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EARTHQUAKE RESISTANT BUILDING USING BASE ISOLATION IN COMBINATION WITH TUNED MASS DAMPER

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ABSTRACT

This abstract explores the significance of base isolation and tuned mass dampers in structural engineering. Base isolation involves decoupling a building or structure from its foundation to mitigate the effects of ground motion during seismic events. Tuned mass dampers, on the other hand, are devices designed to absorb and dissipate vibrations, enhancing structural stability. In most of the cases, high rise buildings cannot effectively resist the lateral loads from the earthquake which leads to the failure of the building [1]. So, as a solution, when base isolators and tuned mass damper are used in combined way, it will create a great effectiveness to the building. Through this project we are going to explain the method with a model by different variation of frequencies. The combined use of base isolation and tuned mass dampers represents an innovative approach in structural engineering for mitigating seismic vibrations. Base isolation involves decoupling a structure from its foundation, allowing it to move independently during an earthquake. Simultaneously, tuned mass dampers are employed to absorb and dissipate dynamic energy, minimizing structural oscillations. This synergistic combination aims to enhance seismic resilience by addressing both translational and rotational responses [2]. The abstract delves into the theoretical underpinnings, design considerations, and practical applications of this integrated system, showcasing its potential to significantly improve the seismic performance of structures in various settings

Keywords: Earthquake resistant, Base Isolation, Tuned Mass Damper

CHAPTER 1

INTRODUCTION

- Combining base isolation and a tuned mass damper in a structure offers enhanced seismic performance. Base isolation helps decouple the building from ground motion, reducing seismic forces transmitted to the structure. The tuned mass damper, on the other hand, addresses resonant vibrations by counteracting them with a mass oscillating in opposition together, they provide a synergistic approach: base isolation mitigates overall seismic forces, while the tuned mass damper targets specific resonant frequencies [3]. This combined system enhances a structure's ability to withstand earthquakes, ensuring improved safety and minimizing structural damage. It's particularly effective in reducing accelerations and displacements, offering a comprehensive solution for seismic resilience [4].
- The aim of the present experiment is to verify the effectiveness of a combined base isolation and tuned mass tamper control strategy in buildings
- The hybrid control consists of a base isolation device and non-traditional tuned mass damper (TMD).
- In the evaluation, the study was conducted for structures with a ten-story reinforced concrete buildings exposed to various far-field and near-field earthquake records.
- The structure is modeled as a combined system. The results of the study clearly confirmed that the response of high-rise buildings during earthquakes could be significantly reduced using base isolation devices and TMDs [3,4].

CHAPTER 2

WORKING OF THE SYSTEM

Combined base isolation and tuned mass damper systems are employed to enhance the seismic performance of structures. Base isolation isolates the structure from ground motion, while a tuned mass damper addresses the building's dynamic response [5,6]. Here's a brief overview of how they work together:

2.1 Base Isolation

Objective: Protects the structure from ground motion during earthquakes.

Mechanism: The building is placed on flexible bearings or isolators, which allow relative movement between the structure and the ground. This decouples the building from the shaking of the ground, reducing seismic forces transmitted to the structure [5,6].

2.2 Tuned Mass Damper (TMD)

Objective: Mitigates structural vibrations induced by dynamic loads, such as wind or earthquakes.

Mechanism: A mass-spring-damping system is added to the structure .The mass is tuned to the natural frequency of the building, absorbing and dissipating energy to reduce structural oscillations[5,6].

2.3 Combined System

Integration: The base isolation and tuned mass damper systems are integrated to address both static and dynamic forces.

Synergy: Base isolation deals primarily with low-frequency, large-amplitude motions during earthquakes, while the tuned mass damper is effective for suppressing higher frequency vibrations induced by dynamic loads [5,6].

