Reduced Effect of Vibration by using Different Liquids in Tuned Liquid Column Damper

Ritesh Pandey[1] Sana Zafar[2]
[1,2]Madan Mohan Malaviya University of Technology, Gorakhpur

Abstract— In present era, the construction of high rise building is increasing day by day. These structures are more flexible and having low damping value. Due to low damping value the failure possibilities increases and also from the point of serviceability. The vibration induced in such type of structure due to wind or earthquake causes large trembling and due to this large deflection. Today various techniques are available to minimize the effect of vibration induced in the structure due to earthquake. Tuned liquid column damper is one of the techniques to minimize the effect of vibration induced in high rise building. A tuned liquid column damper is a special type of damping technique which prevents the vibrations acting on the high rise building due to earthquake by providing a U-tube at top of the building. This technique is based on inertia of U-tube liquid column. In this study we made a model of a structure attached with tuned liquid column damper. Initially we check the displacement of structure without damper at different frequency. Plot a graph between displacement and frequency. We place a tuned liquid column damper on the top of the structure model and filled it with water. Again we check the displacement of the structure at different frequency and plot the graph. This time the water is replaced with hair oil and the displacement is checked at different frequency and plot a graph between displacement and frequency. Lastly, the hair oil is replaced with Mobil oil and check the displacement at different frequency. Plot another graph between displacement and frequency. Compare all the above graphs and get the result. The result confirmed that the use of different oil minimizes the effect of vibration on the structure due to earthquake.

Key words: Seismic Response, Tuned Liquid Column Damper, Sloshing Energy

I. Introduction

In urban areas the area problem are increasing day by day. Now days, high rise building or other type structures are constructed to minimize such type of problem. These structures are light and relatively flexible. Due to the above reason the structure is highly vulnerable to vibration. The earthquake or other wind force generates harmful vibration that creates discomfort and failure of structures. The earthquake and wind forces crate massive forces and vibration that makes the structure highly unstable. Sometimes the structure may collapse.

Presently various techniques or methods are present to reduce such type of vibration ad creates the structure stable. Damping is the most important parameter that reduces the vibration. That damping makes such type of vibration below threshold. There are various methods to fulfill this aim and they are represented below [1, 2]:

Mass	Type	Methods
Auxiliary Damping Device	Passive	Increasing damping ratio of building (SJD, SD, FD, LD, VED, VD etc.)
		To increase the level of damping by adding auxiliary mass system (TMD, TLD).
	Active	By using inertia effect reduces the response of earthquake (AMD, AGS).
		To avoid the resonance change the stiffness (AVS).
	Semi active	TLD, VOD, VFD.
Structural Design	Passive	The mass of the building is reducing to increase building mass ratio.
		To increase the stiffness to minimize non dimensional wind speed.

Table 1: Techniques

From all the techniques listed above Tuned liquid column damper, Tuned mass damper and Base isolator is mostly used.

A Tuned liquid column damper is liquid usually water confined in a U tube vessel to minimize the vibration induced due to earthquake. This is done by using the sloshing energy of liquid when structure is subjected to vibration. The tuned liquid column damper is easily implementable and the highly effective for captivating low and high frequency vibration.

The idea of applying tuned liquid column damper is started in mid 1980. This is done by a scientist named Bauer [3]. He done the experiment by applying a rectangular vessel filled with two types of immiscible liquids to minimize the effect of vibration due to wind or earthquakes. Fujii et al. [4], Wakahara et al. [5], Modi &Welt [6], Kareem [7], Sun et al. [8] were also suggested the idea of tuned liquid column damper. Liquid sloshing is the principle of operation for all the above experiments.

The tuned liquid column damper is classified below:

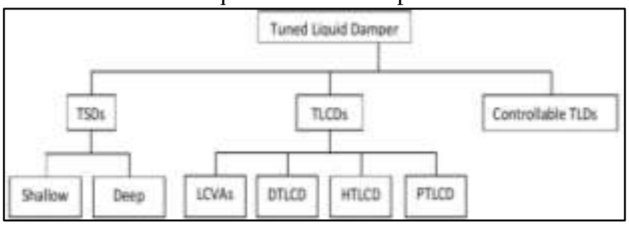

Fig. 1: Classification

A. *Tuned Sloshing Damper:*

Depending on the objective for vibration control tuned liquid sloshing damper is rectangular or circular type. Depending on the height of water tank it can also be classified as shallow water type or deep water type. If the height against the length is 0.15 it is classified as shallow water type otherwise it is deep water type.

