# Experimental Study on Tuned Liquid Damper and Mass Damper under Dynamic Loading

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***Abstract –** In this paper, the liquid damper (TLD) and mass damper (TMD) are used to minimize the structural retort due to moving action. Several experimental sets are measured on a model of structure TLD and TMD systems to check their efficiencies under vocal excitation. Rectangular shapes of TLD with altered type of liquid deepness ratios are checked and various frequency ratios are measured. The experimental revision was approved by expending shake table apparatus. The various values are measured using accelerometers and LVDT sensors. Trendy situation of TMD the toughness and restraining are remain constant for experimental study. From this study, it is established that for TLD, as water deepness raises it leads to minimum amplitude. The huge controller of vibration is noticed under resonant condition by using liquid damper. The outcomes show that TMD can decrease the extreme displacement of assemblies below harmonic motions.*

***Key Words***: **Splashing, tuned liquid damper, tuned mass damper, Harmonic excitation, Earthquake, Response control.**

## 1. INTRODUCTION

Vibration controller is a significant feature when planning buildings, especially if they are high. Buildings can get exposed to considerable shaking owed towards airstream and earthquakes. When an earthquake waves portable over the building, it is exposed massive forces, acceleration and displacement that make the building extremely unbalanced and ultimately it failures. Mass damper, Liquid dampers, base isolators and other additional restraining structures are amongst the several replacements recycled to decrease the shakings on the assemblies. A TLD is water restricted in a vessel that uses the splashing energy of the liquid to decrease the vibrant reply of the scheme when the system is exposed to excitation. TLD has similarly establishing to be very real in abandoning shakings produced owed to wind.

Tuned Liquid Damper (TLD) is an inactive controller device which takes connected in structures to overwhelm straight shakings in the assemblies. TLD is fundamentally a liquid filled tank which is strictly joined to the topmost of the structure. It trusts on the splashing wave emerging and contravention at the allowed surface of the fluid to disintegrate a share of the energy unconfined throughout the vibrant occurrence and therefore raises the correspondent restraining of the assembly. When occurrence of tank gesture is near to the occurrence of the container liquid significance happens. At significance, great quantity of splashing and wave contravention happens at the allowed surface of the fluid which scatters a substantial extent of energy. TLD grants numerous benefits above other restraining schemes such as small installation, running and process rate, rarer motorized difficulties subsequently no moving portions are present-day and can be useful to controller dissimilar shaking kinds of multi-degree of self-determination organizations. The efficiency of Tuned Mass Damper (TMD) for regulatory structural reaction is delicate to its constraints i.e. mass, frequency, and damping ratio. When TMD is altered to occurrence near to natural occurrence of assembly, shaking of structure makes TMD to shake in significance, dispersing extreme shaking energy over restraining in obstacle and also due to comparative movement of damper with deference to the structure. In accumulation TMD is good-looking as it disperses a substantial level of shaking energy of main structure without necessitating any joining to ground. Numerous TMDs have been positively realized universal for wind reaction controller in structures, funnels and turrets. To get optimal reaction the normal frequency of the secondary mass is continuously tuned to that of primary structure such that when that specific frequency of the assembly get motivated, the TMD will reverberate out of stage with the structural gesture.

Supradip Saha and Rama Debbarma [1] - An Experimental study on response control of structures using tuned liquid dampers for dynamic loading. In this paper, the performance of multiple tuned liquid dampers has been investigated in mitigating the response of structure under dynamic loading. For comparative study, the response of Single-tuned damper has also been considered. Several excitation frequency ratios and depths ratios are considered for this study. The effect of resonance as well as tuned condition on structural response has also been noticed. Therefore, from this experimental study, it can be concluded that a TLD can successfully mitigate the response of the structure, but MTLD is not significantly more effective than an STLD when the liquid sloshing in the TLD is large.

Muhammed Murad.K and Lavanya.G [8] **-** Dynamic resistance of tall buildings by using tuned mass damper's (TMD"S). This paper is to study the comparison of shear wall and TMD for reducing vibration of tall buildings due to wind and earthquake loading by using SAP2000 software. Shear walls and Tuned Mass Dampers are assigned in the structure alternatively. Various arrangements of Tuned Mass Dampers in this 30 storey building are studied and the best arrangement among these is applied in a 50 storey building to study the effectiveness in controlling vibration. And also the characteristic of this 50 storey building is studied by applying Time History Analysis of El-Centro earthquake.

The chief objective of this study was to determine the behaviour of structure when devoted to TLD and TMD to decrease structural reaction under vibrant loading. For TLD numerous water depth and excitation frequency the standards for displacement and acceleration are determined with TLD and without TLD measured. For TMD numerous input frequencies are established for altered mass ratios with TMD and without TMD experimentally.

## 2. EXPERIMENTAL PROCEDURE

The arrangement of the steel structure model on the shake table along with liquid damper and mass damper is displayed in **fig- (1)** and **fig- (3)**. in shake table only horizontal motions are going to be carried. The shape of table is in circular shape such that its diameter is 40 cm and its radius is 20 cm. The weight of the apparatus or machine is 30 kg. The worth of frequency that can be used to study experiment is 10 Hz. The essential excitation occurrence is useful to the assembly by using microprocessor 3-phase AC system. The TLD model is placed exactly centre of bottom base plate which is existing in **fig - (1)**. The material which is used for TLD tanks are of acrylic sheet. The entire mass ratio used for TMD system was around 10 % of the mass of the structure. Several figures of TMDs remained used for structural model. The steel model is made with mild steel of sufficient thickness for rigid floor, supported by four steel rods with dimension of 250 × 250 × 270 mm for each floor for all storeys. The columns are jointed to the base plates by welding. The measured parameters are acceleration and displacement for structure. The vertical member column is made with steel rod, and beam acted as story mass, thus the movement is in laterally to longitudinal axis. The models were intended with removable parts and relaxed entrance for energy dissipation devices. The setup for without TLD is as specified in **fig -(2).**The story masses are same, and they can be adjusted along the elevation of the main columns. The details of liquid damper are specified in **table -1**.

