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Action of liquid tune mass dampers and base isolation in high rise buildings

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Abstract

In areas where earthquakes are common, high-rise structure seismic resistance is a major concern. The purpose of this research is to determine whether base isolation and liquid tuned mass dampers (LTMDs) can improve tall building seismic performance. A symmetrical G+8 story RCC structure in Zone V with medium grade soil is analyzed using ETABS software, Response Spectrum Analysis, and Equivalent Static Analysis to see how the structure behaves under different load combinations. For various structural configure rations, including basic models, models with water tanks, and models with base isolation, key factors such joint displacement, storey drift, base shear, and time period are evaluated. The results show that as compared to baseline models, models with damping and isolation systems exhibit much lower joint displacements, base shear forces, and story drift. In particular, base isolation models perform better in terms of reducing structural deformations and resisting lateral forces. Furthermore, shorter time periods and higher frequencies are routinely observed in base isolated models, suggesting enhanced dynamic response and energy dissipation capabilities. The paper also covers the flexibility and benefits of using LTMDs and base isolation to reduce seismic threats. Buildings can be successfully separated from ground motion by base isolation systems, and dynamic response can be countered by LTMDs using regulated liquid sloshing. The attraction of LTMDs in improving overall stability is increased by their adaptability in minimizing torsional and lateral vibrations. The study concludes by emphasizing how crucial it is to use cutting-edge structural retrofitting methods, including base isolation and LTMDs, to improve the seismic resistance of high-rise structures. In earthquake-prone areas, engineers and legislators may proactively protect tall buildings and guarantee a safer, more robust built environment by incorporating these technologies into construction standards and design procedures.

Keywords: Base isolation; Liquid tuned mass dampers (LTMDs); High-rise buildings; Seismic resilience; Structural retrofitting; Joint displacement; Storey drift; etc

1. Introduction

Ensuring structural stability and reducing the impact of dynamic loads, like wind and seismic pressures, are critical in high-rise buildings. Base isolation and liquid tuned mass dampers (TMDs) are two methods that are frequently used to accomplish this. These methods contribute significantly to improving the behaviour of tall structures by lessening the effects of vibrations and raising the general level of comfort and safety. As part of a seismic protection strategy, base isolation uses flexible bearing systems to keep the building's superstructure isolated from its foundation. Base isolation is used to separate a building from the earth so that it can move independently in the case of a seismic activity or other dynamic event. This isolation lessens the amount of seismic forces that are transmitted to the building by absorbing and dissipating the energy produced by the ground motion. Rubber and steel layers are commonly utilized to create the flexible bearings used in base isolation systems, which offer both vertical and horizontal flexibility. Because of its flexibility, the building can swing and distort during seismic events, lessening the damage that occurs to both the building and its occupants. Base isolation has been shown to be very successful in lowering structural damage and improving high-rise structures' overall seismic performance.

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High-rise structures' dynamic response can also be reduced by using liquid tuned mass dampers, or TMDs. Usually, TMDs are used to mitigate the impacts of vibrations caused by wind. The occupants may experience discomfort as a result of these vibrations, and the structure may sustain damage. A TMD is made up of a mass—typically a tank filled with liquid—that is attached to the building's structure by means of several dampers. By tuning the mass to resonate at a frequency that coincides with the building's inherent frequency, the response of the structure to dynamic loads is effectively reduced. The TMD absorbs and dissipates energy when the building vibrates due to wind since it oscillates against the building's motion. By using TMDs, vibration amplitude is greatly reduced, improving overall comfort and stability.of high-rise buildings. In high-rise structures, base isolation and liquid tuned mass dampers both have clear benefits. Because base isolation separates the building from ground motion, it offers superior protection against seismic forces. Because of its ability to move freely, it reduces structural damage and safeguards building occupants. However, liquid tuned mass dampers are made expressly to lessen vibrations caused by wind, offering stability and comfort in high-wind environments. High-rise structures can achieve better structural behaviour, less structural damage, and more occupant safety and comfort in seismically and wind-prone areas by implementing these strategies.

1.1. Base Isolation

One common device used in a structure to shield it from seismic forces is a base isolation system. Dr. Bill Robinson created this technology, known as base isolation bearings, in New Zealand during the 1970s. For both new and renovated buildings, a foundation isolation system is utilized as a damage-resistant seismic design option. For this reason, the system is called the seismic base isolation system.

1.2. Behavior of Liquid Tuned Mass Dampers in High-Rise Buildings

1.2.1. Vibration Absorption

Liquid Tuned Mass Dampers (LTMDs) are installed in high-rise buildings to absorb and dissipate structural vibrations caused by wind loads or other dynamic forces. They consist of a liquid-filled tank coupled with a mass, which moves out of phase with the building's vibrations.

1.2.2. Enhanced Building Stability:

LTMDs improve the stability of high-rise buildings by reducing the amplitude of vibrations induced by wind or other external forces. They counteract the resonant response of the structure, effectively minimizing its motion and maintaining stability.

1.2.3. Increased Comfort for Occupants

By minimizing the building's vibration levels, LTMDs improve occupant comfort in high-rise buildings. They reduce the perception of motion and vibrations, creating a more pleasant environment for residents and minimizing the potential for motion sickness.

1.2.4. Protection of Structural Elements

LTMDs help protect the structural integrity of high-rise buildings by reducing the fatigue and stress experienced by building components. By dissipating energy and reducing the amplitude of vibrations, they prolong the lifespan of critical structural elements, such as columns and beams.

1.2.5. Adaptability to Different Loads

LTMDs can be tuned to specific frequencies, making them adaptable to different loads and environmental conditions. They can be adjusted to provide optimal damping for various wind speeds or other dynamic forces, ensuring effective vibration control throughout the building's lifespan.

1.3. TMD Classification

1.3.1. Passive Energy Dissipation

Because of internal stresses, rubbing, cracking, plastic deformations, and other factors, all vibrating structures lose energy; the smaller the vibration amplitudes, the greater the energy dissipation capacity. Certain constructions exhibit significant vibration amplitudes even during moderately powerful earthquakes due to their extremely low damping, which is on the order of 1% of critical damping. Techniques for raising the energy dissipation capacity are highly successful in lowering vibration amplitudes. Numerous techniques have been employed to increase damping, and numerous others have been suggested. Passive energy dissipation systems can be used to mitigate natural hazards as well as restore old or damaged structures. They do this by utilizing a variety of materials and devices that improve damping, stiffness, and strength. The idea of energy dissipation or supplemental damping has been developed into a practical technology in recent years, and some of these devices have been put in buildings all over the world (Soong and Constantinou 1994; Soong and Dargush 1997). Their ability to improve energy dissipation in the structural systems in which they are installed is what generally defines them. This can be accomplished through the transfer of energy between vibrating modes or the conversion of kinetic energy to heat. Devices using the first way include those that function based on concepts like fluid orifice, yielding of metals, deformation of visco-elastic materials or fluids, and frictional sliding. Additional oscillators in the later technique serve as dynamic vibration absorbers.

Tuned liquid damper

A properly designed partially filled water tank can be utilized as a vibration absorber to reduce the dynamic motion of a structure and is referred to as a tuned liquid damper (TLD). Tuned liquid damper (TLD) and tuned liquid column damper (TLCD) impart indirect damping to the system and thus improve structural performance (Kareem 1994). A TLD absorbs structural energy by means of viscous actions of the fluid and wave breaking.

Tuned liquid column dampers (TLCDs) are a special type of tuned liquid damper (TLD) that rely on the motion of the liquid column in a U-shaped tube to counter act the action of external forces acting on the structure. The inherent damping is introduced in the oscillating.

The performance of a single-degree-of-freedom structure with a TLD subjected to sinusoidal excitations was investigated by Sun (1991), along with its application to the suppression of wind induced vibration by Wakahara et al. (1989). Welt and Modi (1989) were one of the first to suggest the usage of a TLD in buildings to reduce overall response during strong wind or earthquakes.

1.3.2. Tuned Mass Dampers

The 1940s saw the invention of the tuned mass damper (TMD) (Den Hartog 1947). It is made up of a secondary mass that has damping elements and a spring that are suitably tuned. This secondary mass produces a frequency-dependent hysteresis that enhances damping in the main structure. It is now widely known that such a device effectively lowers wind-excited structural vibrations. The usefulness of TMDs in lessening the reaction of structures to blast loading has been the subject of recent computational and experimental research (for example, Villaverde, 1994). Devices called tuned mass dampers, or TMDs, are used to lessen structural oscillations and vibrations, especially in high-rise buildings, bridges, and other engineering structures. Their mechanism of operation involves adding a secondary mass to the structure, which is intended to resonate at a frequency opposite to the vibrations.of the structure itself.

Reducing the impact of dynamic loads, such as wind, earthquakes, and vibrations caused by people, is the main function of a tuned mass damper. Resonant vibrations, which can cause pain, harm, or even structural failure, can be caused by these stresses acting on a structure. Engineers can improve the safety, functionality, and comfort of the structure by controlling and reducing these vibrations with a TMD. A mass-spring-damping system makes up a standard tuned mass damper. The mass is a relatively heavy object that is connected to the structure by a spring and a damping mechanism. It is frequently composed of steel, concrete, or a combination of the two. The mass may move because of the spring's elasticity, and the damping mechanism releases the energy of the

Vibrations

The key to the effectiveness of a Tuned Mass Damper lies in its tuning. The TMD is designed to have a natural frequency that matches or closely aligns with the frequency of the dominant vibrations of the structure. By doing so, the TMD can effectively absorb and dissipate the energy of the vibrations, reducing their amplitude and minimizing the structural response. Tuned Mass Dampers can be installed in various locations depending on the structure and the specific vibration problem. They can be attached to the top of buildings, suspended from cables, integrated into floors or ceilings, or even placed inside structural elements. The design and placement of TMDs require careful analysis and engineering calculations to ensure optimal performance.

Overall, Tuned Mass Dampers provide an efficient and cost-effective solution for controlling vibrations in structures. They have been successfully implemented in numerous high-rise buildings, long-span bridges, and other structures worldwide, contributing to enhanced structural safety, improved occupant comfort, and reduced maintenance costs.

In the realm of structural engineering and seismic design, the behavior of high-rise buildings during seismic events remains a critical concern. This research aims to comprehensively investigate the efficacy of two prominent seismic mitigation strategies: base isolation and liquid tuned mass damper (LTMD). The primary objective is to analyze and compare their performance in reducing seismic forces transmitted to the superstructure of high-rise buildings. The study will employ a shake table to simulate seismic conditions and evaluate the effectiveness of base isolation in mitigating seismic forces. Various parameters, including joint displacement, story drift, base shear, and time period of the building, will be meticulously examined to gain insights into the structural response. Furthermore, a comparative analysis will be conducted among a basic building, a basic building with a water tank, and a basic building incorporating base isolation. By addressing these objectives, this research seeks to contribute valuable knowledge that can inform and enhance the seismic design and resilience of high-rise structures, ultimately fostering advancements in earthquake engineering practices.

The study aims to explore the performance of base isolation and liquid tuned mass dampers (LTMDs) in high-rise buildings. It seeks to assess the efficacy of base isolation in mitigating seismic forces transferred to the superstructure. Additionally, the research intends to examine various parameters such as joint displacement, storey drift, base shear, and time period of the building to understand their behavior under seismic loading conditions. Furthermore, the study aims to compare these parameters among basic building configureurations, including those with water tanks and base isolation systems, to evaluate their respective seismic resilience.

