. Structures with basic geometry and a regular layout perform significantly better than buildings with complicated characteristics and an irregular layout.

Numerous studies have focused on identifying various irregularities in buildings that can compromise their safety during earthquakes. These irregularities include mass irregularity, stiffness irregularity, vertical geometry, re-entrant corners, and torsional irregularity. Among these, torsional irregularity is considered particularly problematic. To ensure earthquake-resistant design, countries worldwide have developed seismic codes, with India relying on IS 1893 (Part 1): 2016 as its standard. Traditionally, seismic design aimed to make structures ductile, allowing them to absorb earthquake energy through plastic deformation. However, this approach often leads to significant damage during major earthquakes, requiring costly maintenances or even destruction of the structure. Seismic isolation is a method that changes how a structure interacts with earthquake ground motion, reducing damage and improving safety during strong earthquakes. It involves using isolation devices to separate the building from the ground. When these devices are placed at the base of the structure, it's called base isolation. Preventing resonance with the earthquake motion and lowering the demands on the base. The idea of isolating buildings from their bases has been around since 1870 and is now recognized as a powerful way to protect buildings from earthquakes.

1.2. EPICENTER OF EARTHQUAKE

An earthquake's epicenter is the location on Earth's surface that is closest to the center of the earth, also referred to as the chosen, which is where seismic waves that begin from the earthquake begin below. The ground vibrates when an earthquake occurs because energy flows out in the form of seismic waves, which move from the hypocenter outside through the crust of the earth. The epicenter is typically determined using data from seismic monitoring stations that detect and measure the appearance times of seismic waves at different locations. By triangulating the appearance periods from multiple stations, seismologists can pinpoint the epicenter location. Understanding the epicenter of an earthquake is essential for assessing its magnitude, depth, and potential impact on nearby communities. It helps emergency responders and disaster management authorities determine where the strongest shaking occurred and where resources should be allocated for response and recovery efforts.

1.3. NEAR FIELD AND FAR FIELD EARTHQUAKE

Near-field earthquakes occur close to the epicenter, resulting in intense ground shaking near the source. The seismic waves generated by these earthquakes can cause significant structural damage due to the high levels of acceleration and velocity imparted to the ground. Near-field earthquakes typically provide shorter warning times compared to far-field earthquakes, as the seismic waves travel shorter distances before reaching populated areas. This limited warning time can make it challenging for people to take protective actions or evacuate buildings in advance. Structures located near the epicenter of a near-field earthquake are more susceptible to localized damage, including structural deformation, collapse, and nonstructural damage such as falling debris and contents. The severity of damage can be influenced by factors such as building design, construction quality, and proximity to the epicenter.

Far-field earthquakes occur at greater distances from the epicenter, resulting in reduced ground shaking intensity compared to near-field events. While the seismic waves still propagate over long distances, they typically lose energy and amplitude as they travel through the Earth's crust. Far-field earthquakes often provide longer warning times compared to near-field events, as seismic waves take more time to travel from the epicenter to populated areas. This increased warning time allows for better preparation, emergency response coordination, and evacuation procedures. Far-field earthquakes can have widespread effects over large geographic areas, affecting numerous structures and infrastructure systems. While the ground shaking may be less intense compared to near-field events, far-field earthquakes can still cause damage to buildings, lifelines, and critical facilities, particularly if they are poorly designed or located in seismically vulnerable regions.

Near-field earthquakes tend to produce more intense ground shaking and localized damage near the epicenter, with limited warning time for affected communities. Far-field earthquakes, on the other hand, result in reduced ground shaking intensity, longer warning times, and more widespread effects over larger geographic areas. Understanding these differences is essential for assessing earthquake risk, implementing effective mitigation measures, and enhancing community resilience to seismic events.

1.4. BASE ISOLATOR

A base isolator is a structural element used in building construction to mitigate the effects of ground motion during earthquakes. It essentially decouples the building from the ground motions by allowing the building to move independently of the ground. Typically made of rubber, steel, or a combination of materials, base isolators are placed between a building's foundation and its superstructure. By transmitting seismic energy throughout an earthquake, the isolators reduce the possibility that the structure above will be damaged by harmful forces. With the use of this equipment, structures and their occupants are protected from structural failure and damage throughout seismic activity.

Base isolation is a sophisticated engineering technique employed to protect structures, particularly buildings, from the destructive forces of earthquakes. Imagine a giant shock absorber for a building – that's essentially what a base isolator is. It's a critical component in seismic design, offering a means to mitigate the potentially catastrophic effects of ground shaking. At its core, a base isolator serves as a buffer between a building's foundation and its superstructure. Traditional construction methods directly anchor buildings to the ground, leaving them vulnerable to the intense lateral forces generated during an earthquake. In contrast, base isolators provide a layer of flexibility, allowing the structure to move independently of the ground motion.

Typically constructed from rubber, steel, or a combination of materials, base isolators are strategically placed at the building's foundation. They're engineered to absorb and dissipate seismic energy, essentially decoupling the building from the shaking ground below. This ingenious design dramatically reduces the transmission of damaging forces to the structure above. By implementing base isolation technology, engineers can significantly enhance a building's seismic resilience. In the event of an earthquake, the isolators absorb much of the ground motion, helping to safeguard the integrity of the building and protect its occupants. This innovative approach has become increasingly prevalent in earthquake-prone regions worldwide, revolutionizing the way we design and construct structures in seismically active areas. A base isolation system's two main components are damping and flexibility. Reaction variation is mostly impacted by the isolation's flexibility. To improve isolation, viscous dampers or hysteretic dampers are often available. The use of dampers to reduce response is a consequence of the stiffness of the structure.

1.5. BASE ISOLATION SYSTEM

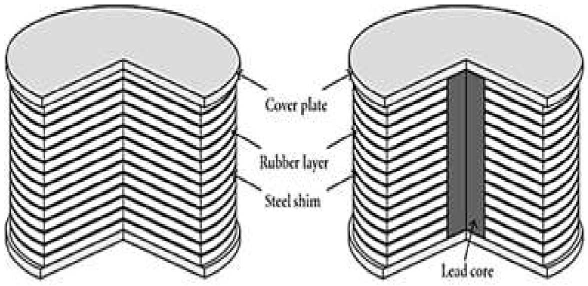
In traditional high-rise buildings, the foundation is built to be rigid. During an earthquake, the superstructure of a building moves in conjunction with the foundation and the surrounding soil. This movement occurs because the weight from the ground is transferred to the structure. The displacement will be greater toward the top of the building, namely at a height that is two-thirds of the total height of the building. Due to the rigidity of the structure, lateral forces resulting from an earthquake can result in damage or even the complete collapse of structures, a phenomenon known as resonance. The seismic forces are uncontrollable. Designing structures with flexibility is an effective method for mitigating the impact of seismic stresses on buildings. This is achieved by installing isolators at the foundation of the building. The rigidity of a structure significantly influences the lateral forces it experiences because of ground motion. The earth and substructure undergo movement due to seismic forces, while the isolator flexes between the substructure and superstructure.

Therefore, the superstructure is relatively unaffected by the earthquake. Base isolation significantly decreases the rigidity of the structure, resulting in a reduction of the inertia forces acting on it. Additionally, it reduces the inherent frequency of seismic force and inhibits the occurrence of resonance. A construction with a stiff base would have a natural period of zero. When the ground moves, the structure experiences acceleration that is equivalent to the acceleration of the ground. The relative displacement between the ground and the structure will be zero. However, in base-isolated systems with a flexible structure, the natural period is infinite. When the ground moves, there is no acceleration imposed on the structure, and the relative displacement of the structure will be equal to the displacement of the ground.

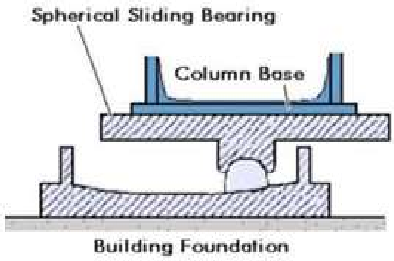
1.5.1. Types of Base Isolator

There are several types of base isolators, each designed to provide varying levels of seismic protection based on the specific requirements of a structure. Here are some common types:

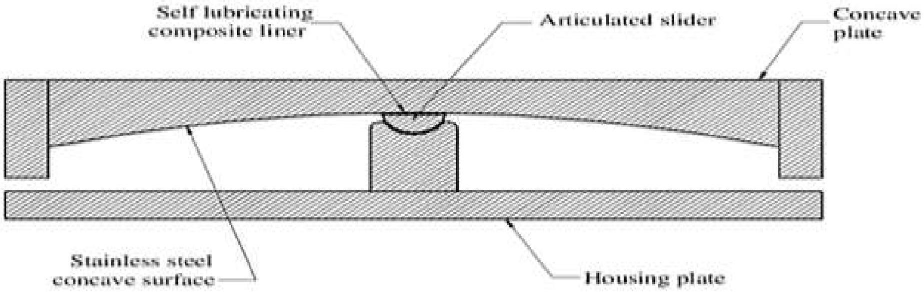
1. **Rubber Bearings**: Rubber bearings, also known as elastomeric bearings, are among the most widely used base isolators. They consist of layers of rubber sandwiched between steel plates. The rubber allows for significant deformation during an earthquake, dissipating energy and reducing the transmitted forces to the building above.
2. **Lead Rubber Bearings (LRBs)**: Lead rubber bearings incorporate lead plugs embedded in rubber layers. The lead cores provide damping characteristics, while the rubber allows for flexibility. This combination effectively isolates the building from seismic forces and minimizes structural damage.
3. **Sliding Bearings**: Sliding bearings employ a low-friction material, such as PTFE (polytetrafluoroethylene), between the foundation and the superstructure. During an earthquake, the sliding bearings enable lateral movement, effectively isolating the building from the ground motion.
4. **Friction Pendulum Systems**: Friction pendulum systems utilize a pendulum mechanism to dissipate seismic energy. The system consists of a steel slider attached to the building and a concave surface on which the slider rests. As the ground shakes, the pendulum oscillates, converting kinetic energy into rotational energy and reducing the forces transmitted to the structure.
5. **Fluid Viscous Dampers**: Fluid viscous dampers consist of a piston moving through a viscous fluid within a cylinder. During an earthquake, the motion of the piston through the fluid dissipates energy, thereby reducing the building's response to seismic forces.
6. **Tuned Mass Dampers (TMDs)**: Tuned mass dampers are not strictly base isolators but are sometimes used in conjunction with them. These devices consist of a mass suspended within the building and tuned to resonate at specific frequencies.



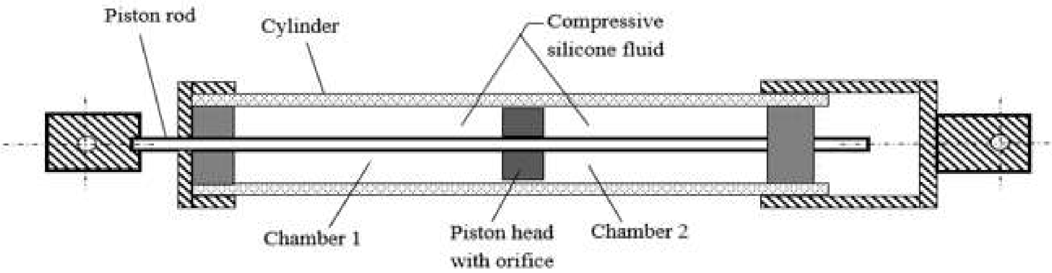
a) Rubber/Lead rubber bearing



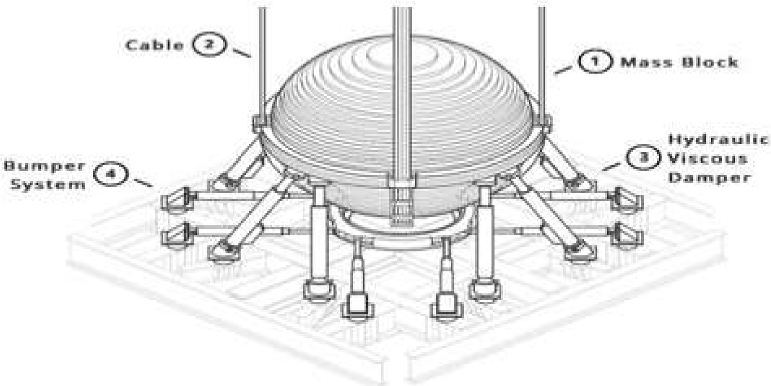
b) Sliding bearing



c) Friction Pendulum bearing



d) Fluid Viscus Damper



e) Tuned Mass Damper

Fig. 1.1. Different types of Isolators

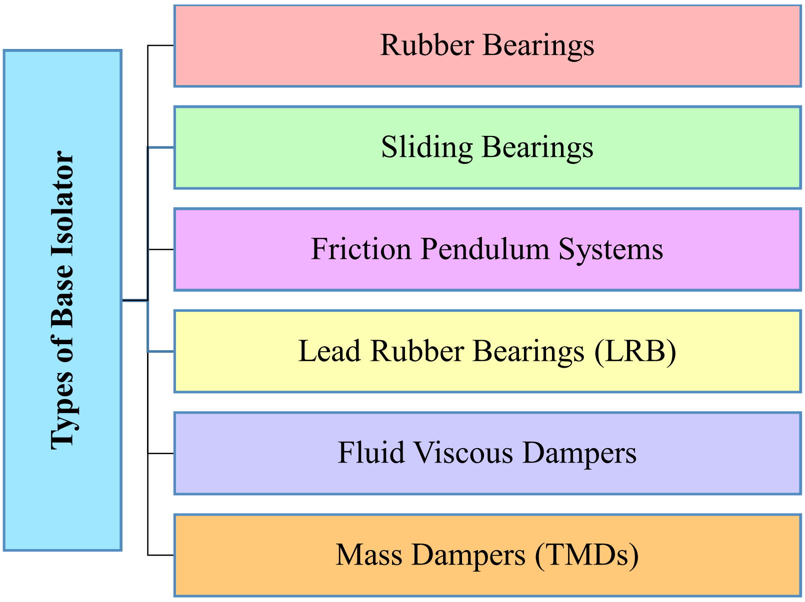


Fig. 1.2. Flow diagram of different base Isolators

1.5.2. Advantages of Base Isolator

Base isolators offer several advantages in enhancing the seismic resilience of structures:

- By decoupling the building from the ground motion, base isolators significantly reduce the transmission of seismic forces to the structure. This helps minimize structural damage, preventing collapse and preserving the integrity of the building.
- The reduced structural damage provided by base isolators not only protects the building but also enhances the safety of its occupants. By minimizing the risk of structural failure, base isolators contribute to a safer environment during seismic events, potentially saving lives.
- Buildings equipped with base isolators are more likely to remain functional after an earthquake. By preventing severe damage, these systems help ensure that critical facilities, such as hospitals, emergency response centers, and infrastructure, can continue operating, even in the aftermath of a seismic event.
- While the initial installation cost of base isolators may be higher compared to traditional seismic design methods, the long-term cost-effectiveness is often realized through reduced repair and reconstruction expenses. The protection

provided by base isolators can result in significant savings in terms of structural repairs, downtime, and potential loss of revenue.

- Base isolators offer engineers greater flexibility in designing structures for seismic resilience. By incorporating these systems into building design, architects and engineers can construct taller and more innovative structures while still meeting stringent seismic performance requirements.
- Base isolators can also be retrofitted into existing buildings to improve their seismic performance. Retrofitting older structures with base isolators can help bring them up to current seismic standards, prolonging their service life and enhancing their safety.
- The installation of base isolators can often be integrated into the construction process with minimal disruption. Compared to some other seismic retrofitting methods, base isolators may require less invasive construction techniques, reducing inconvenience to occupants and neighboring properties.

1.5.3. Disadvantages of Base Isolator

- One of the primary disadvantages of base isolation is the upfront cost. Installing base isolators involves additional materials, engineering expertise, and construction time compared to traditional building methods. The initial investment in base isolation technology can be higher, particularly for retrofitting existing structures.
- Base isolators require regular inspection and maintenance to ensure they remain effective over time. Components such as bearings and dampers may degrade or wear out over years of service, necessitating periodic replacement or refurbishment. Maintenance costs should be factored into the lifecycle expenses of a base-isolated structure.
- Some base isolation systems, such as sliding bearings or pendulum systems, may require additional space at the building's foundation. This can pose challenges in densely populated urban areas where available land is limited.
- Incorporating base isolation into building design adds complexity to the structural engineering process. Engineers must carefully analyze the dynamic behavior of the structure and select appropriate isolator types and configurations to achieve the desired seismic performance.
- The effectiveness of base isolation systems is highly dependent on proper design, installation, and quality control during construction. Even minor errors in design or construction can compromise the performance of the isolators and diminish their ability to protect the building during an earthquake.

- While base isolation is effective for many types of buildings, it may not be suitable or cost-effective for all structures. Buildings with irregular geometries, extremely tall or heavy structures, or unique architectural features may present challenges for implementing base isolation. In such cases, alternative seismic retrofit measures may be more appropriate.

1.6. OBJECTIVES

- To identify the comparative effects of varying distance of epicenter of earthquake on high rise structure.
- To find out the effect of base isolation devices in models during earthquake.
- To control deformation of models with the help of rubber bearing isolator in earthquake zone-V.
- Assess the effectiveness of base isolation systems in reducing seismic forces and displacements in the building.
- Compare the performance of the base-isolated building with a conventionally designed structure under different earthquake scenarios.
- Assess the safety and comfort of building occupants during near-field and far-field earthquakes, considering factors such as bending moment, story drift, shear force and displacement.

1.7. 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

Patil Aishwarya Yogesh (2024): The study addresses the importance of incorporating advanced seismic mitigation techniques to enhance the resilience and safety of structures in earthquake-prone regions. The study utilizes numerical simulations and analytical techniques to model the dynamic behavior of the building under seismic loading conditions. By considering different types of dampers and base isolation systems, such as viscous dampers, friction dampers, and base isolators, the author evaluates their effectiveness in reducing structural responses and improving seismic performance. The outcomes of the research offer practical implications for engineers and designers involved in the design, retrofitting, and risk mitigation of structures in earthquake-prone regions. By evaluating the performance of various seismic mitigation techniques, the study aims to improve the resilience and safety of buildings, ultimately contributing to the development of more robust and sustainable built environments.

Gudainiyan et-al. (2023): The objective of the research is to analyze the effectiveness of the base isolation system in minimizing seismic forces by examining the effects of various ground motion types on the dynamic behavior of base isolated structures. Numerous aspects, including soil conditions, structural layout, and ground motion characteristics, are taken into account in this study. The authors examine the L-shaped building's dynamic behavior and evaluate the base isolation system's effectiveness in various earthquake scenarios using computational modeling. The computer models show that the dynamic behavior of the building under these various earthquake scenarios varies significantly. When compared to far field earthquakes, near field earthquakes exhibit a more noticeable structural reaction due to their greater frequency and larger amplitude ground motions. Furthermore, for near field earthquake ground motions, the study emphasizes how well the base isolation system works to mitigate seismic forces and reduce structure vibrations.

The research advances our knowledge of how various seismic circumstances affect the performance of base isolated buildings by analyzing the L-shaped building's reaction to near and distant field earthquake ground motions. These results highlight how crucial it is to take into account differences in ground motion properties when designing and evaluating earthquake-resistant structures in seismically active areas. The results offer useful information for enhancing the performance and design of base-isolated structures while also furthering the field of seismic engineering. The work adds much to the field of earthquake engineering with its thorough methodology and perceptive conclusions.

Nouri et-al. (2023): An innovative approach to the analysis of irregular base isolated structures under seismic stresses is presented in the study by Nouri and Sangtarash. In order to better account for variations in seismic force distribution brought on by elements like mass eccentricity and stiffness variances, their method entails creating a modified lateral load pattern. The authors verify the efficacy of their methodology in precisely projecting the seismic response of these structures using comprehensive numerical simulations and comparisons with available data. They produce a representation of seismic loading circumstances that is more accurate by taking into account abnormalities in stiffness and mass distribution. This enhances base isolated structures' robustness to earthquake-induced loads by considerably increasing the accuracy of nonlinear seismic analysis. The study's conclusions provide insightful information to academics and engineers who are designing and assessing base-isolated structures, helping to create a more dependable and secure infrastructure.

Singar et-al. (2023): The study addresses the significance of understanding how different building configurations and base isolation strategies influence seismic performance and demands. The study utilizes numerical simulations, analytical techniques, and comparative analyses to assess the dynamic response of both symmetrical and asymmetrical buildings under seismic loading. By considering factors such as building geometry, structural properties, and base isolator characteristics, the authors analyze the effectiveness of rubber base isolation in reducing seismic demands and enhancing structural resilience. The outcomes of the research offer practical implications for engineers and designers involved in the design, retrofitting, and risk mitigation of buildings in earthquake-prone regions. By considering both symmetrical and asymmetrical building configurations, as well as the use of rubber base isolators, the study aims to enhance the seismic resilience and safety of structures, ultimately leading to more resilient and sustainable built environments.

Zhu Xiuyun et al. (2022): The paper addresses the critical need for effective seismic isolation strategies in nuclear facilities to ensure their safety and resilience during seismic events. The authors utilize advanced computational tools and models to simulate the dynamic behavior of the isolation system and assess its effectiveness in mitigating seismic forces. Through numerical simulations and analytical calculations, they evaluate various design parameters and performance indicators to optimize the isolation system's design for enhanced seismic resilience. The findings of the study demonstrate the effectiveness of three-dimensional base-seismic isolation in reducing the seismic response of nuclear island buildings. Their analysis reveals that properly designed isolation systems can effectively isolate the nuclear island building from ground motion, thereby minimizing structural damage and ensuring the safety of critical components during seismic events. The outcomes of the research offer practical guidance for engineers and designers involved in the development of seismic isolation strategies for nuclear island buildings. By optimizing the design of isolation systems, the study aims to enhance the seismic resilience of nuclear facilities and improve their safety and reliability in earthquake-prone regions.

