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A COMPARATIVE ANALYSIS OF DIFFERENT TYPES OF DAMPERS UTILIZED IN HIGH RISE BUILDINGS

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ABSTRACT

Dampers are important for resisting lateral forces on structures, helping to reduce movement in tall buildings during earthquakes. They decrease the chance of damage to columns and beams, making buildings stiffer. The research focuses on a G+10 storey building and compares different dampers for multi-storey buildings. It uses AI programming in Python to evaluate damper performance based on factors like building mass, seismic load, and displacement. The findings show that AI can help identify the best dampers, improving safety and analysis efficiency. The study highlights the role of dampers in enhancing the stability and safety of multi-storey buildings during seismic events.

Keywords: Tuned Mass Dampers, Tuned Sloshing Dampers, Viscous Dampers, Base Isolation Dampers, Tuned liquid Dampers

1. INTRODUCTION

In basic terms, an earthquake is the shaking and movement of the earth's surface caused by underground shifts along a fault line. The shaking is due to seismic waves, which are the most dangerous. However, it's challenging to equip modern tall buildings and structures with these methods, putting their safety and functionality at risk as they get taller. According to standard guidelines, a building that can withstand the strongest earthquake expected in its area is considered earthquake-resistant. The most effective strategy for designing earthquake-resistant buildings is to reduce the number of casualties and the extent of damage to the building's functionality. The unpredictability of when and where earthquakes will strike is one of their most significant challenges to both the economy and the safety of buildings. Historical records and recent events show that the world has seen numerous devastating earthquakes, leading to increased loss of life from building collapses and extensive damage. This has highlighted the need for buildings and structures, including residential homes, public facilities, historical landmarks, and industrial sites, to be designed to withstand seismic forces. The use of seismic response control devices in structural design is now widely recognized and applied in the field of civil engineering. The concept of structural control has been successfully turned into practical technology, with these devices being installed in buildings.

The Various types of damper are summarized below

A. Tuned Mass Dampers

Tuned Mass Dampers (TMDs) are employed to introduce tuned damping into a variety of structures, thereby mitigating their resonant vibrations. A Tuned Mass Damper (TMD) is defined as a vibrating mass that oscillates out of phase with the external perturbing force, thereby counteracting the vibration induced in the structure upon which the TMD is installed.

B. Tuned Sloshing Dampers

A substantial, water-filled container positioned adjacent to the rooftop of a high-rise structure can enhance the performance of a building during periods of strong winds. The elegance of a sloshing damper lies in its simplicity. This is achieved through the utilization of a waterproof concrete box, which houses a sequence of PVC and steel slats. The natural oscillation of water within the container is carefully adjusted to mitigate the building's oscillations.

C. Viscous Dampers

Damping devices are often referred to as viscous damping. Usually, they do this by applying a torque or force that opposes motion in a velocity-proportional manner. Magnetic structure motion or fluid movement may have an impact on this. Enhancement of the damping ratio is the desired outcome. Seismic dampers, or viscous dampers, are hydraulic devices that lessen the force of an earthquake and reduce vibrations between buildings.

D. Base Isolation Dampers

A seismic damper absorbs energy as the structure moves, but a base isolator primarily offers a means of preventing a structure from needing to move and follow the ground when the ground shakes during an earthquake. Isolating the base reduces the movement of the building caused by earthquakes. In the design that is earthquake-resistant, base isolation is often employed. By adding a flexible or sliding interface, this passive control technology essentially decouples the structure from the motion of the ground.

E. Tuned liquid Dampers

A Tuned Liquid Damper (TMD) substitutes a liquid, generally water, for the mass. A unique kind of TLD known as Tuned Liquid Column Dampers (TLCDs) uses the motion of a liquid column inside a container like a U to offset the stresses exerted on the structure. A tuned liquid damper is a device that employs confined water and the sloshing energy of the water to lessen the dynamic response of the system when it is excited. It is often installed on top of a structure.

2. OBJECTIVE OF PRESENT STUDY

A. The objective is to analyze the seismic performance of a chosen G+10 reinforced concrete building utilizing different types of dampers, employing Python integrated with artificial intelligence.

B. The analysis will involve comparing several parameters, including building mass, frequency, sway frequency, wind load, seismic load, correlation heat map, displacement.

C. The goal is to identify the most effective type of damper that enhances earthquake resistance for the selected structure.