2. Literature review

- Arcan Yanik (2023) "Soil–Structure Interaction Consideration for Base Isolated Structures under Earthquake Excitation" This study aims to analytically implement base isolation with soil–structure interaction (SSI) on a sample structure and to develop a very simple solution to add these combined effects into the mass, damping and stiffness matrices of the structure. A spectrum analysis is also carried out considering the base-isolated structures and SSI. Dynamic simulations are performed throughout the study. In these simulations, three shear frame structures with different properties are considered. The strong ground motions selected for these analyses are eighteen different events with far-fault and near-fault components. In addition, four different base and soil structure combination cases are taken into account. These four analytical cases are a conventional structure with a fixed base and with SSI and a seismically isolated structure with or without the SSI. The numerical results showed that when SSI is considered, the effectiveness of the base isolation system may decrease, and the effect is prominent in softer soil conditions.
- Davide Forcellini (2023) "Inter-story seismic isolation for high-rise buildings" Inter-story seismic isolation has become a valuable solution for high-rise buildings to effectively separate the various parts having several functions, and thus different seismic performance requirements, with the main advantage being the interruption of the flux of energy between the upper and lower stories. The isolation layers that are introduced at various heights of the buildings may filter the inertial forces transmitted to the superstructure and improve the seismic behavior of the whole system. This paper studies a 20-floor building and several inter-story conFigureurations where the isolation layer is located at several heights, in order to discuss the performances of each model and to assess the best location along the height of the structure. Open Sees is employed to calculate the high non-linearities of the models and to consider the interaction between the vertical loads and the horizontal forces. The various responses are discussed in terms of shear forces, accelerations and drifts, demonstrating the potentialities of inter-story isolation as a means of base isolation.
- Niraj maharjan (2022) "effect of tuned liquid damper on high-rise building" effect of tuned liquid damper on high-rise building. ISSN: 2350-8914. Year: 2022 month: October volume: 12. Urbanization has led to the construction of lighter and taller structures, which are more susceptible to failure due to low damping and increased flexibility. To address this, control systems need to be introduced in these structures. One newer technique for controlling structural vibration and response is the Tuned Liquid Damper (TLD). This study focuses on evaluating the effectiveness of TLD in controlling vibration and response in high-rise buildings. A 10 and 15-storied building were analyzed with and without TLD placed at the top of the structure. Different mass ratios (2%, 3%, 4%, and 5%) were considered, along with a depth ratio of 0.2. The TLD was symmetrically placed at the center top of the building. The analysis utilized IS 1893:2016 (part I) response spectra. The effectiveness of the TLD was assessed based on the percentage reduction of displacement amplitude in the structures for different mass ratios. The study revealed that increasing the mass ratio enhances the effectiveness of the Tuned Liquid Damper.
- Qinhua wang (2021) "wind-induced vibration control and parametric optimization of connected high-rise buildings with tuned liquid-column-damper–inerter" wind-induced vibration control and parametric optimization of connected high-rise buildings with tuned liquid-column-damper–inerter. This study introduces a novel passive control device called tuned liquid-column-damper-inerter (TLCDI) to mitigate wind-induced responses in adjacent high-rise buildings. The TLCDI combines the advantages of liquid sloshing inside the TLCD container and the mass amplification effects of the inerter. The study establishes a model for adjacent

high-rise buildings connected by a TLCDI and subjected to wind loading. An equivalent linearization method is employed to analyze the model, and the results are validated using numerical methods. The mitigation effects of the TLCDI with optimal designs on wind-induced responses are compared with the results of two tuned liquid column dampers (TLCDS) installed on benchmark buildings. The findings reveal that the TLCDI, despite being lighter than the two TLCDS, significantly reduces wind-induced acceleration responses in the linked buildings. Specifically, the TLCDI achieves a reduction of 37.7% in building-1 and 42.0% in building-2 in the across-wind direction.

- Chunxiang Li (2021) "Performance of a nonlinear hybrid base isolation system under the ground motions". In order to reduce the displacement demand of the isolation layer under strong earthquakes, especially strong near fault pulse-like ground motions, the base isolation system-tuned mass damper inerter (BIS-TMDI) system is explored taking the nonlinear hysteretic characteristics of the isolation layer into inclusion. Likewise, different from traditional layout of the BIS-TMDI systems, the TMD is placed on the superstructure (such as first floor or third floor, etc.) rather than on the isolation layer and linked to the ground by an inerter. By resorting to the equivalent linearization method (ELM) and genetic algorithm (GA) optimization, the optimal design method of nonlinear BIS-TMDI system is established and then, the performance of the system is numerically investigated. Results demonstrate that the nonlinear BIS-TMDI system can significantly reduce the displacement demand of the isolation layer, and its control effectiveness and stroke performance are better than those of the nonlinear BISTMD system. The influences of the parameters of the superstructure, isolation layer, and earthquake ground motions on the vibration mitigation is further scrutinized. It follows that the robustness of nonlinear BIS-TMDI system is much better than that of nonlinear BIS-TMD system. Analyzing the nonlinear BIS-TMDI system subjected to the near-fault pulse-like ground motions, the superiority of the system in reducing the displacement of isolation layer, the responses of superstructure and the stroke performance of TMDI are further verified.

3. Methodology

3.1. Flowchart

The entire flow of activities involved in achieving the objectives of the project involves following crucial stages:

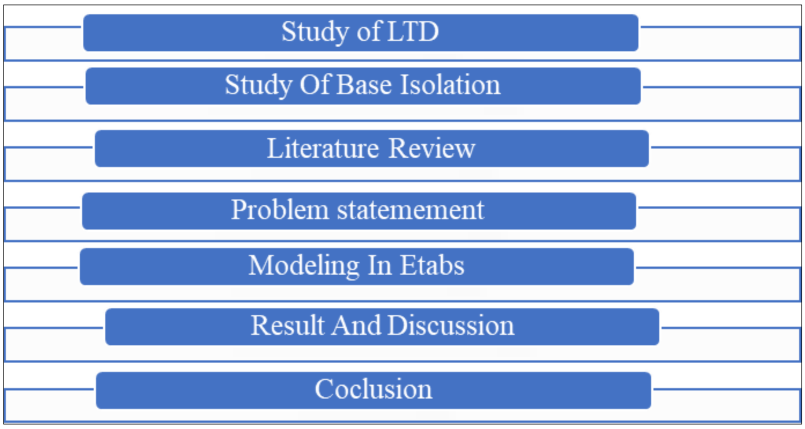

Figure 1 Flowchart

3.2. Blast Loading

An explosion is a rapid release of stored energy characterized by a bright flash and an audible blast. Part of the energy is released as thermal radiation (flash) and part is coupled into the air as air-blast and into the soil (ground) as ground shock, both as radially expanding shock waves

To be an explosive, the material will have the following characteristics.

- Must contain a substance or mixture of substances that remains unchanged under ordinary conditions, but undergoes a fast chemical change upon stimulation.
- This reaction must yield gases whose volume under normal pressure, but at the high temperature resulting from an explosion is much greater than that of the original substance.

- The change must be exothermic in order to heat the products of the reaction and thus to increase their pressure. Common types of explosions include construction blasting to break up rock or to demolish buildings and their foundations, and accidental explosions resulting from natural gas leaks or other chemical/explosive materials.

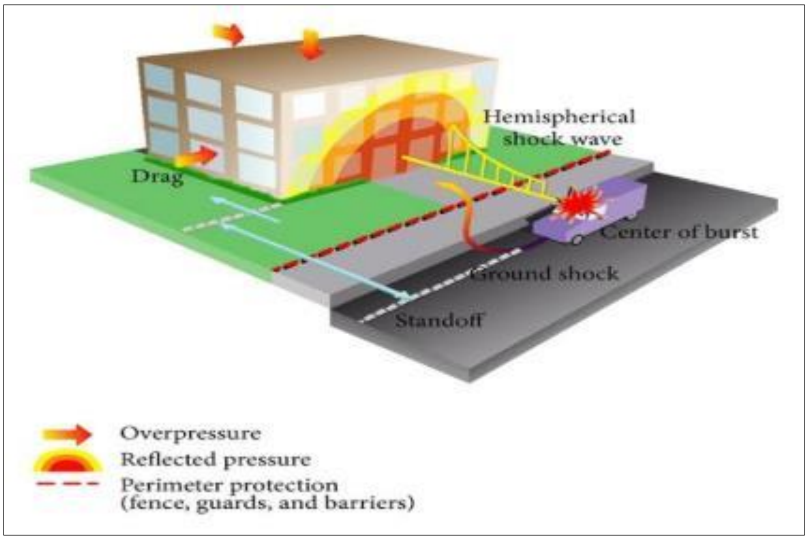

Figure 2 Blast Loading

3.3. Problem statements

The multi-story G+8 story RCC building model that was taken into consideration for the analysis. In plane, the building is symmetrical. The structure has three storeys and a bay width of three meters in both the X and Y directions. There is a 3 m base floor. The building's summit is equipped with a tuned mass damper. Response spectrum analysis and equivalent static analysis are used in the ETABS program to conduct analysis. An eight-story, G+ structure located in Zone V on medium-grade soil is examined, and the displacement and acceleration of the structure under various load combinations—both with and without TMD—are determined. The IS1893:2002 response spectrum approach is used to do seismic analysis. The parameters that are taken into consideration for the modeling of the G+8-story structure are listed below table.

Table 1 Problem statements

Content	Description
Number of storey	G+10
Size of water tank	6m X6 X0.6 m
Floor height	3 m
Base floor height	3 m
Wall thickness	230 mm
Size of column	300mm×300mm
Size of beam	300mm×450mm
Depth of slab	150 mm
Types of soil	Medium soil
Seismic zone	V
Zone factor	0.36
Response of spectra As per IS1893(Part1):2OO2 for 5% of damping	
Live Load	5 KN/m^2

4. Modeling and analysis

4.1. General

The importance of modeling as a prelude to the analysis stage is discussed at the outset of the chapter, illuminating the key ideas and techniques that engineers and architects use to guarantee the structural integrity and stability of structures. It covers a wide range of subjects, from the fundamentals of structural equilibrium to sophisticated modeling methods and industry-standard ETABS software. Our goal in conducting this investigation is to provide readers a thorough understanding of the complexities involved in structural design and analysis. It emphasizes how crucial it is to use a structural model that appropriately captures the actual attributes of the building. After then, the topic shifts to several structural analysis techniques, such as seismic, finite element, and static and dynamic analysis. . These analytical tools are instrumental in evaluating a structure's response to various loading conditions and external forces.