Chanda Abhishikta and Rama Debbarma (2021): The study addresses the necessity of probabilistic approaches in assessing the seismic performance of base isolated structures under varying seismic hazard scenarios. The study utilizes advanced probabilistic techniques and numerical simulations to model the dynamic behavior of base isolated structures subjected to near and far field earthquake ground motions. By considering uncertainties in ground motion characteristics, structural properties, and isolation system performance, the authors conduct probabilistic seismic analysis to evaluate the reliability and safety of base isolated buildings. The outcomes of the research offer practical implications for engineers, policymakers, and stakeholders involved in the design, retrofitting, and risk assessment of base isolated structures. By adopting a probabilistic approach, the study aims to improve the understanding and management of seismic risks in built environments, ultimately leading to safer and more resilient infrastructure.

Mazza, Fabio, and Mirko Mazza (2021): The study addresses the significance of accurate modeling techniques in assessing the seismic response and effectiveness of HDRBs in base-isolated structures. The study utilizes advanced numerical simulations and analytical techniques to model the nonlinear behavior of HDRBs and assess their impact on the seismic response of retrofitted and new buildings. By considering factors such as HDRB properties, building configurations, and ground motion characteristics, the authors conduct comprehensive seismic analyses to evaluate the effectiveness of HDRBs in enhancing structural performance and reducing seismic demands. The outcomes of the research offer practical implications for engineers and designers involved in the design, retrofitting, and risk mitigation of buildings in earthquake-prone regions. By accurately modeling HDRBs and assessing their seismic performance, the study aims to improve the effectiveness and reliability of base isolation systems, ultimately leading to safer and more resilient structures.

Sharma Vijay et-al. (2021): The study addresses the critical need for understanding the vulnerability of semi-rigid frames to seismic events, particularly those occurring in close proximity to the epicenter. The study utilizes advanced analytical techniques and numerical simulations to model the dynamic behavior of semi-rigid frames subjected to near-field earthquakes. By considering factors such as frame stiffness, connection characteristics, and ground motion parameters, the authors conduct fragility analyses to assess the probability of damage and failure of semi-rigid frames under different seismic intensities. The outcomes of the research offer practical implications for engineers and designers involved in the design, retrofitting, and risk assessment of structures in earthquake-prone regions. By assessing the vulnerability of semi-rigid frames to near-field seismic events, the study aims to improve the resilience and safety of structures, ultimately leading to more robust and reliable built environments.

Taghizadeh S and Abbas Karamodin (2021): The study addresses the importance of evaluating different types of isolators under varying seismic conditions to enhance understanding and inform decision-making in structural engineering. The study utilizes advanced numerical simulations and analytical techniques to model the dynamic behavior of base-isolated structures equipped with each type of isolator. By considering factors such as isolator properties, seismic loading characteristics, and structural responses, the authors conduct comprehensive analyses to assess the effectiveness of adaptive MRE isolators relative to elastomeric isolators under near-field and far-field earthquake scenarios. The outcomes of the research offer practical implications for engineers and designers involved in the design, retrofitting, and risk mitigation of structures in earthquake-prone regions. By comparing different types of isolators and assessing their performance in various seismic scenarios, the study aims to improve the effectiveness and reliability of seismic isolation systems, ultimately leading to safer and more resilient structures.

Ghasemi et-al. (2020): The study addresses the importance of understanding how base isolation affects the seismic performance and design considerations of RC structures, with implications for improving seismic resilience. The study utilizes numerical simulations, analytical techniques, and comparative analyses to evaluate the seismic response of both isolated and non-isolated RC structures under various loading conditions. By considering factors such as structural behavior, response spectra, and design parameters, the authors examine how base isolation alters the seismic design provisions for RC structures. The outcomes of the research offer practical implications for engineers and designers involved in the seismic design and retrofitting of buildings in earthquake-prone regions. By understanding how base isolation alters seismic design provisions, the study aims to improve the effectiveness and efficiency of seismic design practices for RC structures, ultimately enhancing their seismic resilience and safety.

Jain, Monika and S S Sanghai (2020): The paper addresses the critical need for effective seismic control strategies for unsymmetrical buildings, taking into account the complex interaction between the structure and the underlying soil. The study utilizes advanced numerical simulations and analytical techniques to model the dynamic behavior of the building and its interaction with the soil. Through parametric studies and sensitivity analyses, the authors assess the effectiveness of various base isolation configurations and soil conditions in mitigating seismic forces and reducing structural response. The outcomes of the research offer practical guidance for engineers and practitioners involved in the design and retrofitting of buildings in earthquake-prone regions. By considering soil-structure interaction effects, the study aims to improve the effectiveness and reliability of base isolation systems for enhancing the seismic resilience of unsymmetrical buildings.

Mokhtari Mehdi and Hosein Naderpour (2020): The paper addresses the critical need for assessing the ability of base-isolated buildings to withstand seismic events and recover from potential losses, thereby enhancing their resilience to earthquakes. The study utilizes advanced analytical techniques and probabilistic methods to model the dynamic behavior of the buildings under seismic loading and assess their performance in terms of structural damage and loss recovery. Through numerical simulations and statistical analyses, the authors quantify the resilience of base-isolated buildings by considering factors such as structural damage, repair costs, and downtime. The outcomes of the research offer practical guidance for engineers, policymakers, and stakeholders involved in the design, retrofitting, and risk management of buildings in earthquake-prone regions. By adopting a loss-recovery approach, the study aims to improve the understanding and assessment of seismic resilience in the built environment, ultimately leading to more resilient and sustainable infrastructure.

Stanikzai et-al. (2020): The study addresses the importance of enhancing the seismic performance and stability of base-isolated structures through supplementary control mechanisms. The study utilizes numerical simulations, analytical techniques, and experimental investigations to assess the effectiveness of TMDs in reducing structural vibrations and displacements during seismic events. By considering factors such as TMD parameters, structural characteristics, and ground motion excitations, the authors analyze the performance of TMD systems in enhancing the seismic resilience of base-isolated buildings. The outcomes of the research offer practical implications for engineers and designers involved in the design, retrofitting, and risk mitigation of base-isolated structures. By incorporating TMDs as supplementary control devices, the study aims to enhance the seismic resilience and performance of buildings in earthquake-prone regions, ultimately improving their safety and reliability.

Suriansyah et-al. (2020): The study addresses the importance of evaluating the seismic response of asymmetric structures with base isolation systems to enhance their resilience against seismic events. The study utilizes pushover analysis, a widely used nonlinear static analysis method, to evaluate the seismic behavior and capacity of the structures. By considering factors such as building asymmetry, base isolator properties, and ground motion characteristics, the authors conduct numerical simulations to analyze the effectiveness of base isolation in reducing seismic demands and enhancing structural performance. The outcomes of the research offer practical implications for engineers and designers involved in the design, retrofitting, and risk mitigation of buildings in earthquake-prone regions. By considering building asymmetry and utilizing base isolation systems, the study aims to enhance the seismic resilience and safety of structures, ultimately contributing to the development of more resilient and sustainable built environments.

Bhandari M et al. (2019): The study addresses the critical need for understanding how different seismic hazard scenarios affect the vulnerability and performance of base-isolated structures. The study utilizes advanced analytical techniques and probabilistic methods to model the dynamic behavior of base-isolated structures under near- and far-field earthquake excitations. By considering factors such as ground motion characteristics, structural properties, and isolation system performance, the authors assess the fragility of base-isolated building frames and quantify their vulnerability to seismic events. The outcomes of the research offer practical implications for engineers, policymakers, and stakeholders involved in the design, retrofitting, and risk assessment of base-isolated structures. By understanding the vulnerability of base-isolated buildings to different seismic hazard scenarios, the study aims to improve the resilience and safety of structures in earthquake-prone regions.

2.2. FINDING

- Many papers investigated the seismic performance of different structural systems, including multi-storied steel buildings, RCC buildings, and nuclear island buildings, under various ground motion scenarios.
- Several studies focused on evaluating the effectiveness of base isolation systems in mitigating seismic forces and protecting structures against earthquakes. This included investigating different types of base isolators and their performance in reducing structural response.
- A few papers conducted comparative studies to analyze the response of structures to different seismic loading conditions, such as near and far-field earthquakes. These studies provided insights into the influence of earthquake characteristics on structural behavior and response.
- Some papers explored the nonlinear behavior of structures under seismic loading, considering factors such as irregularities in structural geometry and

material properties. These analyses contributed to a deeper understanding of the complex response mechanisms of base-isolated structures.

- Several studies performed seismic fragility evaluations to assess the vulnerability of structures to earthquake-induced damage. This involved quantifying the probability of structural failure under various seismic hazard levels and loading conditions.
- Certain papers investigated the integration of retrofit techniques, such as tuned mass dampers and High Damping Rubber Bearings (HDRBs), in improving the seismic resilience of existing structures. These studies aimed to enhance the structural performance and safety of retrofitted buildings.
- Some studies considered soil-structure interaction effects in the seismic analysis of base-isolated buildings. This included examining the dynamic interaction between the structure and the underlying soil to better predict structural response during earthquakes.

2.3. RESEARCH GAPS

- Several papers explore the effectiveness of different types of dampers and base isolation systems. However, there might be a gap in understanding the comparative performance of these systems under various seismic conditions and building configurations.
- Some papers focus on the response of buildings to near and far field earthquakes. However, there might be a gap in understanding how different types of buildings (e.g., symmetric, asymmetric, multi-story) respond to various seismic intensities and distances from the epicenter.
- Nonlinear seismic analysis is addressed in several papers, particularly concerning irregular and retrofitted structures. However, there may be a gap in understanding the long-term performance and reliability of these structures under repeated seismic events.
- Several papers discuss the seismic demands and design requirements of buildings with base isolation systems. However, there might be a gap in understanding the optimization of base isolation systems to minimize structural damage and enhance resilience.
- Some papers focus on the fragility evaluation and performance assessment of base-isolated structures. However, there might be a gap in understanding the relationship between various design parameters, such as damping characteristics, isolation effectiveness, and structural response.
- A few papers consider soil-structure interaction in the seismic response of buildings with base isolation. However, there might be a gap in understanding how different soil conditions affect the effectiveness of base isolation systems.

- One paper discusses the use of tuned mass dampers for seismic response control. However, there might be a gap in understanding the optimal design and placement of TMDs in conjunction with base isolation systems.

CHAPTER 3

METHODOLOGY

In this research work prepare four different cases in ETABS. Base isolation devices are typically installed between a building's foundation and superstructure. They serve as a flexible interface, depending, in the case of a seismic event, on the structure's ability to move regardless of its position on the ground.

3.1. GEOMETRICAL ANALYSIS OF MODEL

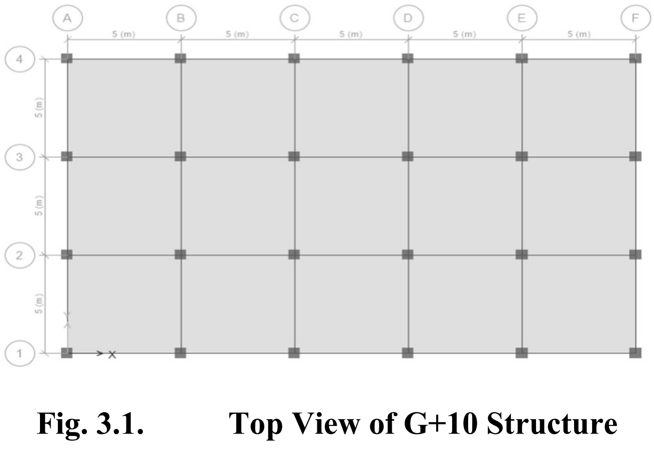


Fig. 3.1. Top View of G+10 Structure

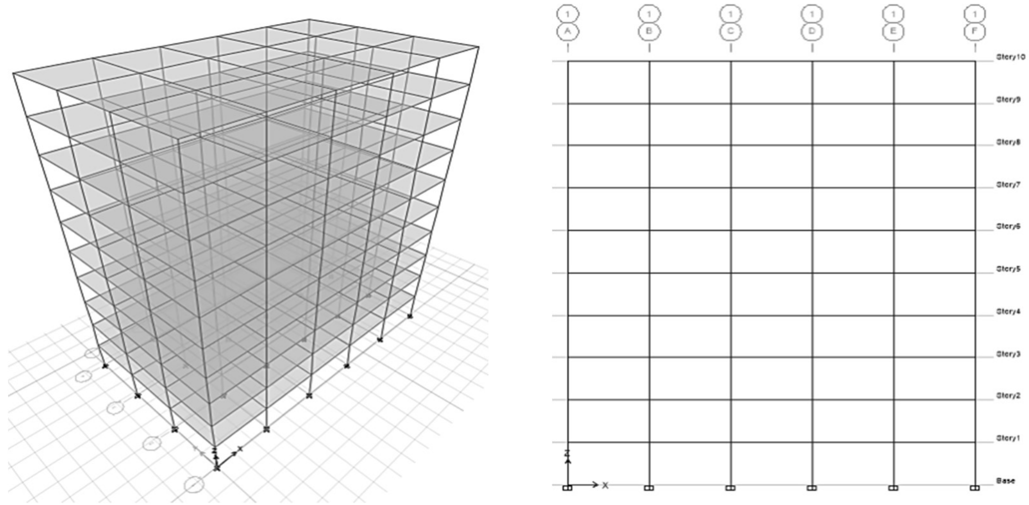


Fig. 3.2. 3D & Elevation View of G+10 Structure

Table 3.1. Model Specifications

S. No.	Data	Value
1	Grade of Reinforcement	HYSD 500
2	Grade Of Concrete	M40
3	No. of stories	G+10
4	No. of bay along X-direction	5
5	No. of bay along Y-direction	3
6	Span along X-direction	5m
7	Span along Y-direction	5m
8	Floor height	3m
9	Column Size	500*500 mm
10	Beam Size	500*400 mm
11	Depth of Slab	200mm
12	Wall Load	13.8 KN/m
13	Live load	2.5kn/m2
14	Software	CSI ETABS
15	Earthquake method	Time History
Earthquake in Bhuj & Uttarkashi		
16	seismic zone	5
17	soil type	2
18	Importance factor	1
19	Response Reduction factor	5

3.1.1. Cases

1. **Case-1 :** Earthquake epicenter nearby model without base isolator
2. **Case-2 :** Earthquake epicenter nearby model with base isolator
3. **Case-3 :** Earthquake epicenter far away model without base isolator
4. **Case-4 :** Earthquake epicenter far away model with base isolator

3.2. MATERIAL PROPERTY

Table 3.2. Materials - basic mechanical features

Material	Unit Weight	Unit Mass	E	Thermal Expansion, A
	KN/m^3	KG/m^3	MPa	1/C
M40	24.9926	2548.538	31622.78	0.0000055
HYSD500	76.9729	7849.047	200000	0.0000177

