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ANALYSIS OF TUNED LIQUID DAMPER IN CONTROLLING EARTHQUAKE RESPONSE OF MULTISTOREY BUILDING

Rahamat Ali Ansari[1*]

[1]*Research scholar, Department of civil engineering, VEC, Ambikapur*

Abstract

Most buildings were constructed in the past with various laws depending on which nation you were in, thus retrofitting is required nowadays. New kinds of structures and uses are emerging, and rules are being revised at the same time. This means that the traditional techniques of constructing earthquake-resistant buildings may not be as effective as they once were. This paper aims to provide a comprehensive review on the most common triggering factors of progressive collapse of RC structures such as blast, fire, earthquake, gas explosion, etc. Different zones are studied and compared here.

Keywords: building collapse, post-disaster management, earthquake.

1. INTRODUCTION

Earthquakes are a major concern because of the devastation they cause, including the breakdown and collapse of structures, the loss of human life, and the destruction of property. Earthquakes can have significant economic consequences, such as the destruction of constructed structures and the resulting recovery expenses for those structures and infrastructure that are destroyed. Figures 1.1 and 1.2 show the damage earthquakes do to buildings.

Studies on buildings' seismic resistance have been conducted all through the years, and the results show that structures that do not meet the criteria of sustainable structures in seismic resistant design

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suffer harm. Because of this, rules and standards have been established to enhance structures' ductility and stiffness in order to withstand earthquakes. In earthquake-prone areas, seismic design rules and methods of analysis are used in the design and construction of structures and civil engineering projects. [1]

Most buildings were constructed in the past with various laws depending on which nation you were in, thus retrofitting is required nowadays. New kinds of structures and uses are emerging, and rules are being revised at the same time. This means that the traditional techniques of constructing earthquake-resistant buildings may not be as effective as they once were. Furthermore, the frequency and intensity of earthquakes may change over time due to changes in the ground's shape and climate. As a result, the knowledge a nation has on earthquakes may vary, and engineers will need to design buildings that are more efficient to meet the existing standards.

1.1. Multi storey building

It is a 3d or light weight steel structure with a large number of storeys and vertical circulation through elevators and stairways that is called a multi-storey building. Buildings of different heights have been designed using a variety of methods, each based on the results of early study and verification. A multi-story structure is often used to house a hospital, a shopping centre, or a complex of apartments.

Using high-level pre-fabrication materials, precise design, highest quality checks, and risk-free construction, multistory buildings are an ideal commercial building option because of their quicker construction speed than other traditional structures.

Figure 1: the structure of multi storey building

Multi-storey building construction is reliant on a variety of factors, including the accessibility of building materials, construction techniques, including building services, like elevators. People in ancient Rome utilised wood to construct multi-story buildings throughout the city-state. When Nero was constructing new structures following the Great Fire of Rome, he made use of brick and a concrete-like substance. Wood was a weak construction material for structures with greater than five storeys, and it was also a fire danger. However, brick and stone structures took up a lot of room due to the sheer size of their walls. The creation of high strength & structurally more efficient materials like wrought iron & later steel was a technological response to the limitations of traditional building materials. Hotel Oberoi Sheraton, India's tallest skyscraper is 35 stories high and made of reinforced concrete (116 m). Despite the fact that India has built many multi-story structures in the past two decades, tall building technology, especially in structural steel, is still in its infancy in the country.

2. LITERATURE REVIEW

(Ishak, Hamid and Amin, 2021) [2] Earthquakes may damage buildings in various ways, resulting in building collapses and the deaths of people. Reduce structural reaction by introducing a damping system to buildings, which gradually reduces system energy until all vibration is removed and the system is brought to rest. This is one method of reducing structural response. While there are numerous techniques to choose from these days, passive control systems have an advantage in terms of cost, especially in Malaysia where earthquakes aren't as common as they are in Japan. However, existing water tanks can be tuned to function as passive dampers if necessary, so long as the situation calls for it. Utilizing SAP2000, the goal of this study is to examine the feasibility of using numerous water tanks as a passive Multiple Tuned Liquid Damper and determine the optimum location for water tanks to decrease the structure's peak reaction to seismic forces.

(Konar and Ghosh, 2021) [3] The efficacy of tuned liquid dampers (TLDs) has been shown, however liquid storage tanks with poor inherent damping, such as those found in deep wells, are seldom used for vibration control of laterally-excited structures. In addition, when the liquid level fluctuates in these tanks, the fundamental sloshing frequency changes which resulting into detuning. We suggest a new TLD with floating base to address these issues, which maintains a constant and shallow liquid level between the free liquid surface and the floating base in order to solve these issues.

