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ANALYSIS OF A TALL STRUCTURE CONSIDERING DAMPERS & LATERAL FORCES USING ETABS

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Abstract

As India is developing rapidly thus population in developing area is more as compared to other areas which requires large space to settle these population. For settling such a hudge number of people over limited area needs tall structures. These talls structures need proper guidance before designing related to stability, soil testing and analysis for safe structure.

Lateral load resisting members area generally adopted to design safe structure but it takes specifications and assignment space also need high skill labour for assignment, which indirectly increasing th cost of construction.

In this study we are analyzing a tall structure considering lateral laod using integrated building designing tool (ETABS), which is capable of assigning various methods of analysis and consist of all nations codes and specification.

Keywords: Dampers, Fluids, Tall Structure, ETABS, Stability, Forces, Lateral Load.

INTRODUCTION

Vibration control is an important aspect when designing buildings, especially if they are tall.Due of lateral forces building faces vibrations in even directions which causes in general auxiliary removal and moving of CG of the structure.
In this study we are considering a tall Steel structure of G+10storey, considering tuned liquid damper at C.G. of the structure considering Non-linear seismic load (Zone-III &V) as per I.S. 1893-I:2016.

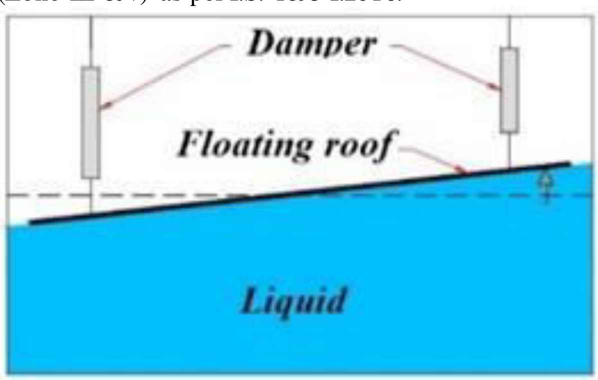

Fig 1: Tuned damper

A tuned liquid damper(TLD) is a type of tuned mass damper (TMD), where the mass is replaced by water. Tuned liquid column dampers (TLCDs) is a special type of TLDs relying on the motion of a column of liquid in a U-tube like a container to contract the forces acting on the structure.

Seismic Analysis

Weight of a structure which is generally crafted as per seismic design codes along with the structure stiffness as an earthquake crake forces from the bottom that are proportional to mass of the structure. The structures need to be designed to behave elastical in case of any seismic attack to resist and emerge with least damage, such projects even act more economical in comparison to conventional structures.

The parameters which need to be included in a structure to be seismic ready are-

(a) Minor (and frequent) shaking with no damage to structural and non-structural elements.
(b) Moderate shaking with minor harm to structural components, and some harm to non-basic components.
(c) Severe (and inconsistent) shaking with harm to structural components, however with NO breakdown (to spare life and property inside/abutting the structure).

LITERATURE REVIEW

Nguyen et. al. (2018) This research paper considered the multi-tuned liquid damper with slat screens (M-TLDWSS) in detail for analyzing dynamic response of multi-degrees of freedom structure due to earthquake. Later, the general condition of movement of the structure and M-TLDWSS underground acceleration of seismic tremor is built up dependent on the dynamic equalization of standard and comprehended by the numerical strategy in the time-space. The examination was done on the impacts of trademark parameters of M-TLDWSS on the dynamic reaction of the structure. Acquired outcomes lead to the end that the M-TLDWSS had fundamentally compelling for lessening the dynamic reaction of the structure. Further, the proportion of profundity per length was influenced firmly on the dynamic character of the M-TLDWSS, it expanded tuning proportion which was one of the most significant parameters for execution of the MTLDWSS on decreasing the dynamic reaction of the structure. Right now, the viability of the M-TLDWSS for lessening structure reaction was progressively huge in the scope of estimation of the proportion from 0.6 to 0.8 than others on a condition that the exhibition of the M-TLDWSS likewise relies upon TLDWSS number.

