Archives available at journals.mriindia.com

International Journal of Advanced Scientific Research and Engineering Trends

ISSN: 2456-0774

Volume 10 Issue 01, 2026

A Review on a Comparative Study of Multi-Storey Building with or Without Using Active Tuned Mass Dampers

[1]Amruta Manojkumar Desai,[2]N. P. Phadatare,[3]N. S. Bembade
[1,2,3]Dept. of Civil Engineering, Padmabhooshan Vasantraodada Patil Institute of Technology, Budhgaon, Tal-Miraj
[1]amrutadesai2021@gmail.com, [2]ernawnathphadtare@gmail.com, [3]nikhilbembade@gmail.com

Peer Review Information

Submission: 21 Dec 2025
Revision: 05 Jan 2026
Acceptance: 18 Jan 2026

Keywords

Active Tuned Mass Dampers, Dynamic analysis, Wind Load, ETABS.

Abstract

In recent decades, urban development has led to the construction of increasingly taller and more flexible multi-storey buildings. With increasing height, buildings become more susceptible to dynamic forces such as earthquakes, wind gusts, and human-induced vibrations, which may cause excessive lateral displacement, discomfort to occupants, and structural damage. To mitigate these dynamic effects, vibration control devices are widely used. Among these, Active Tuned Mass Dampers (ATMD) are advanced systems capable of adjusting their parameters in real time through sensors, controllers, and actuators, unlike passive systems that remain fixed. ATMDs significantly enhance the seismic and wind performance of tall buildings by reducing their dynamic response. This research focuses on the comparative dynamic behavior of a G+25 multi-storey building with and without ATMD positioned at different levels of the structure.

Introduction

In recent years, the fast growth of cities and the increasing number of people have caused a big rise in the building of tall and multi-story structures. Because there is less land available in big cities, engineers and architects have turned to building upwards as a way to meet the growing needs for housing, offices, and public spaces. As buildings get taller, their structure becomes more flexible and more affected by forces like earthquakes, wind, and other natural movements. These forces create shaking and sideways movement in buildings, which can lead to too much movement between floors, damage to the structure, and discomfort for the people inside.

Tall and multi-story buildings are especially at risk from forces like those from earthquakes and strong winds. During an earthquake, the ground moves, which makes the building move sideways and shake. Similarly, strong winds can cause swaying in tall and narrow buildings. If these movements are not controlled, they can cause the structure to become unstable, cracks in the building parts, problems with how well the building functions, and even complete collapse in very serious situations. So, making sure buildings can resist these sideways forces and reduce shaking is a key goal in designing modern high-rise structures.

History

In recent years, ATMD technology has been successfully used in several famous tall buildings around the world to manage vibrations caused by wind and earthquakes. These systems help improve the safety of the structure, reduce sideways movement, limit the amount of movement between floors, and make the building more comfortable for people inside. Even though these systems have proven their effectiveness, their use in India is still limited, and there is not much research focused on how well they perform under India's specific earthquake conditions. Another key factor in ATMD design is where exactly the damper is placed within the structure. The position of the ATMD plays a big role in how well it controls vibrations. Although ATMDs are often placed at the top of buildings where the most movement happens, some studies suggest that putting them at mid-levels can also be effective, depending on the structure's layout and the type of forces acting on it. So, finding the best spot for an ATMD in a multi-story building remains an important research challenge. This study compares the performance of a G+25 reinforced concrete multi-story building with and without an Active Tuned Mass Damper. The goal is to see how the building responds to earthquake forces and to assess how effective the ATMD is in reducing important measures like floor displacement, floor drift, and base shear.

The study also looks into how placing the ATMD in different parts of the building affects its ability to control vibrations, aiming to find the most efficient location. The analysis is done using structural software to model the building under earthquake conditions as per current design standards. By comparing the results from the models with and without the ATMD, this research aims to better understand the advantages of active vibration control systems in high-rise buildings. The results may help create safer and more efficient design strategies for tall buildings, especially in areas that are prone to earthquakes.