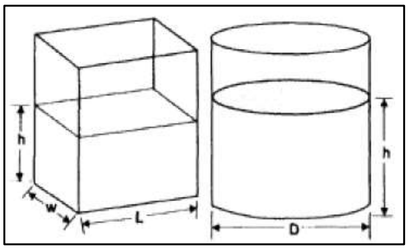

Fig. 2: Tuned Liquid Sloshing Damper

B. *Tuned Liquid Column Damper:*

The tuned liquid column damper reduces the energy by both the action involving liquid mass and damping effect. Tuned liquid column damper can take any type of shape. It can be fitted in any type of structure. The mechanism of tuned liquid column damper is easily understood. The damping capacity of tuned liquid column damper is easily controlled. By adjusting the liquid column in the tube we can adjust the frequency of tuned liquid column damper.

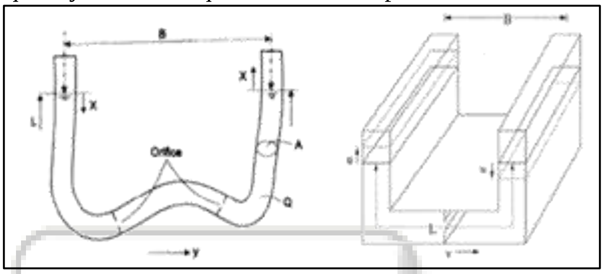

Fig. 3: Tuned Liquid Column Damper

II. EXPERIMENTAL METHODOLOGY

In this experiment a model of a building with ad without damper is crated. Initially, the displacement in structure without damper is observed at difference frequency. Then plot a graph between displacement and frequency.

In the second approach we take a model of structure attached with tuned liquid column damper filled with oil. We observe the displacement at same frequency and plot a graph between displacement and time.

In the next process the water in tuned liquid column damper is replaced with hair oil and observes the displacement at same frequencies. Then plot a graph between displacement and frequency.

In the last approach the hair oil in tuned liquid column damper is replaced with Mobil oil and observed the displacement at same frequencies. Plot the graph between displacement and frequency.

Compare all the graph and check the minimum displacement occur at which one of the above.

Fig. 4: Screenshot

III. RESULT AND DISCUSSION

The vibration induced in the high rise building due to the earthquake and other forces are reduced by placing a tuned liquid column damper in the structure. The liquid in tuned liquid column damper is replaced one by one and observe the displacement at different frequencies. We observe some results which are stated below:

A. *When No Liquid Damper Is Attached:*

When no liquid damper is attached with the structure, following displacement is observed at some frequency which is give in the table below-

Frequency (Hz)	Displacement (mm)
10	1
15	0.8
25	1.5
50	2.5

Table 2: Result

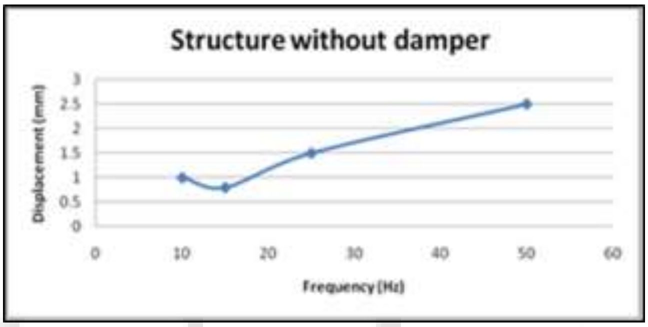

Fig. 5: Structure without damper

In this process, from the graph it is clearly observed that when no liquid column damper is attached with the structure the displacement increases as the frequency of the earthquake increases.

B. *When liquid column is attached with the structure and filled with water:*

When the liquid column is attached with the structure and filled with the water. Then at same frequency following result is observed.

Frequency (Hz)	Displacement (mm)
10	1.5
15	2.0
25	1.7
50	1.3

Table 3: Result

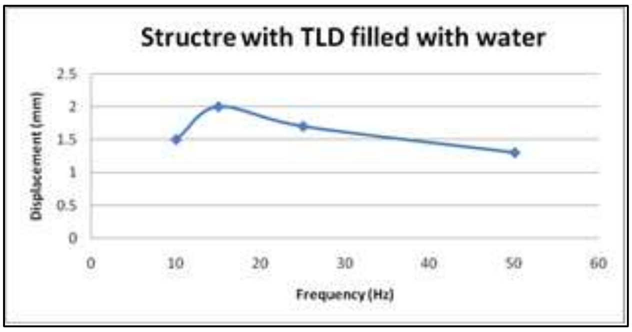

Fig. 5: Structure with TLD filled with water

From the above graph it is observed that when the tuned liquid column damper is filled with water and attached with structure initially at low frequency the displacement increases but at higher frequency the displacement decreases.