The M-TLDWSS applied for decreasing the dynamic reaction of the structure can be reasonable for different ground increasing velocities in real-time. It was diminishing altogether structure reaction than without damper.

Bhattacharya et. al. (2016) The authors paper dealt with evolution of the various numerical codes so as to signify the effectiveness of tuned sloshing dampers considering fluid structure interaction effects. The case study included a five storey structure under harmonic ground excitation maximum percentage reduction of 47.7% in response of the structure as top floor displacement was observed for mass proportioning of 90% at fifth floor and 10% at the fourth floor. It was likewise seen that tuned water tank performed adequately as a damper notwithstanding for the mass proportioning of 60% at fifth floor and 40% at the fourth floor giving a rate decrease of 44.4 in the structure highest floor displacement.

The paper concluded that noteworthy execution of profound water TSD with shifting mass extent inferred that if enough highest floor space was not accessible for the establishment of TSD one can do the proportioning of the damper mass in the upper stories for multi-storeyed structures. Likewise from the structure configuration perspective as opposed to lumping the mass at the top story proportioning of damper mass in the upper stories will lessen the expansion in the loads in the basic membranes because of the expansion of the damper mass.

Objectives of the study

The primary objectives of this study are as follows:

i. Modeling and Analysis of a tall steel structure considering tuned liquid damper using ETABS software.

ii. To determine the effectiveness of liquid dampers steel structure comparing to general steel structure under vibrational load.

iii. To determine the Cost of operating and constructing liquid damper as per S.O.R.

iv. To develop a concept of structural designing with considering Concept of assigning dampers.

METHODOLGY

In this research work our motive is to evaluate seismic assessment of tuned liquid damper over a steel building considering lateral load as per I.S. 1893

Load calculations and Geometrical Formulations:

Table 1: Geometrical details

Geometrical Data	
Plan dimension	**14 x 18 m**
Length (m)	**14 m**
Width (m)	**18 m**
Height each floor(m)	**3.2 m**
Number of floors	**G+10**
Tuned damper	**3.5m X4.5m**
Column Size	**I.S.M.B.200**
Beam Size	**I.S.M.B.200**

following steps are involved for analysis of a tall steel structure:

Step-1: To select Indian provisions code

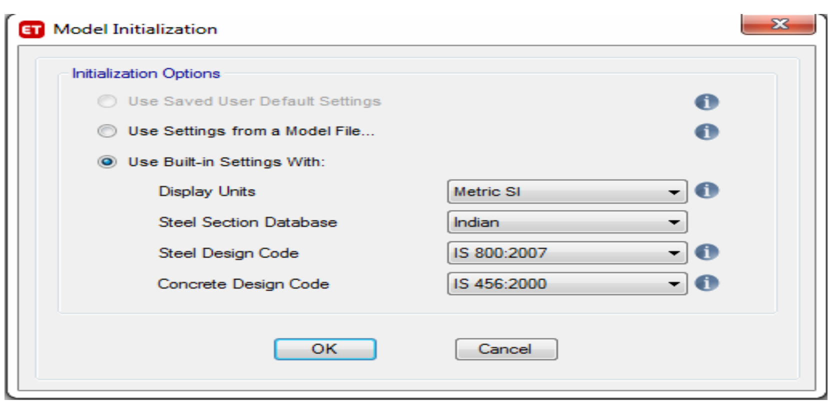

Fig 3: Assigning Indian standards

Volume: 05 Issue: 03 | March - 2021 ISSN: 2582-3930

Step-2: To Prepare geometrical plan

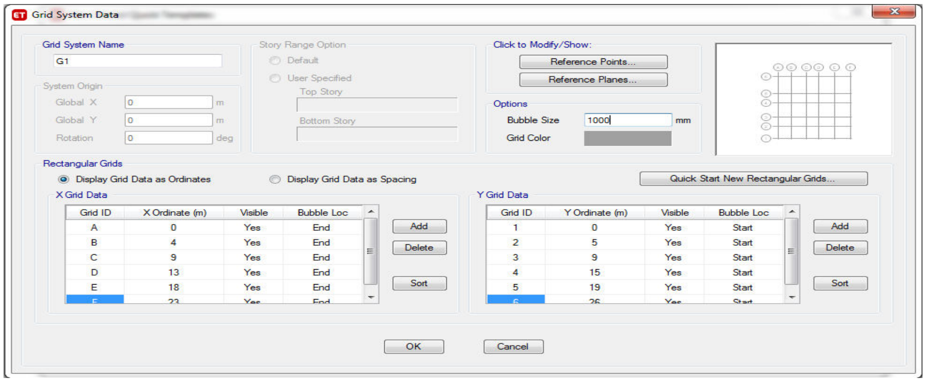

Fig 4: Plan of the structure

Step-3: To Create materials as per Indian standards.