State Of Development

The literature review gives a summary of past research on how multi-story buildings behave when exposed to dynamic forces like earthquakes and wind. Many scholars have looked into different methods to control vibrations and enhance the safety and performance of high-rise structures. Among these methods, Tuned Mass Dampers (TMD) and Active Tuned Mass Dampers (ATMD) are commonly used to minimize building vibrations and sideways movement. A variety of analytical and numerical studies have been done to assess how effective these damping systems are in managing story drift, displacement, and acceleration in buildings.

1. Jian Zhou & Qiu-Sheng Li (2025)

The author found that the dynamic performance of a 600 m high skyscraper equipped with an Active Tuned Mass Damper (ATMD) was studied under a 7.4 magnitude long-distance earthquake. Time history records and time–frequency characteristics of measured acceleration responses were analyzed to understand the structural behavior during seismic excitation. Time-varying modal parameters such as modal frequencies and damping ratios were identified using the SSI-COV method, and their relationship with response amplitudes was examined. The results showed that the ATMD system effectively suppressed structural vibrations, demonstrating its importance in seismic vibration control of super-tall buildings.

2. Zhaowei Shen , Xiaohong Sun (2025).

The author conducted a comparative study on inertial mass dampers (IMD) and negative stiffness dampers (NSD) for controlling multi-mode vibrations of stay cables in bridges. Mechanical models of both dampers were developed and numerical analysis was performed using the finite difference method. The study evaluated different optimization strategies and examined the effectiveness of both devices under harmonic, white noise, and wind-induced vibrations. The results showed that NSD significantly improves damping ratios for multiple vibration modes and provides better control of cable vibrations, whereas IMD performs effectively only within a limited inertia coefficient range.

3. Shaodong Jiang , Ruisheng M. (2025)

The author compared the vibration control performance of tuned mass dampers enhanced with inerter (TMDI) and negative stiffness devices (TMDNS). Analytical models of a single-degree-of-freedom system were developed and an Equal-Peak Dynamic Amplification Factor optimization method was used to determine optimal parameters. The study evaluated control efficiency, robustness, and seismic performance under steady-state and natural earthquake records. The results indicated that both TMDI and TMDNS significantly improve vibration control and reduce the mass requirement compared to traditional TMDs. However, TMDI showed slightly better seismic performance and control effectiveness, while TMDNS demonstrated greater robustness against detuning effects.

4. Ke Tan, Yiming Xie, Fuchao Cao, (2024)

The study examined the performance of a Tuned Mass Damper (TMD) in controlling the dynamic response of high-rise structures under wind excitation. Motion equations of the structure with a TMD system were developed, and vibration mitigation was evaluated based on the reduction in amplitude of stochastic response processes. The influence of mass ratio, frequency ratio, and damping ratio was also considered to determine optimal TMD parameters. The results showed that the optimized TMD system significantly reduced structural response amplitudes under wind loads, demonstrating good adaptability and reliability compared to uncontrolled structures.

5. Morteza Akbari , Mohammad Seifi (2024)
The author investigated seismic response control of a 10-storey building using a combination of a base isolation (BI) system and a passive friction-tuned mass damper (PFTMD). The structural model was analysed under near-field and far-field earthquakes, and system parameters were optimized using the multi-objective particle swarm optimization (MOPSO) method. A PID controller was also introduced to develop a BI-active FTMD (BI-AFTMD) hybrid control system. The results showed that the proposed control systems significantly reduced peak displacement, acceleration, and inter-storey drift compared to an uncontrolled structure. Among the systems, BI-AFTMD achieved the highest reduction in displacement, while the BI system provided the best improvement in acceleration and drift control.

6. Danish Hussain, Ashish Shukla (2024)
The author investigated the effectiveness of fluid viscous dampers in reducing the seismic response of symmetrical and unsymmetrical G+9 buildings. The structural models were developed and analysed using ETABS 2017 considering equivalent static, response spectrum, and nonlinear time history analysis based on IS 1893:2016 for seismic Zone IV and medium soil conditions. The study examined the influence and placement of dampers by comparing structural responses with and without dampers. Key parameters such as storey displacement, storey shear, storey drift, and natural time period were evaluated to assess performance. The results showed that the incorporation of fluid viscous dampers effectively reduces structural vibrations and improves the seismic behaviour of both symmetrical and unsymmetrical buildings.