4.2. Modeling

4.2.1. L Shape

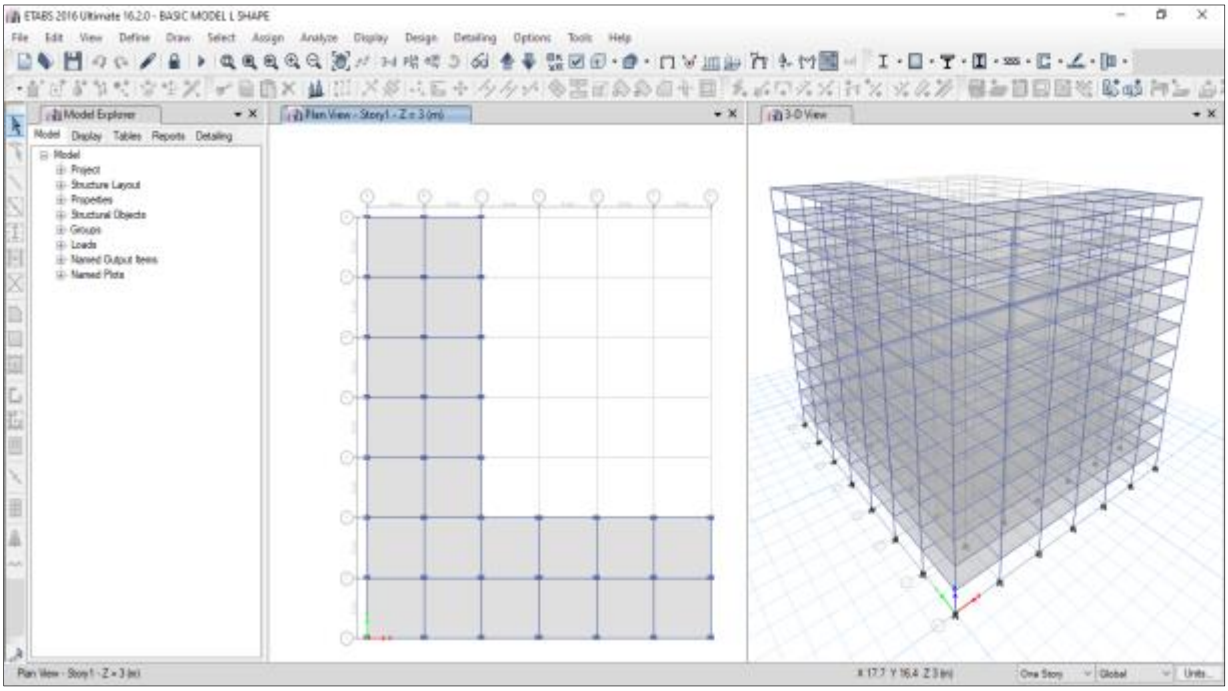

Figure 3 L Shape Base Shape

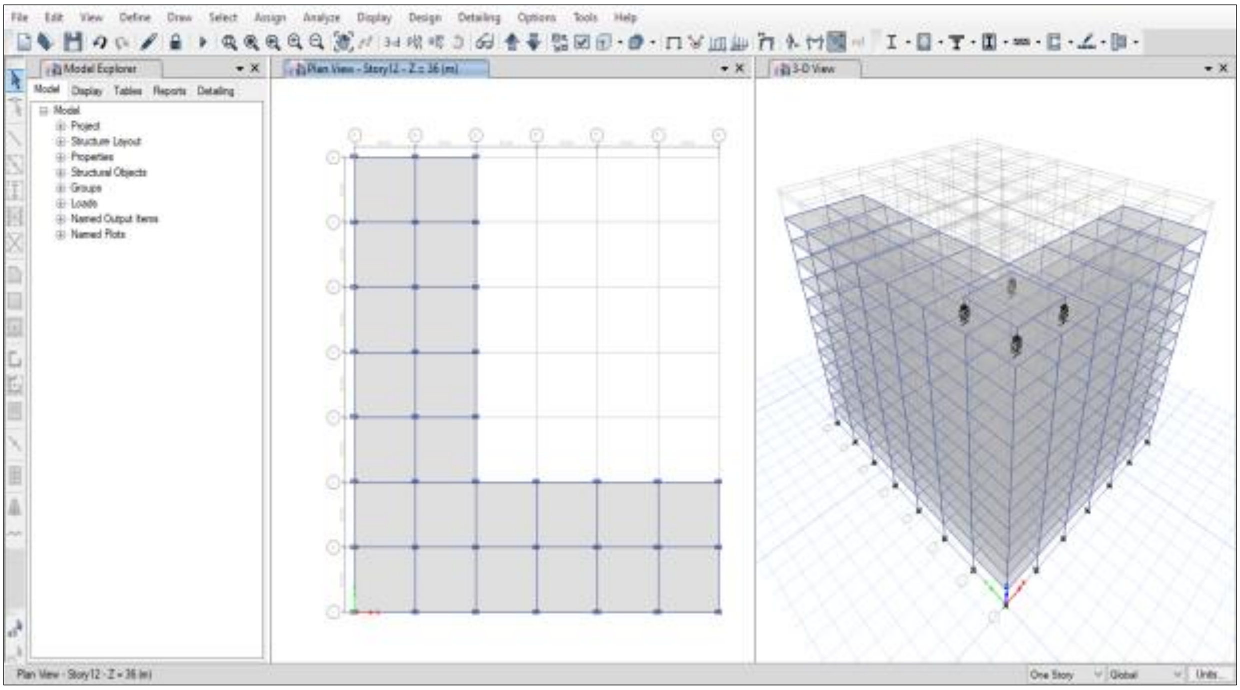

Figure 4 L shape model with water tank and TLD

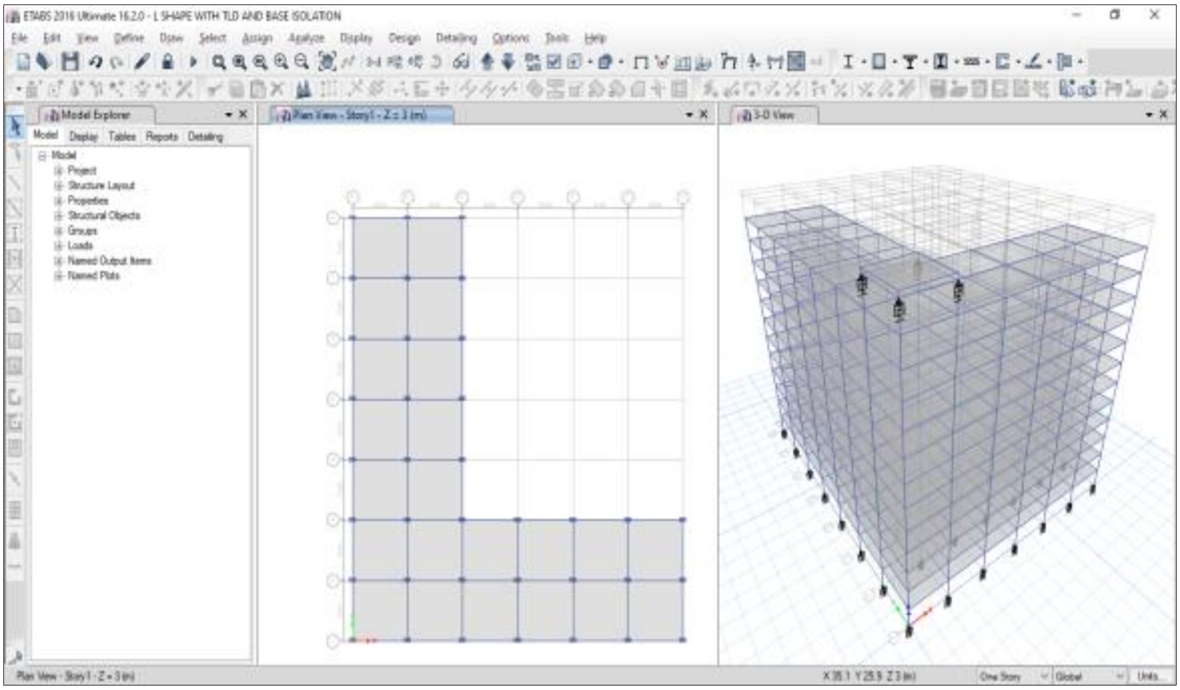

Figure 5 L shape model with water tank. TLD and base isolation

4.2.2. T Shape Model

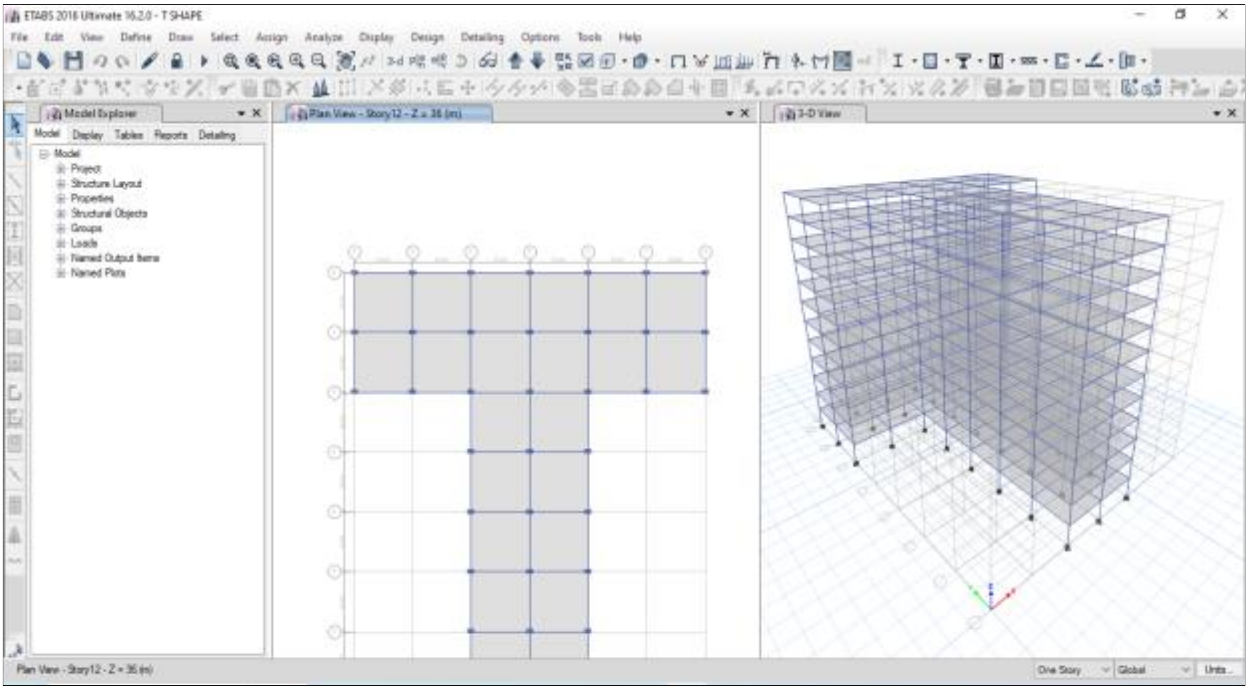

Figure 6 T shape basic model

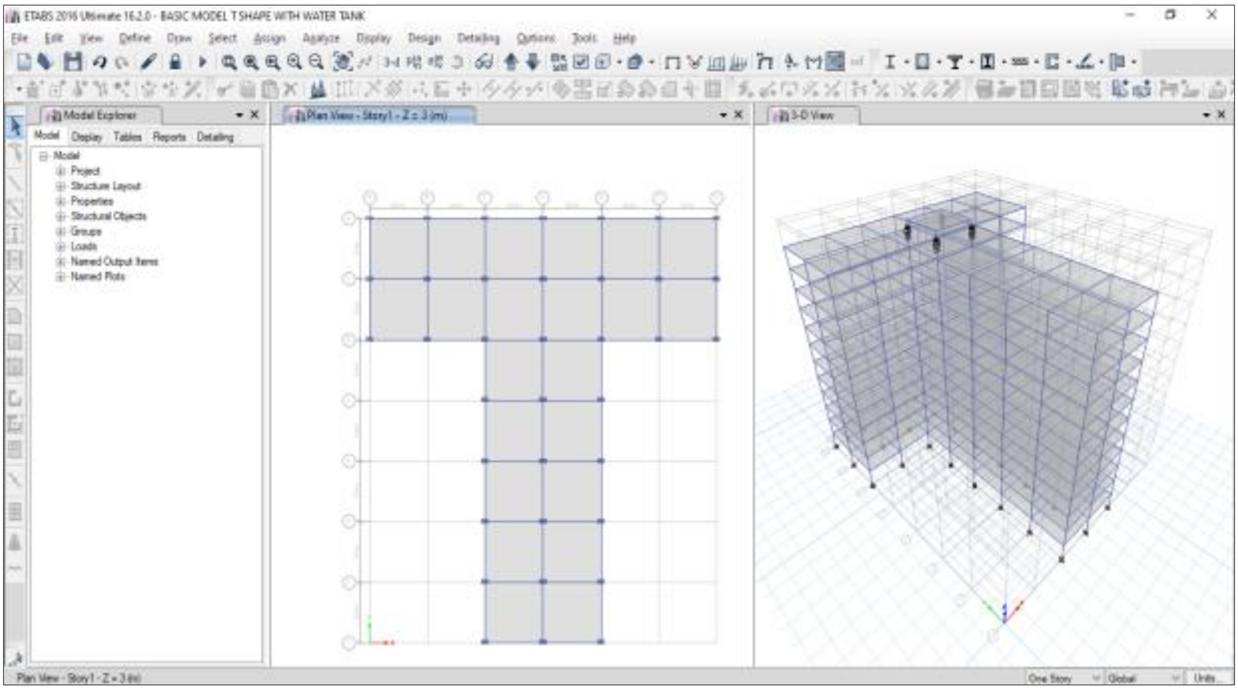

Figure 7 T shape model with water tank and TLD

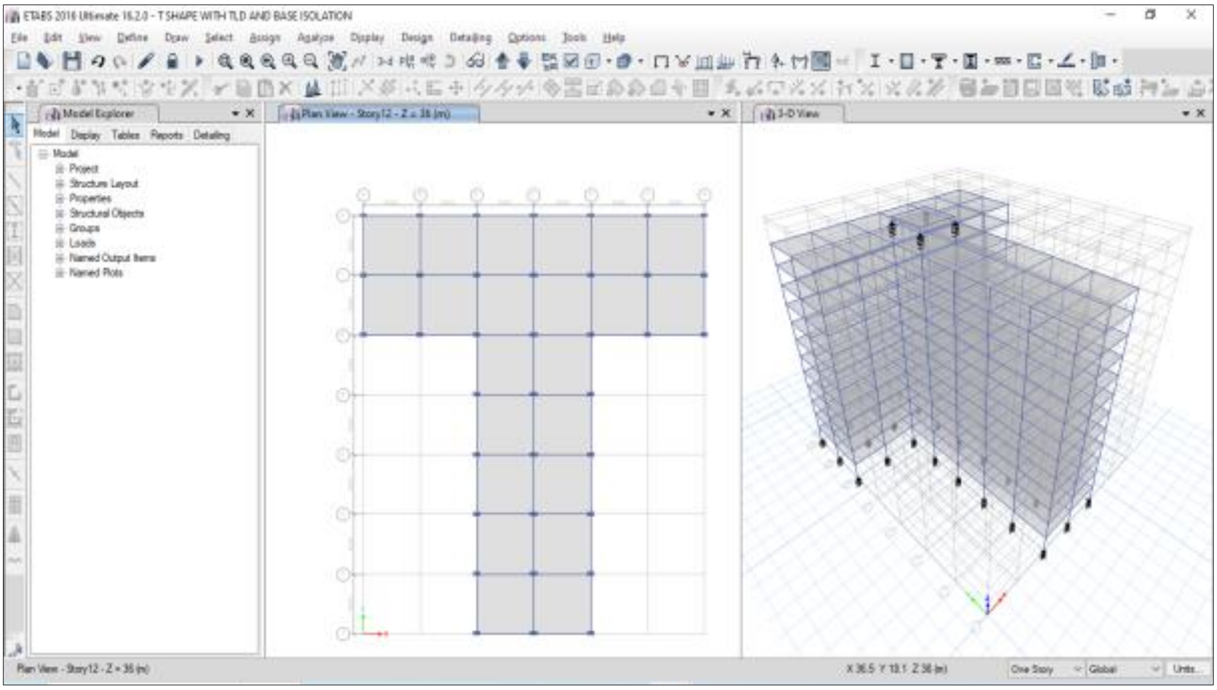

Figure 8 T shape model with water tank TLD and base isolation

5. Result and discussions

In this chapter, we have compared the L shape model and the T shape model with the damper model and the base isolation model with the damper model.

5.1. Shape Model Results

5.1.1. Joint Displacement

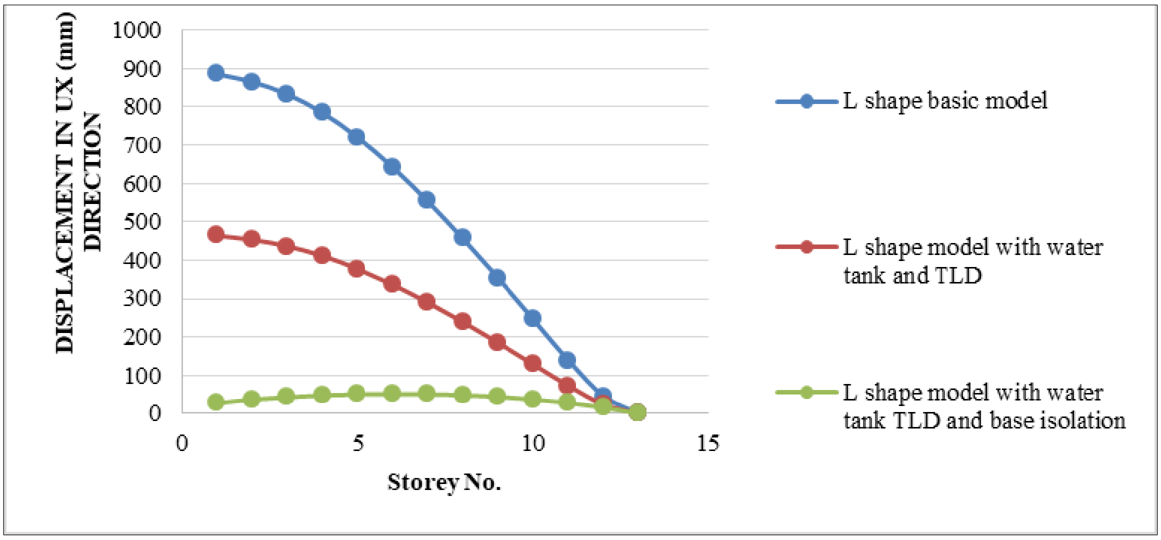

Figure 9 Displacement in U_X direction

The joint displacement in the X direction for the L-shaped model with water tank, L-shaped model with TLD, and L-shaped model with TLD base isolation is displayed in the above graph. Evidently, the L-shaped type featuring a water tank has the largest displacement, measuring 885.905 mm, while the L-shaped variant featuring TLD base isolation has a lesser displacement of 27.134 mm.