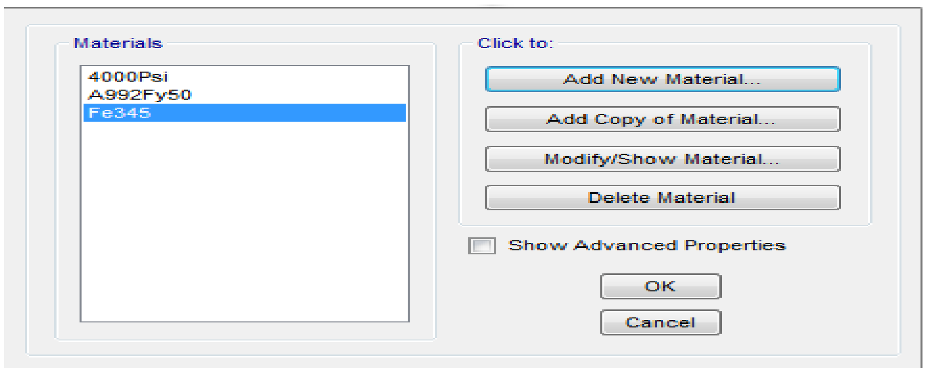

Fig 5: Define materials

Step-4: To Define sectional data

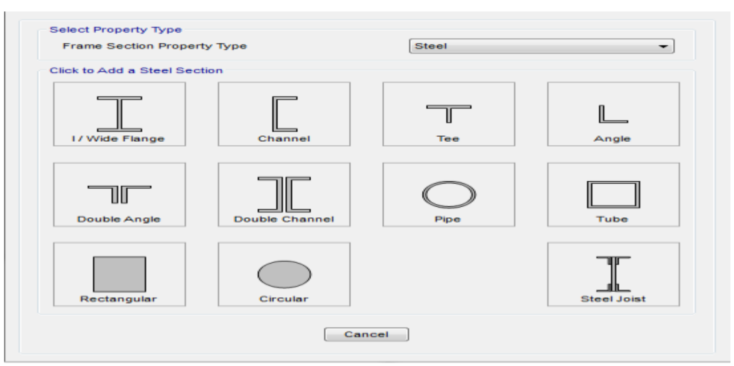

Fig 6: Sectional data

Step-5: To Create building design

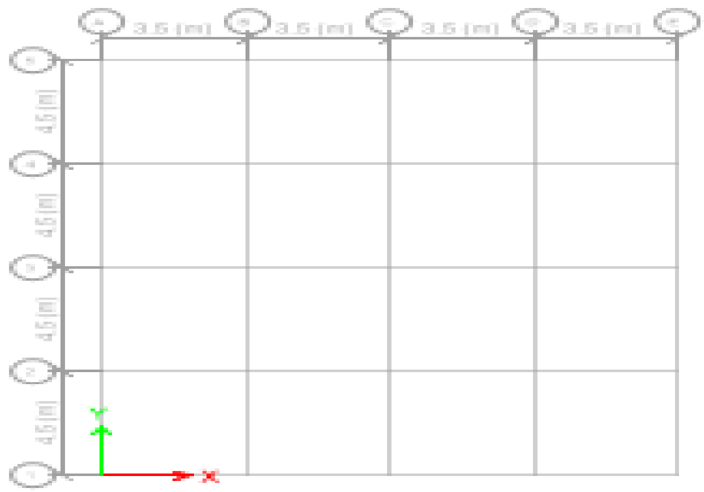

Fig 7: Symmetrical frame

Step-6: Assigning tuned dampers

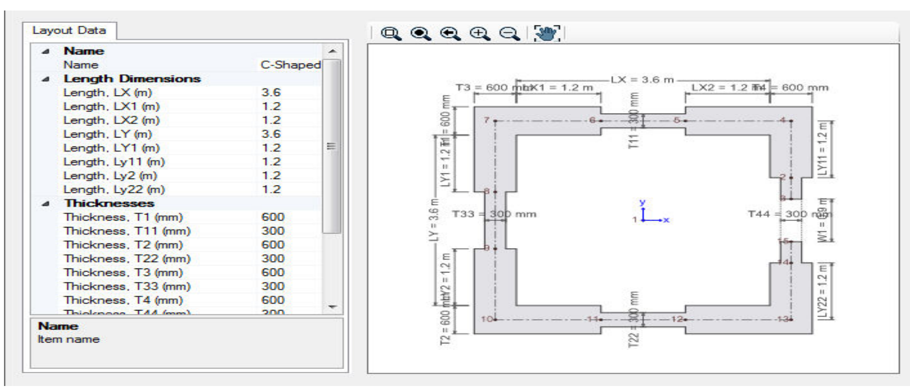

Fig 8: Select and define size of damper

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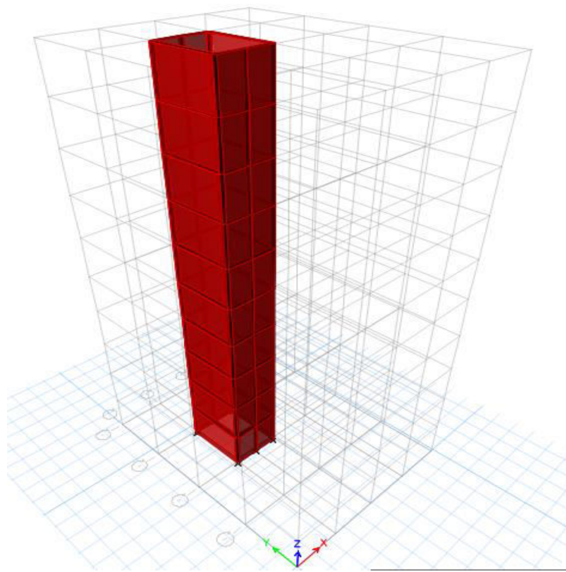


Fig 9: Tuned dampers

Step-7: Assigning fixed end conditions.