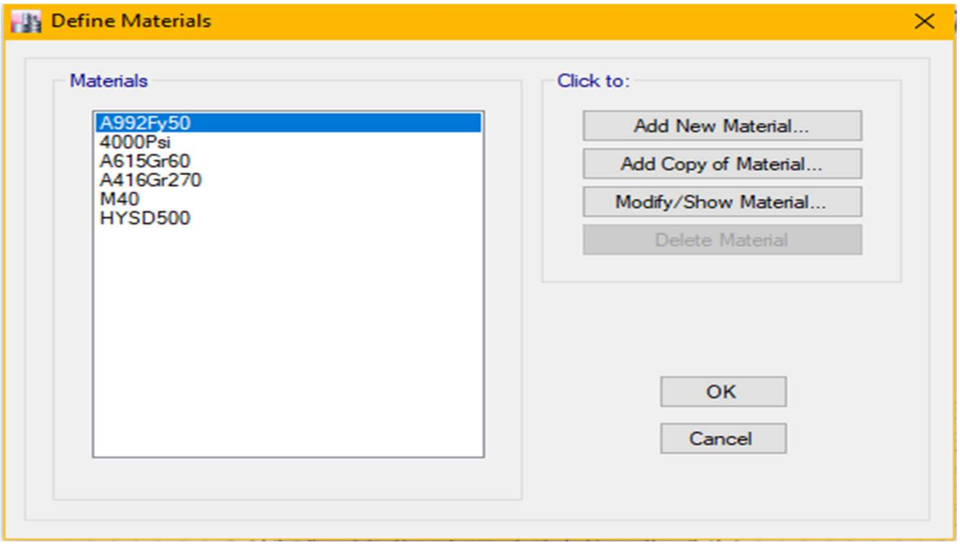


Fig. 3.3. Define Materials

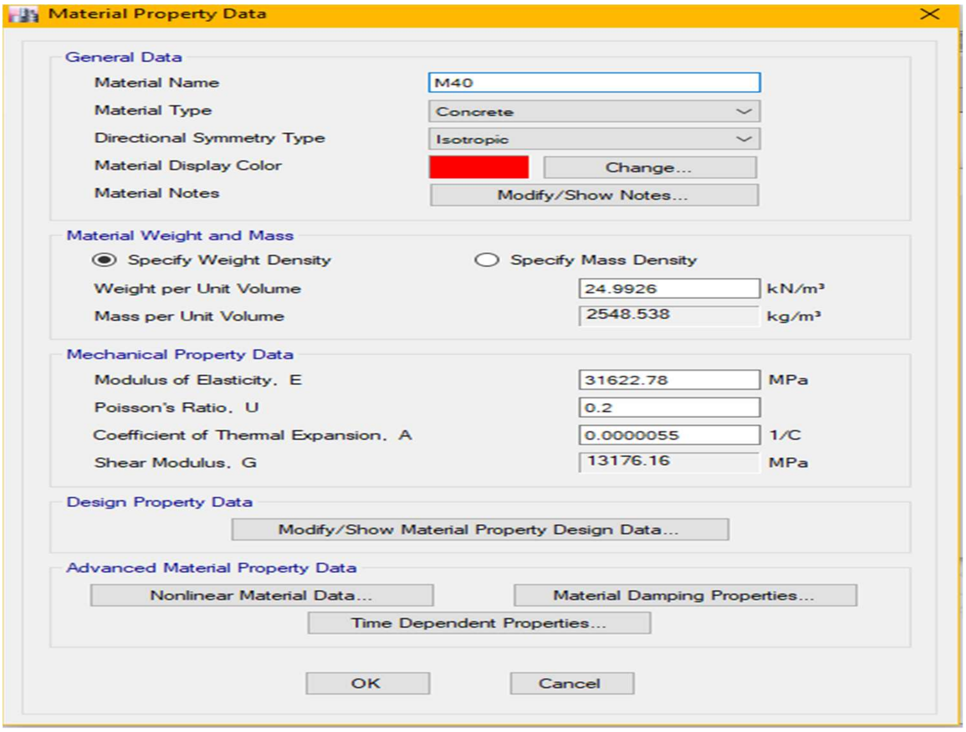


Fig. 3.4. **Property data of Material M40**

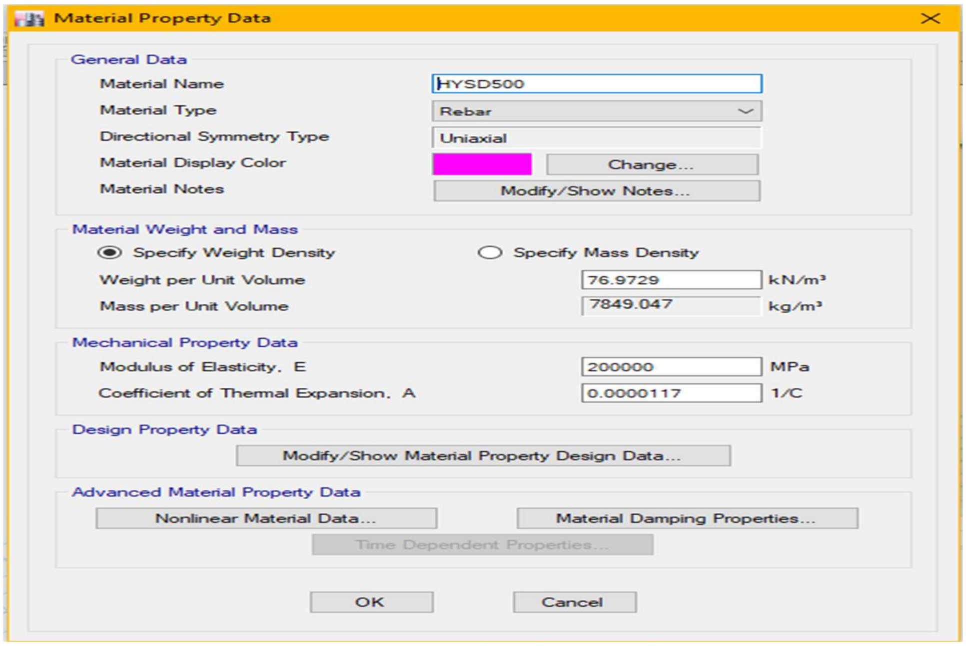


Fig. 3.5. **Property data of Material HYSD500**

3.3. SECTION PROPERTY

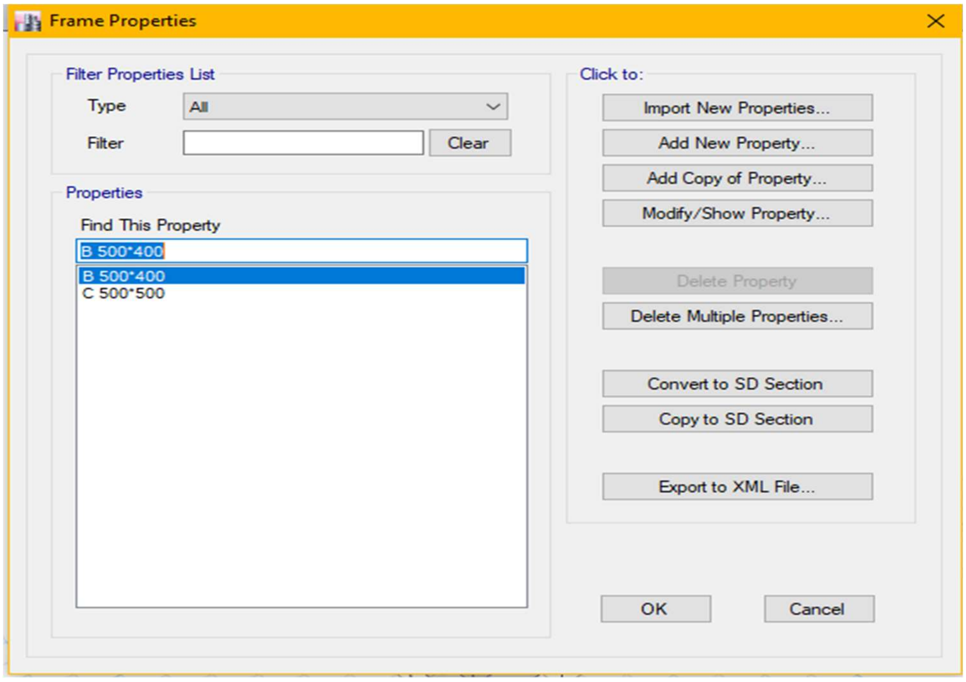


Fig. 3.6. Different Sections

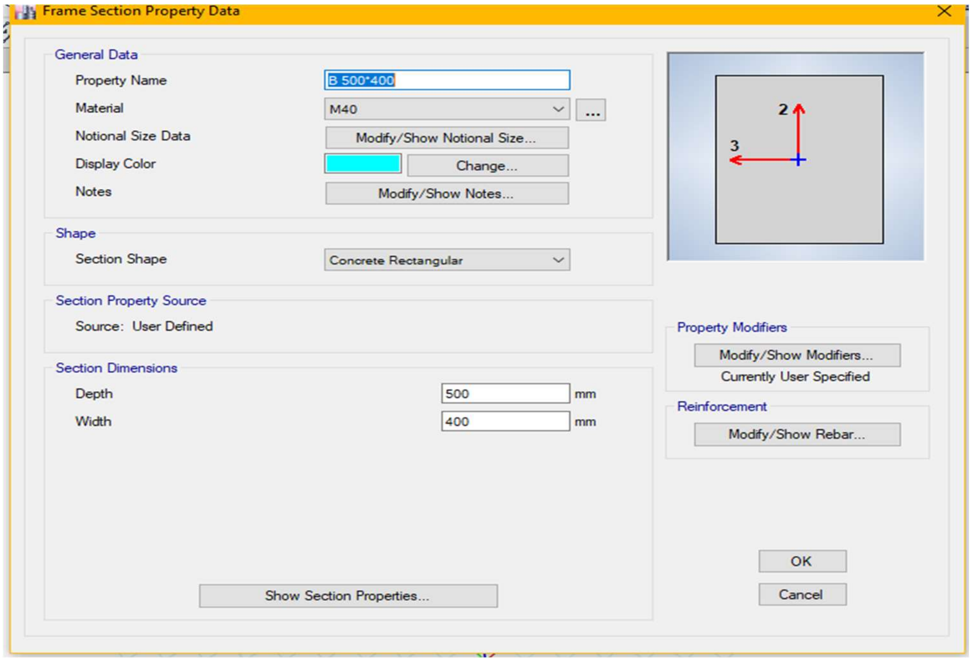


Fig. 3.7. Property Assign for Beam 500*400

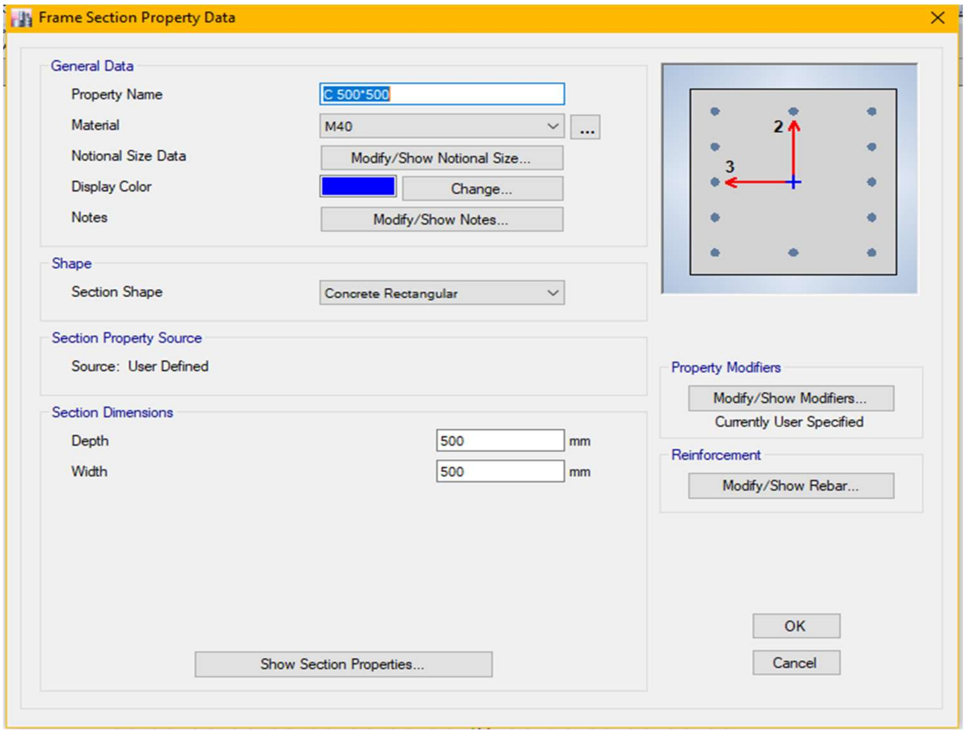


Fig. 3.8. Property Assign for Column 500*500

3.4. SLAB PROPERTY

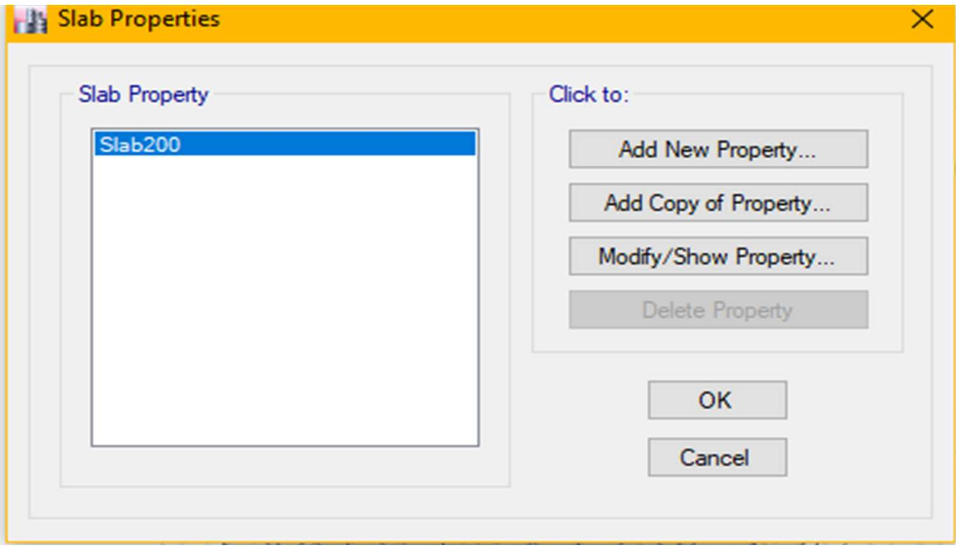


Fig. 3.9. Slab Property

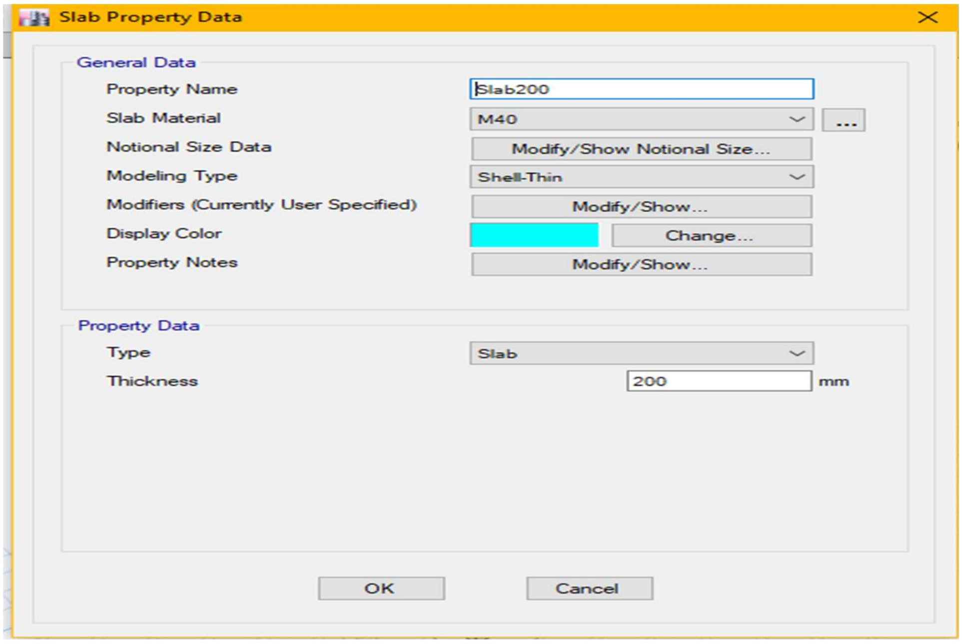


Fig. 3.10. Property data of Slab200

3.5. RESPONSE SPECTRUM AND TIME HISTORY FUNCTION

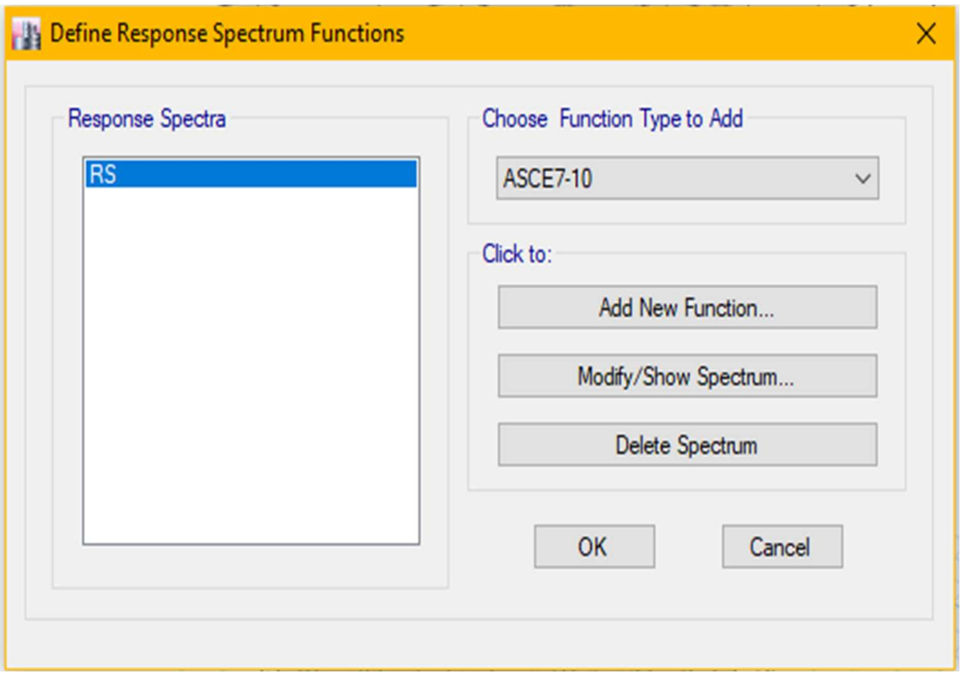


Fig. 3.11. Define Response Spectrum Function

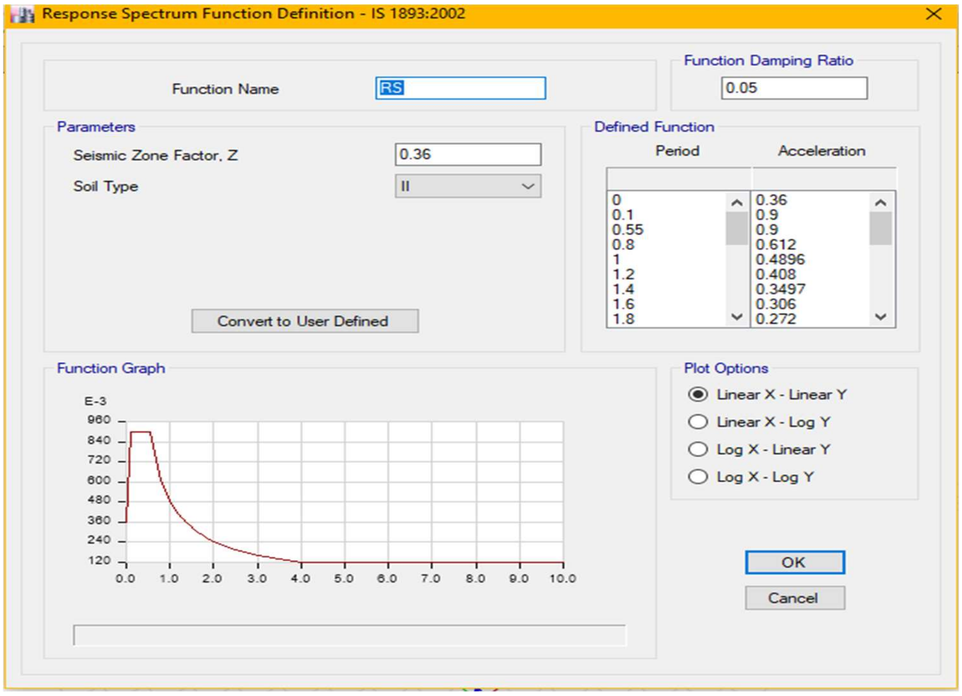


Fig. 3.12. Response Spectrum Function Definition As per IS 1893:2002

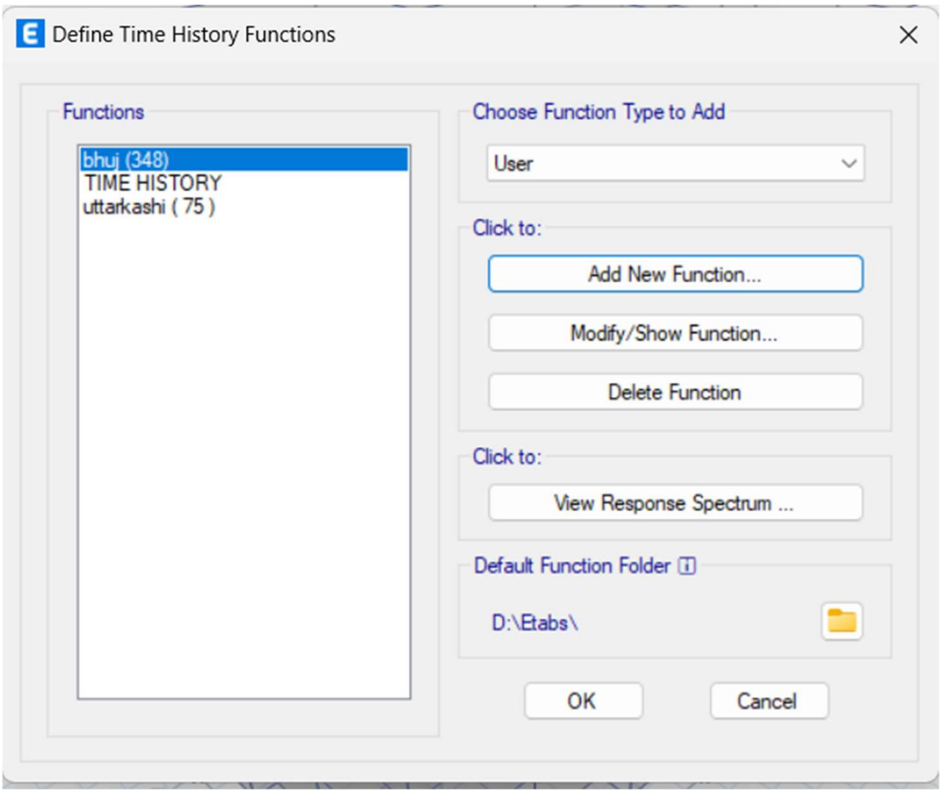


Fig. 3.13. Define Time History Functions

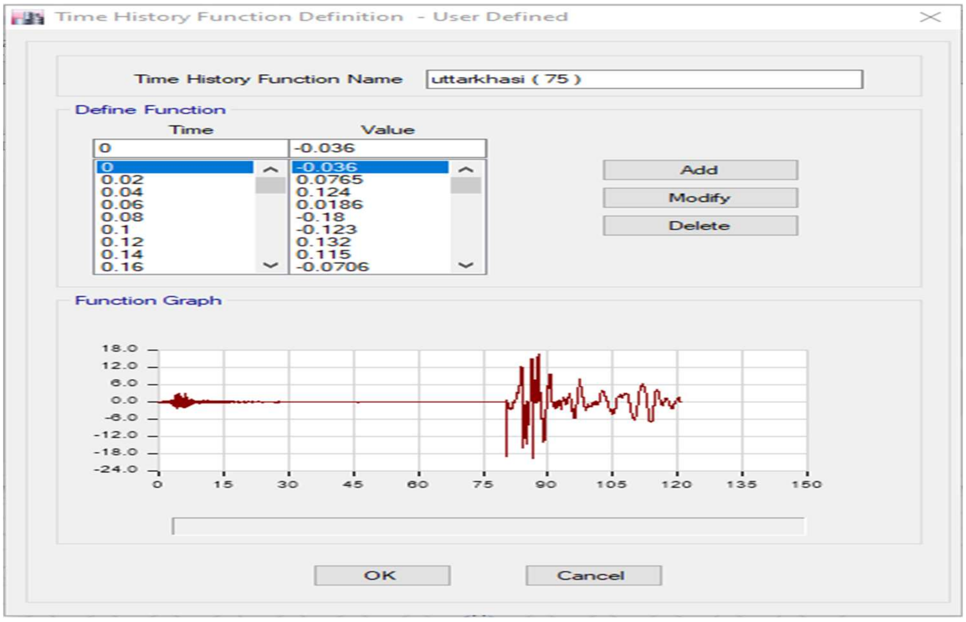


Fig. 3.14. Time History Function for Uttarkashi

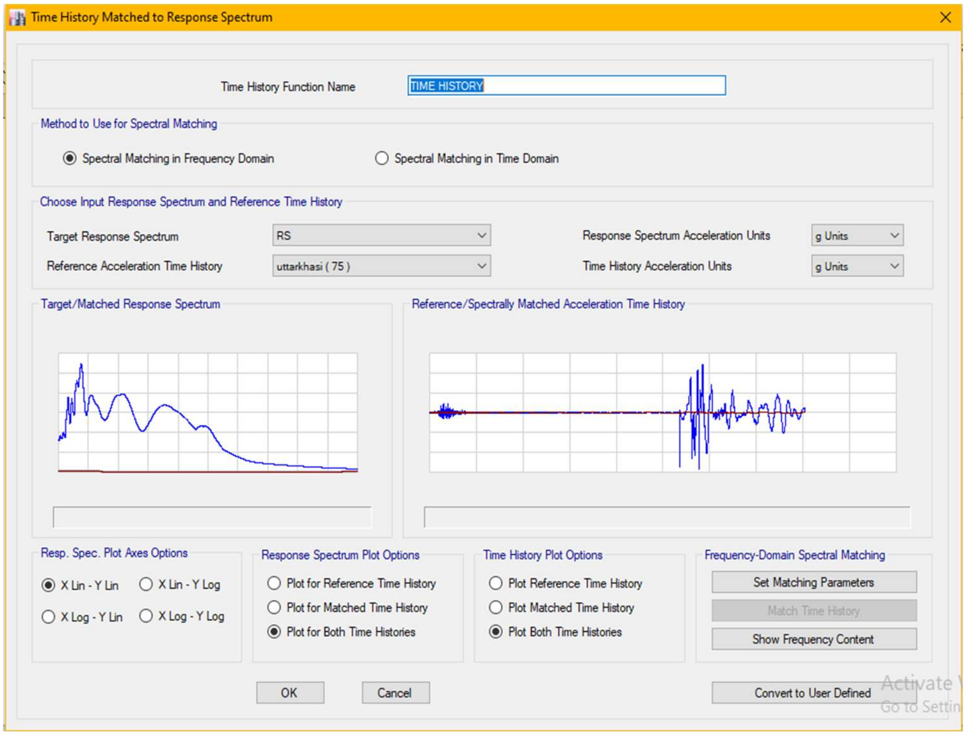


Fig. 3.15. Time History Matched to Response Spectrum for Uttarkashi

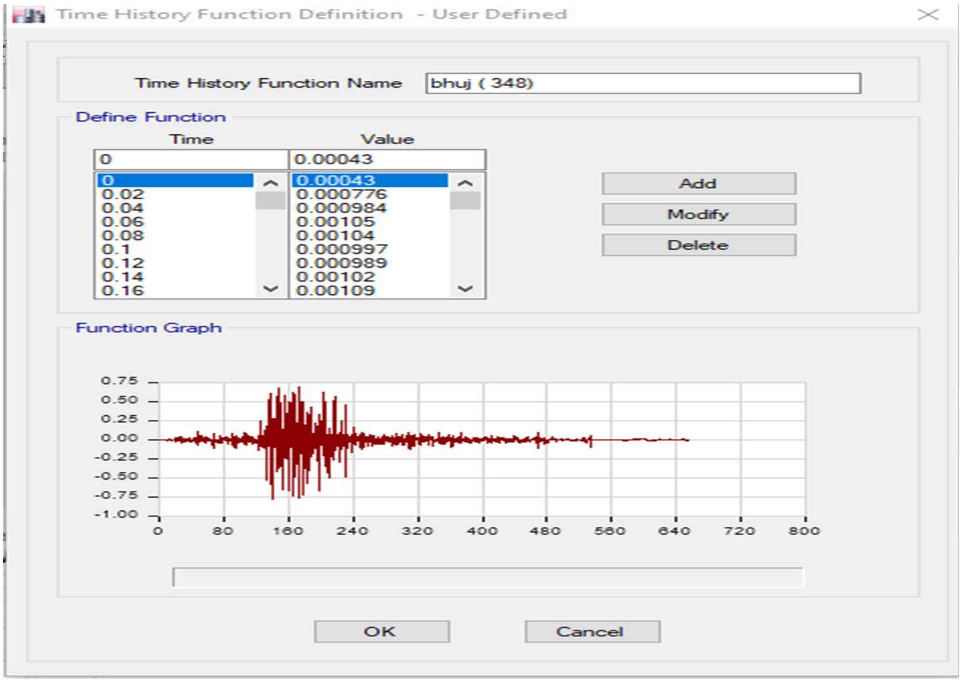


Fig. 3.16. Time History Function for Bhuj

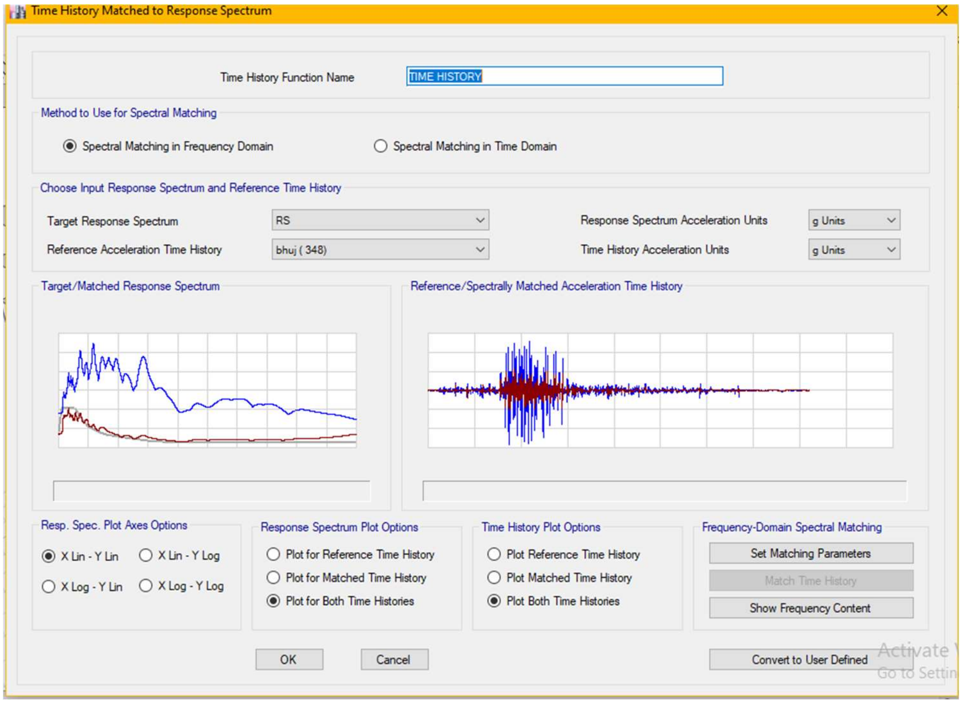


Fig. 3.17. Time History Matched to Response Spectrum for Bhuj

3.6. LINK PROPERTY

Table 3.3. Link/Support directional – Mechanical properties of internal isolator

Properties	U1	U2 & U3
Rotational Inertial (kN/m)	0.016636733	
Effective Stiffness (kN/m)	2887594.568	2887.595
Effective Damping (kN-s/m)	0	0.05
Distance from End-j (m)	-	0.011
Non- Linear Stiffness (kN/m)	-	26039
Non- Linear Yield strength kN	-	119.53
Non- Linear Post yield stiffness ratio	-	0.2

Table 3.4. Link/Support directional – Mechanical properties of external isolator

Properties	U1	U2 & U3
Rotational Inertial (kN/m)	0.016636733	
Effective Stiffness (kN/m)	2202742.78	2202.74
Effective Damping (kN-s/m)	0	0.05
Distance from End-j (m)	-	0.0112
Non- Linear Stiffness (kN/m)	-	19863
Non- Linear Yield strength kN	-	91.41
Non- Linear Post yield stiffness ratio	-	0.2