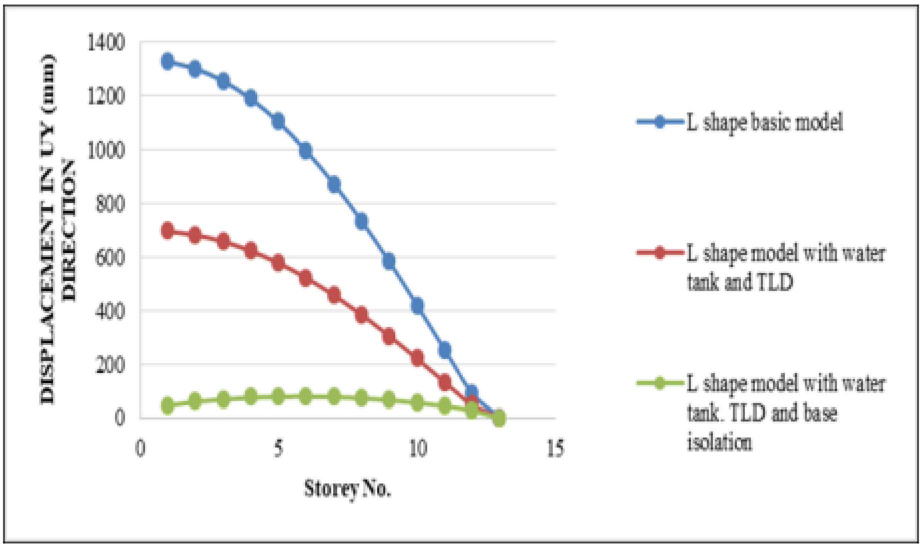

Figure10 Displacement in U_Y direction

The aforementioned graph illustrates the joint displacement in the Y direction for the L-shaped models with the water tank, TLD, and TLD base isolation. The L-shaped variant with the water tank has the largest displacement, measuring 1328 mm, while the L-shaped model with the TLD base isolation has a reduced displacement, measuring 45 mm.

5.1.2. Base Shear

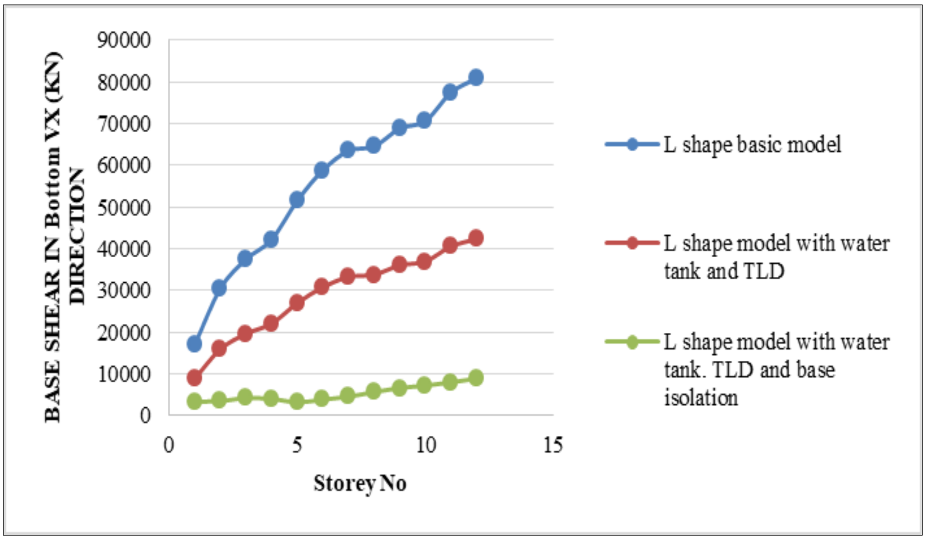

Figure 11 Base Shear V_X Direction

The base shear for the L-shaped models with the water tank, TLD, and TLD base isolation is displayed in the bottom V_X direction of the above graph. The L-shaped model with the water tank has the largest base shear, 17041 KN, while the L-shaped model with the TLD base isolation has the lowest base shear, 3425 KN.

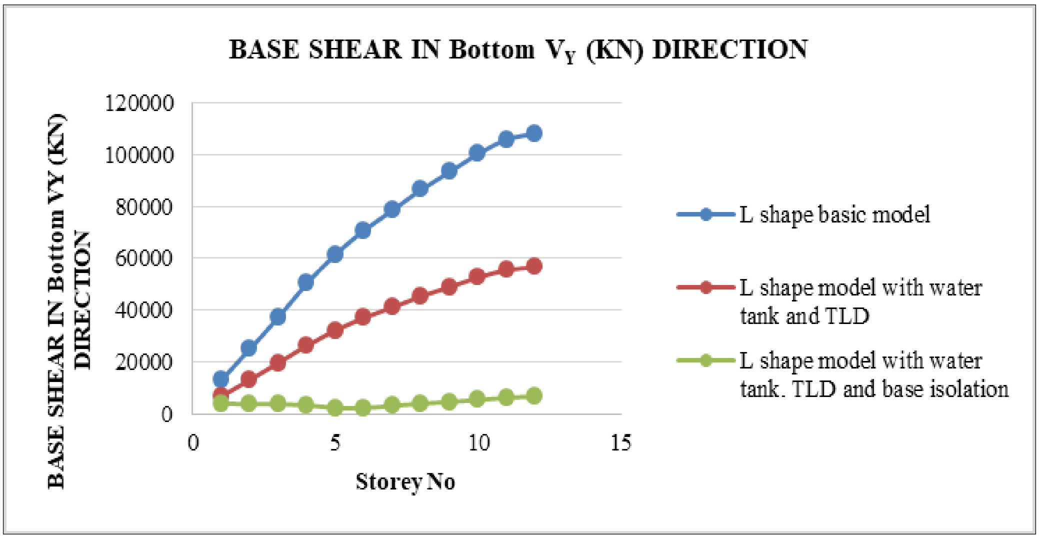

Figure 12 Base Shear Y Direction

The base shear for the L-shaped models with the water tank, TLD, and TLD base isolation is displayed in the bottom V_Y direction of the above graph. Evidently, the L-shaped model featuring a water tank has the maximum base shear of 12913 KN, while the L-shaped model featuring TLD base isolation has a lower base shear of 4097 KN.

