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Study and Analysis of Earthquake Response Tuned Liquid Damper for a Multi-Story Buildings

Owais Khan[1], Jyoti Yadav[2]

[1]M.Tech Scholar, Dept. Of Civil Engineering, Sarvepalli Radhakrishnan University, Bhopal, M.P, India
[2]Assistant Professor, Dept. Of Civil Engineering, Sarvepalli Radhakrishnan University, Bhopal, M.P, India

ABSTRACT-

Damping is a phenomena in which a system's energy is steadily decreased until the system's vibrations are fully removed and the system is brought to a halt. There are many solutions available to reduce structural vibration, with the usage of a Tuned Liquid Damper (TLD) being one of the most current. TLDs are generally composed of a rigid water-filled tank. The water within the tank undergoes sloshing motion as a consequence of the building vibration and releases energy via the sloshing and wave-breaking of the liquid after it has been stimulated. The goal of this work is to see how successful TLD is in reducing seismic vibration in a two-story building frame that is exposed to horizontal excitations. In ANSYS WORKBENCH software, an analytical examination of the undamped frame was performed. The dimensions of the steel building frame were established based on the modes and frequencies derived from the analytical analysis, and the practical investigation was carried out using shaking table tests. Various aspects that determine the efficacy of TLD are also investigated.

Keywords: Dampers, Horizontal Excitation, Sloshing, Tuned Liquid Damper, Structure Vibration Control

1. INTRODUCTION

There has been a rise in the frequency of natural catastrophes such as earthquakes in recent years. Demand for high-rise structures that are more adaptable and have a low damping value has also risen as a result of urbanization and industry. As a consequence, these structures' susceptibility to dynamic excitations has risen. One of the most critical characteristics that limits the structure's responsiveness during such dynamic occurrences is damping. TLD (Tuned Liquid Damper) is a passive control device that has been used in constructions to reduce horizontal vibrations. The TLD is simply a liquid-filled tank that is firmly attached to the structure's top. It depends on the sloshing wave forming and breaking at the liquid's free surface to dissipate a part of the energy generated during the dynamic event, hence increasing the structure's equivalent damping. Liquid resonance occurs when the frequency of tank motion is near to the frequency of the tank. At resonance, the free surface of the liquid experiences a lot of sloshing and wave breaking, which releases a lot of energy. TLD has a number of benefits over other dampening systems. Low installation, maintenance, and operation costs, less mechanical difficulties due to the absence of moving components, and the ability to manage various vibration kinds of multi-degree of freedom systems The goals of this research are to minimize structural response by attaching a TLD model to a structure that is exposed to horizontal excitations and to investigate the impact of different parameters on structural response. The damper liquid depth and mass of liquid are two of the different characteristics. The paper's introduction should clarify the nature of the topic, past work, goal, and contribution. The contents of each part may be presented so that the document may be readily understood.

2. LITRATURE REVIEW

Pirner and Urushadze [7] studied a passive tuned liquid damper (TLD) that uses a moveable rectangular tank with two degrees of freedom (horizontal displacement and rotation). Determine the shaking table's excitation force during vessel resonance. Sloshing dampers diminish horizontal vibrations, as shown. Proper tank support reduces torsional vibrations. Liquid vibration absorbers can be tuned to the actual frequency of the desired vibration mode, not its theoretical value. Tanks are easier to install than ball dampers in severe box beams.

Bhattacharjee et al. [8] studied a unidirectional tuneable liquid damper (TLD) that dissipates vibration energy under harmonic excitation. TLD uses liquid to absorb seismic energy and control vibration. This effort aims to minimize structural response by attaching a TLD model to a sinusoidal energized structure and examining response parameters. To study TLD's dynamic base motionreactivity. The liquid damper reduced structural response. Square TLD manages structure less effectively. Lower stimulation frequency increases peak structural response. This study shows TLD affects structural response.

3. METHODLODY

The experimental setup consists of a rectangular steel frame with three steel slabs mounted at 600mm intervals to four rectangular steel columns. A Horizontal Shake table with an electric motor is used to put the complete building assembly. The shaking table's operating frequencies vary from 0 to 25 Hz. The motor's RPM may be changed to produce harmonic base movements at various frequencies. Table shows the structure's dimensions.Setup of an undamped structure is shown in Table 3.1 and Fig. 3.1.

Table 3.1 Symmetrical Data of the Structure

Sl.No	Parts	Dimensionsinmm		
		Depth(D)	Width(B)	Length(L)
1.	Column	5	25	600
2.	Slab	8	150	300

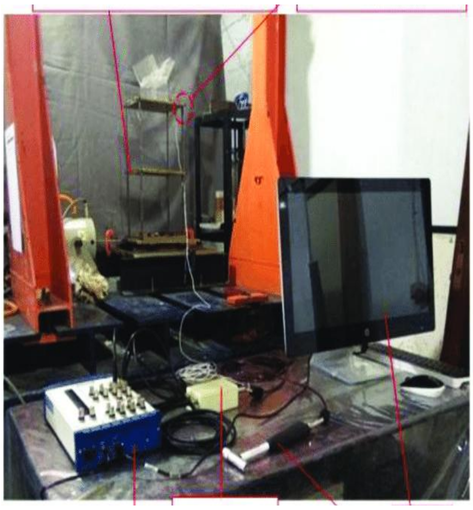

Fig. 3.1: Experimental Setup of the Structural Model Damped with TLD

4. RESULT AND DISCUSSION

The experimental study's main goal was to look at the behavior of water sloshing motion and the impacts of excitation frequencies, liquid depth, and liquid mass on the sloshing behaviour.

