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Application of Tuned Mass Damper to Mitigate the Vibration of the Structure

Divyanshu Dev, Rohit Ralli, Shobha Ram

***Abstract:** A Structural Engineer's principal responsibility is structural design. The design of essential building elements and components is the fundamental principle of structural engineering. The multistory structures are made to save money by expanding the building's floor size without expanding the surrounding land area. Low absorption value, lightweight, flexible, and higher buildings are the result of recent construction trends. During the vibrations the possibility of failure and problems with serviceability will be raised . Tuned mass dampers, or TMDs, have popular device for reducing these lateral vibrations during the earthquake and wind load . The present research uses a Response Spectrum Analysis of a realistic building model with TMD and without TMDs to assess the efficacy of TMDs in vibration management. Important Parameters such base shear, storey drift, maximum displacement, etc were examined. The results show that When actual earthquakes occur in buildings with TMD, there is a noticeable decrease in displacement and Storey Drift,etc values. Buildings that use TMD is better able to withstand the effects of earthquakes.*

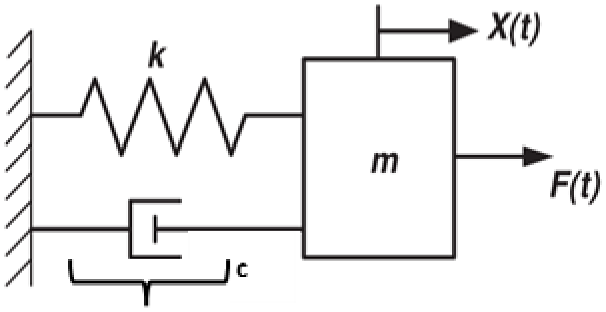
***Keywords:** TMD, SPM, Etabs, Important Parameters.*

I. INTRODUCTION

An earthquake is a unpredictable phenomenon connected to a strong ground trembling.it cause lot of harm in term of humen discomfort ,risk of humen life, Damages in a buildings, economical losses,etc When energy from the Earth's crust is released, usually as a result of tectonic plate movements, the Earth's surface shakes violently, causing an earthquake. Their strength and magnitude are quantified, resulting in surface rupture, ground trembling, and occasionally tsunamis. Preparation and prompt protective measures are necessary for safety so TMDs is a device by collecting kinetic energy, canceling out vibration through tuning, and dispersing energy through inertia force, Tuned Mass Dampers (TMDs) lessen structural vibrations. TMDs may successfully lessen sway and vibrations in buildings when positioned strategically, enhancing structural performance and safety.so Response spectrum analysis is essential for high-rise building seismic assessment. It evaluates the maximal response of structural elements to seismic stimulation by taking damping and various frequencies into consideration. By ensuring that the design can withstand forces caused by earthquakes, this strategy improves the building's performance and safety.The impact of dampers in a Structure which are essential for structural analysis, is investigated in this thesis. ETABS software is used to Examine (G+22) storey structure with and without tuned mass dampers.I used IS code 1893:2002 , IS 875:1987, IS 456:2000 .

A. Tuned Mass Damper

Tuned Mass Damper is the device, which is used to mitigate the lateral vibration during the earthquake and wind loads ,it is also called passive mass damperbecause no external energy is required.A device called a tuned mass damper (TMD) lowers vibrations in buildings, bridges, and towers. Den Hartog (1928). It is made up of a mass that is fixed to the structure, a spring, and a damper. The TMD vibrates out of phase with the structure since it is tuned to the structure's inherent frequency. The TMD mass moves in the opposite direction from the structure's direction of vibration, producing an inertial force that opposes the structure's motion. This lowers the motion's amplitude and dissipates the vibration's energy. The optimal location for a tuned mass damper is where the lateral load is maximum, or more accurately, where the structure's deflections are greatest. A TMD's efficacy is determined by the ratio of the Mass ratio of TMD to structural mass. The degree to which the TMD is tuned to the inherent frequency of the structure. The TMD's damping capacity.and it prevents from discomfort, Building damages and failure of structure ,etc.



Tuned Mass Damper System
Fig. 1 Sdof Principal System

B. Response Spectrum Method

Structural engineers employ the reaction Spectrum Method, a seismic analysis approach, to estimate the peak reaction of structures during earthquakes. It entails generating a response spectrum, which displays the highest response possible for systems with one degree of freedom at different frequencies.