5.1.3. Story drift X direction

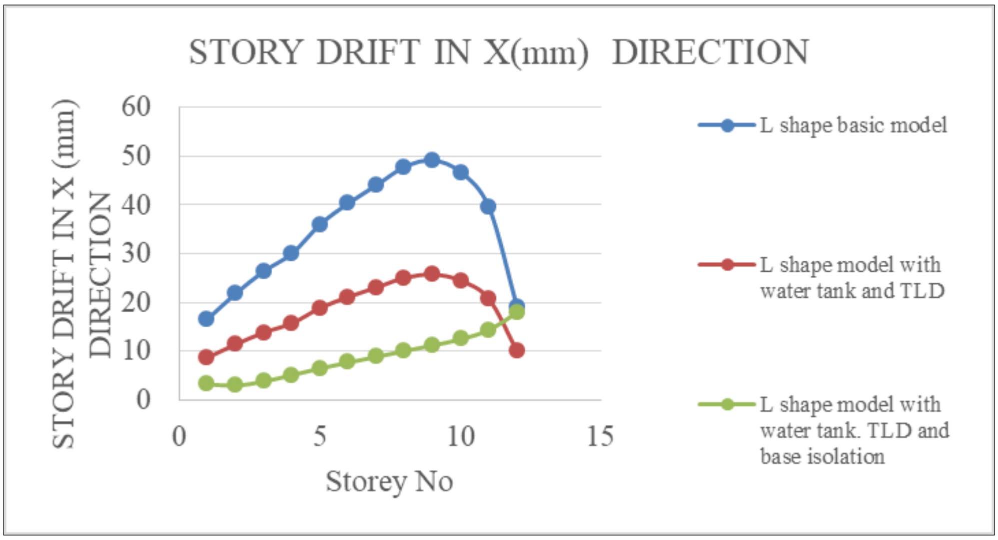

Figure 13 Story drift X direction

The aforementioned graph illustrates the X-direction tale drift for the L-shaped models with water tanks, TLD, and TLD base isolation. The L-shaped model with the water tank has the largest tale drift, measuring 16 mm, while the L-shaped model with the TLD base isolation has the lowest story drift, measuring 3 mm.

5.1.4. Story drift Y direction

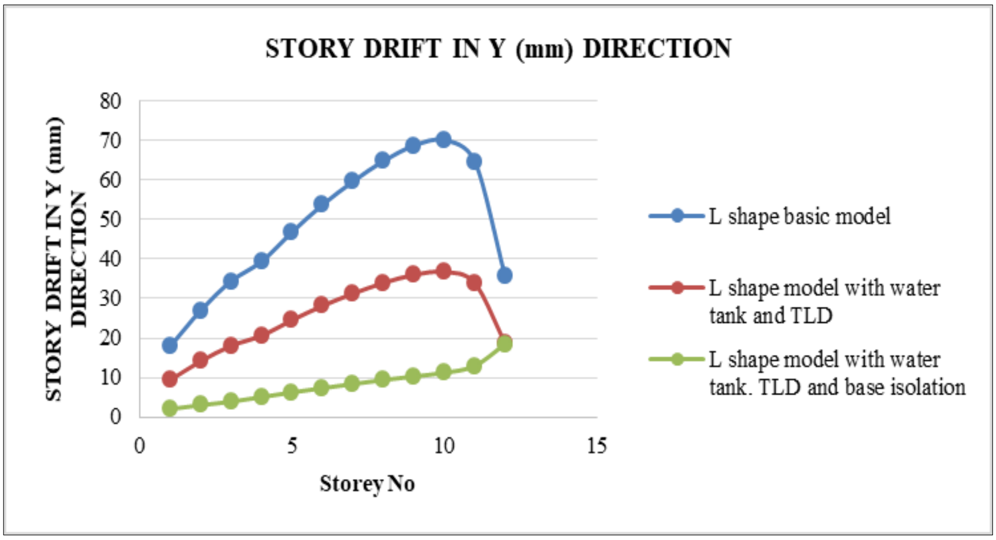

Figure 14 Story drift Y direction

The aforementioned graph illustrates the Y-direction tale drift for the L-shaped models with the water tank, TLD, and TLD base isolation. The L-shaped model with the water tank has the greatest tale drift (17 mm), while the L-shaped model with the TLD base isolation has the lowest story drift (2 mm), as can be seen.

5.1.5. Time period

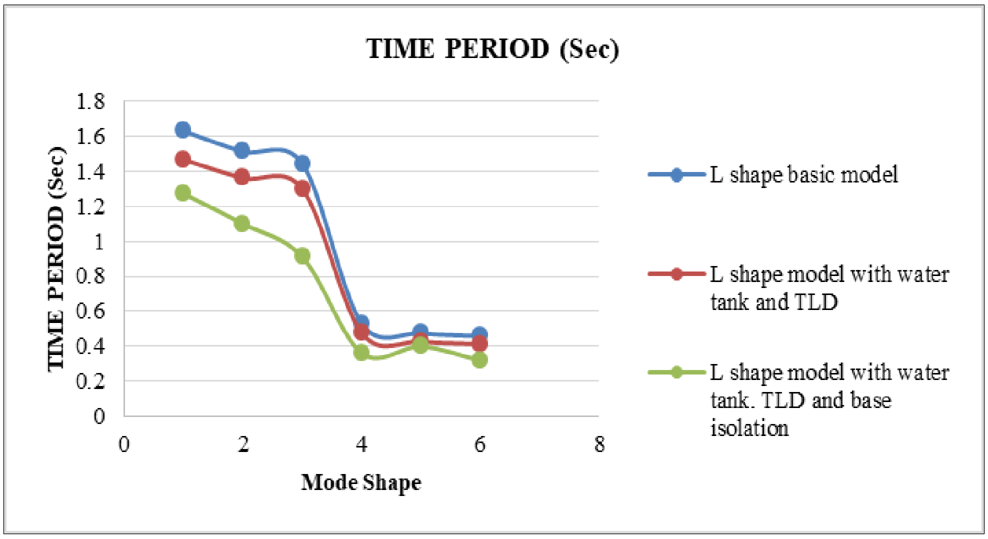

Figure 15 Time period

The time periods for the L-shaped models with the water tank, TLD, and TLD base isolation are displayed in the above graph. It is evident that the L-shaped model with the water tank has the longest time period (1.63 seconds), while the L-shaped model with the TLD base isolation has the shortest time period (1.27 seconds).

5.1.6. Frequency

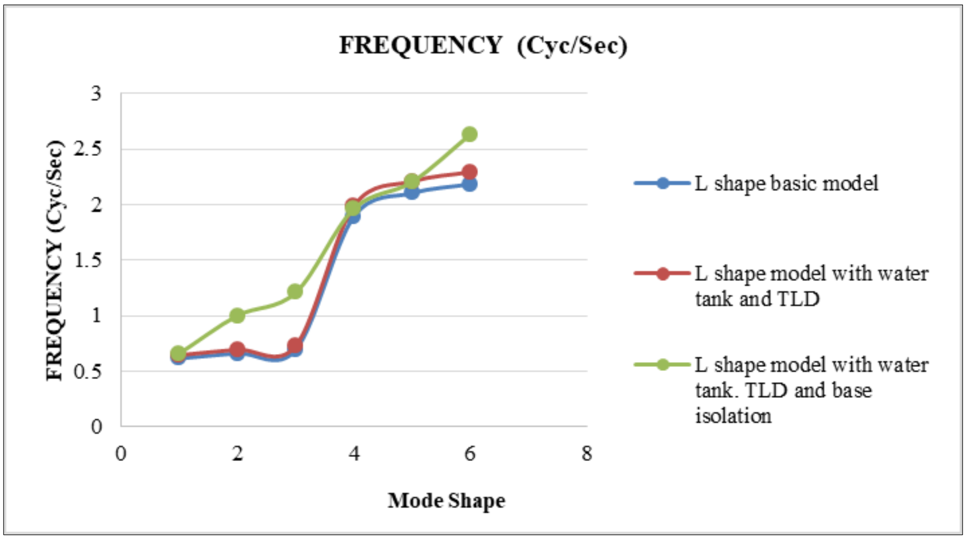

Figure 16 Frequency

The frequency for the L-shaped model with water tank, L-shaped model with TLD, and L-shaped model with TLD base isolation are displayed in the above graph. The L-shaped model with the water tank has the highest frequency, measuring 0.64 cycles per second, while the L-shaped model with the TLD base isolation has a lower time period, measuring 0.61 cycles per second.

5.2. T Shape Model results

5.2.1. Joint Displacement

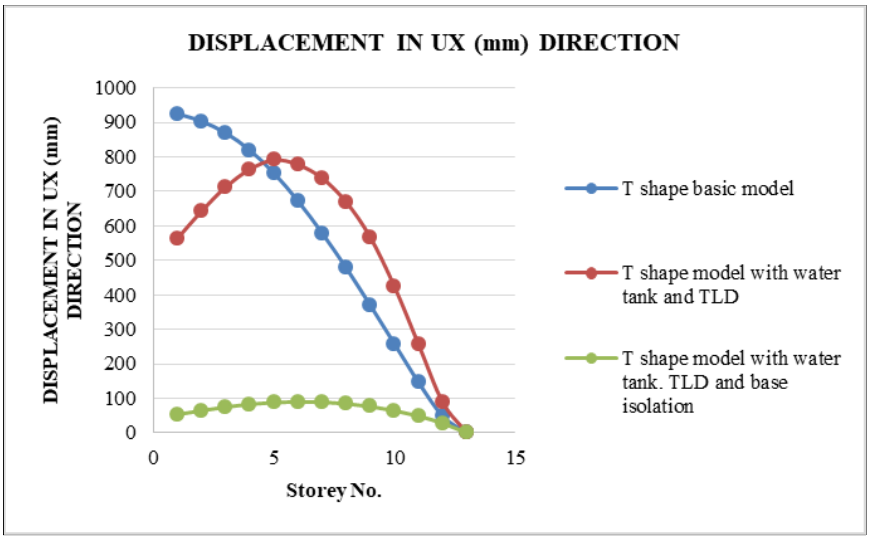

Figure 17 Displacement in X direction

The joint displacement in the X direction for the T-shaped model with water tank, T-shaped model with TLD, and T-shaped model with TLD base isolation is displayed in the above graph. It is evident that the T-shaped variant featuring a water tank has the largest displacement, measuring 925 mm, while the T-shaped model featuring TLD base isolation has a smaller displacement of 53 mm.

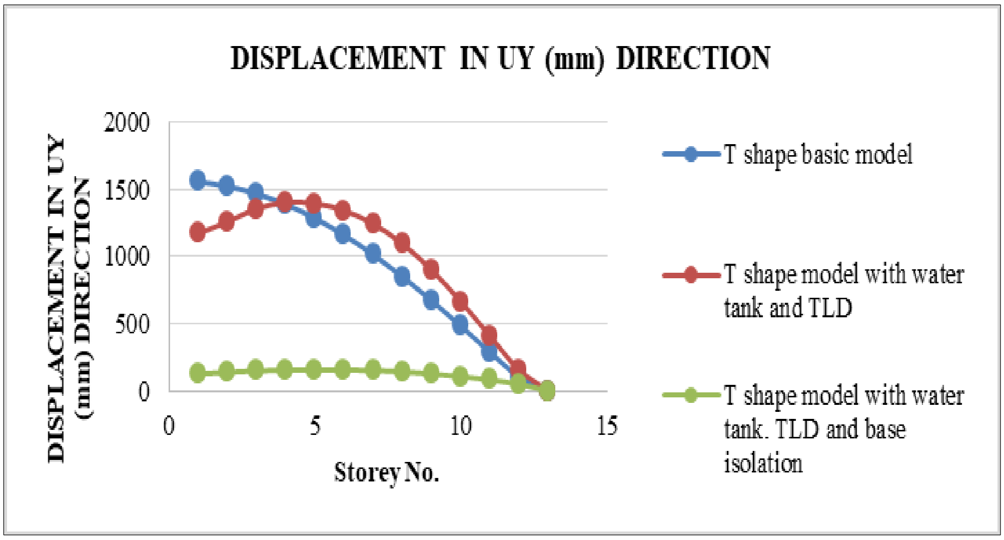

Figure 18 Displacement in Y direction

The T-shaped model with water tank, T-shaped model with TLD, and T-shaped model with TLD base isolation have joint displacement in the Y direction, as shown in the above graph. Evidently, the T-shaped type featuring a water tank has the largest displacement, measuring 1557 mm, while the T-shaped variant featuring TLD base isolation has a lesser displacement of 125 mm.