3. PROBLEM STATEMENT

Table 1: Problem statement for analysis

Structural Details	Remark
Building Height in Meter	30
Building Mass in Tons	11000
Sway Frequency in Hertz	02
Wind Load in Newton/Square Meter	38
Seismic Load - Newton	12000 (12 KN/SQ.M)

4. RESULT AND DISCUSSIONS

Table 2: Analysis of Dampers

Tuned Mass Dampers	
Mass of TMD (M) - Tons	142.58
Spring Constant (K) - Newton/Meter	193911.78
Damping Coefficient (C) -Newton-Second / Meter	22835.81
Natural Frequency (ω) - Hz	1.04
Displacement (x) - Several Centimeters to Meters - Depends on the required damping capacity.	1.85
Damping Ratio (ζ)	0.03
Tuning Ratio (TR)	1.03
Tuned Sloshing Dampers	

Liquid Volume in TSD - Gallons	24305.58
Baffle Systems	Internal baffles to control sloshing motion - Baffles are used to reduce sloshing and improve damping efficiency.
Sloshing Frequency - Hz	Tuned to match building sway frequency - Sloshing frequency is adjusted based on building dynamics
Building Displacement (x) - Several Centimeters to Meters Depends on the required damping capacity.	1.44
Damping Characteristics	Influenced by liquid properties and baffles -The effectiveness of damping depends on liquid properties and baffles
Viscous Dampers	
Viscous Damper Damping Coefficient (C) - Newton Second/Meter	99819.89
Viscous Damper Design	Various designs using hydraulic or viscous fluid - The specific design of the viscous damper may vary.
Displacement (x) - Several Centimeters to Meters - Depends on the required damping capacity.	0.62
Base Isolation Dampers	
Base Isolation System	Elastomeric bearings, sliding bearings, or hybrid systems -The type of base isolation system used may vary.
Natural Period of Base Isolation (T) Second	1.83
Tuned liquid Dampers	
Liquid Volume in TLD (V) - Gallons	57235.91
Baffle Systems	Internal baffles or sloshing suppressors- Baffles are used to control the motion of the liquid and enhance damping efficiency
Sloshing Frequency - Hz	Tuned to match building sway frequency -The sloshing frequency is adjusted based on building dynamics.
Displacement (x) - Several Centimeters to Meters - Depends on the required damping capacity.	0.7

The analysis of the table indicates that Tuned Mass Dampers are the most suitable option for the specified model. It is recommended to incorporate Baffle Systems alongside the Tuned Sloshing and Liquid Dampers, while the Sloshing Frequency should be modified according to the dynamics of the building. The viscous damper exhibits the lowest displacement, recorded at 0.62.

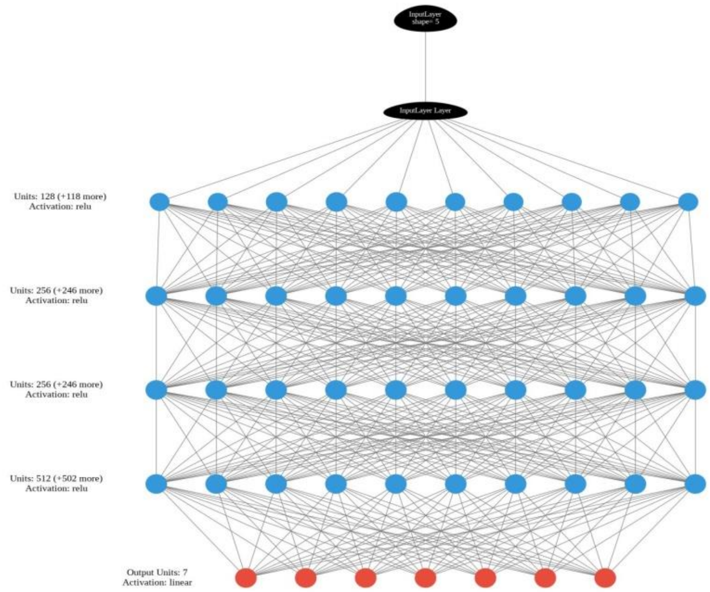

Figure No. 1, "Tuned Mass Dampers optimization diagram"