4.1 Seismic Excitation's Effect on an Undamped System

A shaking table experiment was used to assess the displacement response of an undamped MDOF structure when it was exposed to sinusoidal base exci tation.

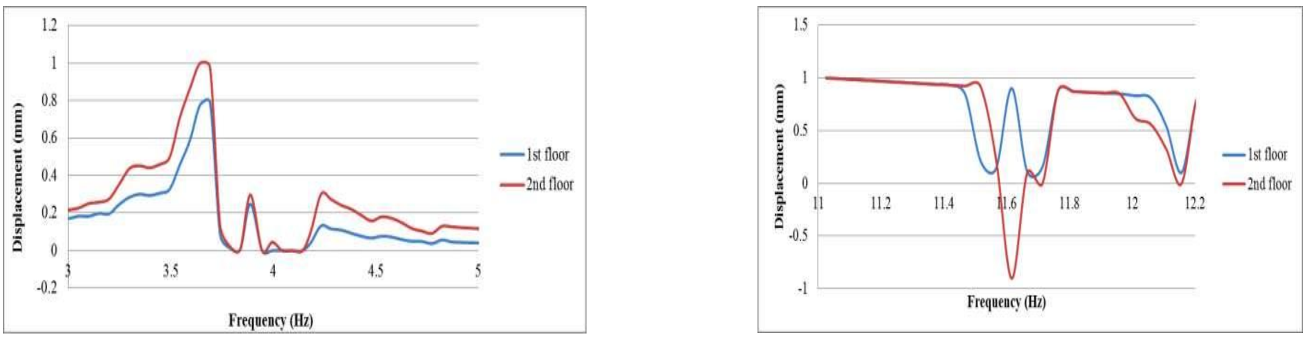

Fig. 4.1 (a) and (b): The experiment yielded the first and second mode forms

4.2 Comparison of Damped and Undamped Model Structural Response

Shake table experiments are carried out for both damped and undamped systems to better understand the impact of damping. When the main system is connected with the damper, as shown in Fig. 4.2, the effective damping of the combined system increases.

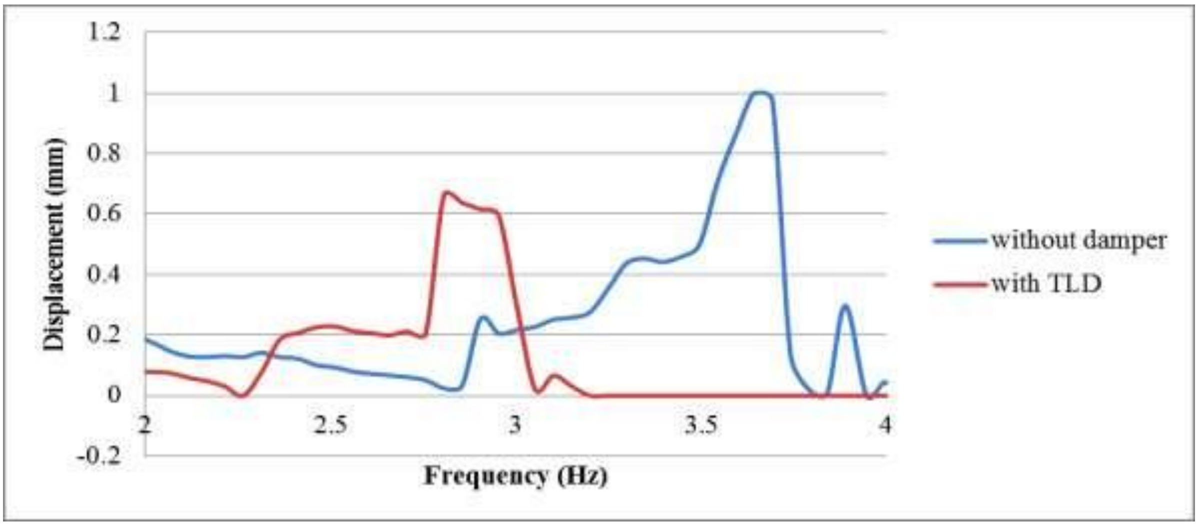

Fig. 4.2: Structural response of the Undamped System and the System Damped with TLD

5. CONCLUSION

The main goal of this thesis was to see how successful a Tuned Liquid Damper was in controlling structural vibration. Finite element modeling and analysis, as well as experimental verification, are included in the thesis. The TLD's efficiency is measured in terms of the displacement of the structure's narrative.

1. For the undamped structural model, the natural frequency derived from the finite element analysis and the experimental research show excellent agreement.
2. It was discovered that when the primary system is connected with a tuned liquid damper, the combined system's effective damping increases.
3. TLD frequencies estimated using the formula for linear water sloshing frequency correspond well with empirically measured TLD frequencies.
4. The damping effect of the TLD diminishes as the depth of liquid in the TLD grows due to liquid sloshing, and wave generation and breaking decreases since the full mass of water in the damper does not contribute to sloshing.
5. TLD has been shown to be capable of successfully regulating structural vibration.

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