5.2.2. Base Shear

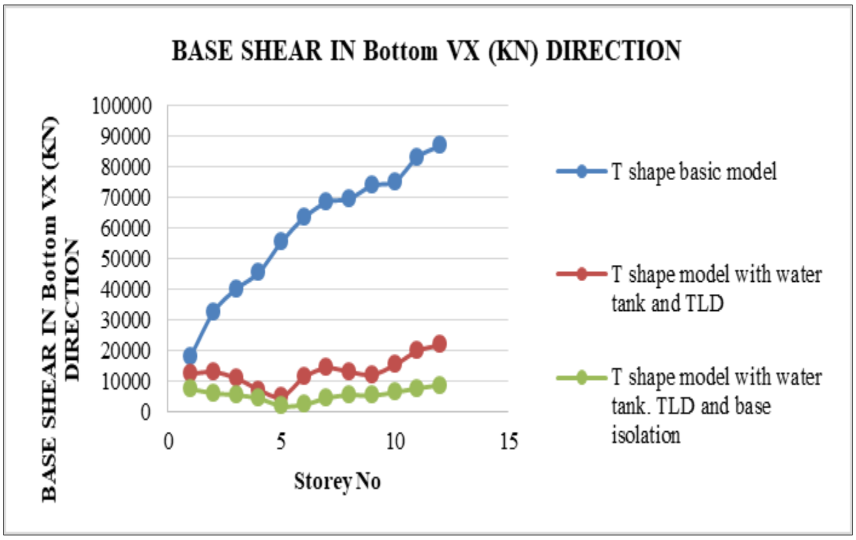

Figure 19 Base Shear X Direction

The T-shaped model with water tank, T-shaped model with TLD, and T-shaped model with TLD base isolation are shown in the above graph with base shear in the bottom VX direction. The T-shaped model with the water tank has the largest base shear, 18202 KN, while the T-shaped model with the TLD base isolation has the lowest base shear, 7475 KN.

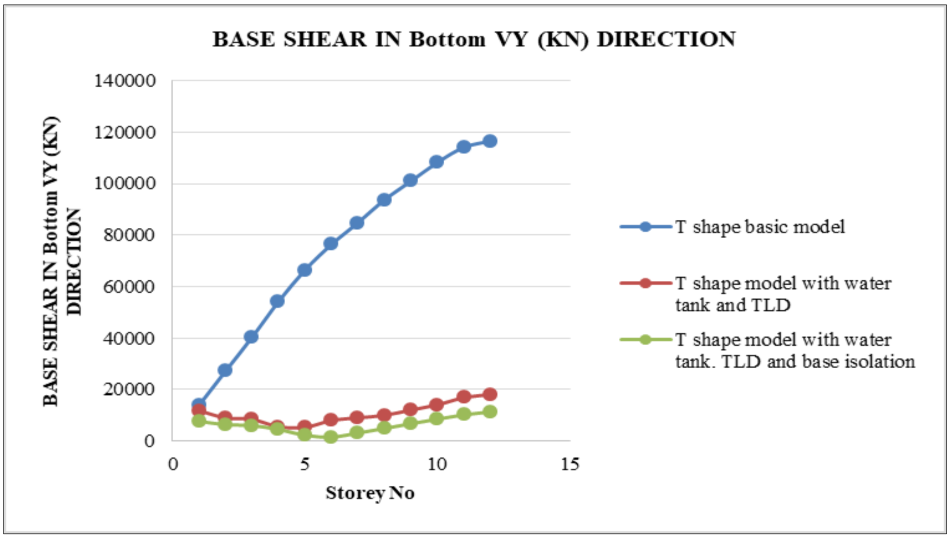

Figure 20 Base Shear Y Direction

The T-shaped model with water tank, T-shaped model with TLD, and T-shaped model with TLD base isolation are shown in the above graph with base shear in the bottom VY direction. Clearly, the T-shaped model with the water tank has the largest base shear (13929 KN), while the T-shaped model with the TLD base isolation has the lowest base shear (7711 KN).

5.2.3. Story Drift

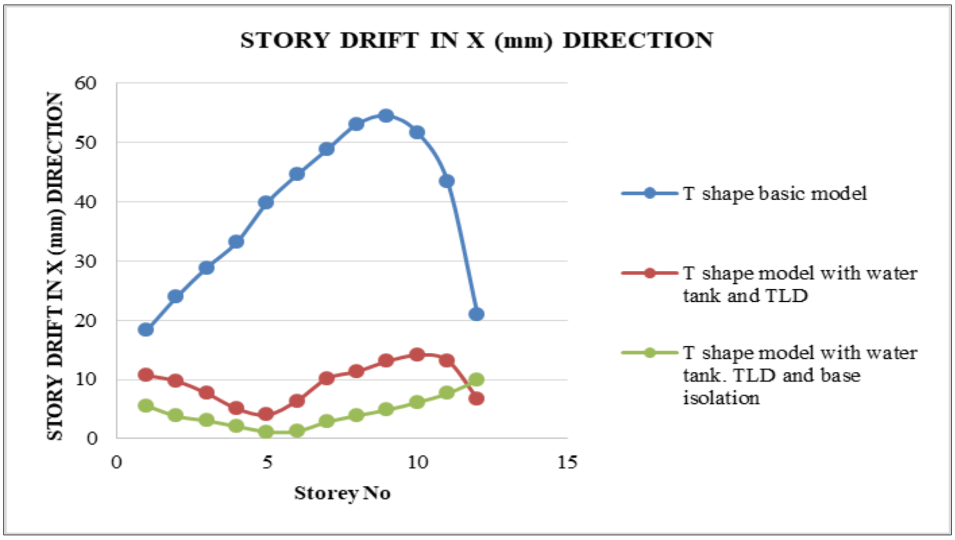

Figure 21 Story drift X direction

The T-shaped model with water tank, T-shaped model with TLD, and T-shaped model with TLD base isolation all exhibit tale drift in the X direction, as seen in the following graph. The T-shaped model with the water tank has the biggest tale drift, measuring 18 mm, while the T-shaped model with the TLD base isolation has the lowest story drift, measuring 5 mm.

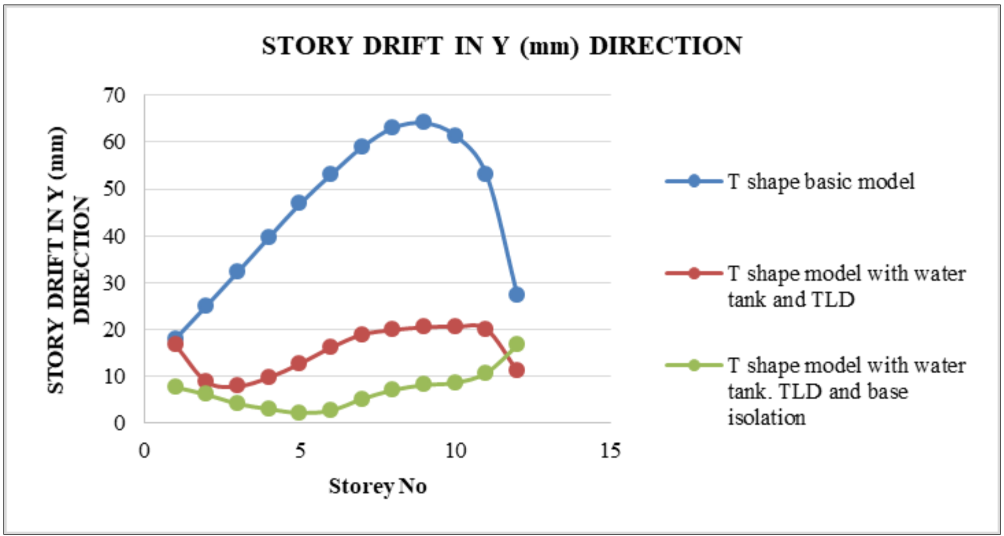

Figure 22 Story drift Y direction

The afore mentioned graph illustrates the Y-direction tale drift for the T-shaped models with the water tank, TLD, and TLD base isolation. The T-shaped variant with the water tank has the biggest tale drift, measuring 18 mm, while the T-shaped model with the TLD base isolation has the lowest story drift, measuring 7 mm.

5.2.4. Time period

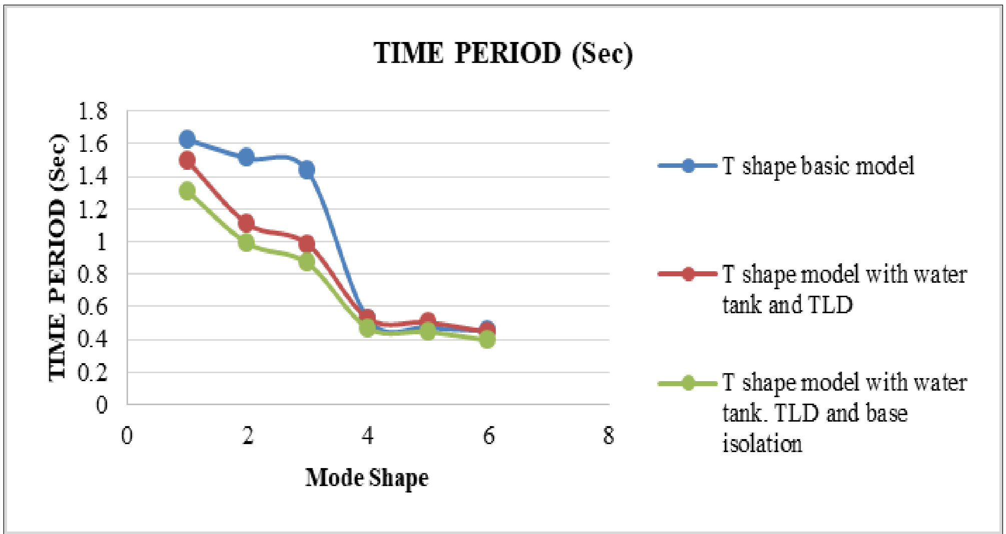

Figure 23 Time period

The time periods for the T-shaped models with the water tank, TLD, and TLD base isolation are displayed in the above graph. It is evident that the T-shaped model featuring a water tank has the longest time period, measuring 1.62 seconds, while the T-shaped model using TLD base isolation has a shorter time period, measuring 1.31 seconds.

5.2.5. Frequency

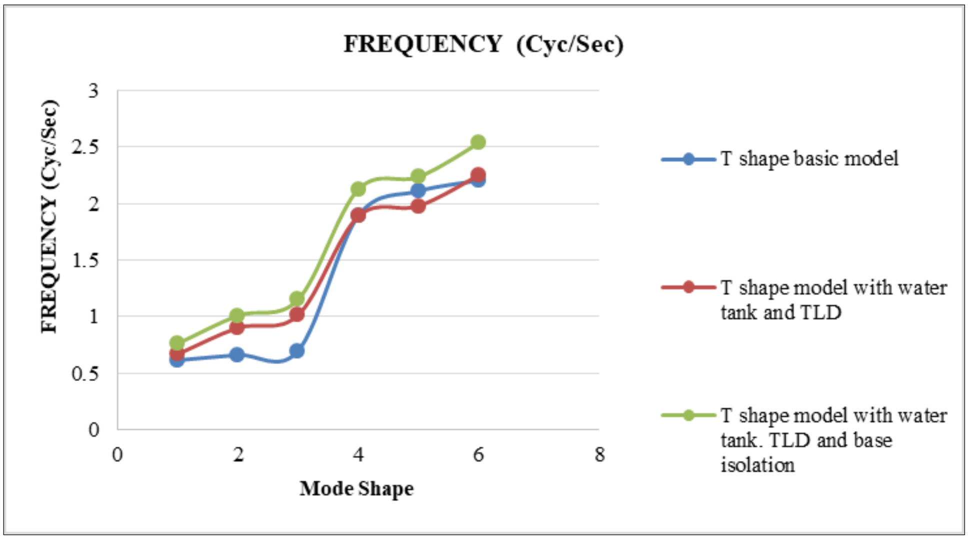

Figure 24 Frequency

The frequency for the T-shaped model with water tank, T-shaped model with TLD, and T-shaped model with TLD base isolation are displayed in the above graph. The T-shaped model with the water tank has the highest frequency, measuring 0.76 cycles per second, while the T-shaped model with the TLD base isolation has a lower time period, measuring 0.61 cycles per second.