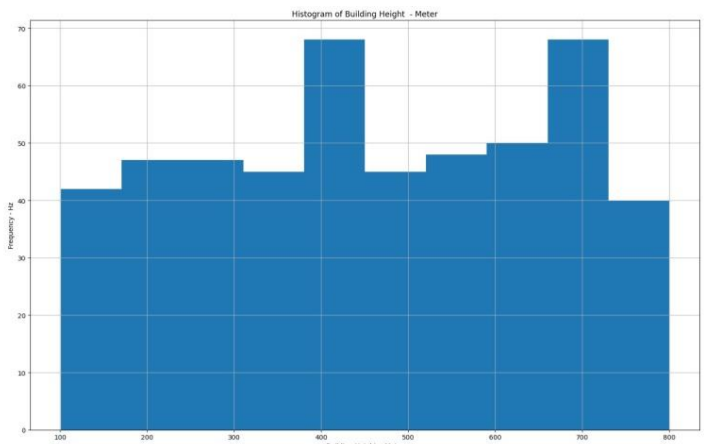

Figure No. 2, "Histogram between Building Height & Frequency"

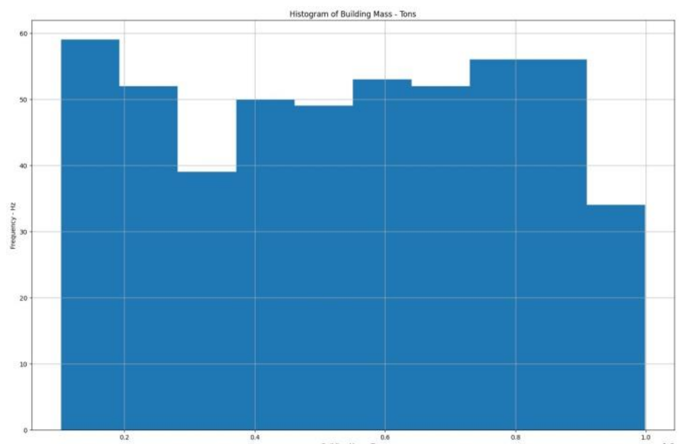

Figure No. 3, "Histogram between Building Mass & Frequency"

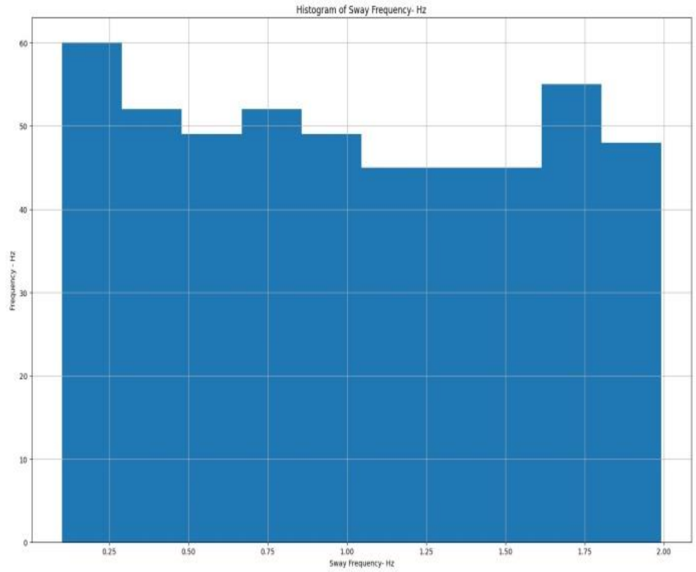

Figure No. 4, “Histogram between Sway Frequency & Frequency”

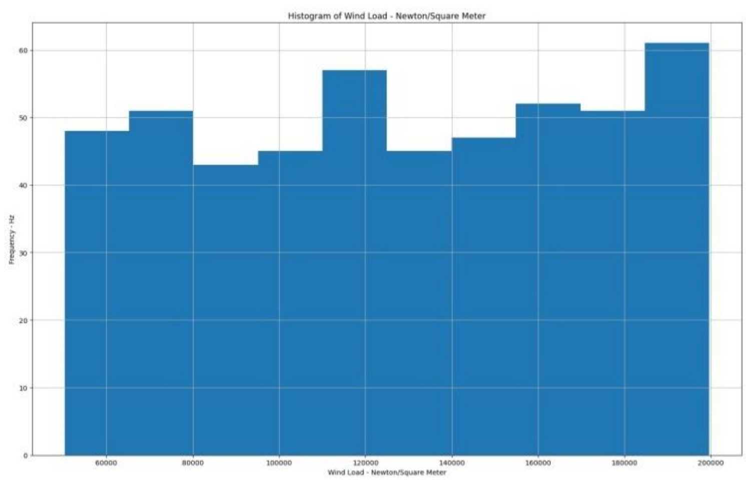

Figure No. 5, “Histogram between Wind & Frequency”

