PARAMETRIC STUDY OF VISCOUS DAMPERS FOR SESMIC APPLICATION

Yedulla Jyothi [1], Kanchan B Kangali [2]

[1] Post-Graduate Student, Dept. of Civil Engineering, KLS Gogte Institute of Technology, Belagavi, India
[2], Assistant Professor, Dept. of Civil Engineering, KLS Gogte Institute of Technology, Belagavi, India

---***---

Abstract- *The current study investigates the effect of viscous damper on the response of the structure, when it is subjected to earthquake. A G+9 structure is analysed with and without dampers. The response of the structure such as Relative displacement, Relative velocity, Absolute acceleration and damping forces has been compared. The percentage reduction has been computed for each of the above. It was found that viscous dampers are very effective in controlling the response of the structure. All the algorithms are developed in MATLAB software. Based on number of dampers used six cases are considered.*

Key words: Viscous Damper, State Space method, El-Centro Earthquake, Seismic Excitation, Vibration Control, MATLAB.

1. INTRODUCTION

The vibration control has taken its root from the automobile industries. The Shock absorbers are installed in the automobiles, aircrafts, and mechanical machines to absorb the vibrations during any accidents or to reduce the discomfort caused to its users. This concept migrated into civil engineering and infrastructural such as bridges subjected to heavy loads of wind and earthquake, protecting high-rise buildings from dynamic loads. The number of high-rise building constructed is increasing year by year, this structure are usually of low damping capacities and therefore they are vulnerable to the vibrations. Therefore, increasing the damping capacity of the structure or protecting with the aid of mechanical devices of high damping ratio can dissipate this energy.

The vibration control method includes active control, passive control, semi active control, hybrid control. The selection of particular type of control method and devices depends on various factors such as configuration of the structure, dominating force whether earthquake or the wind, or both based on the location of the structure, cost of installation, operating cost, maintenance requirements and finally the level of the safety.

1.1 What is Tuned Mass Dampers (TMD)?

A tuned mass damper is a device consisting of mass, spring and the damper, which is attached to the main structure to reduce the dynamic response of the structure. The TMD is tuned to the particular frequency of the structure, when this frequency is excited, the damper will resonate out of phase with the structure. The TMD transfers the kinetic energy of the damper from the main structure to the damper and it dissipates the energy through vibration that is less likely to cause discomfort to the occupants. This concept was used by Frahm in 1909 (Frahm, 1909) for controlling the motion of ship in the sea and absorbing the vibrations caused in the ship.

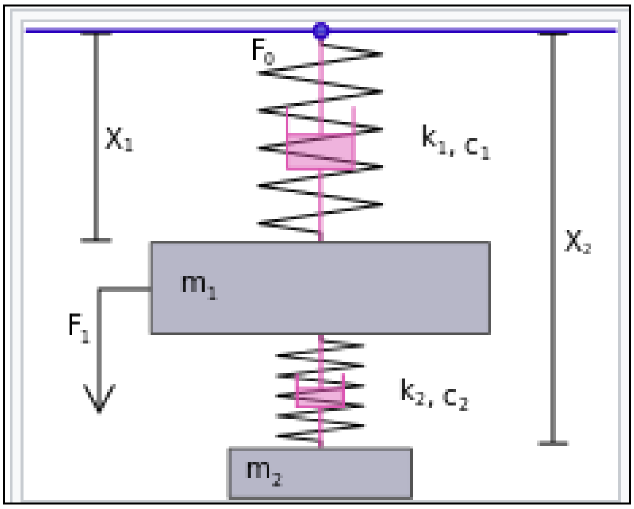

Figure 1: A schematics of simple spring-mass-damper system added to demonstrate TMD

2. METHODOLOGY

The force induced to the structure by the viscous damper at each of the attachment points of the viscous damper can be expressed as $\mathbf{F_{md}=C_{md}\,(\dot{X})^{n}}$, where

$\mathbf{F_{md}}$ =damping force from manufactured viscous damper
$\mathbf{C_{md}}$ =manufactured viscous damper damping coefficient,
n =power law coefficient

For single degree of freedom total damping force is given as

$F_d= F_{nd} +F_{md}$

Where F_{nd} is force due to natural damping force

The dynamic equilibrium equation of motion for a SDOF system subjected to an earthquake ground motion is given by

$$\mathbf{m\,\ddot{x}(t) +c_{nd}\,\dot{x}(t)+ c_{md}\,\dot{x}(t)+k\,x(t)= -m\,a(t)} \qquad (1)$$

Where $w_n=\sqrt{k/m}$, ζnd= is critical damping ratio from natural damping, $C_{nd}=2\zeta_{nd}w_n m$, $C_{md}=2\zeta_{md}w_n m$

Equation 1 can be written as

$$\ddot{x}(t) +2\zeta w_n\,\dot{x}(t)+ c_{md}\,\dot{x}(t)+(w_n)^2x(t)= -a(t) \qquad (2)$$

Where ζ represents the total critical damping ratio of the structure, and is given by

$$\zeta=\zeta_{nd}+\zeta_{md} \qquad (3)$$

The equation 2 is second order differential equation and thus it requires two initial conditions to be defined. These initial conditions generally are the initial displacement of the mass, $x(0) = x_0$, and initial velocity of the mass $(0) = \dot{x}_0$, the response is obtained using State Space method. The response obtained is compared for reduction.