(Ubair Gull Khan, 2020) [4] There have been many elevated structures constructed throughout the globe, and the total keeps growing. Instead than being concerned about dense populations in cities, commercial districts, and the need for more room to develop landmarks, this is a result of space constraints. Because the seismic load following a structure is a part of the structure's own load, these structures are built light and adaptable with a fairly low common damping, and so as a result, the structures become more wind and tremor vibration inclined. Tall buildings need many plan modifications to ensure efficient execution, ranging from optional fundamental frameworks to the employment of passive and active control devices. An overview of cutting-edge methods to reduce the fundamental response of tall buildings is presented in this article, including a discussion of seismic tremor and wind-initiated movement of structures and dampening devices for moderating them.

(Gowda, N and Sindgi, 2020) [5] Current trends in the construction sector call for buildings that are both higher and lighter, as well as more flexible and with a lower damping value. This raises the risk of disappointing results, as well as posing problems from the standpoint of utility. There are now a few processes available to restrict the structure's vibration, and the concept of using TLD is the most up-to-date one of the few vibration control techniques available today. “Tuned Liquid Dampers (TLD)” are being investigated for their potential to reduce seismic vibration in buildings that are subjected to horizontal stimulation.

(Tanveer et al., 2019) [6] Vibrations in buildings caused by wind or earthquakes may be reduced using a TLCBD (tuned liquid column ball damper). The above modified tuned liquid column damper is known as a TLCD. A four-storey steel frame building is examined in this article to see how TLCBD affects it. The TLCBD's performance is also compared to that of a traditional TLCD. Both the TLCD and the TLCBD analytical models are given here. Testing the efficacy of these mathematical models on a shaking table with various excitation levels, including harmonic loadings and seismic excitations, is a good way to find out. The use of a steel ball as a moving orifice in TLCBD reduces vibration considerably as compared to TLCD.

(Rana, Bista and Sunagar, 2018) [7] Through the use of “horizontal sinusoidal stimulation and tuned liquid dampers (TLD)”, this research will test the efficacy of these dampers in minimising seismic vibration in buildings. An excitation reduces a structure's dynamic response by using a water-confined container, which may be thought of as an enormous water tank. This research proposes a process for creating a building's TLD and a way for simulating the TLD in SAP2000 software. After then, many studies were performed to determine the impact of various TLD factors that may have an impact on the software's performance.

3. METHODOLOGY

3.1. Flow Chart of the study

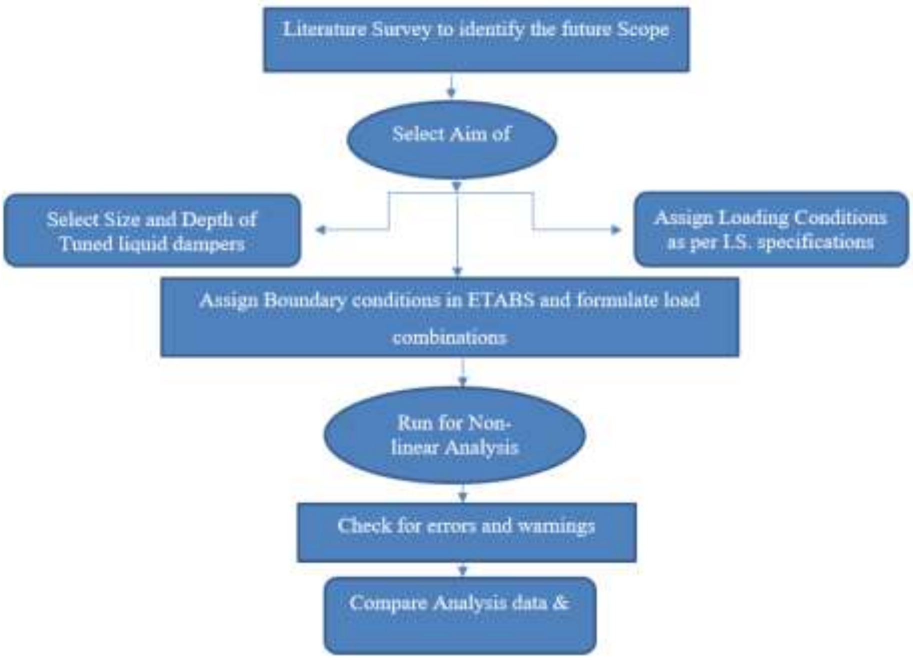

Figure 2: Flow chart of the study

4. RESULTS AND DISCUSSION

This chapter describe software analysis results and discussion from above analysis of modeling of general structure and tuned liquid damper (TLD) structure using ETABS software in zone III & zone V. We observed the following results:

4.1. Comparative Results and Discussion:

Comparison between general structure and TLD structure in Zone III & V

- Maximum Shear Force in Zone III & V
- Maximum Axial Force in Zone III & V
- Maximum Story displacement in Zone III
- Maximum Story displacement in zone V
- Plate Stresses in TLD structure
- Plate Stresses in general structure

4.2. Maximum Shear Force:

Table 1: Max. Shear Force

Zone	General structure	TLD structure
III	490.34	443.2
V	877.4	794.55

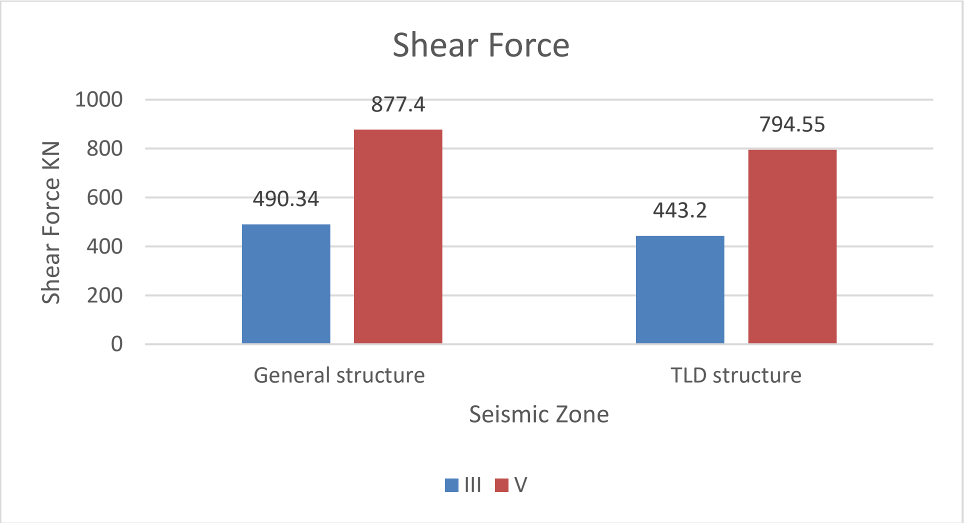

Fig 3: Max. Shear Force

Discussion:

Unbalanced forces generally develop due to rigidity in joints which cause un-proper distribution of load, In fig 6.1 it has been observed that TLD steel structures are distributing lateral and vertical loads properly which cause low unbalance forces at the joints.

4.3. Maximum Axial Force:

Table 2: Max. Axial Force

Zone	General structure	TLD structure
III	1076.5	1021.05
V	1013.21	1063.22

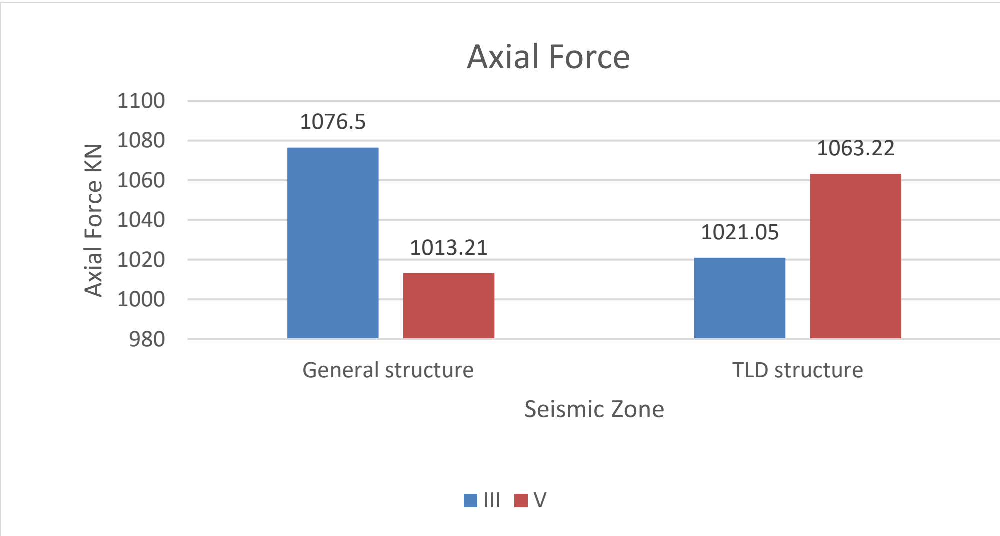

Fig 4: Max. Axial Force

Inferences:

Axial forces are the vertical distribution of forces in column to distribute the building "load to the footing". In this study ISMB 200 section is considered as structural members with the help of liquid dampers it is become more convenient for "individual column to distribute the load properly to the footing".