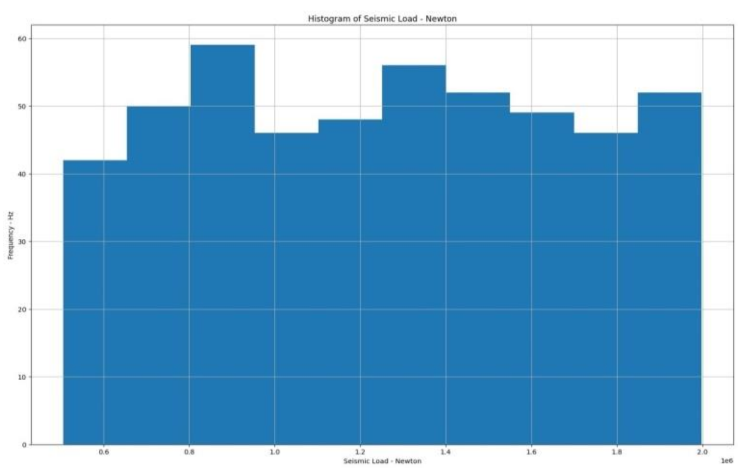

Figure No. 6, “Histogram between Seismic Load & Frequency”

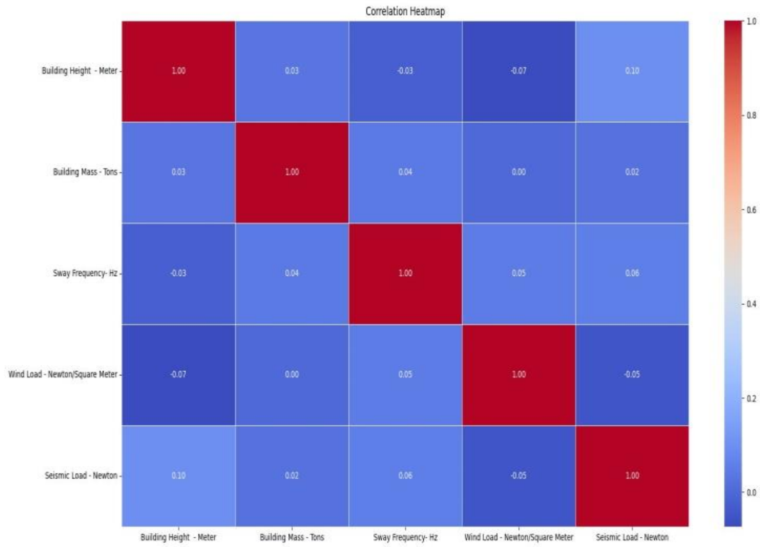

Figure No. 7, "Correlation Heatmap"