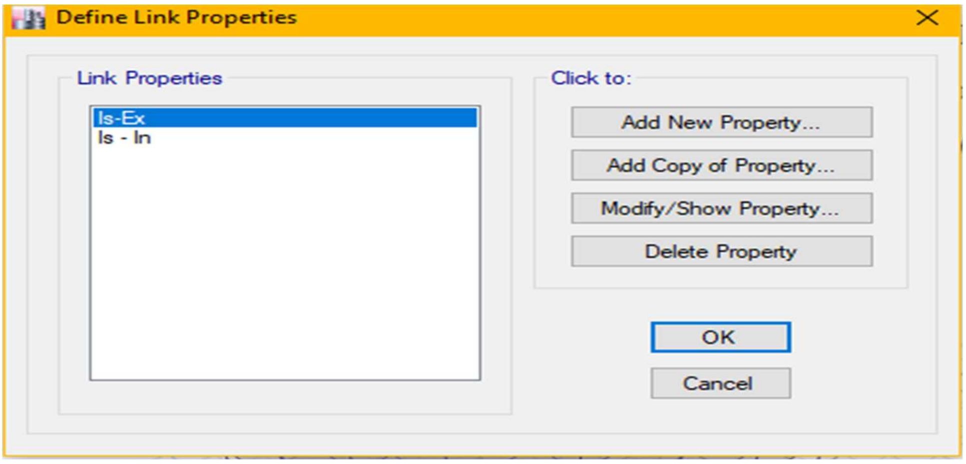


Fig. 3.18. Define Link Properties

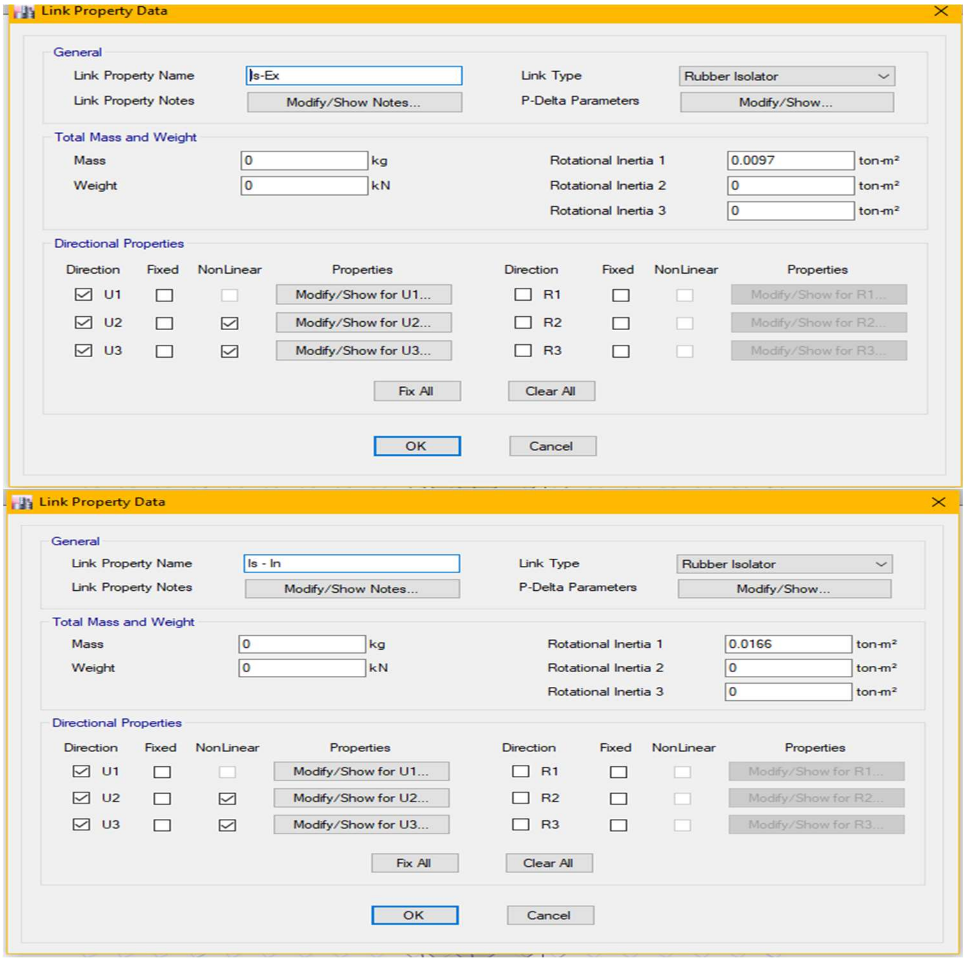


Fig. 3.19. Link property data

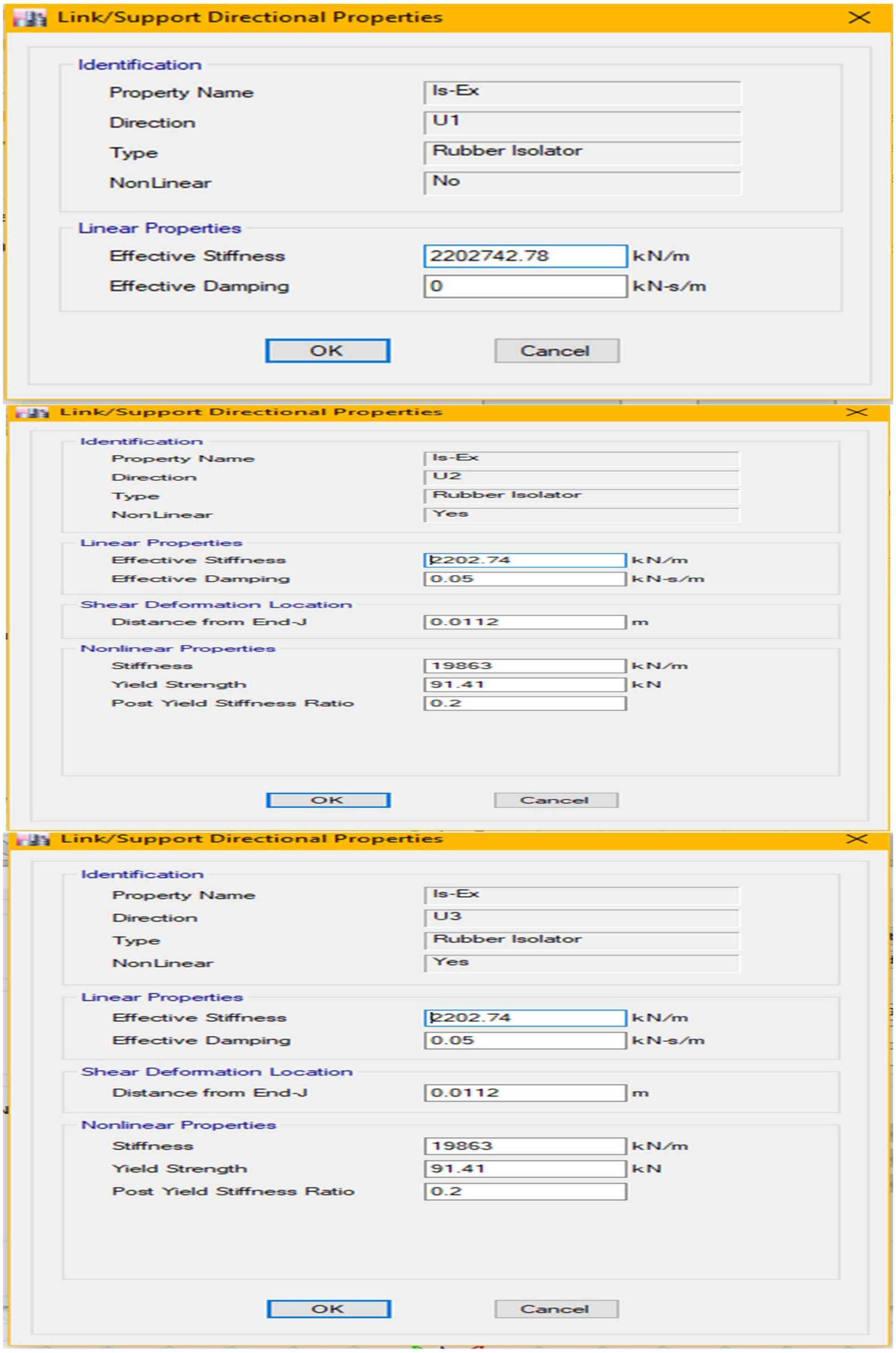


Fig. 3.20. Link/Support property for Isolators applied on External Directions

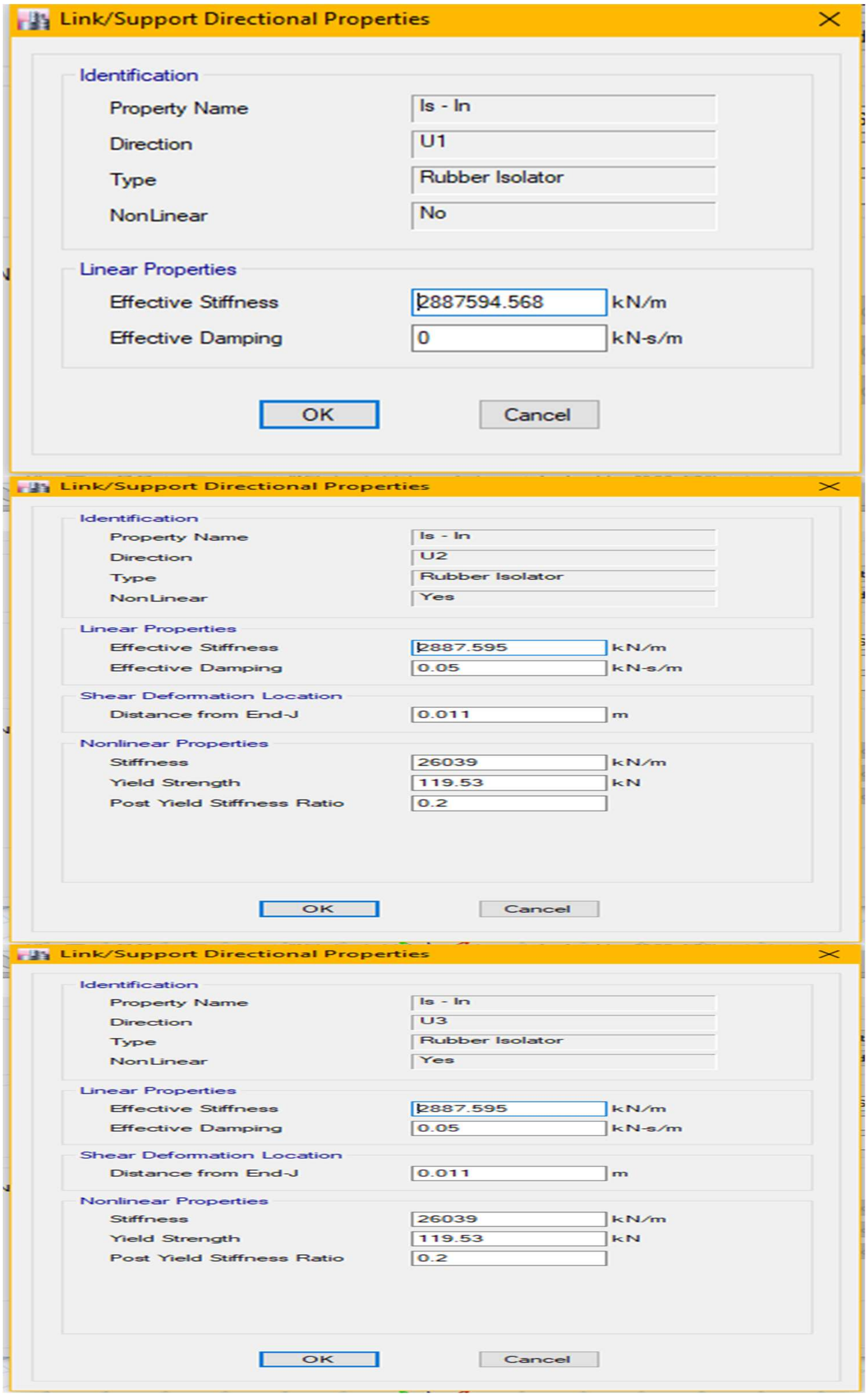


Fig. 3.21. Link/Support property for Isolators applied on Internal Directions

3.7. MASS SOURCE

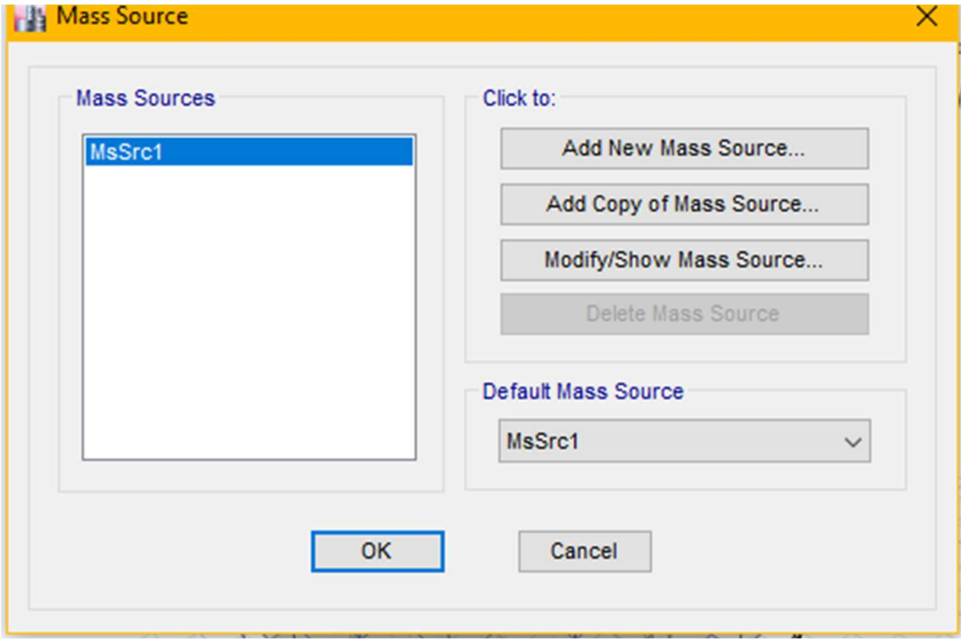


Fig. 3.22. Define Mass Source

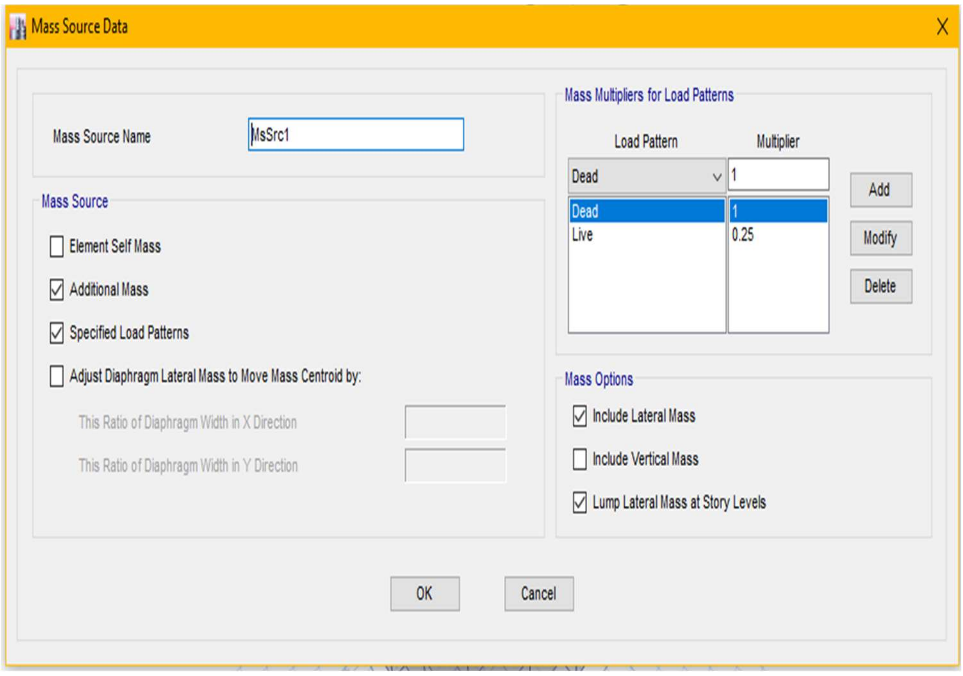


Fig. 3.23. Mass Source data

3.8. LOAD DEFINITIONS

Table 3.5. Load input data

<table>
<tr><th colspan="6">Load Definitions</th></tr>
<tr><th rowspan="2">Load</th><th rowspan="2">Load Type</th><th rowspan="2">Self-Weight Multiplier</th><th rowspan="2">Auto lateral load</th><th colspan="2">P – Delta</th></tr>
<tr><th>Scale factor</th><th>Automation Method</th></tr>
<tr><td>Dead</td><td>Dead</td><td>1</td><td>-</td><td>1.2</td><td rowspan="4">Iterative – Based on loads</td></tr>
<tr><td>Live</td><td>Live</td><td>0</td><td>-</td><td>0.5</td></tr>
<tr><td>EQL-X</td><td>Seismic</td><td>0</td><td>India IS 1893:2002</td><td>1.5</td></tr>
<tr><td>EQL - Y</td><td>Seismic</td><td>0</td><td>India IS 1893:2002</td><td>1.5</td></tr>
<tr><th colspan="4">Load Cases</th><th colspan="2">Load Combinations</th></tr>
<tr><th colspan="2">Name of case</th><th colspan="2">Load Case type</th><td colspan="2">1.2 (DL+LL+EQL-X)</td></tr>
<tr><td colspan="2">Dead</td><td colspan="2">Linear static</td><td colspan="2">1.2 (DL+LL+TH-X)</td></tr>
<tr><td colspan="2">Live</td><td colspan="2">Linear static</td><td colspan="2">1.2 (DL+LL+TH-Y)</td></tr>
<tr><td colspan="2">EQL -X</td><td colspan="2">Linear static</td><td colspan="2">1.5 (DL+EQL-X)</td></tr>
<tr><td colspan="2">EQL -Y</td><td colspan="2">Linear static</td><td colspan="2">15 (DL+EQL-Y)</td></tr>
<tr><td colspan="2">RS -X</td><td colspan="2">Response spectrum</td><td colspan="2">1.5 (DL+TH-X)</td></tr>
<tr><td colspan="2">RS -Y</td><td colspan="2">Response spectrum</td><td colspan="2">1.5 (DL+TH-Y)</td></tr>