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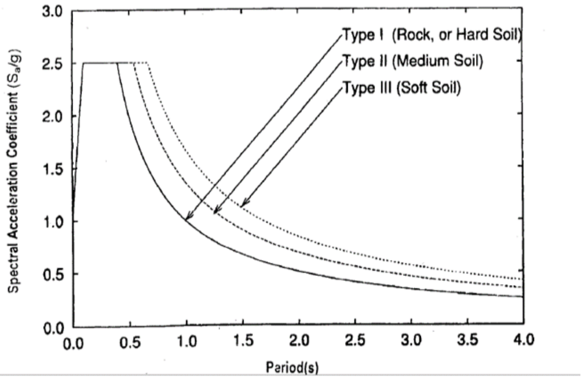
Natural frequencies and modes of structures are identified through analysis, and peak modal responses are obtained from the spectrum. The entire structural reaction is then estimated by combining these responses using techniques such as SRSS (Square Root of the Sum of the Squares) or CQC (Complete Quadratic Combination). Although this approach, which is prevalent in seismic design codes, is effective in forecasting peak responses, it makes assumptions about linear behavior and adds approximations to modal interactions.



II. OBJECTIVE

i. Selection of type of structure: Symmetric building of G+22 storeys.
ii. Case(1) is Building without Tuned mass Damper.
iii. Case(2) is Building with Tuned mass Damper.
iv. Investigate how buildings respond to base shear, story drift, displacement, and other factors.

III. LITERATURE REVIEWS

This section provides an overview of studies conducted by different writers in the area of structural control, emphasizing important conclusions and research methods. The review of the literature covers developments in control schemes, analytical methods, and real-world applications meant to enhance the dynamic performance and seismic resilience of structures.

A. P. Den Hartog (1931)

Historical Evolution and Current Trends in Tuned Mass Dampers (TMDs): -In the field of structural engineering, the development of Tuned Mass Dampers (TMDs) has been crucial, especially for reducing dynamic reactions brought on by wind, earthquakes, or vibrations caused by people. Through an analysis of the historical background, this article offers insightful information about the fundamental ideas and conceptual frameworks that underlie technique.

B. Daniel Brown 2014

"Tuned Mass Dampers for Flexible Structures: - A Review of Modal Analysis and Mode Localization" written by Daniel Brown the review by Daniel Brown explores the use of tuned mass dampers for flexible structures. It covers modal analysis methods, the phenomenon of mode localization, and optimization techniques to efficiently target key vibration modes and improve damping efficiency.

C. Dargush, G.F., & Soong, T.T. (1997)

PTMDs, or passive tuned mass dampers: Active control methods are not necessary for Passive Tuned Mass Dampers (PTMDs), which only use passive components. An extensive investigation of different passive energy dissipation systems, such as PTMDs, in structural engineering applications was given by Soong and Dargush (1997). Furuichi and Fujino (1998) presented hybrid control systems that highlight the possible integration of passive and active techniques. These strategies included active variable stiffness and passive variable damping employing MR dampers.-. Structural Dynamics & Earthquake Engineering, 27(2), 181-195.To sum up, this literature review includes early publications on transverse damping devices (TMDs), more recent developments in ATMDs and PTMDs, and thorough analyses of the theory, architecture, and practical uses of these damping systems. Additional information about the most recent advancements and case studies in the discipline will become available with more investigation of scholarly databases and pertinent periodicals.

D. Deore, Talikoti, and Tolani 2017

Explore how modern structures—which are getting taller, lighter, and more flexible with low damping values—can be made more vibration-free by using Tuned Mass Dampers (TMD). The likelihood of failure and serviceability problems is increased by these traits. Response spectrum analysis will be used in the study to assess the maximum deflection, storey drift, base shear, natural frequency, and fundamental period by building a realistic model with and without TMD. The findings show that TMDs significantly improve structural stability by reducing displacement, storey drift, and fundamental period—especially when placed on the top level.

E. Michael Thompson's 2005

"Tuned Mass Dampers in Tall Buildings: A Review of Design Guidelines and Case Studies": - The assessment by Michael Thompson addresses design principles and suggestions for installing TMDs in tall structures to reduce vibrations caused by wind and improve structural integrity. It provides case studies of tall building projects that effectively integrate TMDs, emphasizing installation difficulties, design issues, and performance evaluation standards.

IV. METHODOLOGY

This section gives a general summary of the significance of reducing lateral forces and seismic loads on tall buildings. It describes the technique used, the goal of the study, and the importance of employing TMDs.

i. The choice of building type was a G+22-story symmetrical structure.
ii. In accordance with IS 456:2016, the multi-story building is developed using ETABs v20 software and the loading procedure follows IS 875:1987.
iii. ETABs v20 are used to model the structure.
iv. Case (1)is Building without a tuned mass damper
v. Case No(2)is Building with a Tuned Mass Damperr .
vi. To evaluate how an adjusted tuned mass damper affects structural response.
vii. Using ETABS software,examine the response spectrum of a multistory structure frame with and without dampers.

viii. Examine how structures react to displacement, base shear, story drift, and other elements.