4.4. Storey Displacement in Zone III:

Table 3: Storey displacement in zone III (MM)

S.NO.	Storey displacement in Zone III	
	Conventional	TLD
10 STOREY	31.045	18.351
9 STOREY	28.21	16.44
8 STOREY	25.307	14.537
7 STOREY	22.358	12.647
6 STOREY	19.379	10.788
5 STOREY	16.387	8.969
4 STOREY	13.396	7.225
3 STOREY	10.42	5.59
2 STOREY	7.472	4.075
1 STOREY	4.571	2.706
GF	1.809	1.512
BASE	0	0

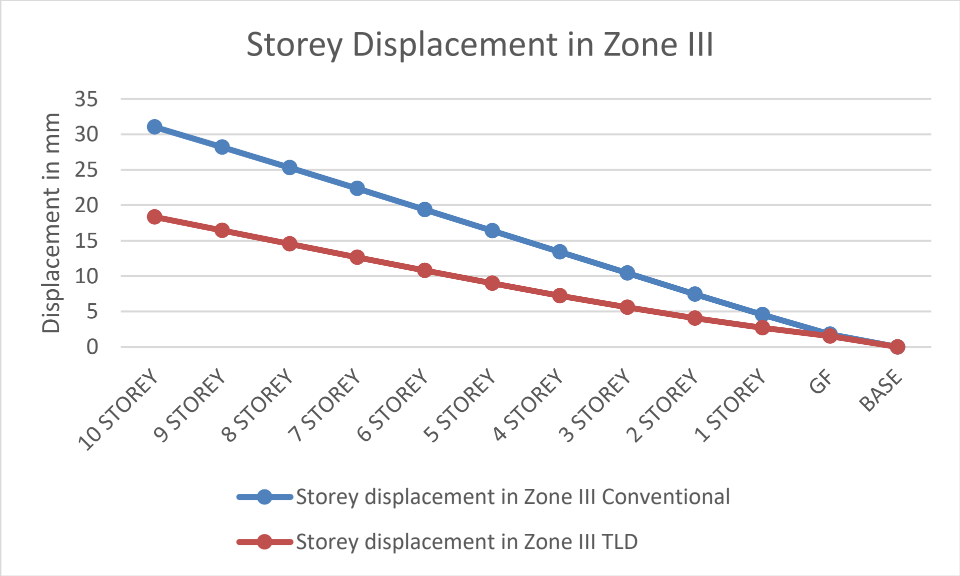

Fig 5: Storey Displacement in Zone III

Inferences:

As observed on Above fig 6.3 it can be said that displacement is comparatively less in TLD steel structure due to its stiffness and stability to resist the structure in lateral pressure.

4.5. Max. Storey Displacement in Zone V:

Table 4: Storey displacement in zone V (MM)

S.NO.	Storey displacement in Zone V	
	Conventional	TLD
10 STOREY	69.852	43.594
9 STOREY	63.471	38.927
8 STOREY	56.941	34.294
7 STOREY	50.305	29.725
6 STOREY	43.603	25.276
5 STOREY	36.87	20.967
4 STOREY	30.141	16.848
3 STOREY	23.445	12.98
2 STOREY	16.811	9.44
1 STOREY	10.285	6.393
GF	4.071	3.966
BASE	0	0

