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Analysis of Tuned Liquid Damper

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Abstract: The aim of this paper is to study the behavior of tuned liquid damper (TLD). When the structure is in harmonic seismic excitation. The tuned liquid damper is a device used to reduce the structural vibration. It is simply a tank filled with water which is situated at the top of structure. The tuned liquid damper uses the phenomenon of sloshing effect to reduce the vibration of structure. In this paper we are going to model the tunned liquid damper for a building using the ETABS software and the comparison of result between the building with tunned liquid damper and the building without tunned liquid damper is done.
Keywords: Tuned liquid damper, harmonic, seismic, excitation, sloshing, vibration.

I. INTRODUCTION

Earthquake are one of the most dangerous natural calamities which is destructive in nature. Earthquake of higher intensity may cause huge damage.

It not only harms the living being but also causes tremendous effect over structure. To safeguard the structure and to overcome from such problem, many devices and technologies are available. One of the techniques called tuned liquid damper (TLD) is an effective method to reduce the effect of earthquake and to safeguard the structure. [5]

The tuned liquid damper is container which is rigid in nature and generally rectangular in shape which is rigidly fixed at top of building or structure.

Depending on the space available, the container may be of many small tank combinations or a large single tank.[2] The structural vibration can be reduced by TLD through the sloshing effect which dissipate the energy. In recent research, it is seen that the TLD are widely used as vibration absorber due to its advantages like lower cost, easy to handle and require less maintenance. tubed liquid damper can be placed as number of small tanks or a single huge tuned liquid damper tank.[7]

II. TYPES OF TUNED DAMPERS

To deal with natural calamity like earthquake, different types of damper are available. These different types of damper use different working principles. They also have different efficiency, durability and effectiveness which depends on various factors. [1] So following are different types of damper

A. Tuned liquid damper
B. Viscous tuned mass damper
C. Dashop type tuned mass damper
D. Cable type tuned mass damper

III. OBJECTIVES

A. To study and analysis, the effect of TLD on building using software ETABS
B. To get significant results which shows that TLD dissipate the energy of earthquake and move structure Elastically by using dampers.
C. To reduce the dynamic response of the system by using TLD

IV. METHODOLOGY

The following are the steps use to analysis the tuned liquid damper

1) Modelling of the structure using ETABS
2) Designing the Tuned liquid Damper for structure
3) Modelling of the Tuned liquid damper using ETABS
4) Analysis

A. Modelling of Structure using ETABS

1) Properties of the RCC frame

a) Type of building – RCC
b) Story – G+6
c) Floor height – 3.5 m
d) Grid in x and y direction – 3 and 4 respectively.

2) Defining material Properties

a) Grade of concrete – M30
b) Grade of steel – Fe500
c) Density of concrete- 25 KN/ m^3

3) Defining the frame Sections

a) Beam size – 230 mm x 300 mm and 230 mm x 380mm
b) Column size – 600 mm x 600 mm

4) Defining the slab Section

Slab thickness – 125 mm

5) Defining Load Pattern

a) Live load – 2 KN/m^2
b) Floor finish – 1.5 KN/m^2
c) Dead load - width x depth x density of concrete
d) Importance factor – 1
e) Seismic zone – v
f) Seismic zone factor - 0.36
g) Response of reduction factor – 5

6) Defining Time History Function:

We use Bhuj Earthquake data to define time history function

B. Modeling of Structure With Tuned Liquid Damper

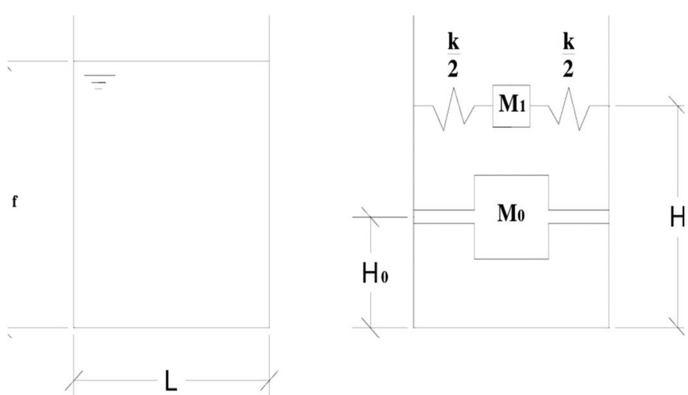

Fig 1: Lumped mass model for a rectangular Tuned liquid damper.