Modeling And Analysis (Floor Area Is 15m X14m)

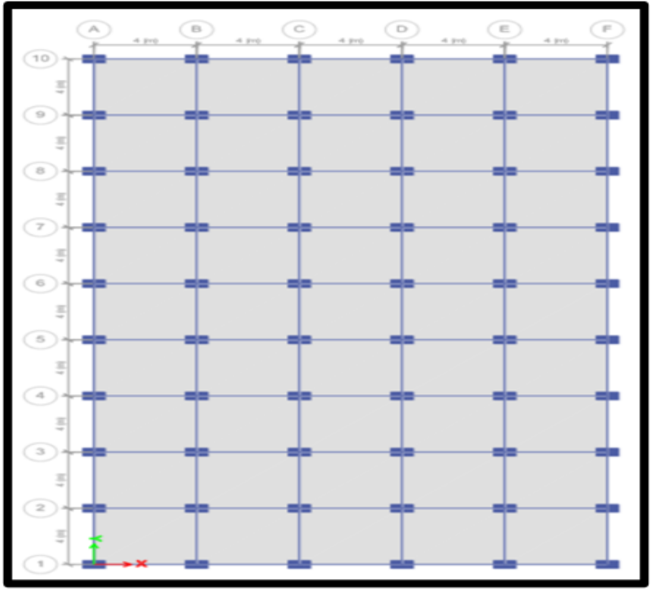


Fig. 2 Section View of Structure

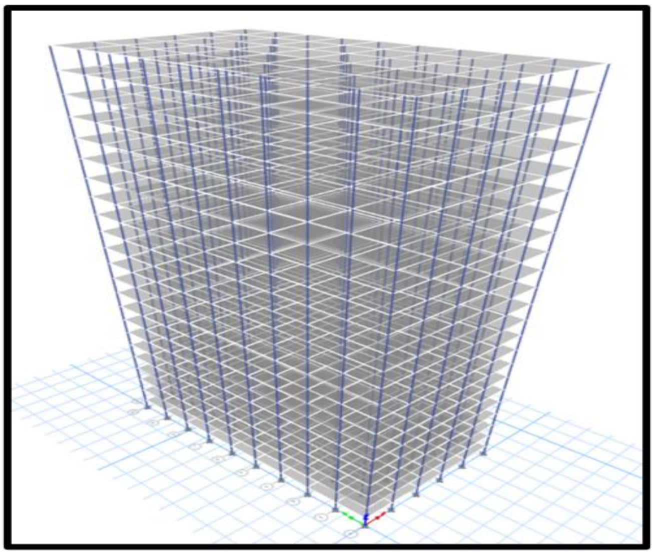


Fig. 3 (3D View of Structure)