C. When liquid column is attached with structure and filled with the hair oil

In this process the water present in the tuned liquid damper is replaced with hair oil and found the below result-

Frequency (Hz)	Displacement (mm)
10	1.3
15	1.8
25	1.0
50	0.8

Table 4: Result

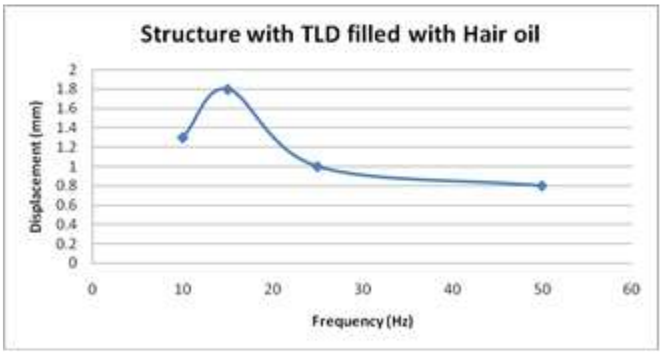

Fig. 6: Structure with TLD filled with hair oil

From this graph the displacement at higher frequency reduces at higher range but at low frequency same result observed.

D. When liquid column is attached with structure and filled with Mobil oil

In this process the hair oil filled in the tuned liquid column is replaced with Mobil oil and attached with structure. Following result is observed:

Frequency (Hz)	Displacement (mm)
10	1.2
15	1.5
25	0.7
50	0.5

Table 5: Result

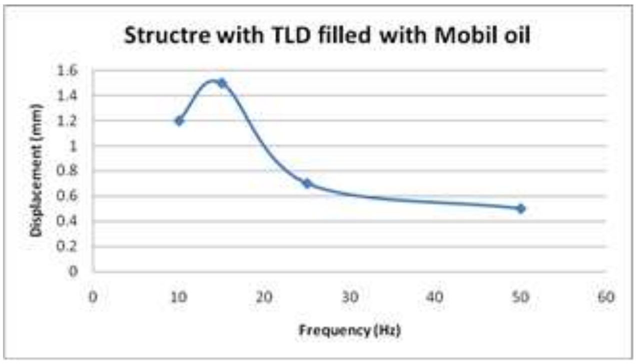

Fig. 7: Structure with TLD filled with Moibl oil

From the above result and graph it is clearly observed that the displacement is largly minimises when mobil oil is filled but low frequency displacement increases.

IV. FUTURE SCOPE OF STUDY

- In this experiment both damper and structure is linear that provide scope to study for nonlinear model.
- By Mess Free Method it is also studied.

ACKNOWLEDGMENT

The author wish to acknowledge the Department of Civil Engineering Madan Mohan Malaviya University of Technology, Gorakhpur. The author is thankful to Mrs. Sana Zafar, Associate Professor Depatment of civil engineering Madan Mohan Malaviya University of Technology, Gorakhpur for her continuous support.

REFERENCES

[1] Kareem Ahsan, and Kijewski Tracy, “Mitigation of motions of tall buildings with specific examples of recent applications.” Wind and Structures, Vol. 2, No. 3, (1999), pp. 201-251.
[2] Spencer B.F. Jr., and Sain Michael K., “Controlling Buildings: A New Frontier in Feedback.” Special Issue of the IEEE Control Systems Magazine on Emerging Technology, Vol. 17, No. 6,(1997), pp. 19-35.
[3] Bauer H.F., “Oscillations of immiscible liquids in a rectangular container: A new damper for excited structures”. Journal of Sound and Vibration 93(1), (1984), pp.117-133.
[4] Fujii K., Tamura Y., Sato T., Wakahara T., “Wind-induced vibration of tower and practical applications of Tuned Sloshing Damper”. Journal of Wind Engineering and Industrial Aerodynamics, 33, (1990), pp. 263-272.
[5] Wakahara T., Ohyama T., and Fujii K., “Suppression of Wind-Induced Vibration of a Tall Building using Tuned Liquid Damper”. Journal of Wind Engineering and Industrial Aerodynamics, 41-44, (1992), pp. 1895-1906.
[6] Modi V.J., and Welt F., “Damping of wind induced oscillations through liquid sloshing”. Journal of Wind Engineering and Industrial Aerodynamics, 30, (1988), pp. 85-94.
[7] Kareem Ahsan, “Reduction of Wind Induced Motion Utilizing a Tuned Sloshing Damper”. Journal of Wind Engineering and Industrial Aerodynamics, 36, (1990), pp. 725-737.
[8] Fujii K., Tamura Y., Sato T., Wakahara T., “Wind-induced vibration of tower and practical applications of Tuned Sloshing Damper”. Journal of Wind Engineering and Industrial Aerodynamics, 33, (1990), pp. 263-272.