5.3. Time History of L shapes

5.3.1. Model: L Shape basic model

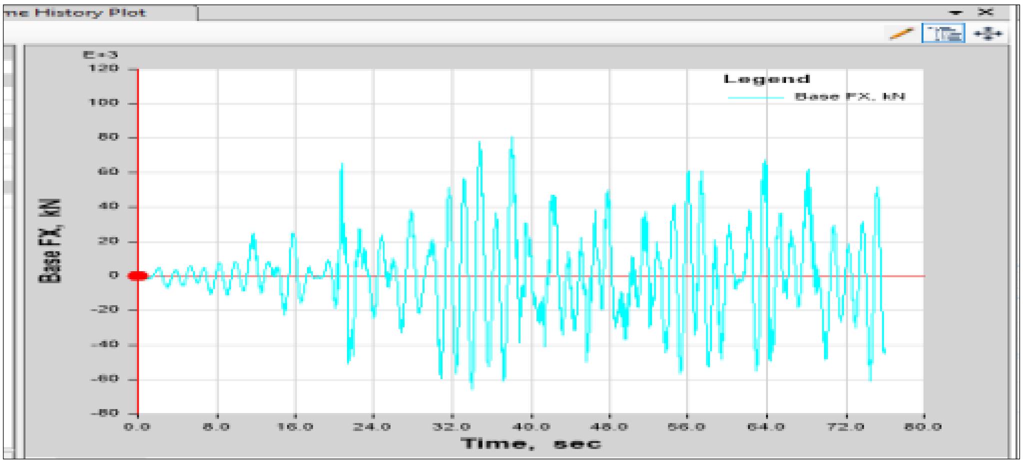

Figure 25 Base Fore Due to Blast load

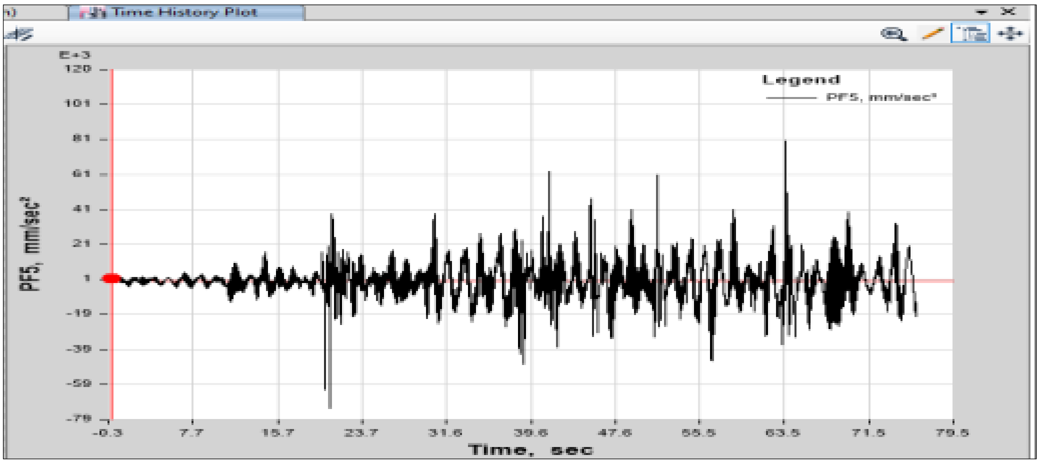

Figure 26 Joint Accelerations due to Blast Load

5.3.2. Model: L Base Shape with TLD and Water Tank

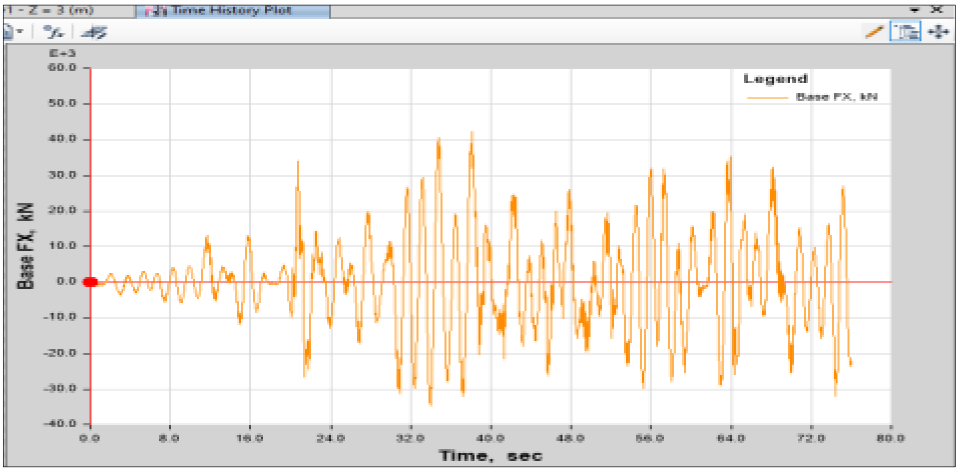

Figure 27 Base Fore Due to Blast load

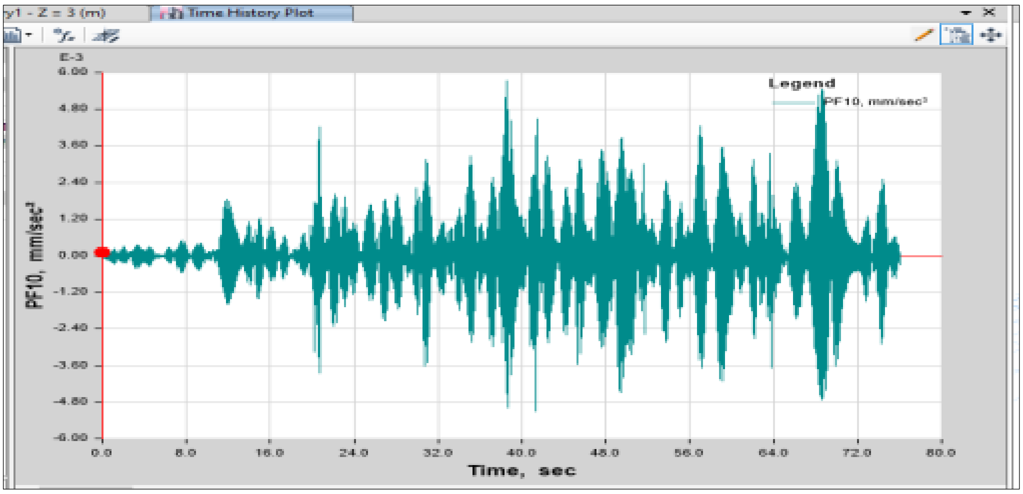

Figure 28 Joint Accelerations due to Blast Load

5.3.3. Model: L Base Shape with TLD and Base isolation

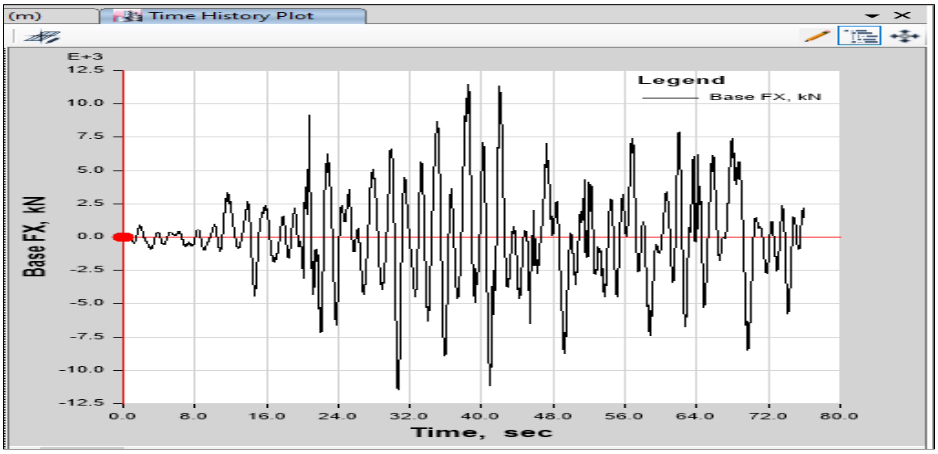

Figure 29 Base Fore Due to Blast load

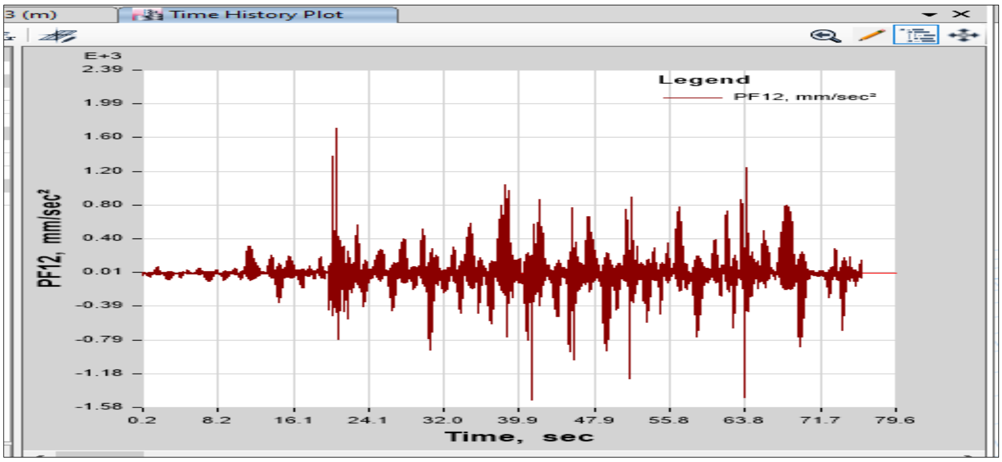

Figure 30 Joint Accelerations due to Blast Load

5.4. Time History of T shapes

5.4.1. Model: T Shape Basic model

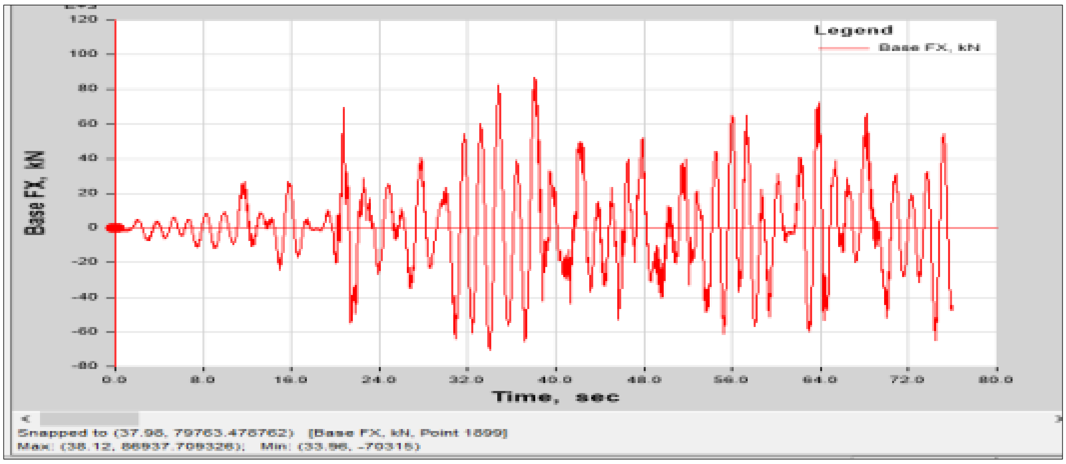

Figure 31 Base Shear Due to Blast Load

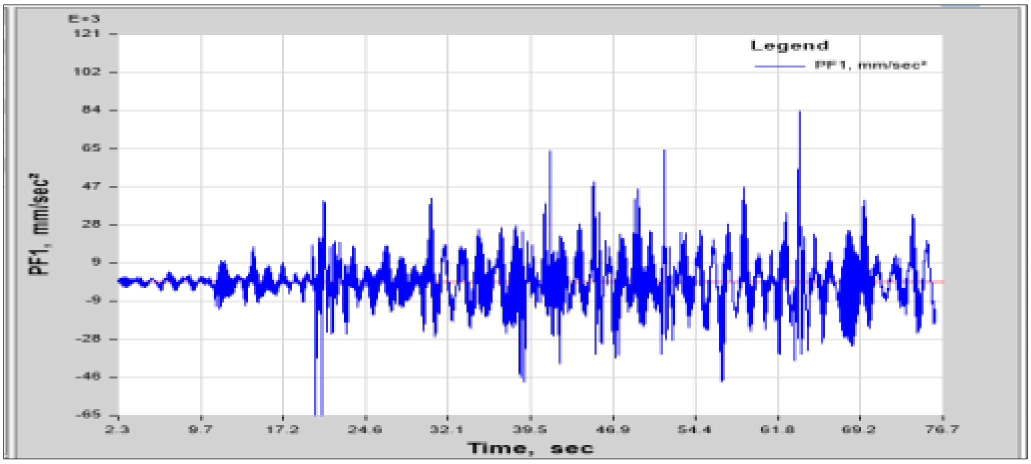

Figure 32 Joint Accelerations due to Blast Load

5.4.2. Model: T Base Shape with TLD and Water Tank

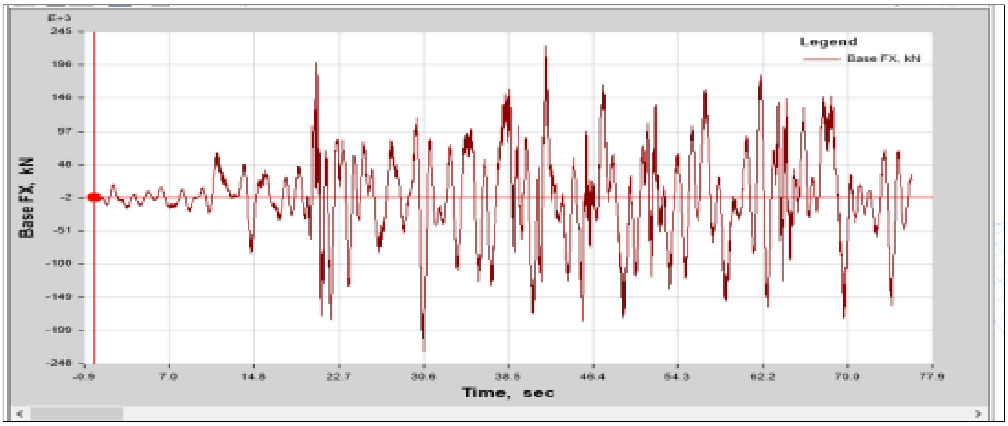

Figure 33 Base Fore Due to Blast load

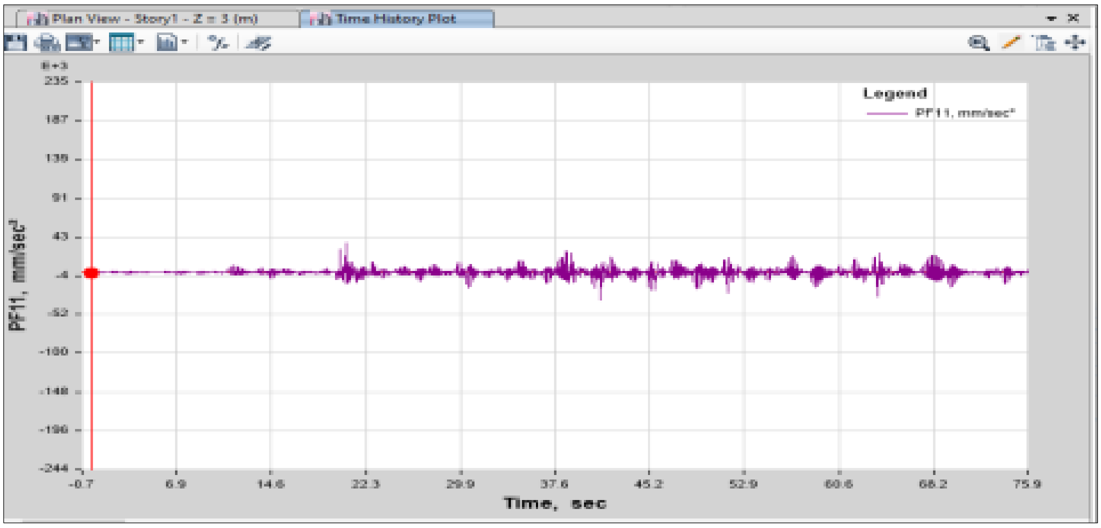

Figure 34 Joint Accelerations due to Blast Load

5.4.3. Model: T Shape with TLD and Base Isolation

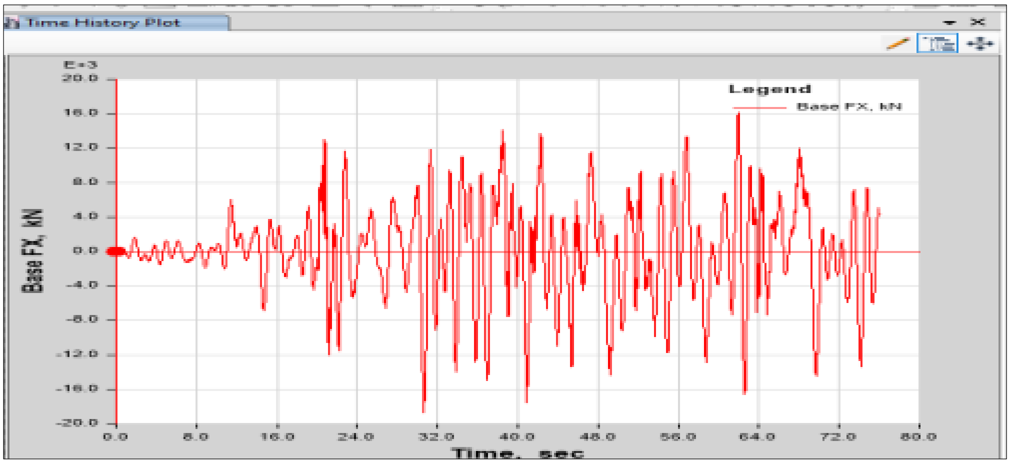

Figure 35 Base Fore Due to Blast load

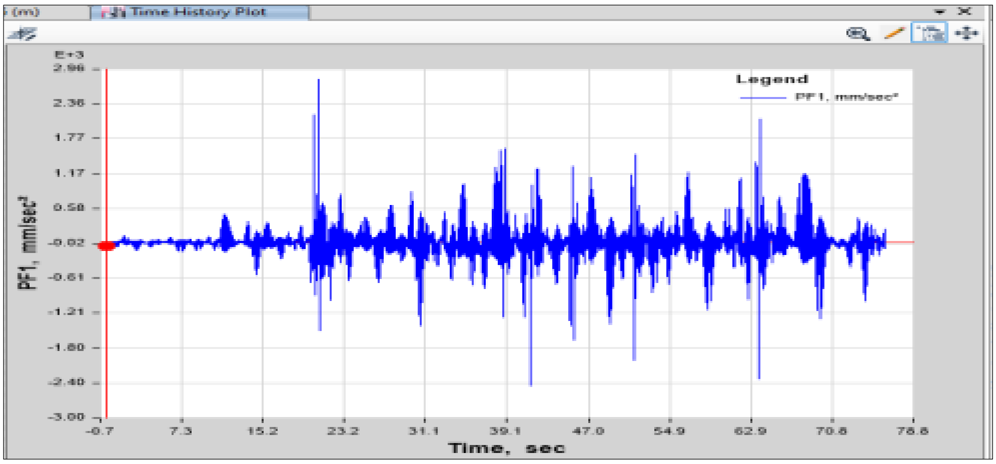

Figure 36 Joint Accelerations due to Blast Load

6. Conclusion

In conclusion, a major development in the fields of structural engineering and earthquake mitigation may be seen in the behaviour of liquid tuned mass dampers and base isolation in high-rise buildings. These cutting-edge technologies have the power to completely change how tall structure design and construction are done in seismically active areas. The main conclusions and ideas covered in this paper will be summed up in this section.

The comparison between different structural models, including L shape and T shape models with various damping and isolation systems, provides valuable insights into their performance in high-rise buildings.

6.1. Joint Displacement

- Models equipped with damping and isolation systems exhibit significantly reduced joint displacements compared to basic models.
- Both L shape and T shape models with base isolation show the lowest displacement, indicating the effectiveness of this seismic retrofitting technique.

6.2. Base Shear

- Incorporating damping and isolation systems results in a considerable reduction in base shear forces, particularly noticeable in models with base isolation.

- L shape and T shape models with base isolation demonstrate superior performance in resisting lateral forces compared to their counterparts without such systems.

6.3. Story Drift

- The introduction of damping and isolation systems notably mitigates story drift, ensuring better structural integrity and occupant safety during seismic events.
- Models with base isolation exhibit minimal story drift, highlighting the effectiveness of this technique in limiting structural deformations.

6.4. Time Period and Frequency

- Models with damping and isolation systems generally show lower time periods and higher frequencies, indicating improved structural stiffness and dynamic response.
- Base isolated models consistently demonstrate shorter time periods and higher frequencies, emphasizing their ability to dissipate seismic energy efficiently.
    - All things considered, the seismic performance of high-rise structures is improved by the integration of damping and isolation systems, especially base isolation, which lowers displacements, base shear forces, and story drift while simultaneously increasing structural stiffness and dynamic response. These results highlight how crucial it is to use cutting-edge structural retrofitting methods to increase a building's resistance to seismic threats.