**Table -1:** Details of TLD parameters

| Shape of TLD | TLD Dimensions | | |
|---|---|---|---|
| | Length L(cm) | Width B(cm) | Depth H(cm) |
| Rectangular | 12 | 8 | 40 |

**Fig -1:** Experimental setup for tuned liquid damper

**Fig -2:** Setup without tuned liquid damper

**Fig -3:** Structure with tuned mass damper

## 3.RESULTS AND DISCUSSION

In this investigation are considered to study the vibrant behaviour of assembly with TLD and TMD when exposed to harmonic base gesture specified to the vibration table apparatus. From this work, the significance of displacement and acceleration of the assembly with and without TLD are measured. The result of experimental study has been plotted with water depth ratio and movement as frequency ratio. In **table-2** the various liquid- depth ratio including external frequency and excitation occurrence ratio is given from experimentally.

**Table -2:** TLD experimental cases

| Model | Water-depth ratio($\Delta$) | External frequency in Hz | Excitation frequency ratio $(\omega/\omega_s)$ |
|---|---|---|---|
| TLD | 0.15, 0.25, 0.35, 0.45, 0.5 | 4.0, 4.3, 4.6, 4.9, 5.2, 5.5, 5.8, 6.1 | 0.82, 0.88, 0.94, 1.0, 1.06, 1.12, 1.18, 1.24 |

In **table -3** the different values of displacement are given with mass damper and without mass damper with its dynamic magnification factor.

**Table -3:** TMD experimental cases

| Input frequency | Maximum Displacement(mm) | | Dynamic Magnification Factor |
|---|---|---|---|
| | TMD | No TMD | |
| 1.5 | 0.8 | 1.2 | 0.67 |
| 1.8 | 2 | 5.6 | 0.36 |
| 2.1 | 10.8 | 9.8 | 1.10 |
| 2.4 | 6.8 | 7.2 | 0.94 |
| 2.7 | 6.4 | 6.4 | 1.00 |

### 3.1 Effect of water depth ratio on structural response

Several water depth ratios, which is water depth (h) to tank length (L), varying from 0.15 to 0.5 are considered and maximum structural response has been specified in **Chart -1**. It is also observed that displacement decreases with the increase in water- depth ratio. Similarly curves for acceleration vs. excitation occurrence ration are also plotted as specified in **Chart -2**. The variation of displacement with excitation occurrence ratio for tuned mass damper system for structure is specified in **Chart -3**.

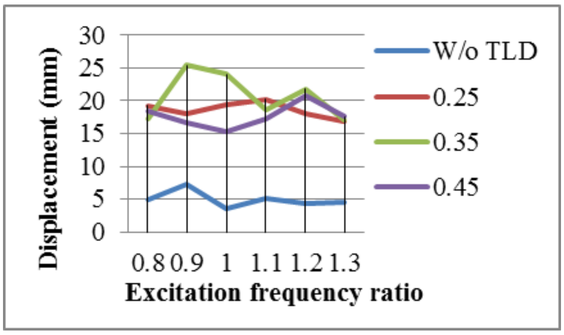


**Chart -1**: Variation of Displacement with excitation frequency ratio for TLD

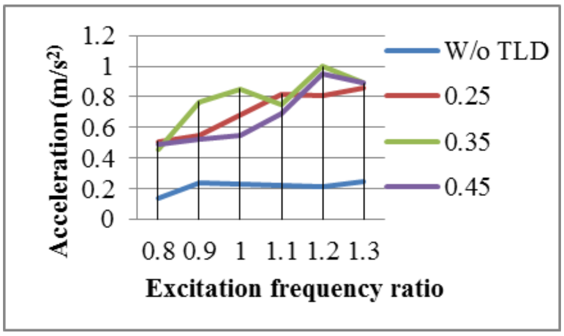


**Chart -2**: Variation of Acceleration with excitation frequency ratio for TLD

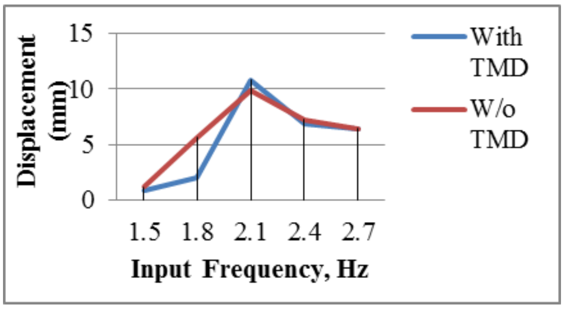


**Chart -3**: Variation of Displacement with excitation frequency ratio for TMD

## 4. CONCLUSIONS

In this paper, determination of structural reply underneath vibrant loading by using liquid damper and mass damper are described. Based on this study following conclusions could be made;

1. The worth of displacement is decreases with increasing in water depth ratio.
2. Several excitation occurrence ratios varying from 0.8 to 1.3 are considered during this study. The performance of TLD is observed to be effective for reducing the structure response when excitation frequency ratio is near to unity.
3. Different liquid depth ratios varying from 0.15 to 0.5 are taken to consideration to evaluate performance at resonant condition.
4. From experimental study, it is observed that after using TMD optimum reduction is occurring when frequency ratio is near to unity.
5. With increase in mass ratio in TMD the peak displacement is decreasing and at certain times it again increasing with rise in mass ratio.

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