For modelling of structure with tuned liquid damper we use the same data of building without tuned liquid damper. Now for modelling tuned liquid damper the column size is same as that of building. Then we define wall section of 150 mm. We require M1, M0 and K.[3] As shown in Fig. 1 which can be calculate by using formula as shown below:

$m_f = \rho\, hf \cdot b \cdot L$

$M_0 = \frac{\tan h\,(\sqrt{3} * (L/2)\,/\,hf)}{(\sqrt{3} * (L/2)\,/\,hf)}.\,mf$

$M_1 = \frac{0.83\,.\,\tan h\,(1.6 * hf\left(\frac{L}{2}\right))}{(1.6 * hf\left(\frac{L}{2}\right))}.\,mf$

$H_0 = 0.38\,.\,hf\,.\,[\,1 + \alpha\left(\frac{mf}{M0} - 1\right)\,]$

$H_f = hf.\,[1\text{-}0.33.\,\left(\frac{mf}{M0}\right)\left(\frac{L/2}{hf}\right)^2 + 0.63\,\beta\left(\frac{L/2}{hf}\right).\,\sqrt{0.28\left(\frac{mf.(\frac{L}{2})}{M1.hf}\right) - 1.}\;\;]$

$K = 3.g.\,M_1^2\,.\,hf\,/\,mf.\,L^2$

Where, mf is mass of fluid, r is density of fluid, hf if height of fluid inside the tank, b is width of tank L is length of tank, =2.0 and =1.33.

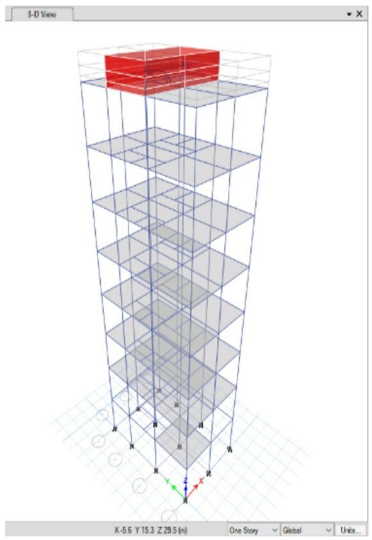

Fig 2: Model of building with tuned liquid damper.

V. RESULT

Table 1: Maximum Displacement of Building Without Tuned Liquid Damper Due To Earthquake Load in X-Direction

Story	Elevation	X-Dir mm	Y -Dir mm
Terrace	28	23.837	0.318
Story 6	24.5	22.153	0.296
Story 5	21	19.747	0.262
Story 4	17.5	16.633	0.218
Story 3	14	12.99	0.168
Story 2	10.5	9.052	0.113
Story 1	7	5.124	0.061
Plinth	3.5	1.696	0.02
Base	0	0	0

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Table 2: Maximum Displacement of Building With Tuned Liquid Damper Due To Earthquake Load in X-Direction

Story	Elevation	X - Dir mm	Y - Dir mm
Tank	29.5	19.904	0.154
Terrace	28	19.897	0.153
Story 6	24.5	18.848	0.136
Story 5	21	16.853	0.121
Story 4	17.5	14.172	0.101
Story 3	14	11.039	0.077
Story 2	10.5	7.675	0.051
Story 1	7	4.336	0.026
Plinth	3.5	1.433	0.008
Base	0	0	0

Table 3: Maximum Displacement of Building Without Tuned Liquid Damper Due To Earthquake Load in Y-Direction

Story	Elevation	X-Dir mm	Y -Dir mm
Terrace	28	0.063	23.572
Story 6	24.5	0.059	21.976
Story 5	21	0.053	19.652
Story 4	17.5	0.046	16.601
Story 3	14	0.037	12.997
Story 2	10.5	0.028	9.077
Story 1	7	0.018	5.148
Plinth	3.5	0.006	1.701
Base	0	0	0

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Table 4: Maximum Displacement of Building With Tuned Liquid Damper Due To Earthquake Load in Y-Direction

Story	Elevation	X - Dir mm	Y - Dir mm
Tank	29.5	0.05	19.669
Terrace	28	0.058	19.435
Story 6	24.5	0.054	18.448
Story 5	21	0.049	16.545
Story 4	17.5	0.042	13.954
Story 3	14	0.034	10.898
Story 2	10.5	0.025	7.595
Story 1	7	0.016	4.301
Plinth	3.5	0.005	1.42
Base	0	0	0