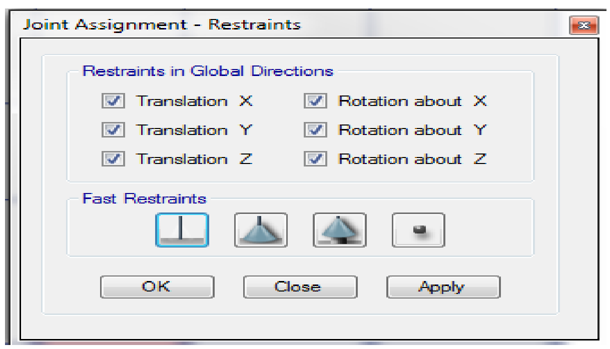


Fig 10: End conditions

Step-8: Define Loading Conditions

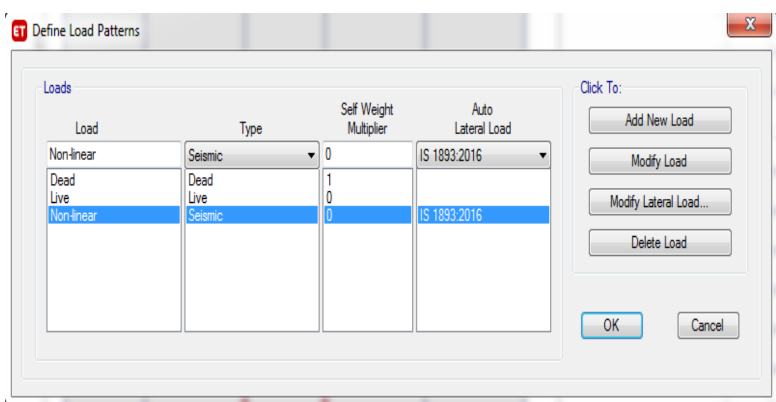


Fig 11: Loading Conditions

Step-9: Assigning damping loading

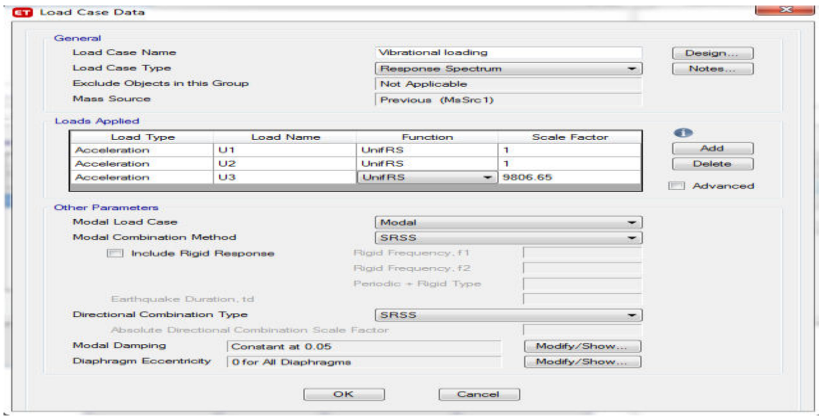


Fig 12: damping loading

Step-10: Assigning Load combination:

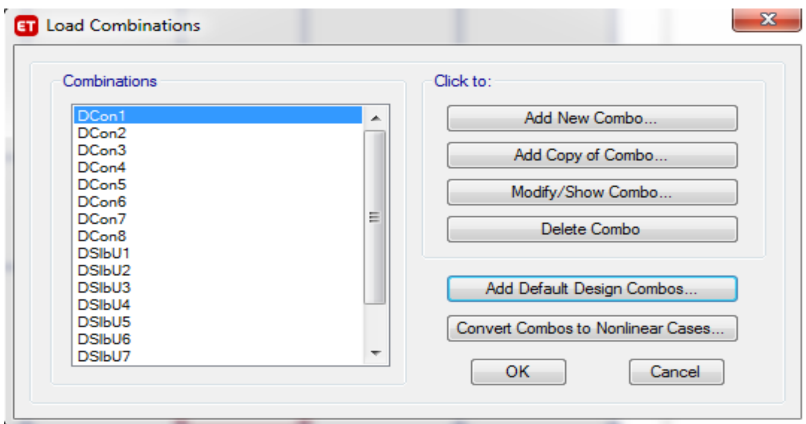


Fig 13: Load Combinations

Step-11: Check complete modelling and boundary conditions of the structure

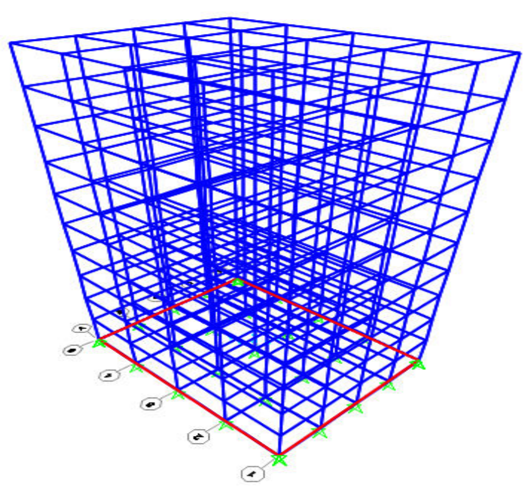


Fig 14: 3-d modelling of the structure

Step-12: Analysis 3-D model considering boundary conditions

Case-I Structure without tuned liquid damper (General structure):

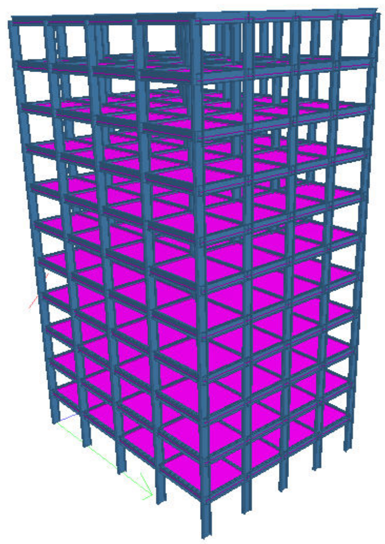


Fig 15: General structure

Case-II: Structure with tuned liquid damper:

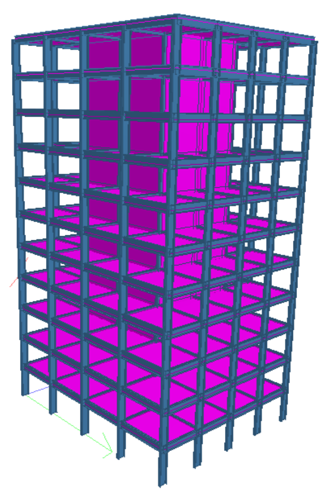
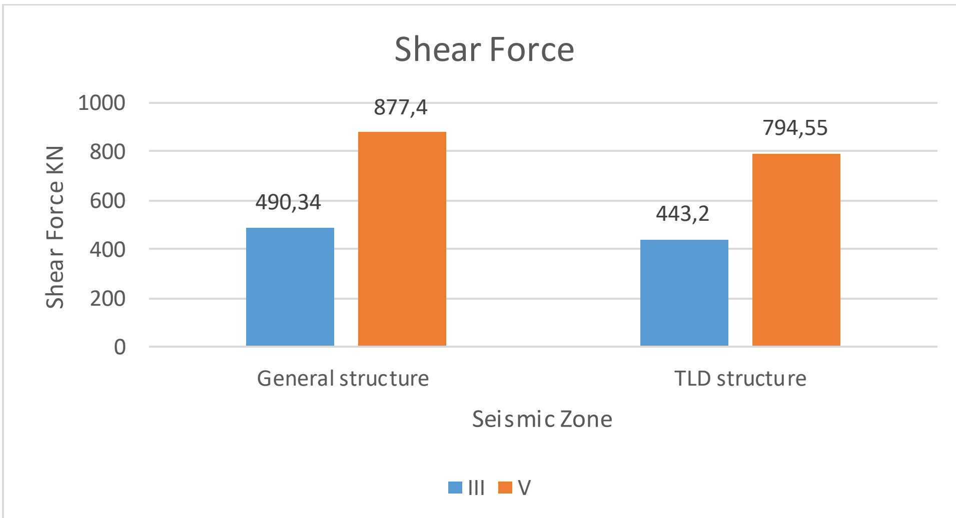