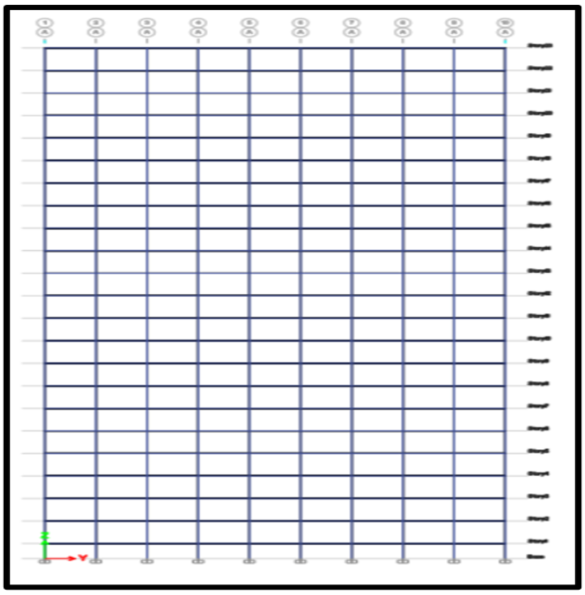


Fig. 4 Front View of the Structure

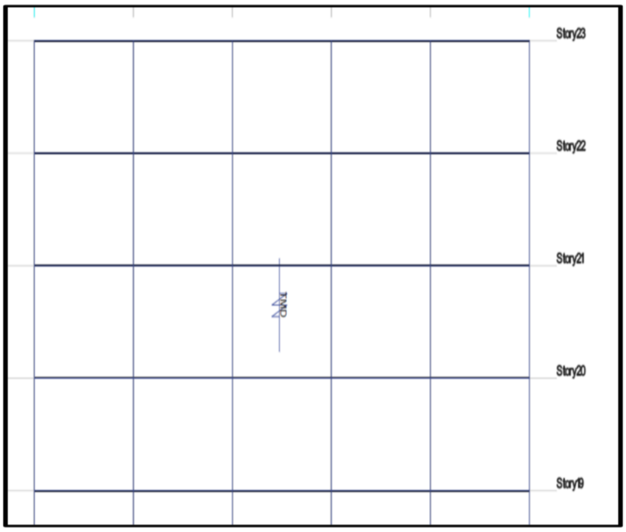


Fig. 5 View of the Structure with TMD

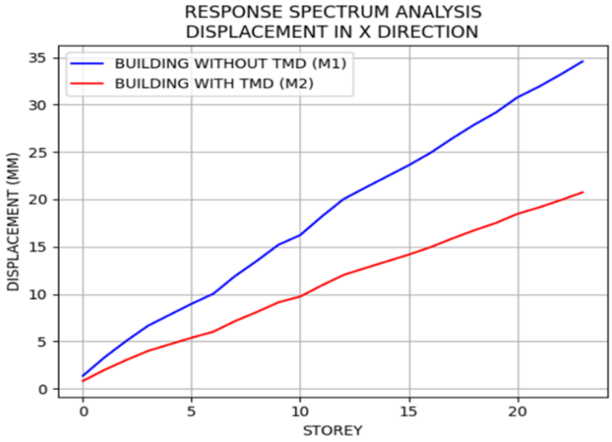
Table No-1 Load Consideration and Combinations

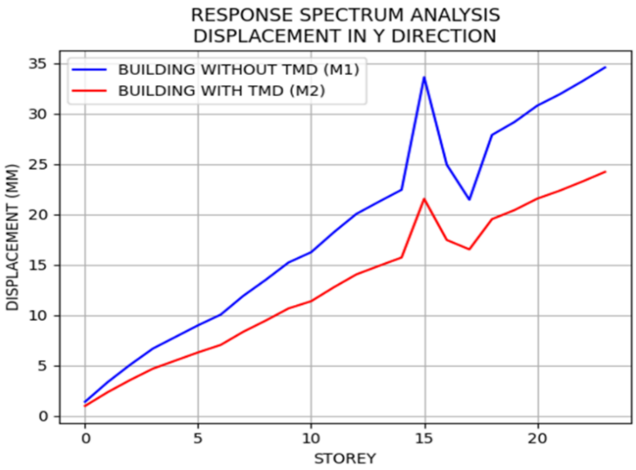
Dead Load	Self-Weight
Floor Finish Load	2 KN/m2
Wall Load	12 KN/m3
Live Load	3 KN/m2
Seismic Zone	IV
Importance Factor	1
Reduction Factor	5
Damping Ratio	5%
Zone factor	0.24
Beam	300x600mm
Column	300x600mm
Slab Thickness	140mm
Wall Thickness	150mm
Concrete grade	M25
Steel grade	Fe-450

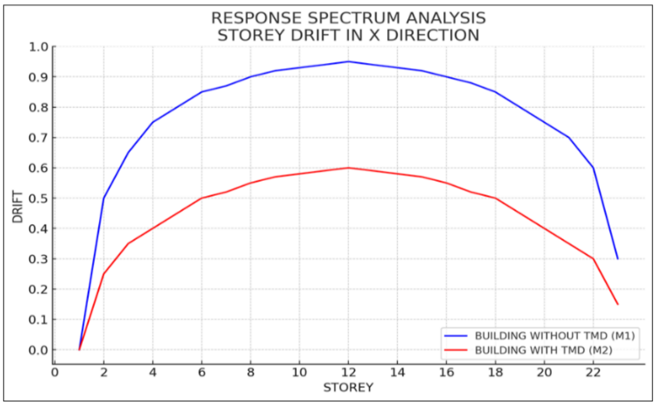
A. Geometrical Parameters of the Tuned Mass Damper are as Follow

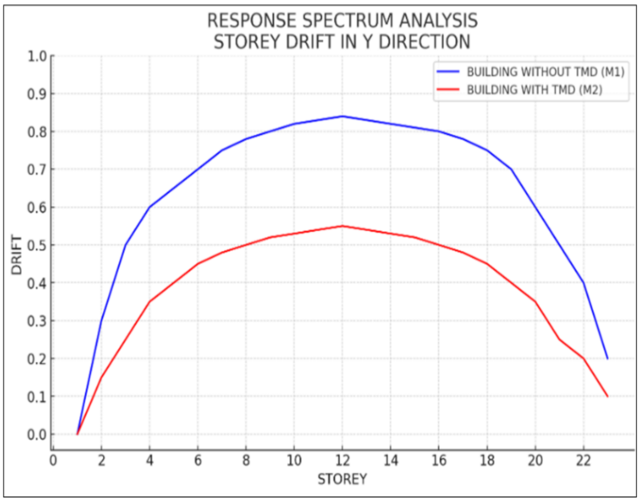
Assume mass ratio	5%
mass of damper	25KN
freqency of damper	12 red/sec
stiffness of damper	14467985.85N/m
Optimum damping ratio	0.12
values of damping	46088.58Ns2m.