7. Ging-Long Lin et. al. (2024)
The author investigated the effectiveness of a friction-type multiple tuned mass damper (FT-MTMD) system for reducing the seismic response of high-rise buildings. The system consisted of several TMD units arranged in parallel to provide a wider frequency bandwidth compared to a conventional TMD. A prototype FT-MTMD was designed and installed on a scaled structural model representing a 36-storey building, and its performance was evaluated through shaking table tests. An optimal design method was used to determine the system parameters considering frictional nonlinearity. The results showed that the FT-MTMD system effectively reduces seismic vibrations and improves structural performance, while the proposed design method accurately predicts the system response and ensures reliable vibration control.

8. Ke Tan, Yiming Xie, Fuchao Cao (2024)
The author found that the motion equations of a high-rise building with a Tuned Mass Damper (TMD) under wind excitation were developed by considering both controlled and uncontrolled conditions. Vibration reduction coefficients were determined based on the amplitude of stochastic responses. Numerical analysis of a 33-storey building model was carried out to obtain optimal frequency and damping ratios of the TMD system. The results showed that an optimized TMD effectively reduces structural vibrations under wind loads, and the influence of mass ratio further improves the reliability of the vibration control method.

9. Hashim Ataie & Taiki Saito (2023)
The study examined the effectiveness of Tuned Mass Dampers (TMDs) for buildings that exhibit non-linear behavior under dynamic loads. A pushover analysis was performed to obtain the capacity curve, which was idealized into a trilinear model representing linear and non-linear response ranges. Based on the time periods of these segments, three Single TMD (STMD) cases and one Multiple TMD (MTMD) case were analyzed for 7-storey and 25-storey reinforced concrete buildings using non-linear dynamic analysis. The results showed that STMDs tuned to the non-linear segments performed better than those tuned to the fundamental period, while the MTMD system provided the best vibration control, reducing maximum displacement and peak acceleration under both earthquake and wind loads.

10.Kang Zhou , Jun-Wei Zhang (2022)
The author found that the Active Tuned Mass Damper (ATMD) installed in a 600 m tall skyscraper significantly improves vibration control performance. Results from forced vibration tests showed that the ATMD system increased the damping ratio of the fundamental sway modes by nearly 11 times. Further ambient vibration measurements during Super Typhoon Hato indicated that the system effectively reduced wind-induced vibrations,

mainly controlling the fundamental modes while having limited influence on higher modes. The study highlights the importance of ATMD systems in improving wind resistance of super-tall buildings.

11.Kang Zhou, Qiu-Sheng Li (2022)
The study investigated the vibration mitigation performance of a super high-rise building equipped with an Active Tuned Mass Damper (ATMD) using field measurements recorded during seven tropical storms. The acceleration responses showed that the ATMD system activated properly and effectively reduced the acceleration of the fundamental sway modes, while having limited effect on higher modes. The results also indicated that the damping ratio increased from about 0.6% to nearly 2–7% due to the ATMD system. The findings highlight the importance of ATMD in controlling wind-induced vibrations in super-tall buildings and provide guidance for designing vibration control systems.

Problem Statement
In this study, the building structure is designed to account for Active Tuned Mass Dampers. The building plan measures 30 meters by 30 meters and consists of 25 stories, each with a height of 3.0 meters in seismic zone III.

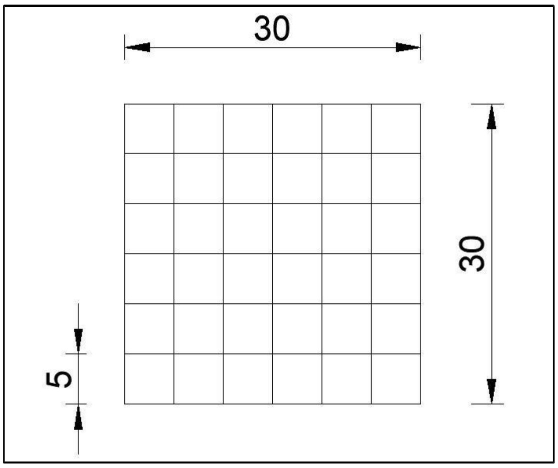

Fig 1: Plan dimensions

Design of ATMD Mass
The mass of the Active Tuned Mass Damper (ATMD) is one of the most important parameters in the vibration control system. The effectiveness of the ATMD depends on the mass ratio, which is defined as the ratio of the damper mass to the total mass of the structure. Generally, the damper mass is selected between 1% to 5% of the total structural mass to achieve effective vibration control.
The mass ratio is calculated using the following expression $\mu = md / M$
Where:
μ = Mass ratio
Mass of tuned mass damper M = Total mass of the structure
The total mass of the building is calculated from the dead load components including the self-weight of beams, columns, slabs, and other permanent loads. After estimating the total structural mass.