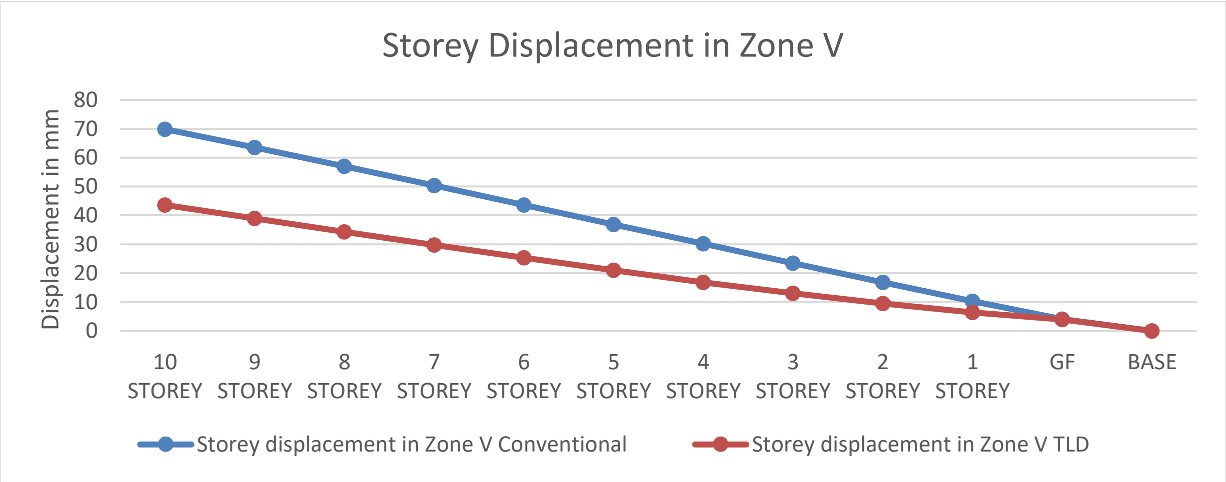

Fig 6: Storey Displacement in zone V

Inferences:

As shown in fig 5.4: It can be said that with the help of TLD one can resist the structure from lateral failure by 37.4 % which is necessary for the structure to be in its permissible limit.

4.6. Plate Stresses:

Table 5: TLD Structure

Plate	SQX N/mm2	SQY N/mm2	MX kNm/m	MY kNm/m	MXY kNm/m	SX N/mm2	SY N/mm2	SXY N/mm2
1	6.45	-4.56	-380.34	-1903	1290.46	0.054	0.98	1.23
2	6.2	-2.58	-290.58	-1045.6	1589.03	-0.76	0.43	0.87
3	5.95	-0.6	-200.82	-188.29	1887.6	-1.574	-0.12	0.51
4	5.7	1.38	-111.06	669.05	2186.17	-2.388	-0.67	0.15
5	5.45	3.36	-21.3	-103.98	2484.74	-3.202	-1.22	-0.21
6	5.2	5.34	68.46	7.6	2783.31	-4.016	-1.77	-0.57
7	4.95	7.32	158.22	119.18	3081.88	-4.83	-2.32	-0.93
8	4.7	9.3	247.98	230.76	3380.45	-5.644	-2.87	2
9	4.45	11.28	337.74	342.34	3.43	-6.458	-3.42	0.027

Table 6: General structure

Plate	SQX N/mm2	SQY N/mm2	MX kNm/m	MY kNm/m	MXY kNm/m	SX N/mm2	SY N/mm2	SXY N/mm2
1	7.66	-5.77	-381.55	-1904.2	1289.25	-1.156	-0.23	2.44
2	7.18	-3.56	-291.56	-1046.6	1588.05	-1.74	-0.55	1.85
3	6.7	-1.35	-201.57	-189.04	1886.85	-2.324	-0.87	1.26
4	6.22	0.86	-111.58	668.53	2185.65	-2.908	-1.19	0.67
5	5.77	3.04	-21.62	-104.3	2484.42	-3.522	-1.54	0.11
6	5.65	4.89	68.01	7.15	2782.86	-4.466	-2.22	-0.12
7	5.53	6.74	157.64	118.6	3081.3	-5.41	-2.9	-0.35
8	5.41	8.59	247.27	230.05	3379.74	-6.354	-3.58	2.71
9	4.45	11.28	337.74	342.34	3.43	-6.458	-3.42	0.027

4.7. Cost Analysis in zone III and V

Table 7: Cost Analysis

Case	**Quantity (Kg)**	**S.O.R. Rate/Kg**	**Total Cost (Rs)**
General Structure Zone III	142800.67	48	6854432.16
TLD Structure Zone III	134220.21	48	6442570.08
General Structure Zone V	157004.00	48	7536192.00
TLD Structure Zone V	146000.54	48	7008025.92

Inferences:

As shown in table 5.2.6 it can be said that TLD structure is cost effective than general structure in both the seismic zone (III & V) with cost reduction of 8%.

5. CONCLUSION

In an earthquake disaster hundreds and thousands of buildings may collapse at the same time. The weaknesses of the existing disaster management structure to provide emergency response in such a disaster are pointed out. Some measures are suggested to strengthen the post-disaster management system in the country for facing an earthquake disaster.

Other damage indicators from the damaging earthquake, such as peak story drift and peak residual drift, did not correlate strongly with the change in collapse risk. However, the full distribution of story drifts and residual drifts offer the potential to use the drift profiles to help identify damage and potentially inform the building safety assessment. This suggests opportunities to utilize post-earthquake analyses and/or dense (multi-floor) building instrumentation to enable more reliable assessments of building safety as related to decisions about building repairs, re-occupancy, and safety cordons.

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