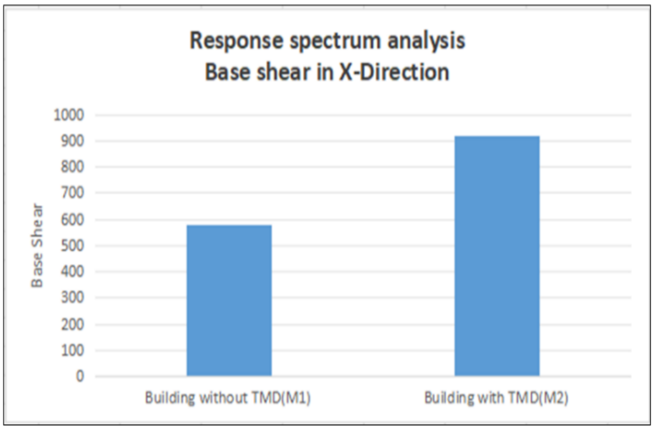
V. RESULTS

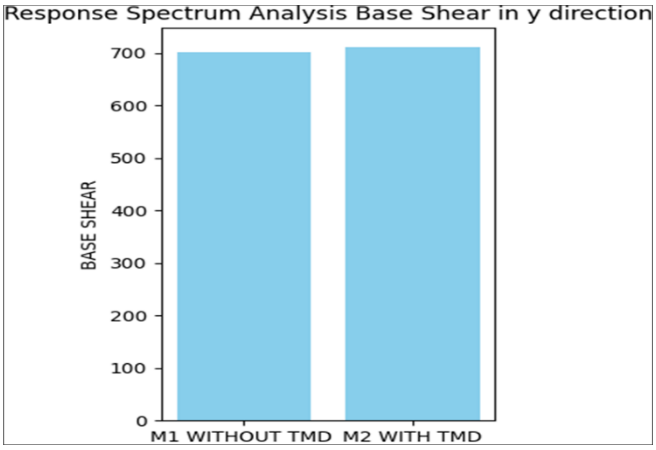












VI. DISCUSSIONS

i. The top storey's maximum displacement has been reduced by 35.81% in the X direction and 38.23% in the Y direction.

ii. The top storey's Maximum Storey Drift was reduced by 36.84% in the Y direction and 36.40% in the X direction.

iii. The top storey's maximum Base Shear has been reduced by 36.95% in the X direction and 0.25% Increased in the Y direction

VII. CONCLUSIONS

Tuned Mass Dampers (TMDs) are effective in mitigating vibrations in structures, which can improve seismic performance by reducing dynamic reactions such as story drift, Displacement. TMDs help support structures during seismic events by absorbing and dissipating energy, reducing lateral movement between levels and so protecting finishes like sliding windows. However, the influence of TMDs on absolute displacement reduction varies greatly depending on factors such as building height, mass distribution, and seismic force intensity. While TMDs can minimize accelerations and peak forces, they do not negate the importance of overall structural ductility in earthquake-resistant design. Furthermore, their installation can occasionally change the distribution of forces within the structure, potentially influencing factors such as base shear. Therefore, whereas TMDs are useful tools in Seismic engineering, including its effectiveness and special benefits, should be carefully assessed in light of each building's unique characteristics and seismic environment.

DECLARATION STATEMENT

After aggregating input from all authors, I must verify the accuracy of the following information as the article's author.

- **Conflicts of Interest/ Competing Interests:** Based on my understanding, this article has no conflicts of interest.
- **Funding Support:** This article has not been sponsored or funded by any organization or agency. The independence of this research is a crucial factor in affirming its impartiality, as it has been conducted without any external sway.

- **Ethical Approval and Consent to Participate:** The data provided in this article is exempt from the requirement for ethical approval or participant consent.
- **Data Access Statement and Material Availability:** The adequate resources of this article are publicly accessible.
- **Authors Contributions:** The authorship of this article is contributed equally to all participating individuals.

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