1. Slab Self Weight
Thickness of slab = **150 mm = 0.15 m** Density of reinforced concrete = **25 kN/m³**
Slab load per m²:
= 0.15 × 25
= 3.75 kN/m²
Area of one floor = **900 m²**
Total slab weight per floor:
= 3.75 × 900
= 3,375 kN

2. Floor Finish Load
Floor finish = **1.5 kN/m²**
= 1.5 × 900
= 1,350 kN

3. Live Load Contribution
Live load = **3 kN/m²**
For seismic weight, **25% of live load** is considered (as per IS 1893).
0.25 × 3 = 0.75 kN/m²
0.75 × 900 **= 675 kN**

4. Wall Load
Wall load = **5 kN/m²**
= 5 × 900
= 4,500 kN

5. Total Load per Floor
= 3375 + 1350 + 675 + 4500
= 9,900 kN
Total Load of Building
Number of storeys = **25**
Total structural load = 9900 × 25
= 2, 47,500 kN
Mass ratio:
μ = 3%
md = μ × M
md = 0.03 × 2,47,500
= 7425 kN
In ETABS, U1, U2, and U3 stiffness represent the translational stiffness of the link or damper in the three global directions:

- U1 → stiffness in X-direction
- U2 → stiffness in Y-direction
- U3 → stiffness in Z-direction (vertical)

For a Tuned Mass Damper in buildings,

vibration control is mainly required in horizontal directions (X and Y), so stiffness is calculated for U1 and U2, while U3 is kept very large (or fixed) to avoid vertical movement.

Finding

From looking at past research on vibration control in multi-story buildings, it is clear that many researchers have looked into using Tuned Mass Dampers (TMD) to reduce vibrations caused by dynamic forces such as earthquakes and wind. A lot of studies have focused on how passive TMD systems work to control things like side movement, floor drift, and acceleration in tall buildings. However, not much research has been done on the detailed analysis of Active Tuned Mass Dampers (ATMD) in reinforced concrete multi-story buildings.

Especially, there isn't much work evaluating how well ATMD systems perform at different heights within a building. Where you place an ATMD can greatly affect how well it controls vibrations, but there aren't many studies comparing the effects of installing ATMD at different floors. Many studies focus on theory or general vibration control, but fewer actually build detailed models of high-rise buildings using software like ETABS based on the Bureau of Indian Standards (BIS) codes. So, there is a need to study how a multi-story building behaves with and without ATMD, and to assess the impact of placing ATMD at different levels of the structure. The current study aims to analyze a G+25 RCC building using ETABS, install ATMD at various floor levels (7th, 13th, and roof), and compare the building's response to vibrations. This will help in understanding how effective ATMD systems are in improving the performance of multi-story buildings under dynamic loading conditions.

References

Jian Zhou & Qiu-Sheng Li "Dynamic analysis of 600-m-high skyscraper with active tuned mass damper system under 7.4 magnitude long-distance earthquake excitation" Journal of Building Engineering, 2025.

Zhaowei Shen , Xiaohong Sun "A Comparative Study of Inertial Mass Dampers and Negative Stiffness Dampers for the Multi-Mode Vibration Control of Stay Cables" MDPI, Buildings, (2025).

Shaodong Jiang , Ruisheng M. "On performance comparison of tuned mass dampers (TMD) enhanced with inerter and negative stiffness device" Engineering Structures, Volume 343, Part C, (2025)

Ke Tan, Yiming Xie, Fuchao Cao, Yiping Wang & Yinfeng Dong "Optimal parameters of tuned mass damper for the reduction of wind-induced vibration of high-rise buildings" Vibro engineering Procedia, 2024.