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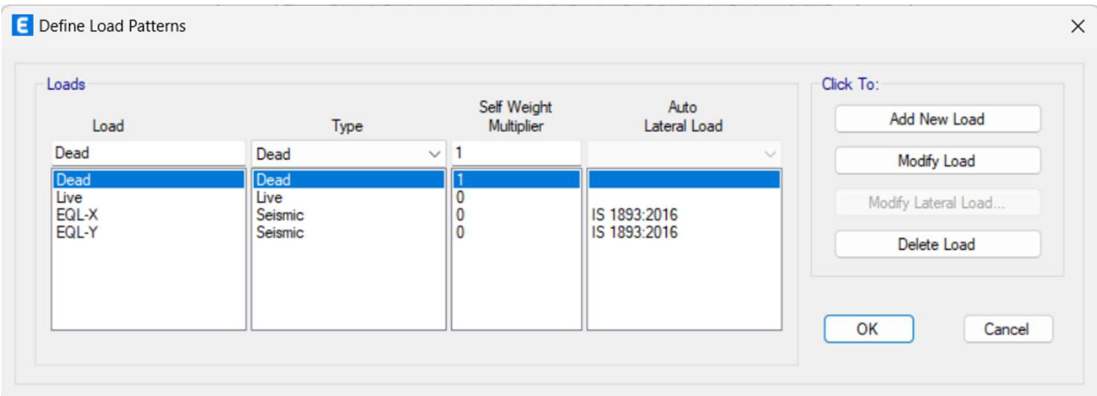


Fig. 3.24. Define Load Pattern

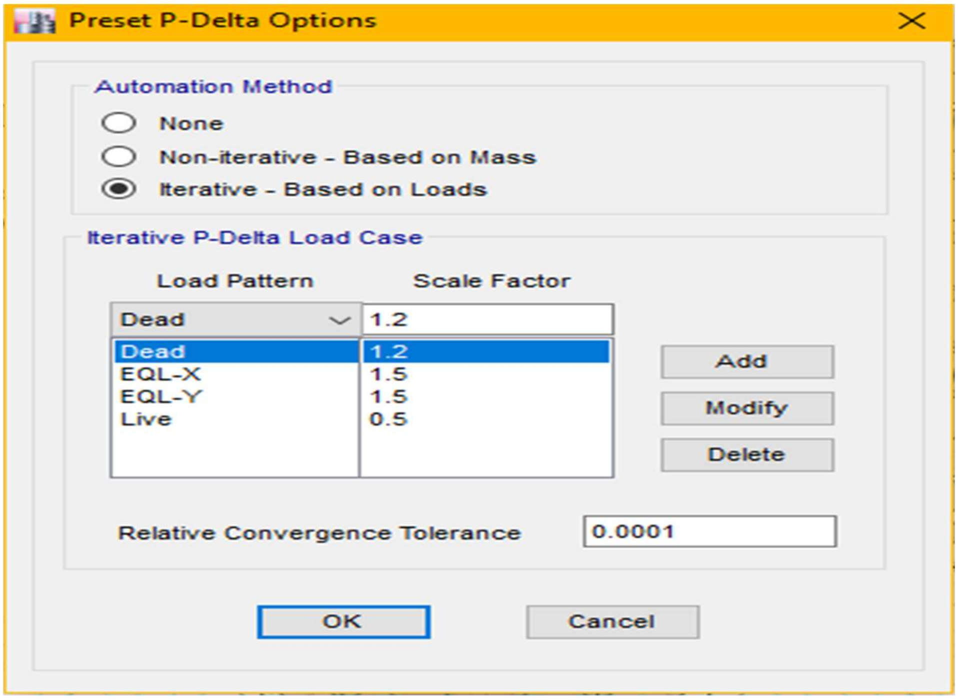


Fig. 3.25. Preset P-Delta Options

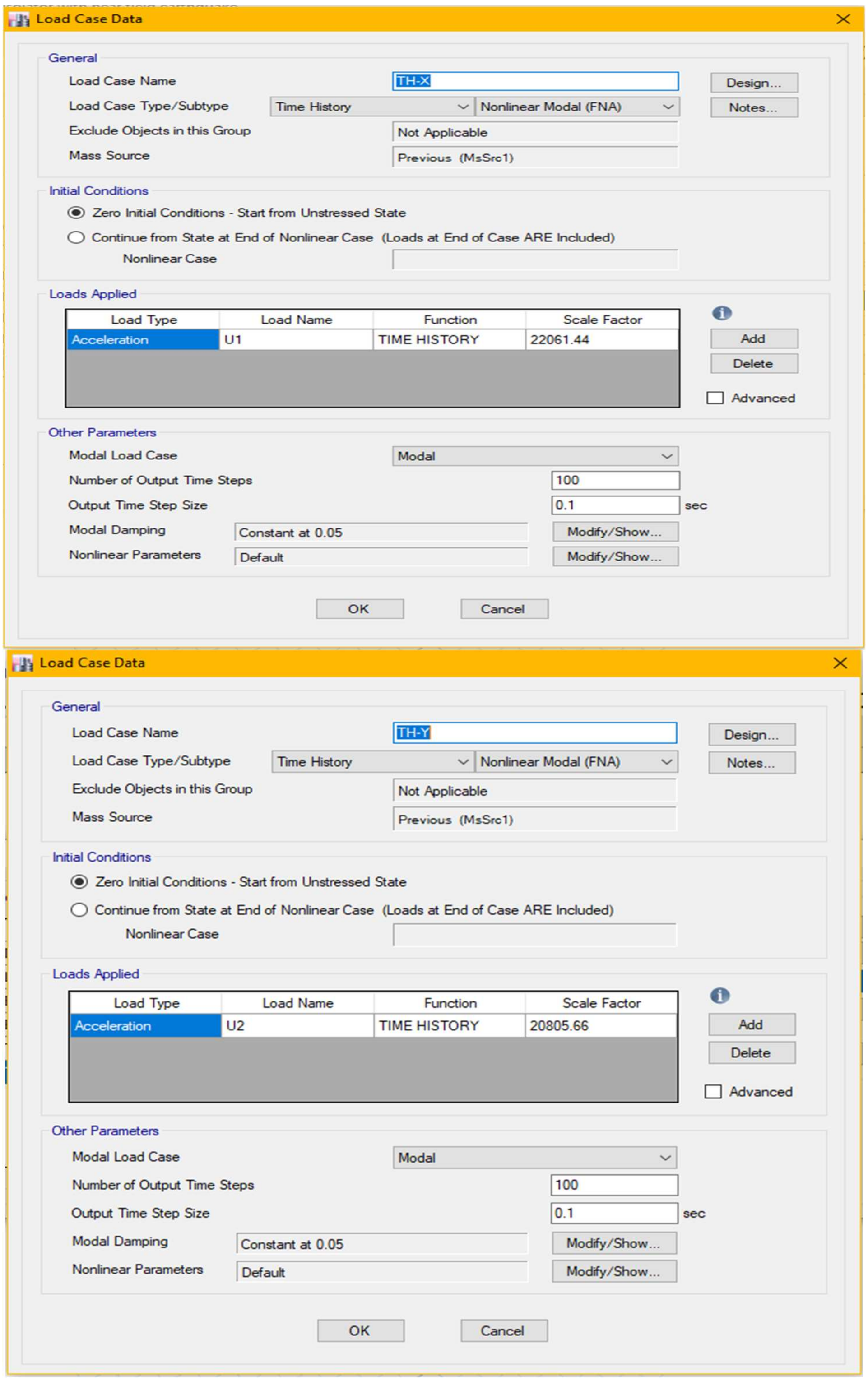


Fig. 3.26. Load Case data

CHAPTER 4

RESULT AND DISCUSSION

In this section, we conduct the design of a G+10 floor structure, both with and without the application of an isolator in various directions. 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. STOREY DISPLACEMENT

Table 4.1. Storey displacement of G+10 structure in different cases

Storey displacement (mm) 1.2 (DL+LL+TH-X)					
Storey	**Storey height (m)**	**Case-1**	**Case-2**	**Case-3**	**Case-4**
Storey-10	30	39.75	46.08	36.59	42.71
Storey-9	27	37.62	45.40	35.65	42.16
Storey-8	24	36.82	44.28	34.04	41.18
Storey-7	21	34.35	42.81	31.73	39.79
Storey-6	18	33.73	40.97	28.68	38.02

Storey-5	15	31.41	38.54	24.91	35.75
Storey-4	12	25.87	35.30	20.42	32.86
Storey-3	9	17.82	31.24	15.21	29.35
Storey-2	6	10.49	26.55	9.41	25.21
Storey-1	3	4.13	20.63	3.55	19.49
Ground	0	0	3.41	0	2.92

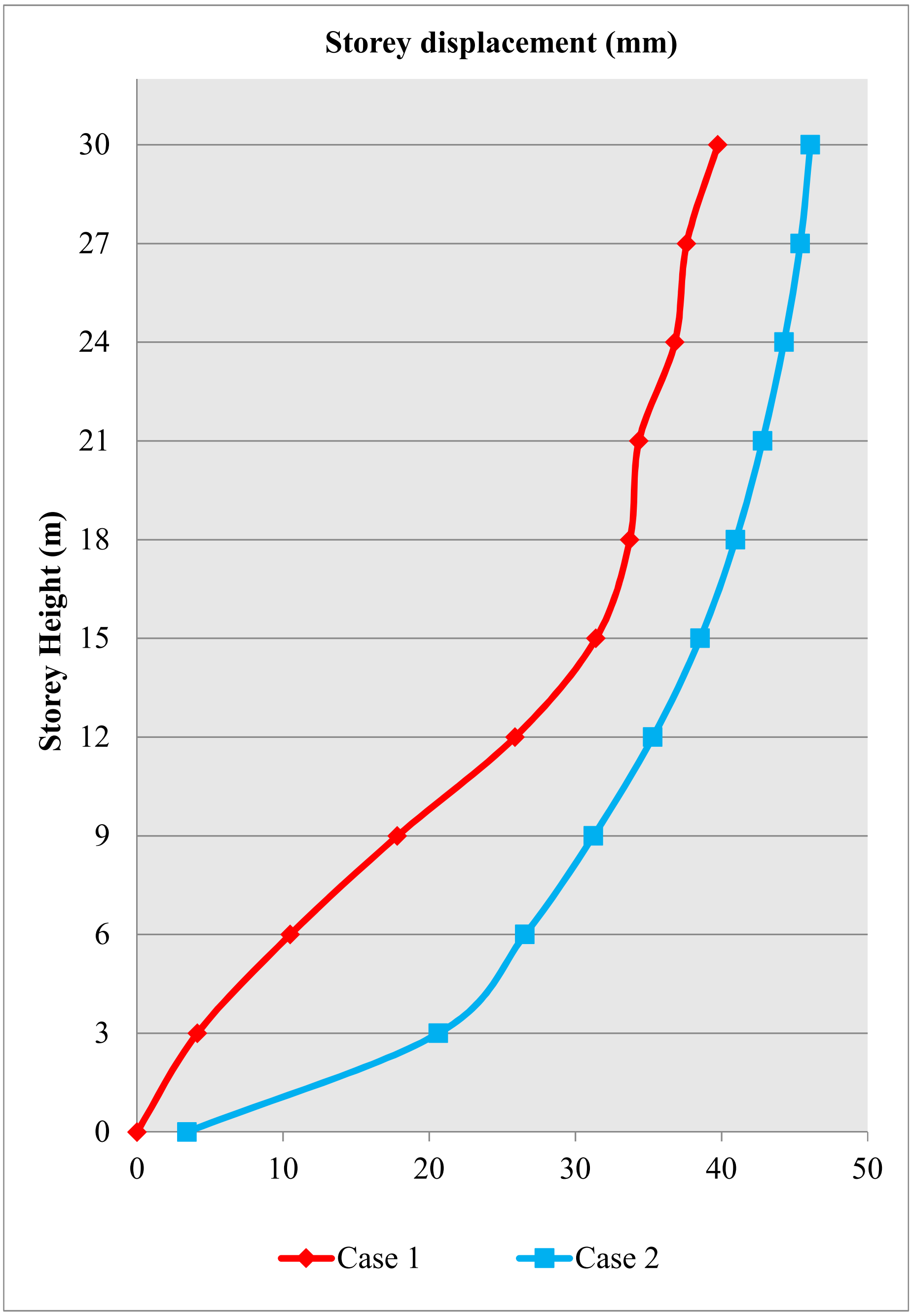


Fig. 4.1. Comparison of Storey displacement in case-1 and case-2

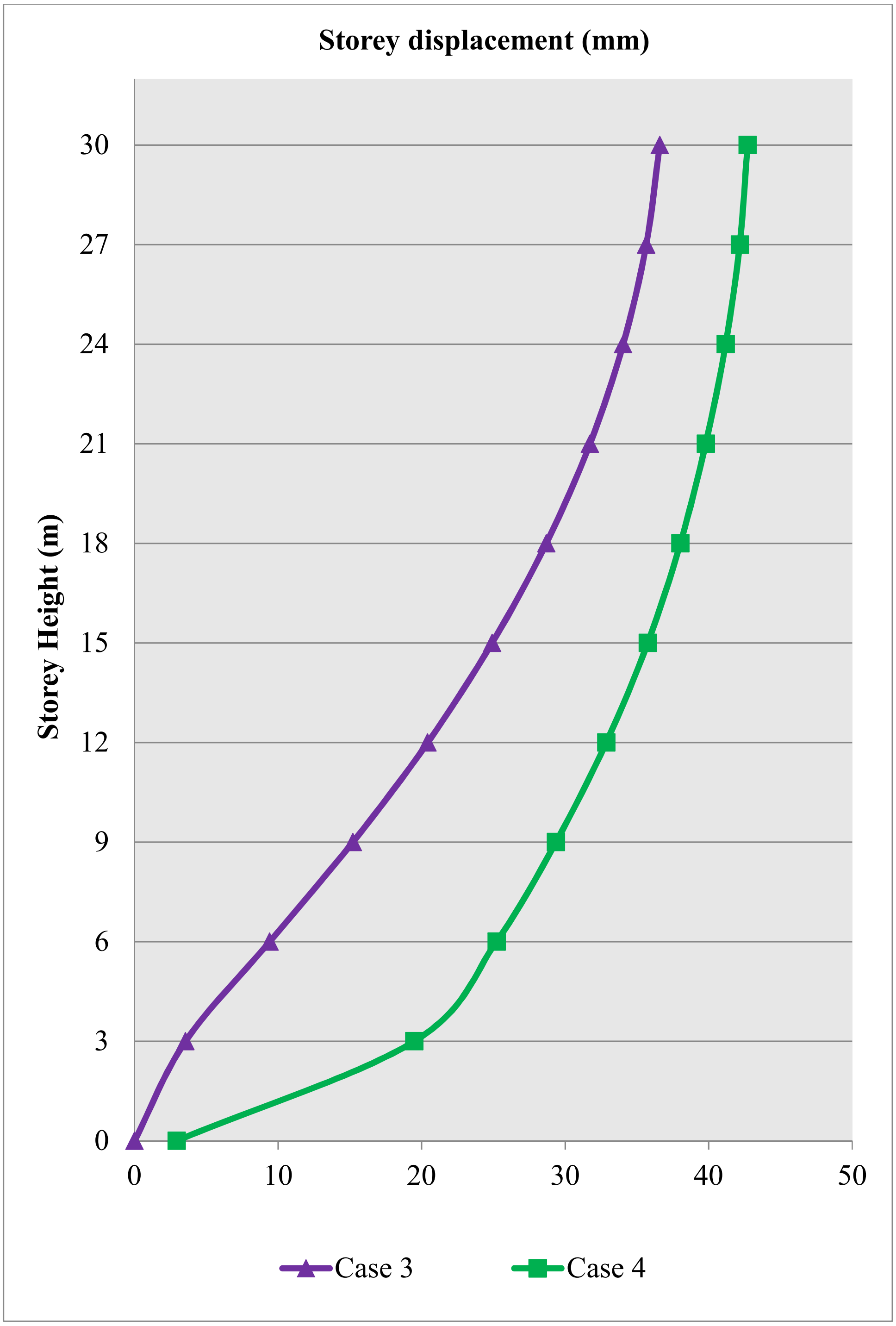


Fig. 4.2. Comparison of Storey displacement in case-3 and case-4

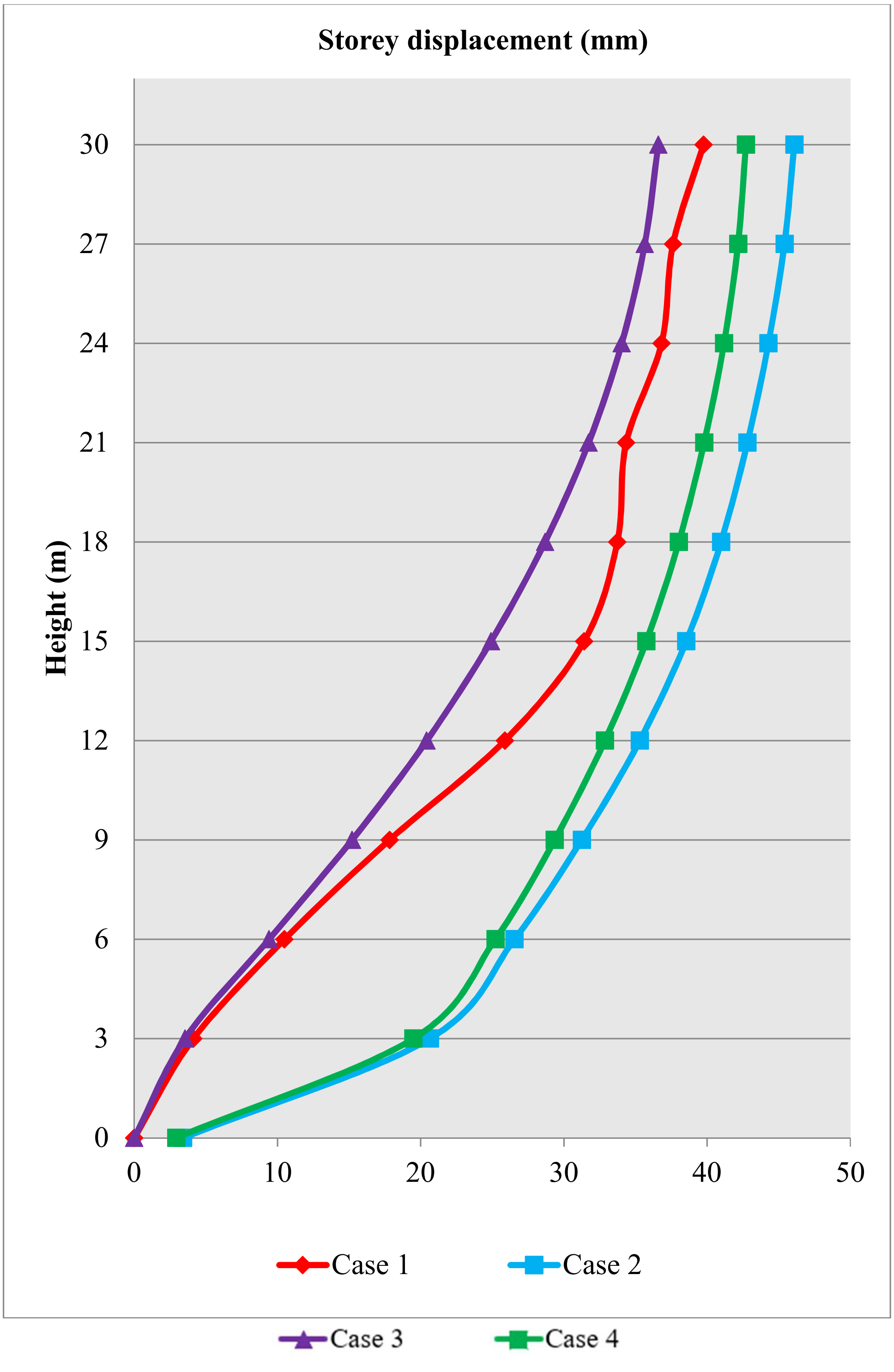


Fig. 4.3. Combine Storey displacement of G+ 10 structures

4.2. STOREY DRIFT

Table 4.2. Storey Drift of G+10 structure in different cases

Storey Drift 1.2 (DL+LL+TH-X)					
Storey	**Storey height (m)**	**Case-1**	**Case-2**	**Case-3**	**Case-4**
Storey-10	30	0.001137	0.000378	0.000313	0.000207
Storey-9	27	0.001507	0.000622	0.000546	0.000364
Storey-8	24	0.001528	0.00078	0.000805	0.000512
Storey-7	21	0.001857	0.000828	0.001055	0.000657
Storey-6	18	0.001972	0.001039	0.001288	0.000821
Storey-5	15	0.002016	0.001203	0.00151	0.001002
Storey-4	12	0.002701	0.001429	0.001736	0.001185
Storey-3	9	0.002773	0.001579	0.001943	0.001383
Storey-2	6	0.002152	0.002048	0.001955	0.001907
Storey-1	3	0.001377	0.005739	0.001182	0.005522
Ground	0	0	0	0	0