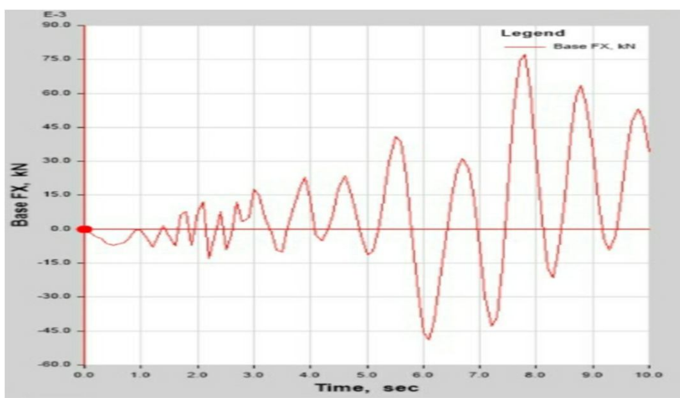

Fig 3: Time history plot of building without TLD

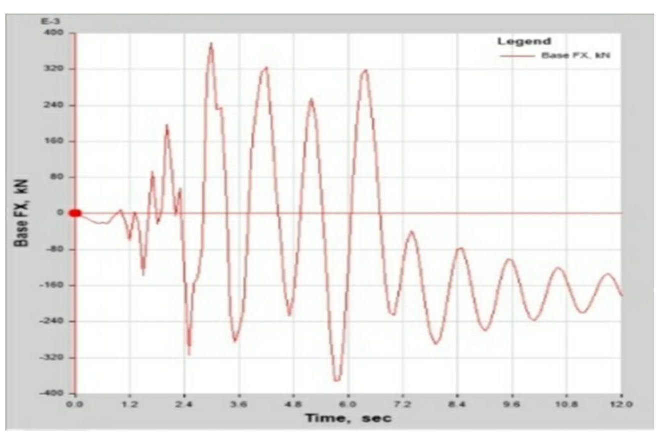

Fig 4: Time history plot of building with TLD

VI. CONCLUSION

The main object of paper is to analysis the tuned liquid damper and to compare the result between the building with tuned liquid damper and the building without tuned liquid damper. So, according to the result the displacement of building get reduces by some amount if we use the tuned liquid damper.

A. The tuned liquid damper can be use significantly on tall buildings to reduce the structural excitation and to control the structural damage.
B. Efficiency of TLD is based on various parameters i.e., mass ratio, depth ratio, number of tanks, running ratio.
C. The TLD become more effective with decrease in natural period of structure.
D. Tuned liquid damper offer greatly improved seismic/wind performance for conventional structure.

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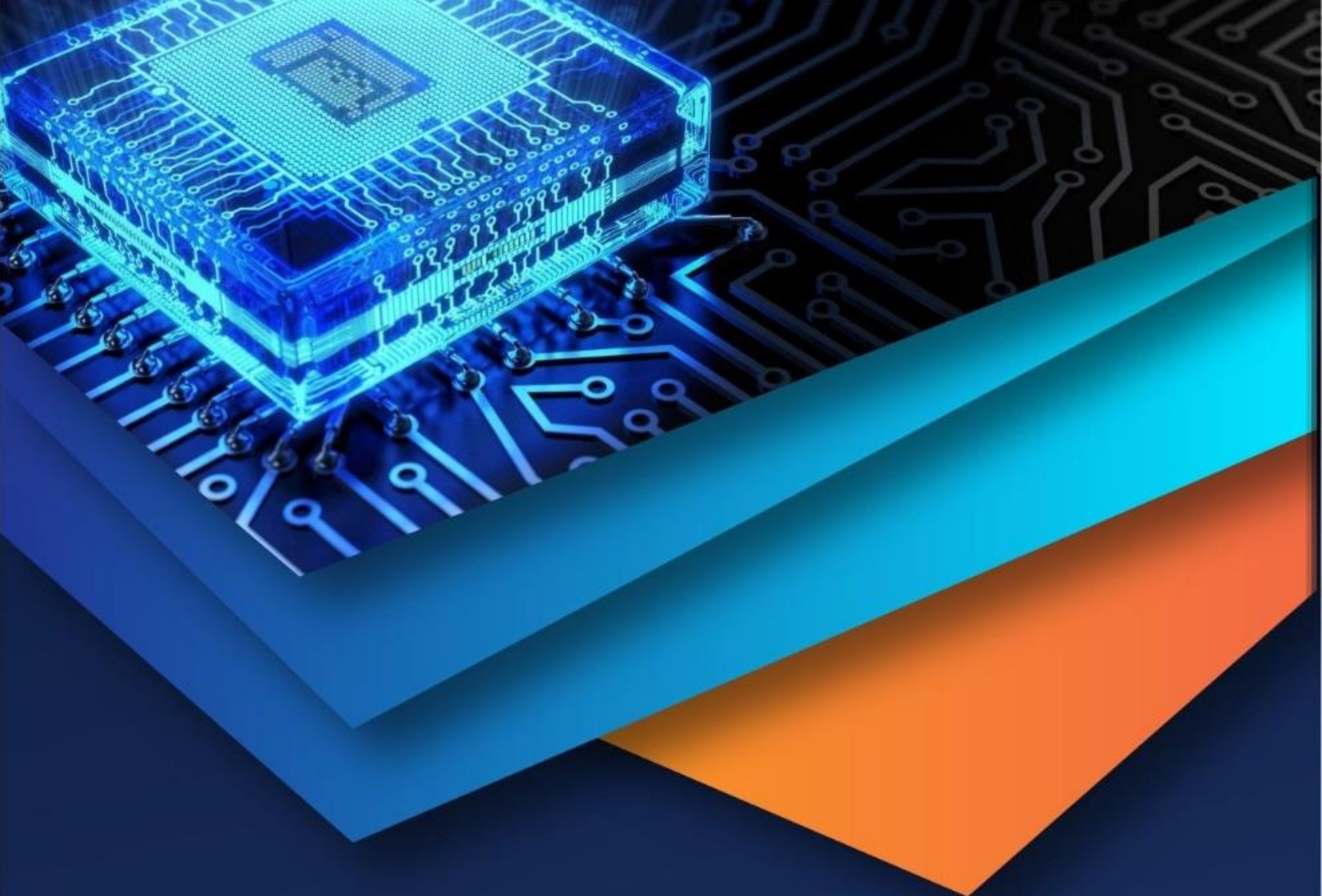

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