CHAPTER 3

EFFECT OF BASE ISOLATION ALONE

Fig A – Base Roller

The base roller given in the above picture is used in this project as it is arresting the seismic loads along the base to the structure so that the structure can easily withstand the waves**.**

Decoupling from Ground Motion: Base isolation allows the building to move independently of ground motion during an earthquake, reducing the forces transmitted to the structure. It helps in limiting accelerations experienced by the building, thereby lowering the rise of structural damage [7]. By isolating the building from seismic forces, base isolation helps minimize structural damage, including cracks and deformations .Preservation of Contents: Protects interior contents and equipment from earthquake-induced damage .The reduced forces transmitted to the building contribute to enhanced safety for occupants during an earthquake .Base-isolated buildings often experience less damage, allowing for faster recovery and reoccupation after an earthquake

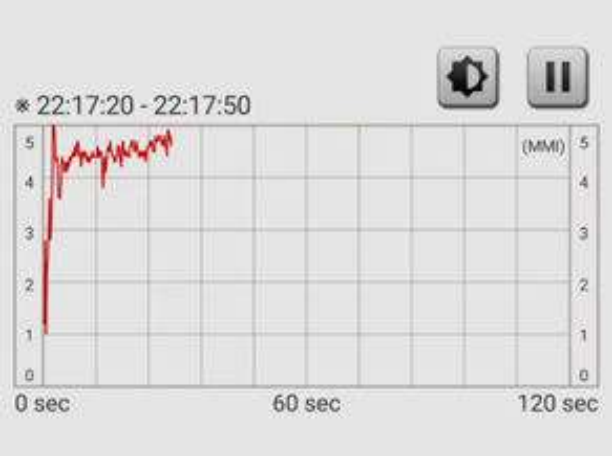


Fig B – Frequency Wave of the Structure

The figure shows that the seismic magnitude of 5.4, often measured on the Richter scale or other magnitude scales like the moment magnitude scale (Mw), signifies a moderate earthquake. Here are some key points to understand about a magnitude 5.4 earthquake [8]

Table 1 – Results While Using Base Isloation Alone

Duration of vibration at base (In seconds)	Magnitude received	Result
30	5.4	Often felt with minor causes

3.1 EFFECT OF COMBINING BOTH THE SYSTEM

A seismic magnitude of 4.9 indicates a light to moderate earthquake. Here are some details about a magnitude 4.9 earthquake

Effects: A 4.9 magnitude earthquake can be felt over a larger area, and people are likely to notice the shaking. However, the damage it causes is usually minimal, especially in regions with well- designed and earthquake-resistant structures [9]

Fig C – Tuned Mass Damper

The tuned mass damper given in the above picture is to arrest the excess shaking of the structure with the base roller resisting system as it is oscillate to the opposite direction of the seismic waves.

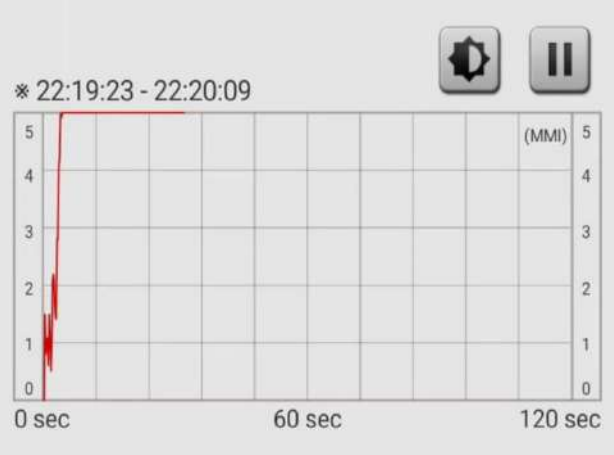


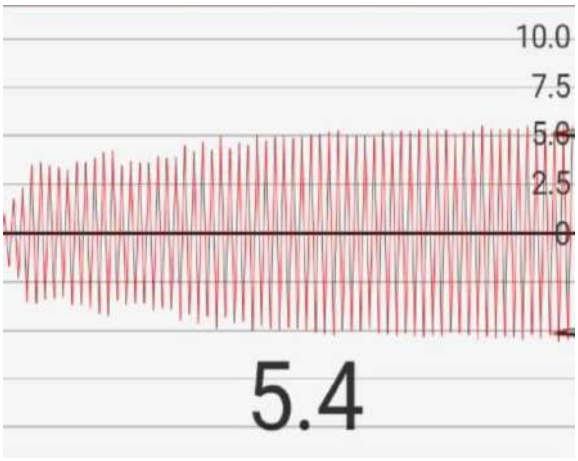
Fig D – Frequency Wave of the Structure

The figure(D) shows that the seismic magnitude of 4.9, often measured on the Richter scale or other magnitude scales like the moment magnitude scale (Mw), signifies a minor earthquake and it can be felt [10]