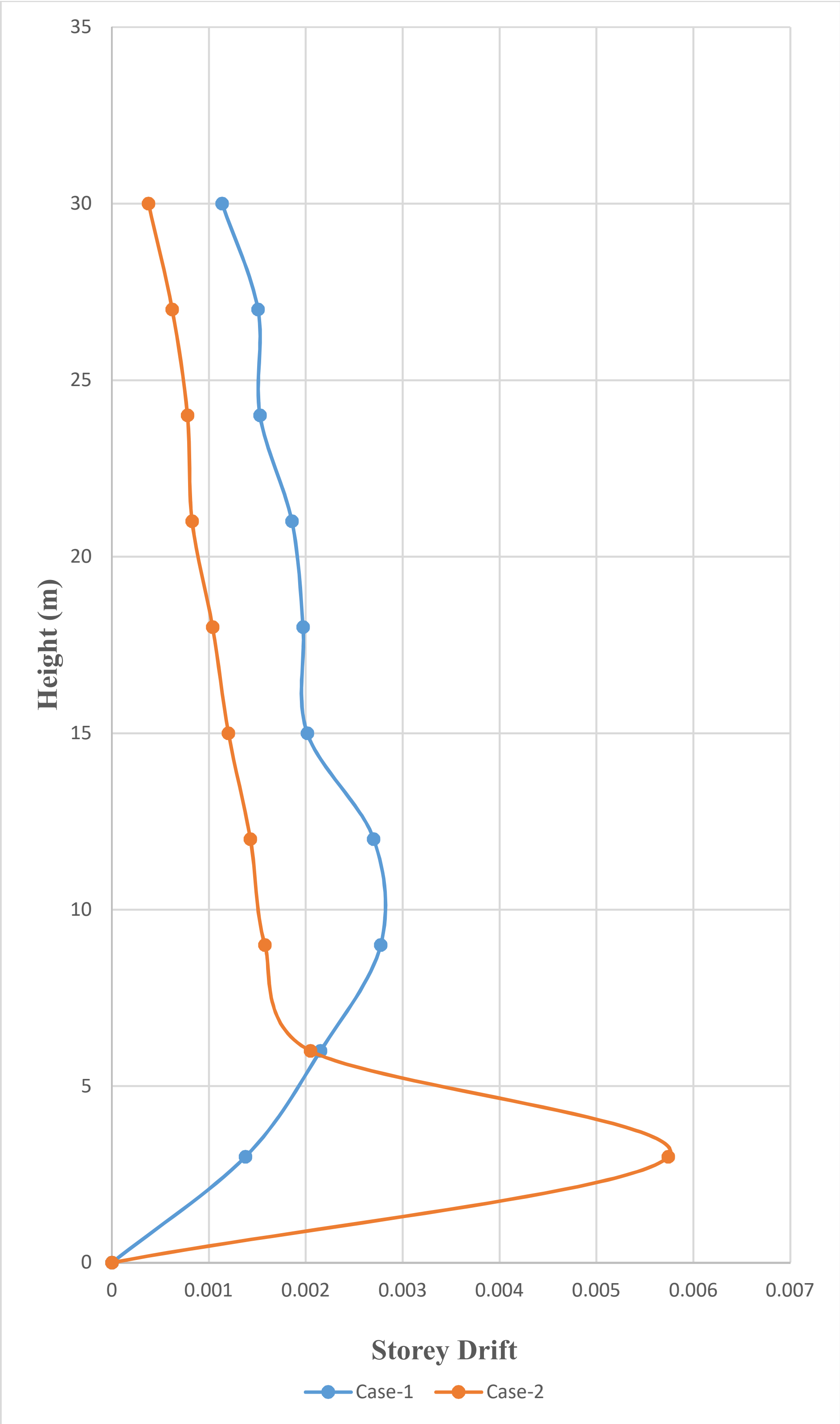


Fig. 4.4. **Comparison of Storey drift in case-1 and case-2**

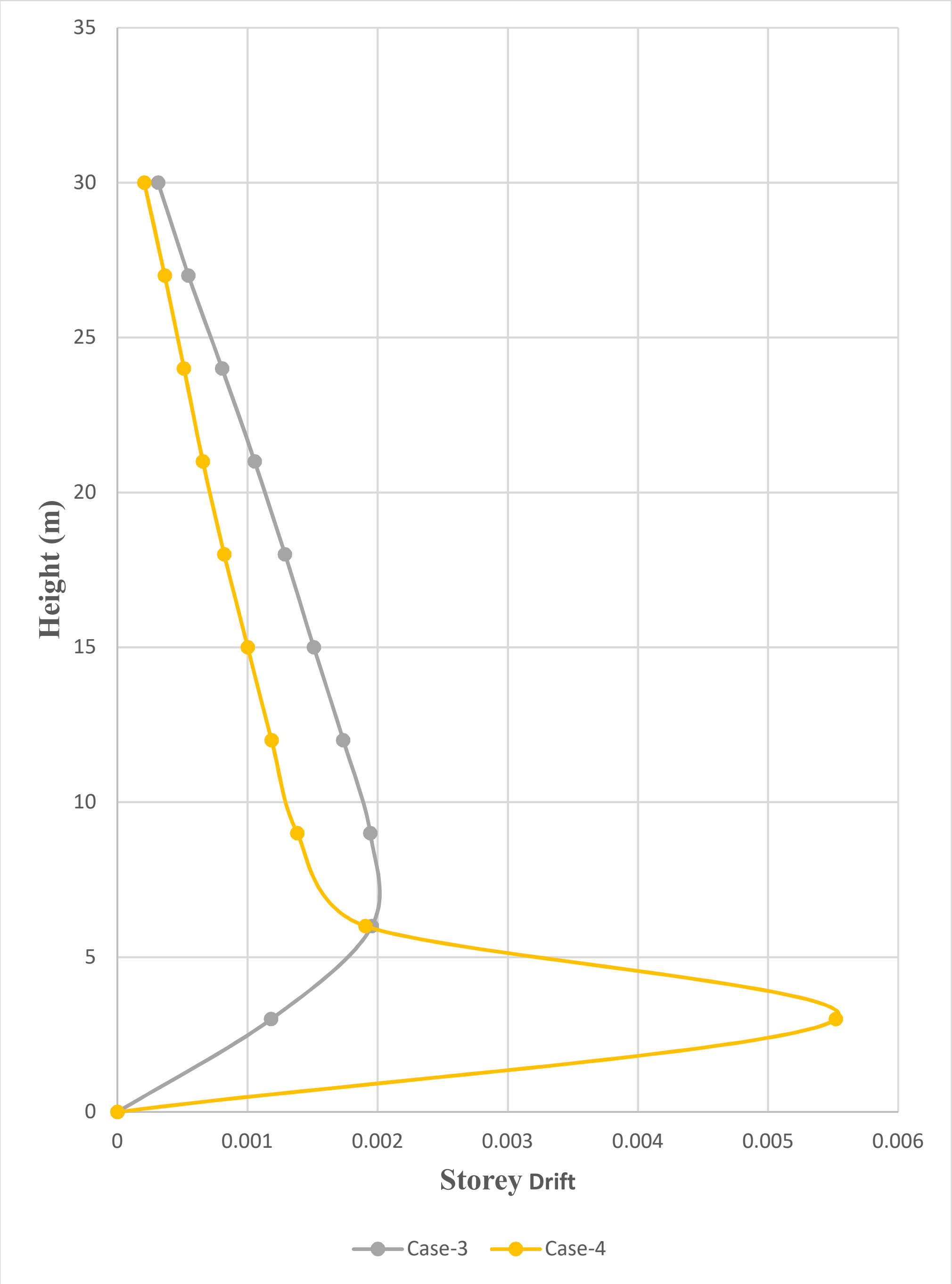


Fig. 4.5. Comparison of Storey drift in case-3 and case-4

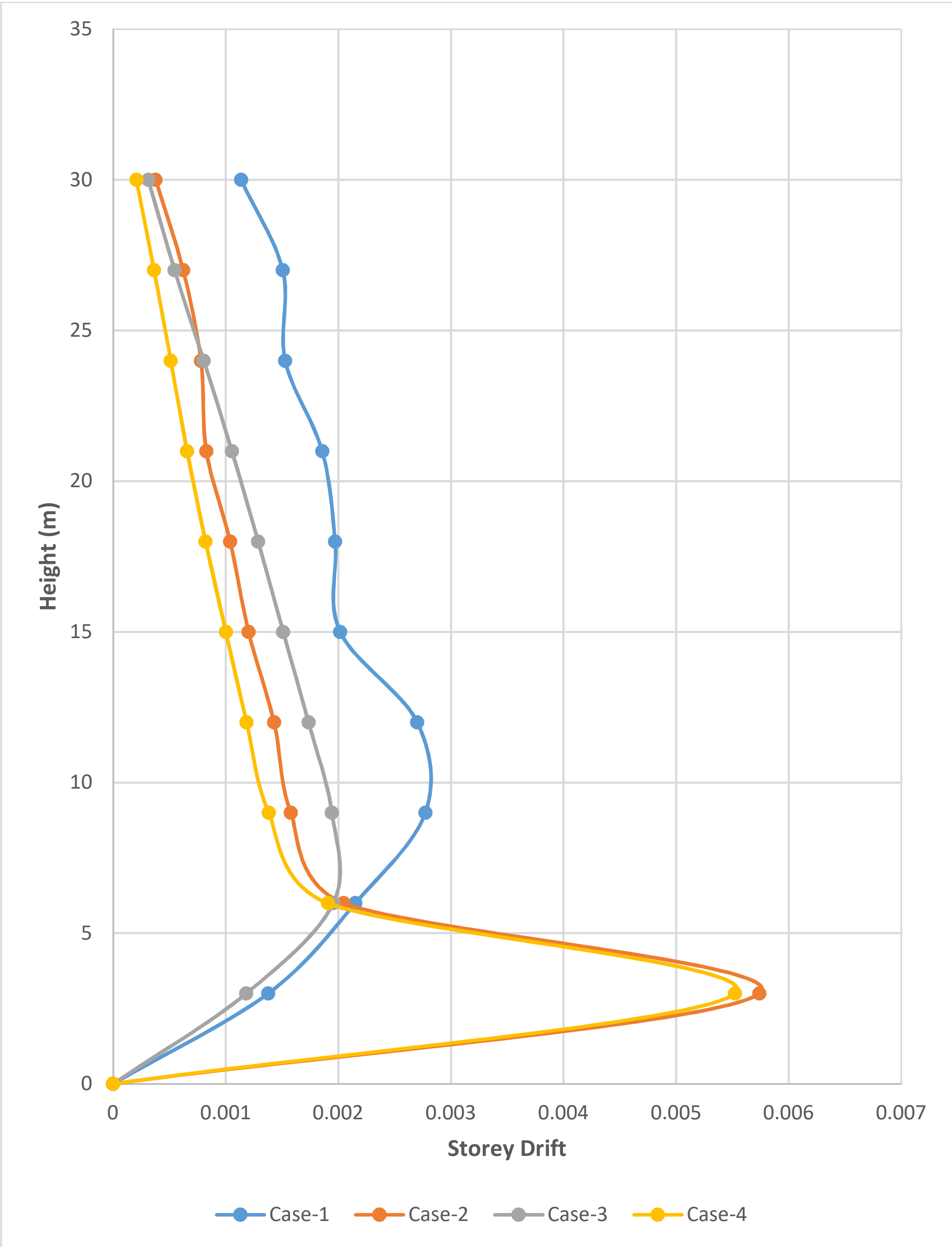


Fig. 4.6. Combine Storey drift of G+ 10 structures

4.3. BENDING MOMENT

Table 4.3. Bending moment of G+10 structure in different cases

Bending moment (kN-m) 1.2 (DL+LL+TH-X)					
Storey	**Storey height (m)**	**Case-1**	**Case-2**	**Case-3**	**Case-4**
Storey-10	30	87.19	62.57	69.11	59.33
Storey-9	27	101.19	59.09	55.84	52.58
Storey-8	24	107.17	64.56	65.94	57.18
Storey-7	21	106.47	65.18	72.19	59.12
Storey-6	18	124.84	66.62	78.15	61.62
Storey-5	15	112.73	69.08	82.99	64.46
Storey-4	12	124.16	72.85	88.80	67.16
Storey-3	9	147.58	74.17	96.83	68.99
Storey-2	6	141.70	57.97	121.12	53.52
Storey-1	3	189.40	3.58	162.25	4.30
Ground	0	0	0	0	0