Fig 16: Tuned structure

Analysis

Table 2: Max. Shear Force

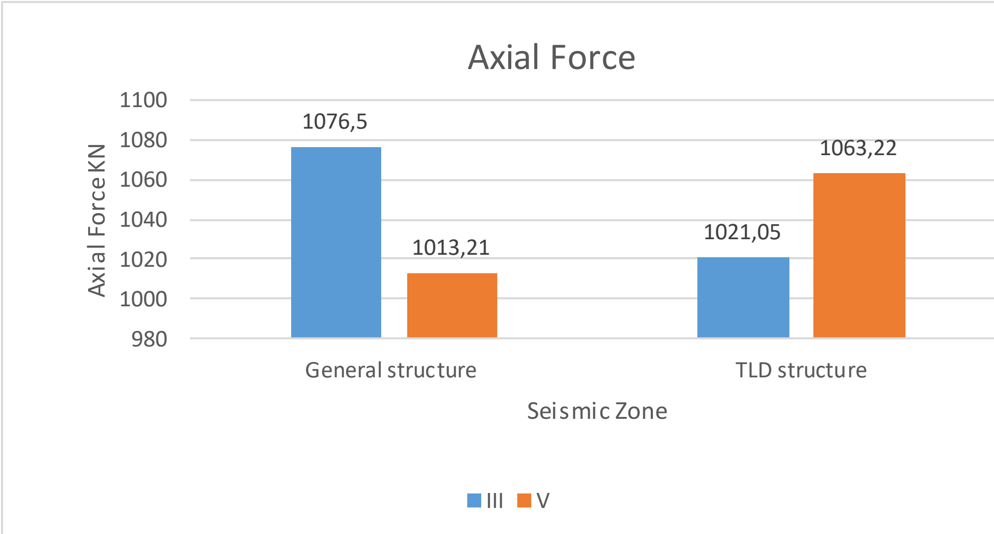
Max. Shear Force (KN)		
Zone	**General structure**	**TLD structure**
III	**490.34**	**443.2**
V	**877.4**	**794.55**



Graph 1: Max. Shear Force

Table 3: Max. Axial Force

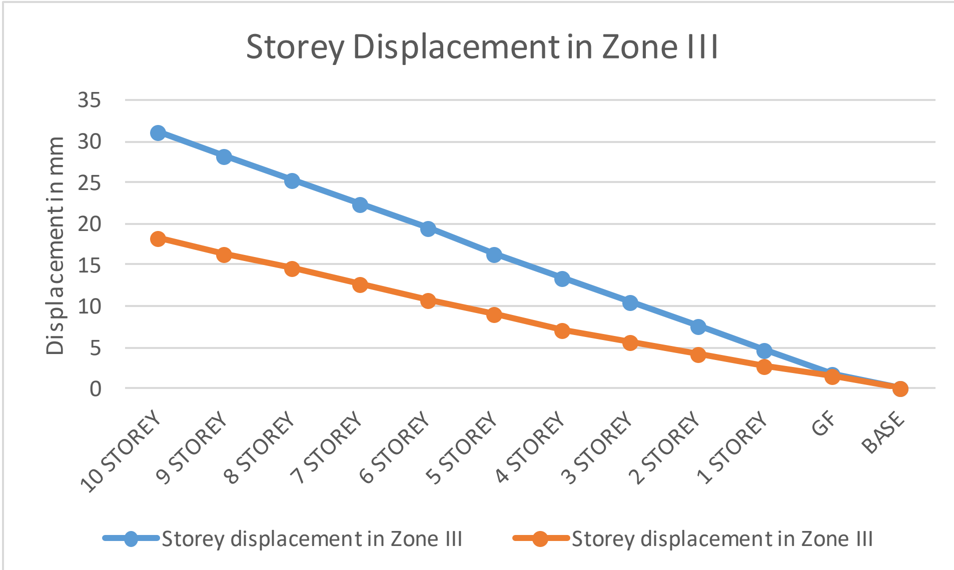
Max. Axial Force (KN)		
Zone	**General structure**	**TLD structure**
III	**1076.5**	**1021.05**
V	**1013.21**	**1063.22**



Graph 2: Max. Axial Force

Table 4: Storey displacement in zone III (MM)