    - Base isolation systems have emerged as a highly effective strategy for enhancing the seismic resilience of high-rise structures. By decoupling the building from ground motion during an earthquake, base isolators reduce the transmission of seismic forces and accelerations to the superstructure. This not only protects the building itself but also ensures the safety and well-being of its occupants. Through extensive research and real-world applications, it has been demonstrated that base isolation can significantly mitigate the damage caused by seismic events.
    - One of the key advantages of base isolation is its adaptability to various building types and sizes. Whether it's a residential skyscraper or a commercial high-rise, base isolation can be customized to meet the specific needs of the structure. Moreover, it is a passive system that requires minimal maintenance and can be integrated into both new and existing buildings. This makes it a cost-effective solution for earthquake-prone regions.
    - On the other hand, liquid tuned mass dampers (LTMDs) offer an alternative approach to mitigating the dynamic response of tall buildings. These devices use the principles of mass and damping to counteract the motion induced by seismic forces. LTMDs consist of a container filled with liquid, which can be tuned to the resonant frequency of the building. When the building sways due to an earthquake, the liquid inside the damper sloshes in a controlled manner, effectively reducing the building's oscillations.
    - It is important to note that while both base isolation and LTMDs offer significant advantages, they are not mutually exclusive. In fact, many high-rise buildings are designed with a combination of these technologies to maximize their seismic performance. This hybrid approach leverages the strengths of each system, providing an even higher level of protection against earthquakes.
    - In summary, the behavior of base isolation and liquid tuned mass dampers in high-rise buildings is a testament to the continuous evolution of structural engineering in response to the challenges posed by seismic activity. These technologies have proven their effectiveness in safeguarding buildings, their occupants, and critical infrastructure during earthquakes. As our understanding of these systems continues to evolve and as new innovations emerge, we can expect even greater advancements in the field of earthquake-resistant design.
    - Moving forward, it is essential that engineers, architects, and policymakers embrace these technologies and integrate them into building codes and design practices. By doing so, we can ensure that our high-rise buildings not only reach greater heights but also stand firm in the face of nature's most powerful forces. As seismic events remain a constant threat in many regions around the world, the adoption of base isolation and liquid tuned mass dampers represents a proactive and essential step toward a safer, more resilient built environment.
    - One of the main advantages of LTMDs is their versatility. They can be installed in a wide range of building structures, including those with irregular shapes and varying heights. Additionally, LTMDs are capable of reducing both lateral and torsional vibrations, making them a valuable tool for enhancing the overall stability of high-rise buildings

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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