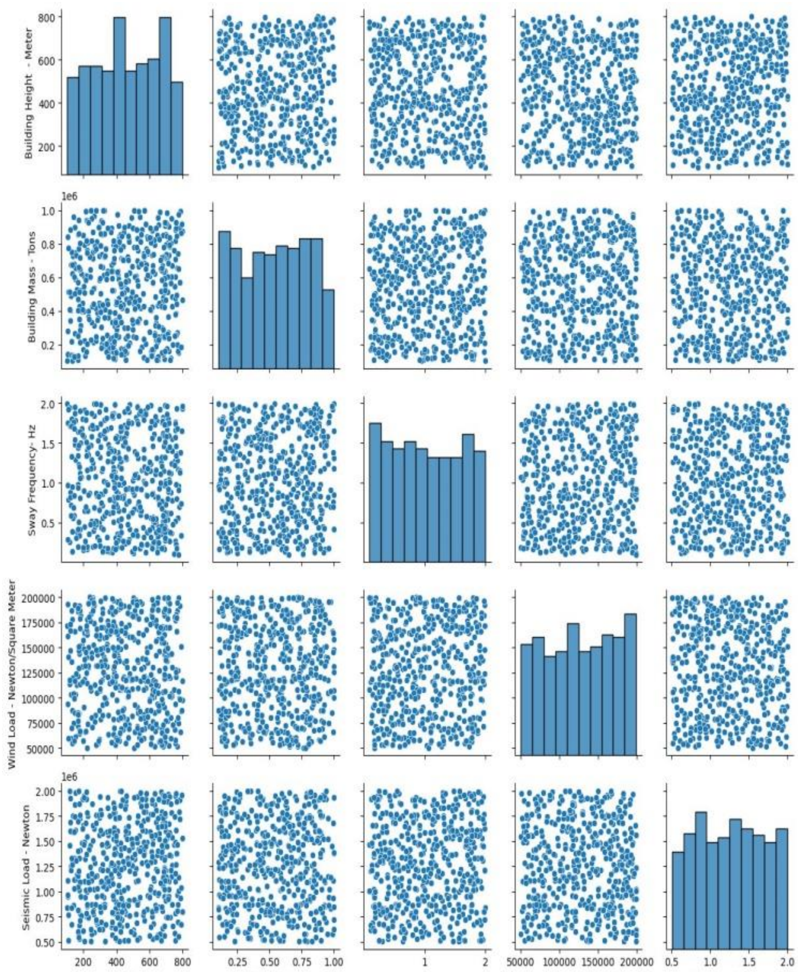

Figure No. 8, "Pair Plot"

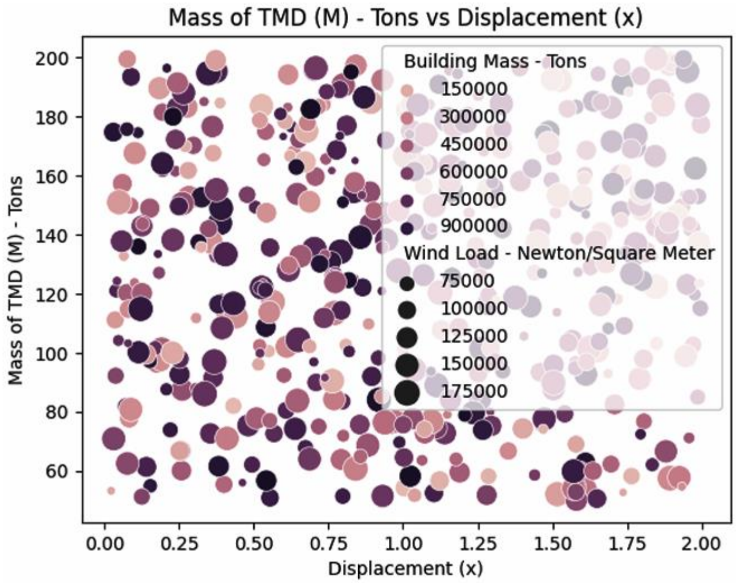

Figure No. 9, "Displacement vs Mass of TMD considering building mass & wind load"

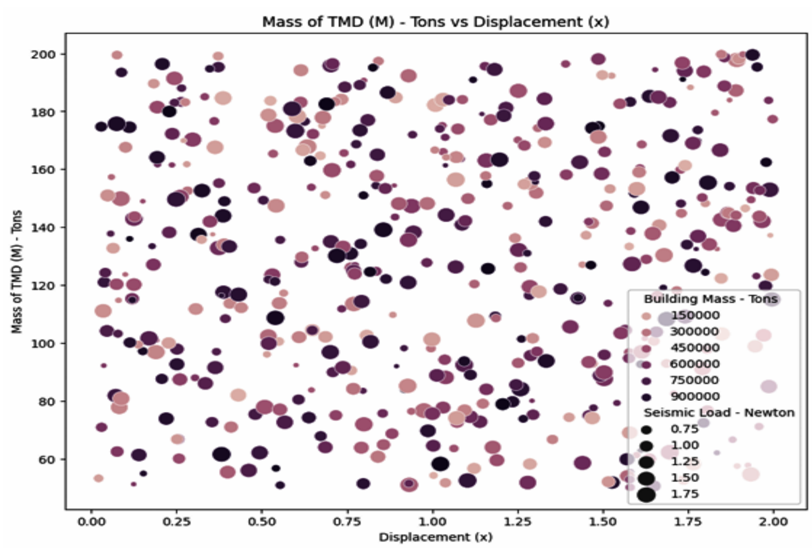

Figure No. 9, "Displacement vs Mass of TMD considering building mass & Seismic load"

CONCLUSION

A. The natural time period for the base isolation damper is 0.83 seconds.

B. The displacement (x) can range from several centimeters to meters, depending on the required damping capacity, which is measured at 1.85, 1.44, 0.62, and 0.7 for Tuned Mass Dampers, Tuned Sloshing Dampers, Viscous Dampers, and Tuned Liquid Dampers, respectively.

C. Internal baffles or sloshing suppressors are utilized to manage liquid motion and enhance damping efficiency in Tuned Liquid Dampers, while in Tuned Sloshing Dampers, baffles serve to mitigate sloshing and improve overall damping performance.

D. It can be concluded that Tuned Mass Dampers play a crucial role in minimizing and managing the seismic response of structures compared to other damper types.

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