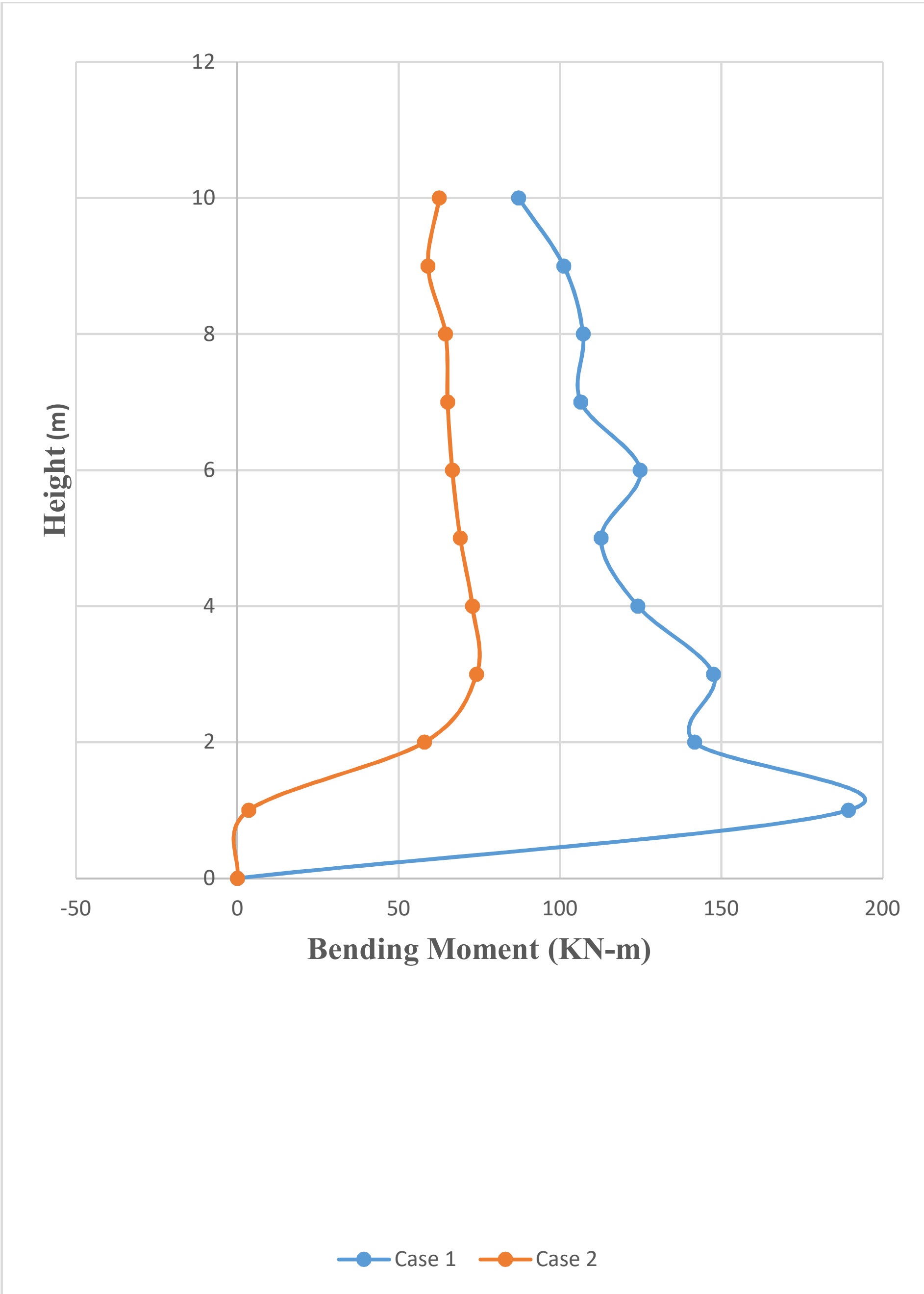


Fig. 4.7. **Comparison of bending moment in case-1 and case-2**

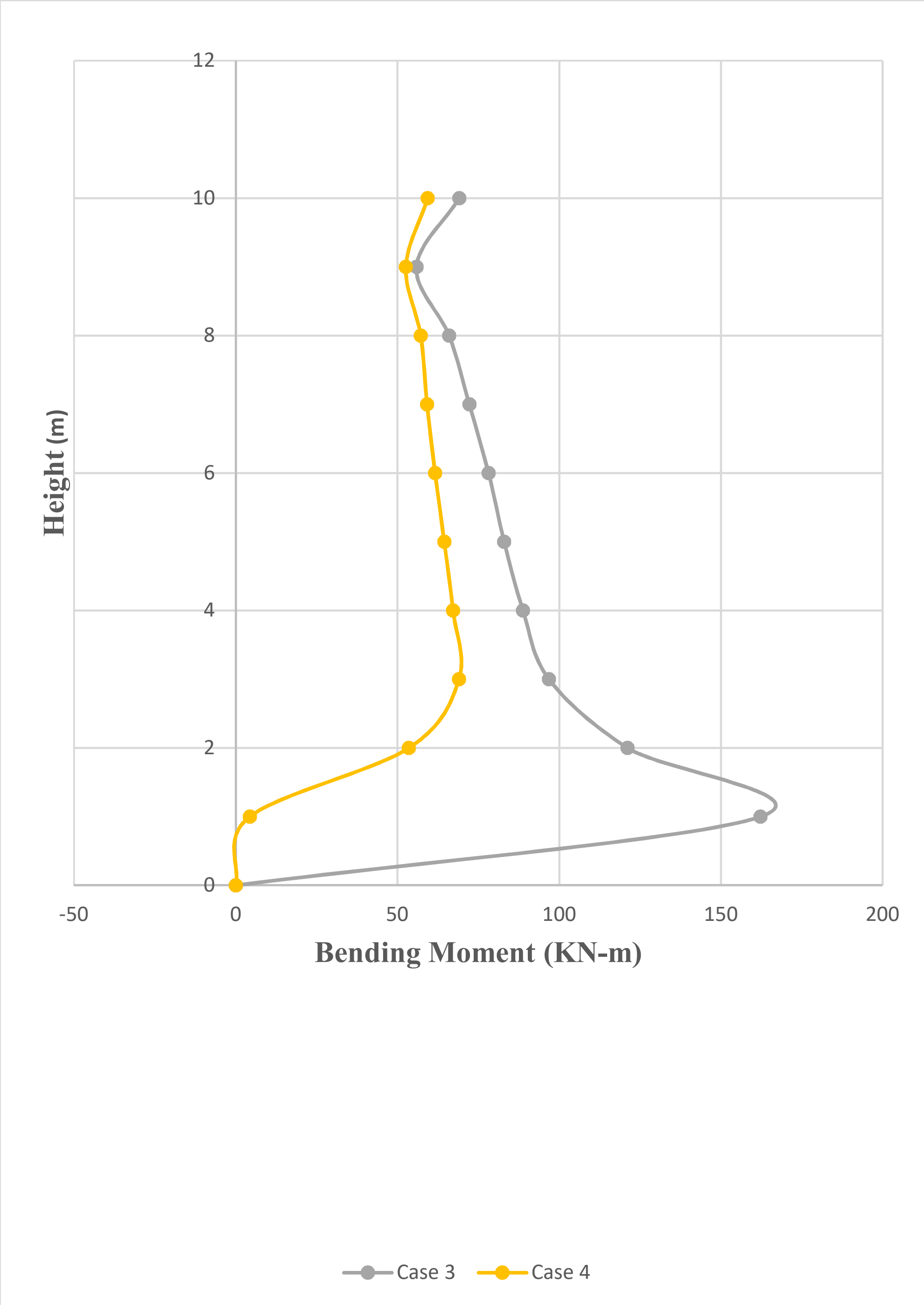


Fig. 4.8. Comparison of bending moment in case-3 and case-4

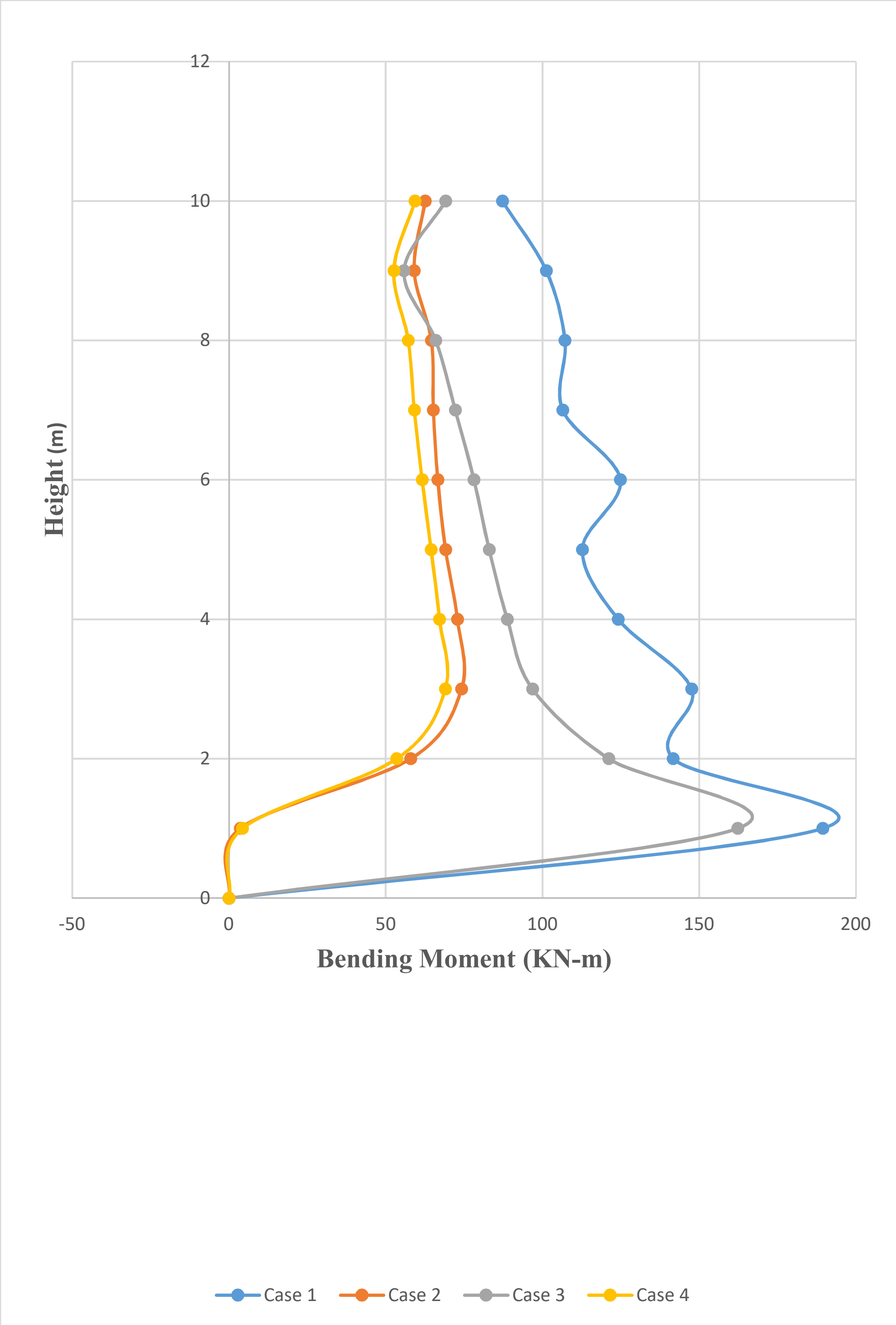


Fig. 4.9. Combine Bending moment of G+ 10 structures

4.4. SHEAR FORCE

Table 4.4. Shear force of G+10 structure in different cases

Shear force (kN) 1.2 (DL+LL+TH-X)					
Storey	**Storey height (m)**	**Case-1**	**Case-2**	**Case-3**	**Case-4**
Storey-10	30	882.28	134.35	230.98	123.44
Storey-9	27	1125.24	232.13	481.63	242.20
Storey-8	24	1016.40	283.08	729.96	350.75
Storey-7	21	1089.43	350.16	949.46	455.37
Storey-6	18	1266.85	442.17	1130.88	563.68
Storey-5	15	1203.60	534.57	1301.60	676.31
Storey-4	12	1283.93	663.08	1496.90	787.38
Storey-3	9	1475.10	746.12	1721.96	878.19
Storey-2	6	1612.01	748.74	1938.56	941.13
Storey-1	3	1668.21	731.44	2046.11	981.72
Ground	0	0	0	0	0

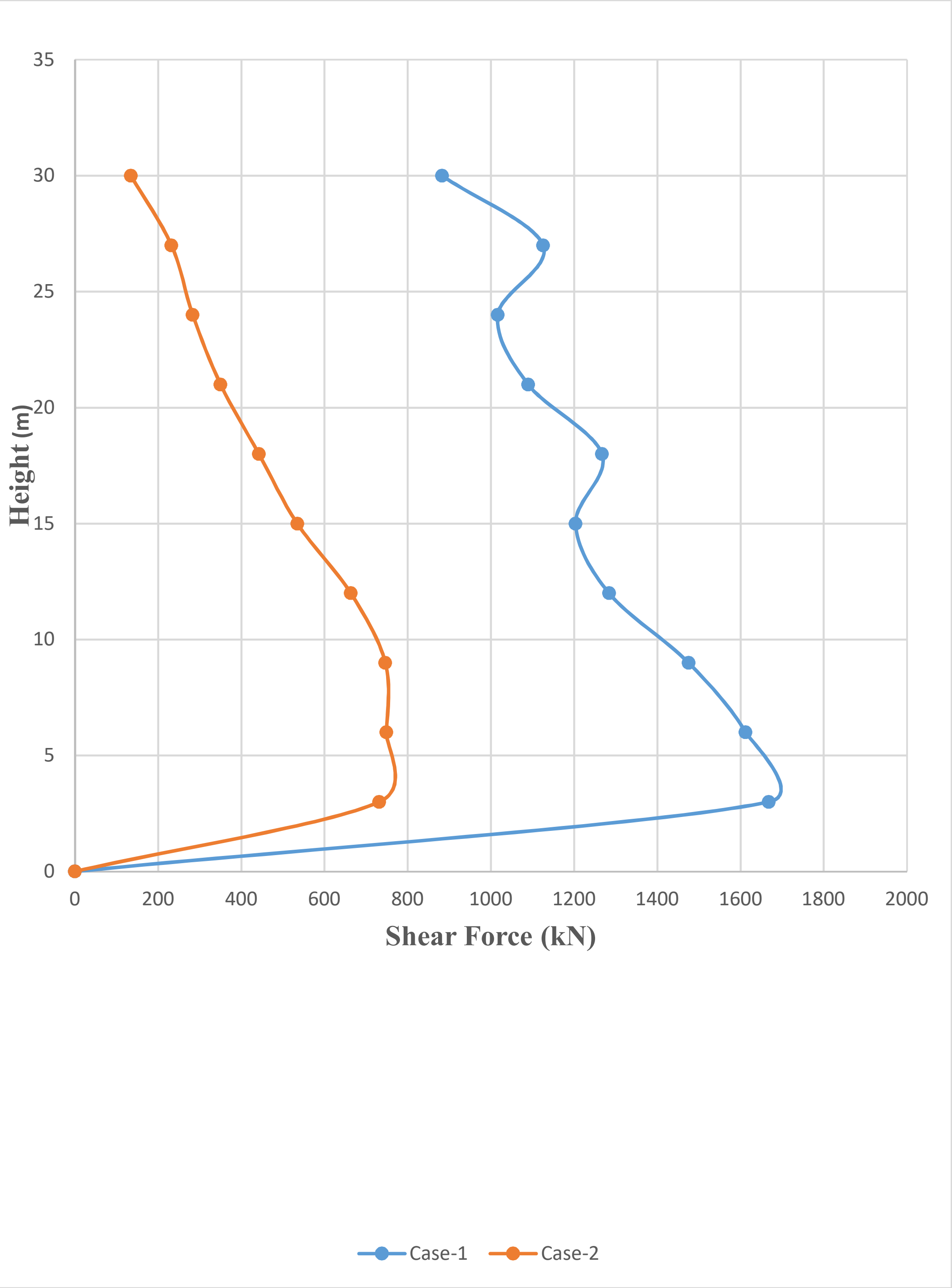


Fig. 4.10. Comparison of Shear force in case-1 and case-2

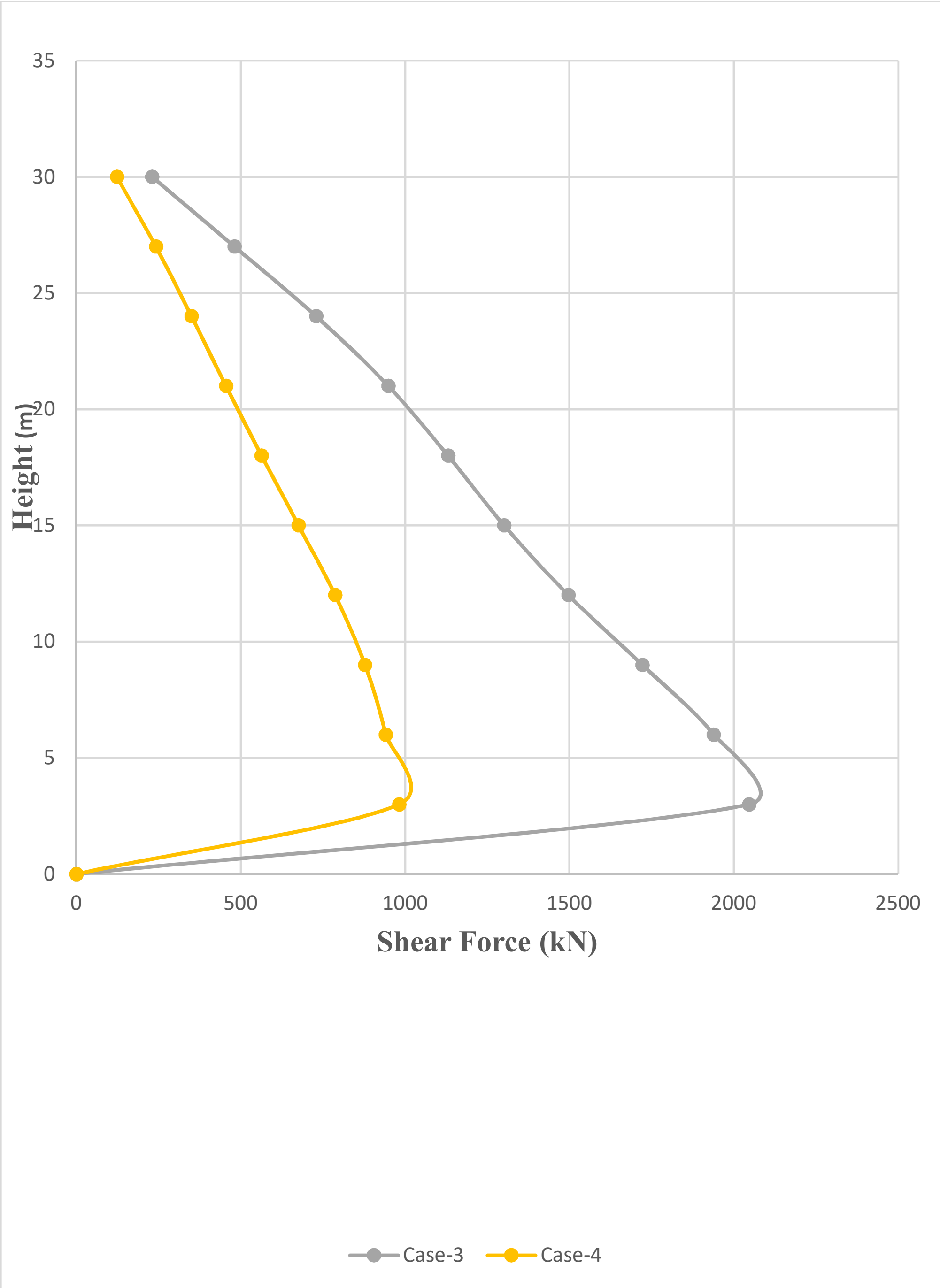


Fig. 4.11. Comparison of Shear force in case-3 and case-4

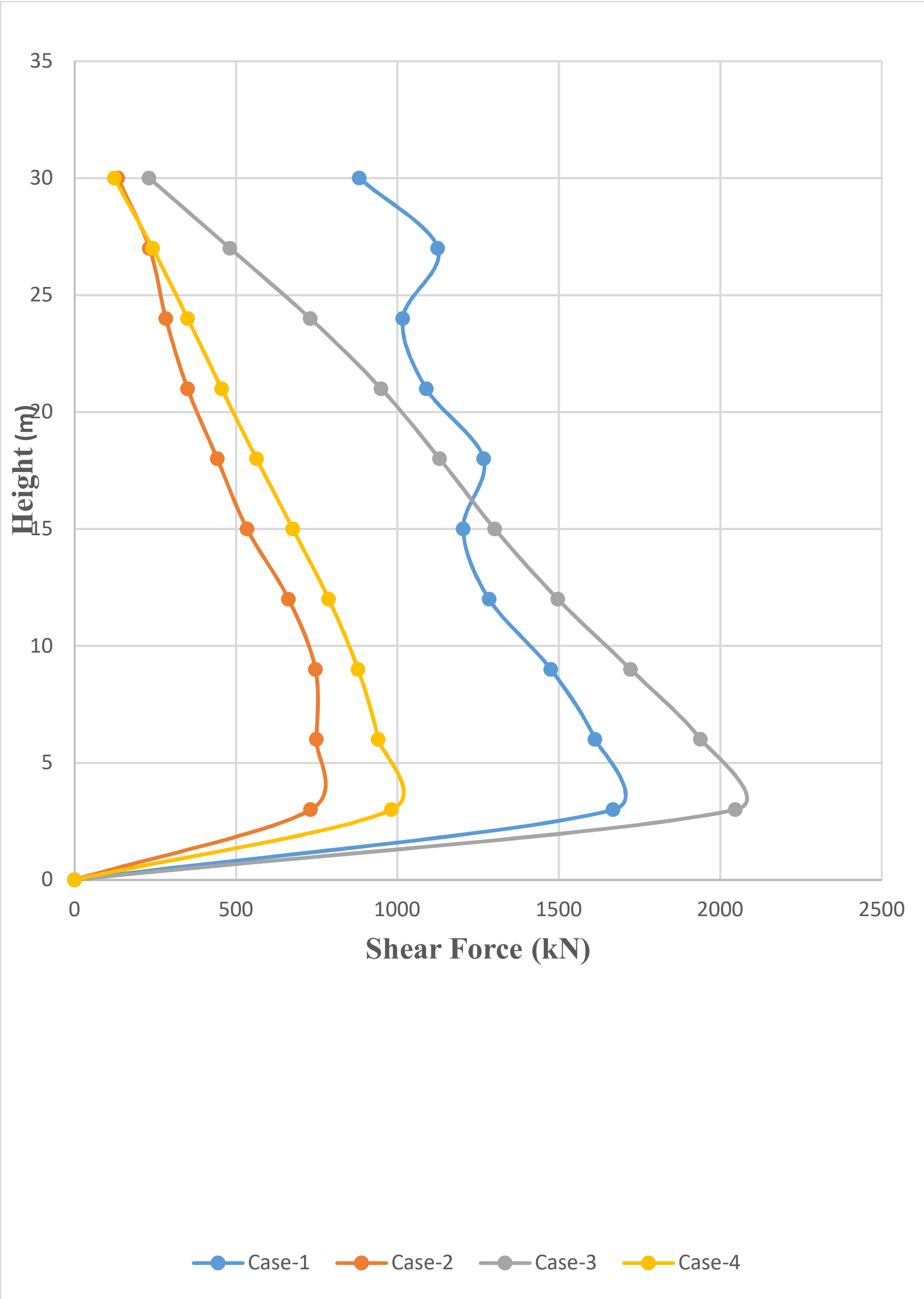


Fig. 4.12. Combine Shear force of G+ 10 structures

4.5. BASE SHEAR

Table 4.5. Base shear of G+10 structure in different cases

Cases	Base Shear (kN) 1.2 (DL+LL+TH-X)
Case-1	1668.21
Case-2	1564.02
Case-3	2046.1065
Case-4	1846.60

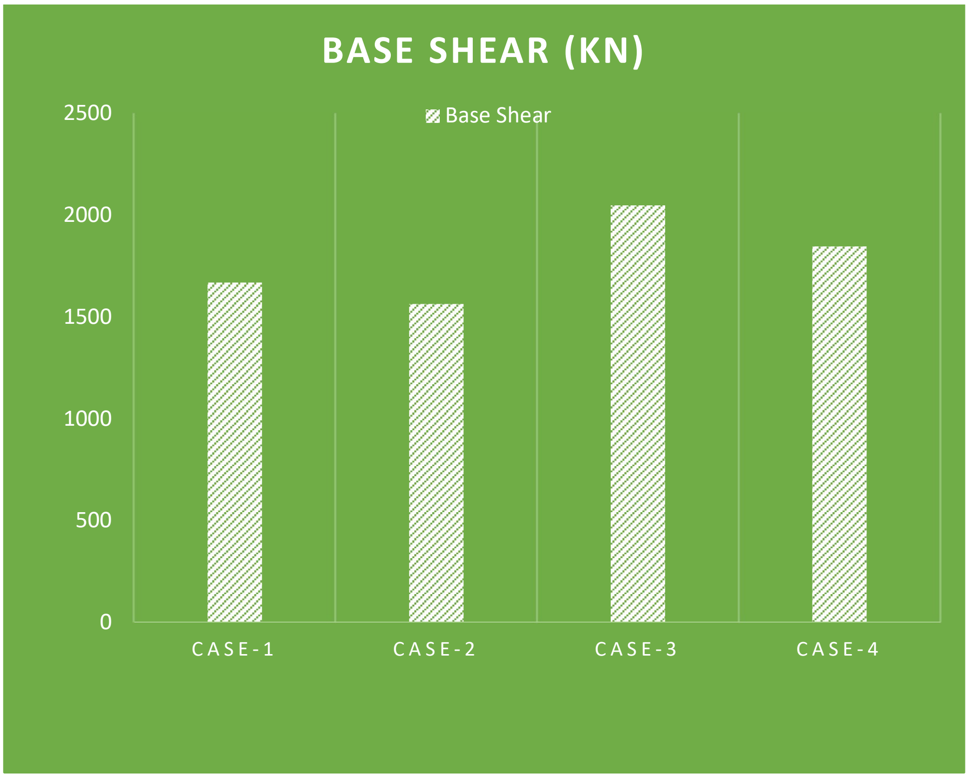
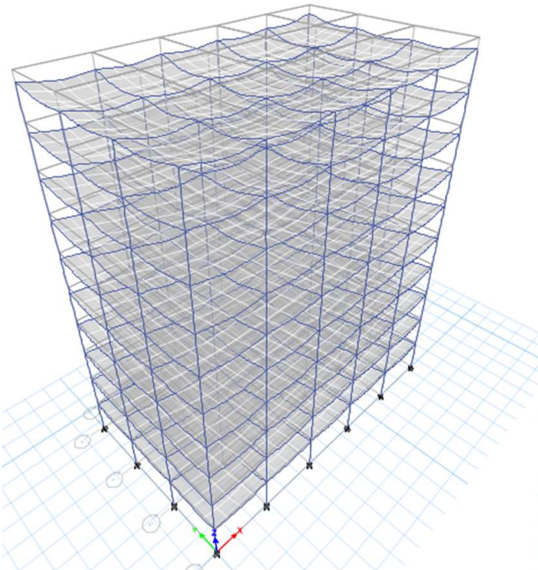
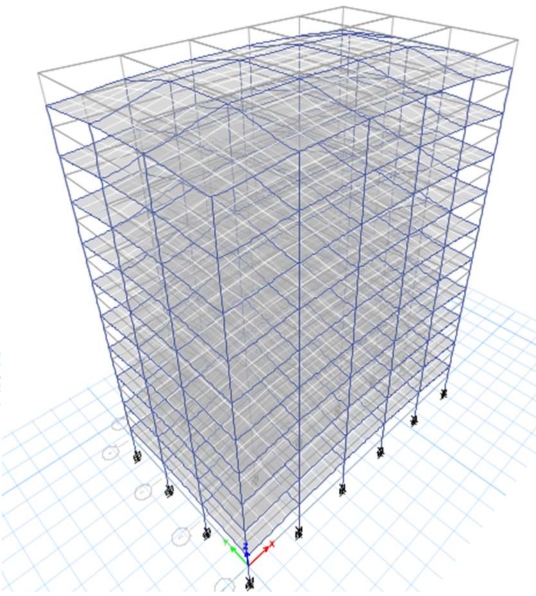