Table 2 – Result While Using Both the Systems

Swinging of the damper (In seconds)	Magnitude received	Result
5	4.9	Slightly felt with minor causes

The damper is swing for 5 seconds and the vibration felt by the structure during the swing is noted.

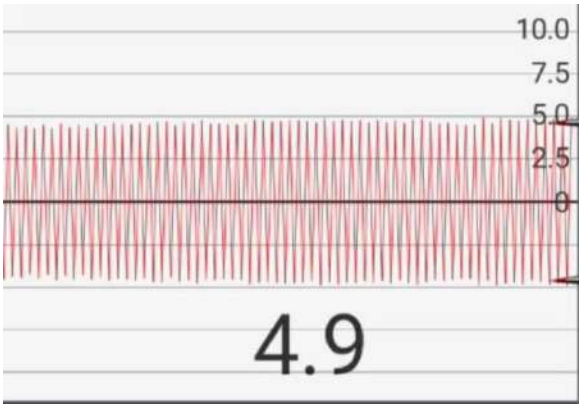


3.2 Fig E - Vibration Scale Foe Base Isolator Alone

The figure shows that the magnitude 5.4 earthquake is considered moderate, it does not necessarily guarantee widespread or severe damage. The impact depends on several factors, including the earthquake's depth, proximity to populated areas, and the region's building standards.

Frequency: Earthquakes of this magnitude are relatively common globally. Thousands of earthquakes of varying magnitudes occur each year, with most being of low magnitude and often going unnoticed.

Monitoring and Response: Seismologists use networks of seismometers to monitor and locate earthquakes accurately [11]. Local authorities and emergency services are prepared to respond to seismic events based on their magnitude and potential impact.



3.3 Fig F - Vibration Scale after Installing Tuned Mass Damper

The figure shows that the magnitude 4.9 earthquake is lesser than the 5.3 magnitude and it is considered moderate and has the potential to be felt by people over a larger area

Frequency: Earthquakes of this magnitude are relatively common globally. Many occur daily but often go unnoticed because they are small or happen in remote areas.

Monitoring and Response: Seismologists use networks of seismometers to detect and locate earthquakes accurately. Emergency services and local authorities are typically prepared to respond to seismic events based on their magnitude and potential impact [11]. In summary, a magnitude 4.9 earthquake is lesser than the 5.3 magnitude and it is considered moderate and has the potential to be felt by people over a larger area

CHAPTER 4

CONCLUSION

Through this project we completed a study of combined method of base isolation and tuned mass damper and only shows the vibrating variations in different forms of system.

- The integration of base isolation and tuned mass damper technologies in building design represents a comprehensive seismic mitigation strategy.
- This combined approach addresses both the structural integrity and occupant comfort aspects, providing a robust solution for structures in earthquake-prone regions.
- The magnitude occurred while using base roller only received a magnitude of 5.4 magnitude which results in the minor causes for the structure.
- And the magnitude occurred for the combined method is 4.9 results in the slightly felt by the humas and doesn't cause any damages.
- Vibration scale is used to determine wave length of the structure during the shaking of the structure with the range starts from 0 – 10hz at an increase of 2.5hz
- TMD design modelling for discrete and continuous structures; and the TMD design optimization procedures [12].
- General overview on development of the TMD design including devices, design concepts, and their real applications has also been presented.