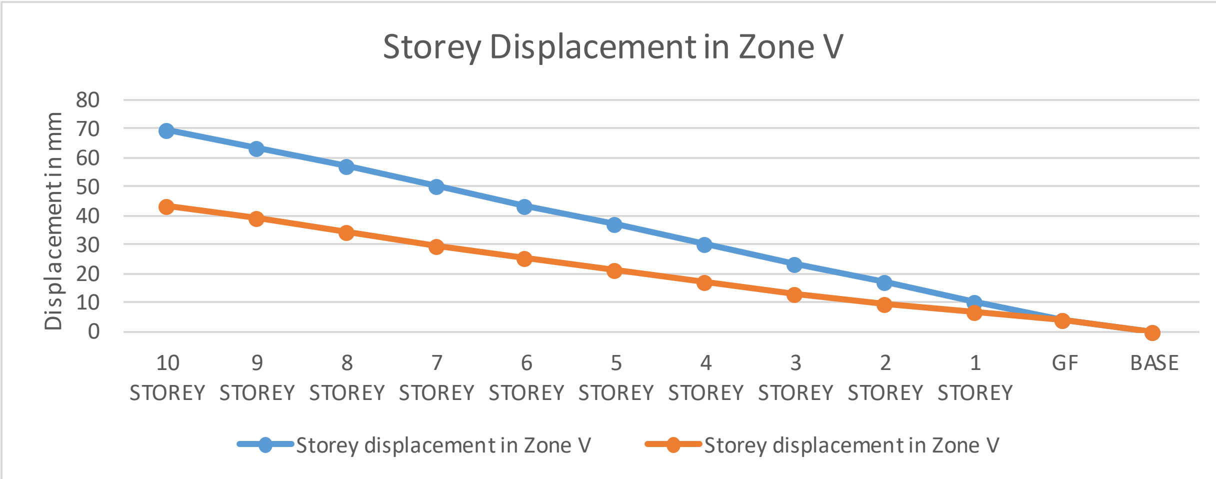
S.NO.	Storey displacement in Zone III	
	Conventional	TLD
10 STOREY	31.045	18.351
9 STOREY	28.21	16.44
8 STOREY	25.307	14.537
7 STOREY	22.358	12.647
6 STOREY	19.379	10.788
5 STOREY	16.387	8.969
4 STOREY	13.396	7.225
3 STOREY	10.42	5.59
2 STOREY	7.472	4.075
1 STOREY	4.571	2.706
GF	1.809	1.512
BASE	0	0



Graph 3: Storey Displacement in Zone III

Table 5Storey 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



Graph 4: Storey Displacement in zone V

Cost Analysis in zone III and V

Table 6: 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

Conclusion:

In conclusion of this investigation it may be said that TLD steel structure is equipped ;for keeping up the structure stable which results in opposing CG of the structure at its own position. Following observations are made in above chapters:

Storey Displacement:

It is observed that tuned liquid dampers are fit for opposing the general removal of the structure because of seismic forces, in contrast with general structure it is 37.4 % increasingly steady and opposing uprooting which outcomes in keeping up structure in reasonable point of confinement.

Bending Moment:

Tuned liquid damper structure is efficient in contrast with general structure as it has limiting twisting minute which will cause decrease in bending moment and large steel requirement.

Forces:

It is seen that the dispersion of burden become uniform and linear it instance of tuned liquid dampers. As far as hub forces the vertical circulation of forces become steady and flat forces produced

Cost: As observed in cost analysis TLD structure is cost effective than general structure in both the seismic zone with cost reduction of 8%.

Future Scope of the work:

i)In the proposed work high rise steel building is considered which can be increased to some more floors in future with variation in floor to floor height.

ii) In this study seismic analysis is considered whereas in future study wind load or blast load can be consider.

iii) In this study analysis is done using ETAB whereas in future SAP2000 can be prefer for P-delta analysis

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