Fig. 4.13. Combine Base Shear of G+ 10 structures

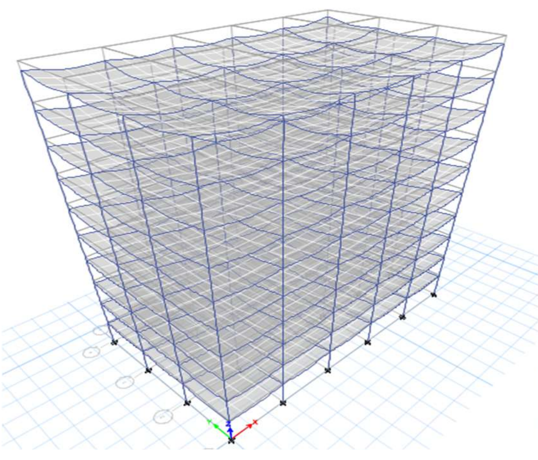
4.6. DEFORMED SHAPES OF MODEL IN DIFFERENT LOAD SCENARIO



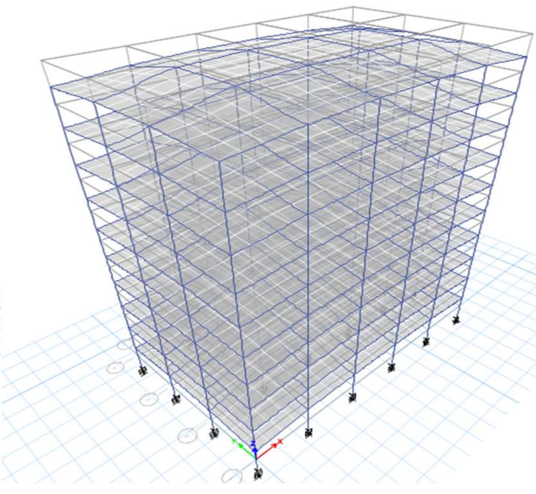
a) Case-1



b) Case-2

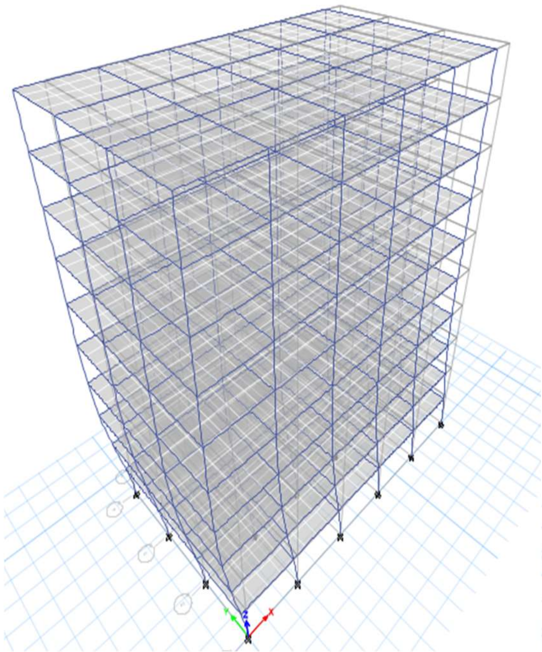


c) Case-3

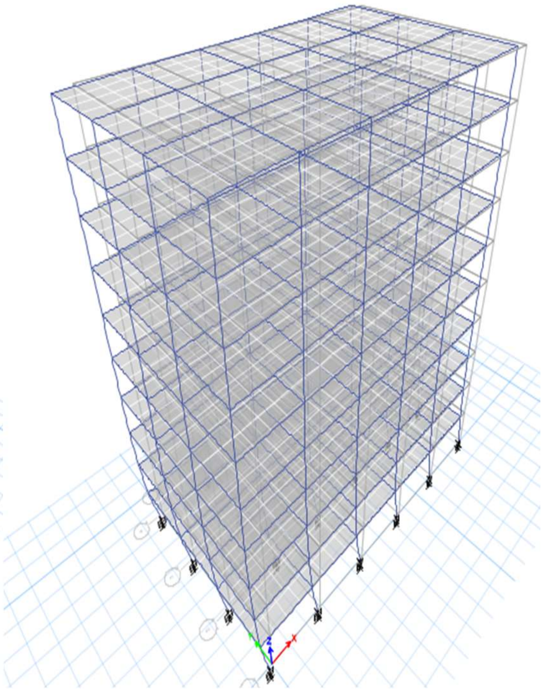


d) Case-4

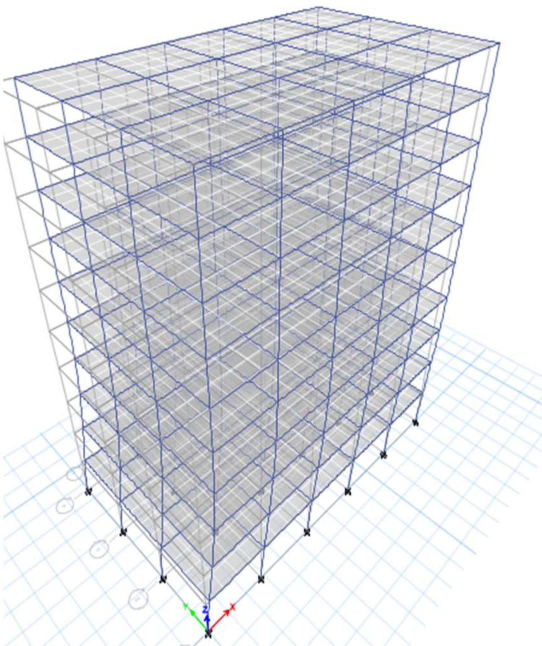
Fig. 4.14. Deformed shapes of structure caused by Dead load



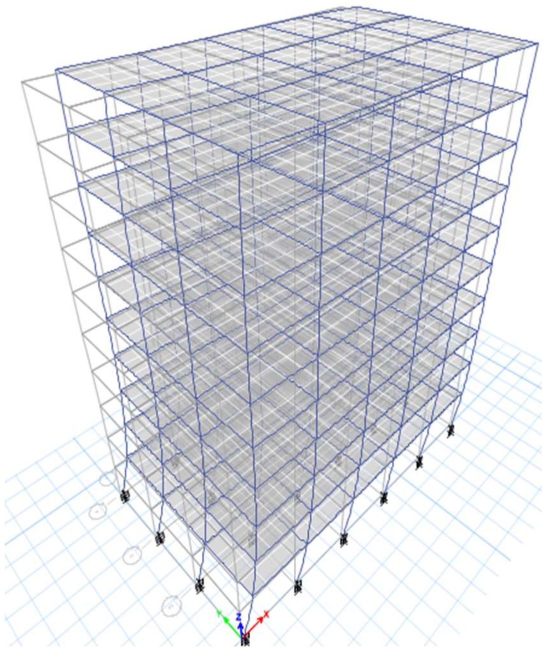
a) Case-1



b) Case-2

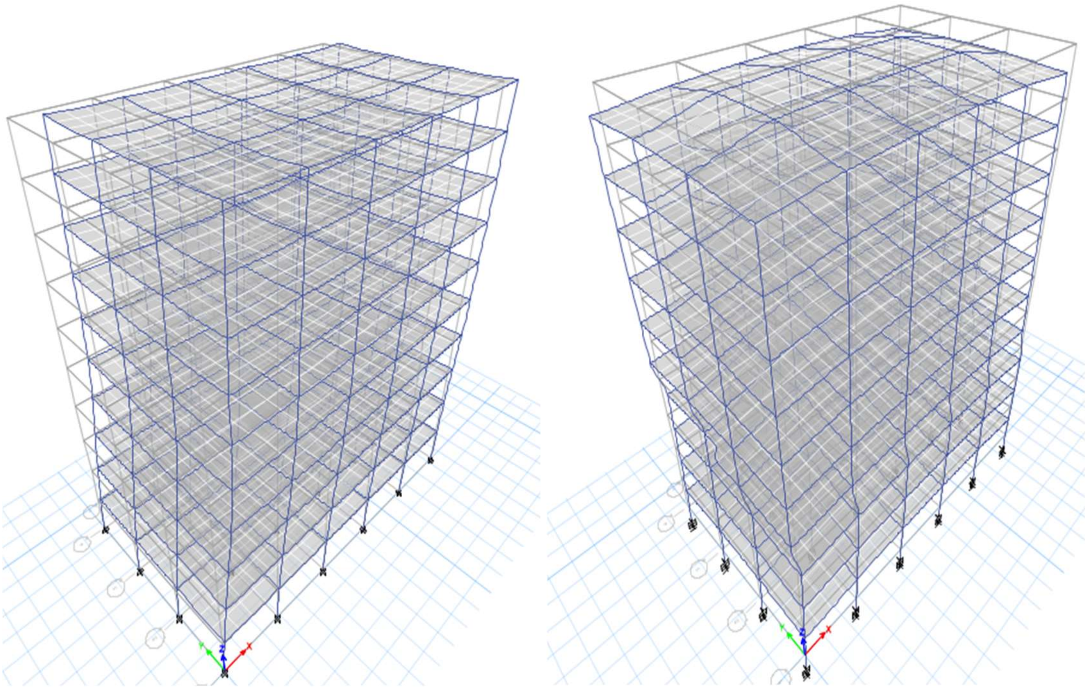


c) Case-3

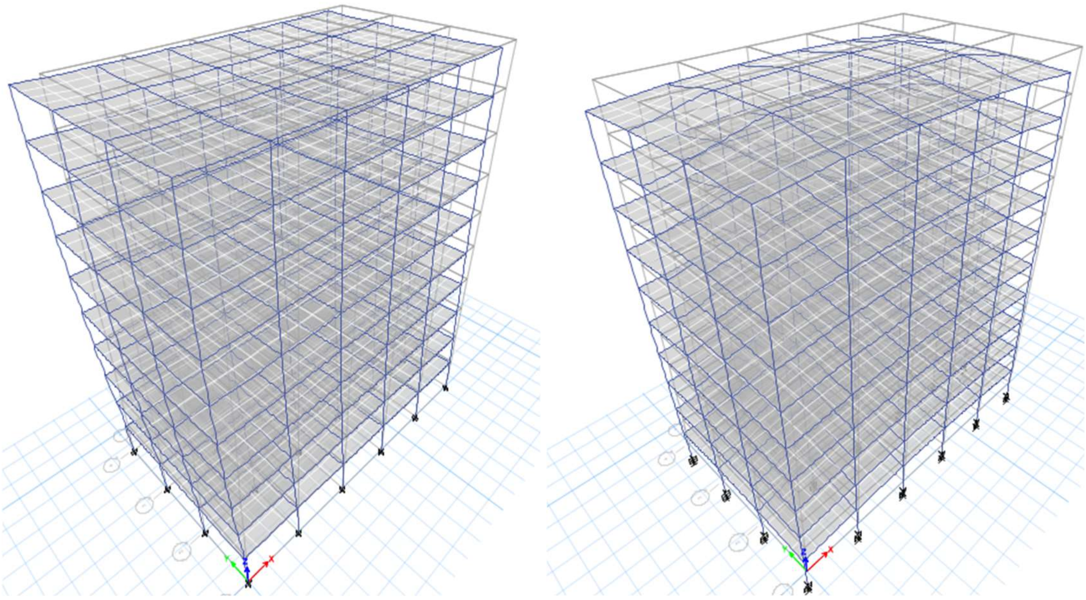


d) Case-4

Fig. 4.15. Deformed shapes of structure caused by Time History load

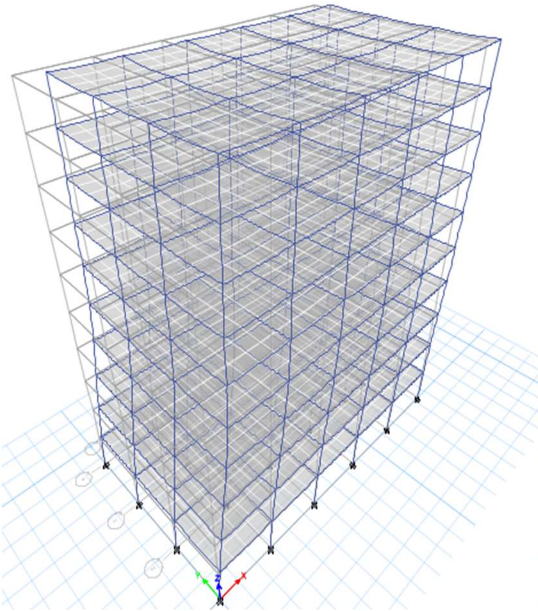


a) Case-1 b) Case-2

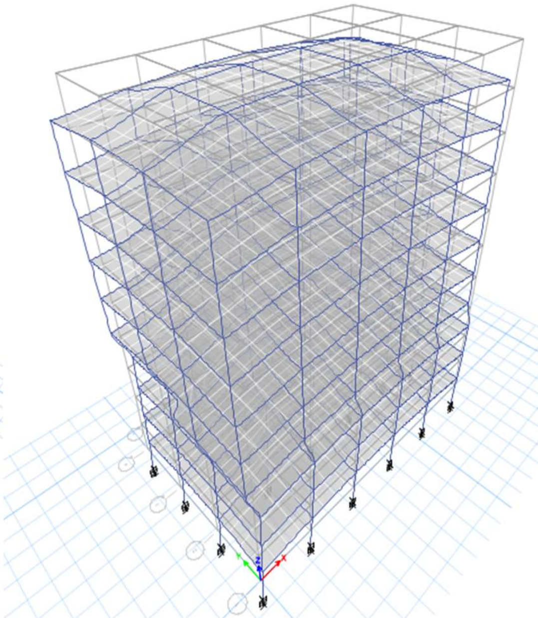


c) Case-3 d) Case-4

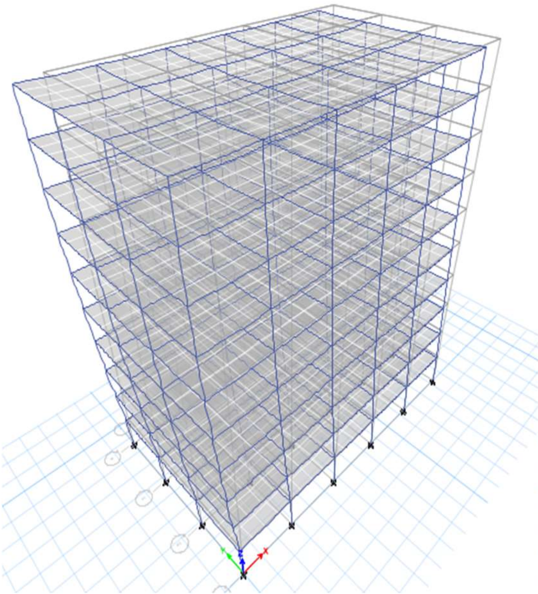
Fig. 4.16. Deformed shapes of structure caused by 1.5 (DL+TH-X)



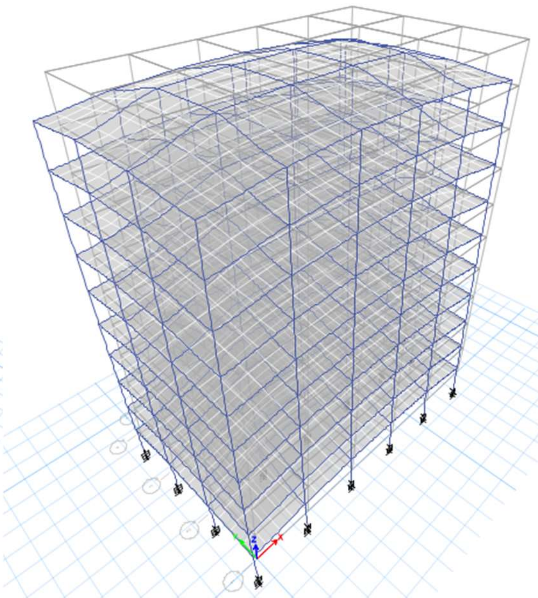
a) Case-1



b) Case-2



c) Case-3



d) Case-4

Fig. 4.17. Deformed shapes of structure caused by 1.2 (DL+LL+TH-X)

4.7. DISCUSSION

- The provision of a lead rubber bearing (LRB) as a base isolation mechanism decreases the seismic impact on the building by decreasing the story shear.
- The use of LRB (Lead Rubber Bearing) reduces the base shear, enhancing the stability of the structure during an earthquake.
- Higher storeys have reduced story drift, enhancing the structural safety against earthquakes
- The installation of LRB (Lead Rubber Bearing) increases the displacements in each story of a structure, which is crucial for enhancing its flexibility during an earthquake..
- The duration of the mode periods is extended, resulting in a longer reaction time of a structure during an earthquake.
- In conclusion, the use of LRB as a base isolation system enhances the stability of structures during earthquakes and decreases the need for reinforcement, resulting in a more cost-effective structure.

CHAPTER 5

CONCLUSION

5.1 CONCLUSION

- The greatest Storey displacement of 39.75mm was observed from an earthquake originating near the model without the inclusion of a base isolator. With the implementation of a base isolator, this displacement increased to 46.08mm. When the earthquake originated far from the model and no base isolator was utilized, the maximum Storey displacement recorded was 36.59mm. However, with the incorporation of a base isolator under the same conditions, the displacement rose to 42.71mm.
- It was observed that when the earthquake epicenter was close to the model, there was a 15.92% increase in Storey displacement with the application of the base isolator. Conversely, when the epicenter was further away, there was a 16.72% increase in Storey displacement with the application of the base isolator.
- The greatest Storey Drift of 0.002773 was observed from an earthquake originating near the model without the inclusion of a base isolator. With the implementation of a base isolator, this drift increased to 0.005739. When the earthquake originated far from the model and no base isolator was utilized, the maximum drift recorded was 0.001955. However, with the incorporation of a base isolator under the same conditions, the drift rose to 0.005522.

- It was observed that when the earthquake epicenter was close to the model, there was a 106.96% increase in drift with the application of the base isolator. Conversely, when the epicenter was further away, there was a 182.46% increase in drift with the application of the base isolator.
- The greatest Bending moment of 189.4kN-m was observed from an earthquake originating near the model without the inclusion of a base isolator. With the implementation of a base isolator, this Bending moment increased to 74.17kN-m. When the earthquake originated far from the model and no base isolator was utilized, the maximum bending moment recorded was 162.25kN-m. However, with the incorporation of a base isolator under the same conditions, the Bending moment rose to 68.99kN-m.
- It was observed that when the earthquake epicenter was close to the model, there was a 60.84% decrease in bending moment with the application of the base isolator. Conversely, when the epicenter was further away, there was a 57.48% decrease in bending moment with the application of the base isolator.
- The greatest Shear force of 1668.21kN was observed from an earthquake originating near the model without the inclusion of a base isolator. With the implementation of a base isolator, this shear force increased to 748.74kN. When the earthquake originated far from the model and no base isolator was utilized, the maximum shear force recorded was 2046.11kN. However, with the incorporation of a base isolator under the same conditions, the shear force rose to 981.72kN.
- It was observed that when the earthquake epicenter was close to the model, there was a 55.12% decrease in shear force with the application of the base isolator. Conversely, when the epicenter was further away, there was a 52.02% decrease in shear force with the application of the base isolator.
- The greatest Base Sear of 1564.02kN was observed from an earthquake originating near the model without the inclusion of a base isolator. With the implementation of a base isolator, this shear force increased to 1668.21kN. When the earthquake originated far from the model and no base isolator was utilized, the maximum base Sear recorded was 2046.1065kN. However, with the incorporation of a base isolator under the same conditions, the base Sear rose to 1846.6kN.
- It was observed that when the earthquake epicenter was close to the model, there was a 6.66% increase in base Sear with the application of the base isolator. Conversely, when the epicenter was further away, there was a 9.75% decrease in base Sear with the application of the base isolator.

5.2 SUMMARY

- The introduction of lead rubber bearing (LRB) as a base isolation system decreases story shear, thereby mitigating seismic effects on the building.
- With LRB implementation, base shear is diminished, enhancing the structure's stability during earthquakes.
- Higher stories experience reduced story drift, enhancing the structure's earthquake resistance.
- Point displacements in all stories increase with LRB installation, promoting structural flexibility during earthquakes. Mode periods lengthen, extending the structure's reaction time during seismic events.
- In conclusion, the utilization of LRB as a base isolation system improves the structure's earthquake stability, reducing the need for reinforcement and enhancing its economic viability.

Near-Field Earthquakes:

- Reduction in High-Frequency Content: Base isolation systems are particularly effective in filtering out high-frequency seismic waves, which are more prevalent in near-field earthquakes. This reduces the impact of sudden, sharp motions on the building.
- Energy Dissipation: The isolators can absorb and dissipate the energy from these intense ground motions, thereby reducing the forces transmitted to the structure.
- Improved Structural Performance: By decoupling the building from the ground motion, base isolation minimizes structural damage and inter-story drifts, which are critical in near-field events.

Far-Field Earthquakes:

- Reduced Resonance: Far-field earthquakes can cause resonance in buildings with natural frequencies similar to the seismic waves. Base isolation shifts the building's natural frequency away from the dominant frequencies of the seismic waves, reducing resonance effects.
- Lower Long-Duration Impacts: The isolators help in reducing the impact of long-duration shaking, maintaining the structural integrity over prolonged seismic activity.
- Enhanced Comfort: The smoother motion provided by base isolation systems during far-field events improves occupant comfort and safety.

5.3 FUTURE SCOPE

- In this survey, we propose a lead rubber bearings isolator. However, further research is needed instead of isolator consider damper and compare the results.
- Simple beam-column-wall-string element because the complete FEM model must be included.
- For further study of belt wall are also done with only steel structures and base isolators.
- In further analysis, also use unsymmetrical models to compare the current result.

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