Morteza Akbari , Mohammad Seifi "Comparative analysis of seismic response reduction in multi-storey buildings equipped with base isolation and passive/active friction-tuned mass dampers" Advances in Engineering Software, Volume 198, (2024)

Danish Hussain, Ashish Shukla "Seismic Parametric Analysis of RC Multi-Storied Buildings with and Without Fluid Viscous Dampers" Web of Conferences Vol. 529, Issue 01017, (2024)

Ging-Long Lin et. al. "Experimental verification of seismic vibration control of high-rise buildings with friction-type multiple tuned mass dampers" Engineering Structures, Volume 302, (2024)

Ke Tan, Yiming Xie, Fuchao Cao "Optimal parameters of tuned mass damper for vibration control of high-rise structures under wind loads" Extrica, Dec. 2024

Hashim Ataie & Taiki Saito "Dynamic vibration control of non-linear buildings using multiple tuned mass dampers" Building Engineering, 1(1), 2023

Kang Zhou , Jun-Wei Zhang "Control performance of

active tuned mass damper for mitigating wind-induced vibrations of a 600-m-tall skyscraper" Journal of Building Engineering, 45 (2022)

Kang Zhou, Qiu-Sheng Li "Vibration mitigation performance of active tuned mass damper in a super high-rise building during multiple tropical storms" Engineering Structures, 269 (2022)

Haoshuai Qiao "Structural control of high-rise buildings subjected to multi-hazard excitations using inerter-based vibration absorbers" Engineering Structures, Volume 266, (2022)

Komal Rajana et. al. "Optimal design and assessment of tuned mass damper inerter with nonlinear viscous damper in seismically excited multi-storey buildings" Bulletin of Earthquake Engineering (2023)

Mariyala Vaishnavi et. al. "Seismic analysis of high-rise building with tuned mass damper and core column" Web of Conferences, Volume 391, Issue 01199, (2023)

Ayman Abd Elhamed et. al. "Analytical Solution of Seismic Responses of Multi Storey Building Structures Controlled by Tuned Mass Damper Inerter" Engineered Science, (2023)

Daniel Caicedo, Luis Lara-Valencia "Seismic response of high-rise buildings through metaheuristic-based optimization using tuned mass dampers and tuned mass dampers inerter" Journal of Building Engineering, 34 (2021)

Bibiana Bertolin Rossato & Letícia Fleck Fadel Miguel "Robust optimum design of tuned mass dampers for high-rise buildings subject to wind-induced vibration" Nonlinear Analysis: Real World Applications, 60 (2021)

Abdalsaheb Ebrahimi "Increase the effectiveness of AMTMDs and PMTMDs on the seismic behaviour of structures case study: Ten-stories short period concrete building" Engineering Structures, Volume 237, (2021)

Ali Kaveh et. al. "A Comparative Study of the Optimum Tuned Mass Damper for High-rise Structures Considering Soil-structure Interaction" Periodica Polytechnica Civil Engineering, Vol. 65(4), pp. 1036–1049, (2021)

Fatemeh Rahimi, Reza Aghayari & Bijan Samali "Application of Tuned Mass Dampers for Structural Vibration Control: A State-of-the-art Review" Civil Engineering Journal, Vol. 6 No. 8, 2020

L. Suresh & K. M. Mini "Effect of Multiple Tuned Mass Dampers for Vibration Control in High-Rise Buildings" Practice Periodical on Structural Design and Construction, 24(4), 2019

Nimmy Lancelot and Vivek Philip, "Effectiveness of Spring Mass Dampers in Articulated Platform Supporting Offshore Wind Turbine" International Journal of Research in IT, Management and

Engineering, (2016)

Rutuja S. Meshram, S N. Khante, "Effectiveness of Water Tank as Passive TMD for RCC Buildings" International Journal of Engineering Research, (2016)

Mr. Ashish A. Mohite, Prof. G.R. Patil, "Earthquake Analysis of Tall Building with Tuned Mass Damper" IOSR Journal of Mechanical and Civil Engineering, (2015)

Jitaditya Mondal, Harsha Nimmala, Shameel Abdulla, Reza Tafreshi , "Tuned Liquid Damper" Proceedings of the 3rd International Conference on Mechanical Engineering and Mechatronic , Prague, Czech Republic s,Paper No. 68,August 14-15, 2014.