- The result is a more resilient building that can better withstand seismic forces and enhance overall safety.
- The combined use of base isolation and tuned mass damper (TMD) in building design provides a comprehensive approach to mitigate the effects of seismic forces.
- Base isolation focuses on isolating the building from ground motion, while a tuned mass damper is designed to absorb and dissipate vibrational energy. Together, they offer a synergistic solution for enhancing structural resilience.
- This dual strategy aims to minimize structural damage and improve occupant safety during seismic events.
- Base isolation helps in decoupling the building from ground motion, reducing the transfer of seismic forces to the structure. This is particularly effective in mitigating horizontal displacements and accelerations, offering an added layer of protection to the building and its contents.
- Finally, some practical realization of the TMD system has also been summarized.
- It has also been shown that the future research points related to the TMD area will be focused on the practical friction and/or stiffness model with the base roller.
- The perspective of the study is clearly showed and combined working of base roller and TMD

REFERENCES

1. Jr. Billie f. SPENCER, Erik A. JOHNSON, Juan c. RAMALLO JSME International journal series C mechanical systems, Machine Elements and Manufacturing – 2003
2. Palazzo, B; Petti Seismic response control in base isolated systems using tuned mass damper – 1994: Volume 2. PVP – Volume 275-2
3. M. De Luiis, Petti l, Palazzo B Combined control strategy base isolation and tuned mass damper: An effectiveness analysis of its application to non- linear benchmark base isolated structure-2008,china.
4. Ashwini kukude, Manish Chudare Analysis of earthquake RCC building by base isolation and damper system - 2007.
5. Jeromme Connor , Simon Laflamme Intro to structural motion conchov2 – 2002
6. N. Maureira – Carsalade , E. Pardo A roller type base isolation device with tensile strength-2020 volume 221
7. Qingglog Zhang, Zaizhan an A review on roller compaction quality control and assurance methods for earthwork in five application scenarios – April 2022 china.
8. G R Gillich , v Lanchu , N Gillich Decoupling the structure from the ground motion during earthquakes by employing friction pendulums – may 2017 Romania 294.
9. Hamada Saadalla , Ahmad Hamed Source characteristics of June 2020 M_L 5.4 earthquake – Article number : 41 (2022) – 2022 China
10. Tholkapiyan, M., Mohan, A., Vijayan, D.S.: Tracking The Chlorophyll Changes Using Sentinel-2A/B Over The Gulf Of Manner, India, Oxidation Communications, 45(1), pp. 93–102 (2022).
11. Dr.G.Velrajkumar, R.Muralikrishnan, A.Mohan, R.Bala Thirumal, P.Naveen John: Performance of GGBFS and silica fume on self compacting geopolymer concrete using partial replacements of R-Sand, materials today : proceedings, Volume 59, Part 1, Pages 909-917 (2022).
12. D. S. Vijayan , A. Mohan , C. Nivetha , Vidhyalakshmi Sivakumar , Parthiban Devarajan , A. Paulmakesh , And S. Arvindan: Treatment of Pharma Effluent using Anaerobic Packed Bed Reactor, Journal of Environmental and Public Health, Volume 2022, Article ID 4657628, 6 pages (2022).

13. Ayyasamy, L.R., Mohan, A., Vijayan, D.S., ...Devarajan, P., Sivasuriyan, A.: Finite element analysis of behavior and ultimate strength of composite column , Science and Engineering of Composite Materials, 29(1), pp. 176–182, (2022).
14. S. Lavanayaprabha, A. Mohan, G. Velrajkumar, A. Mohammedharoonzubair., Study On Structural Behaviour Of Ductile High-Performance Concrete Under Impact And Penetration Loads ., Journal of Environmental Protection and Ecology 23, No 6, 2380–2388 (2022) .
15. Mithila Verma , Anup K. Sutar M_W 4.9 Earthquake of 21 august, 2014 in kangra region, Northwest Himalaya : Seismotectonics implications – 2015 volume 109
16. Josip Atalic, Mario Uros, Marta Savor Novak A impact study on 5.4 magnitude and its response – may 2021.
17. Fan yang, Ramin Sedaghati Vibration suppression of structure using tuned mass damper technology – 2021 volume 28,issue7-8.