3. Modeling and Analysis

Problem Statement 1

- Type of structure : Multi-stored rigid jointed plane frame(special RC moment resisting frame)
- Number of stories : Ten (G+9)
- Floor height : 3.0 m
- Infill wall : 230 mm wall thick including plaster
- Imposed load : 3.0 kN/m^2
- Materials : Concrete M20, Reinforcement Fe415
- Size of Columns :230x450 mm
- Size of beams : 230x350 mm
- Depth of slab :150 mm
- Specific weight of RCC :25kN/m^3
- Specific weight of infill :20kN/m^3
- Natural damping of the building : 5%
- Type of earthquake considered for analysis of response: 1940 El- Centro earthquake.

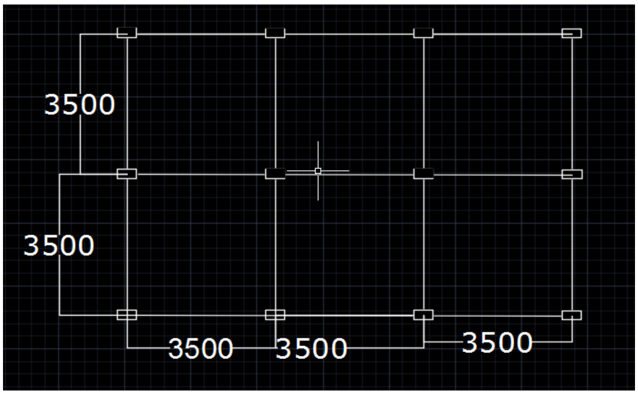

Figure 2: Plan showing column and beams at floor levels of frame

Different cases are considered for the analysis of the performance of damper based on the location and the number of the damper. Six such cases are considered for this problem. Those six cases are as follows

Case 1: Without any damper
Case 2: Damper is placed on the 10th storey
Case 3: Damper positioned at 10th and 8th storey
Case 4: Damper positioned at 10th, 8th and 6th storey
Case 5: Damper positioned at 10th, 8th, 6th storey and 4th storey
Case 6: Damper positioned at storey 6

The response is obtained using state space method,. The power law coefficient is taken as 0.5 and damping ratio of damper is taken as 0.15. Chart 1 to 6 shows the displacement(m) v/s time for various cases considered. Each chart shows displacements of all 10 stories.

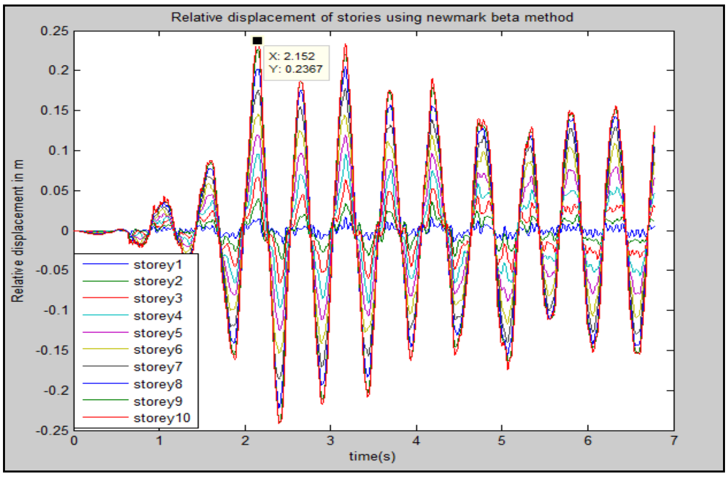

Chart 1: Case 1-with natural damping

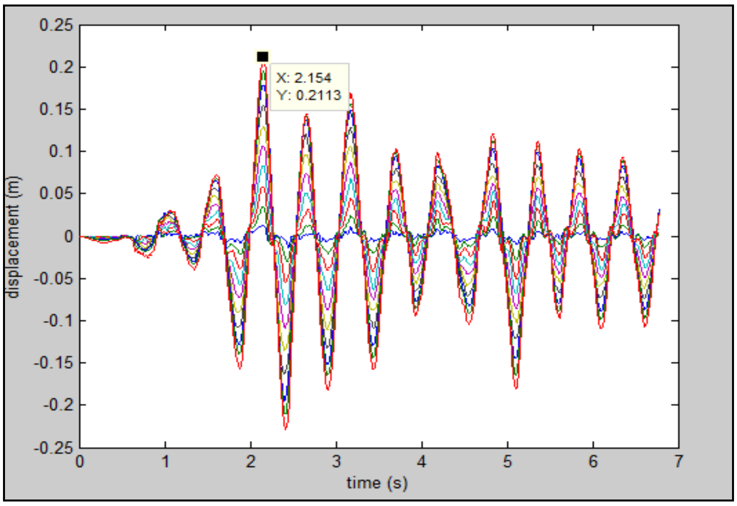

Chart 2: Case 2- Damper is placed on the 10th storey

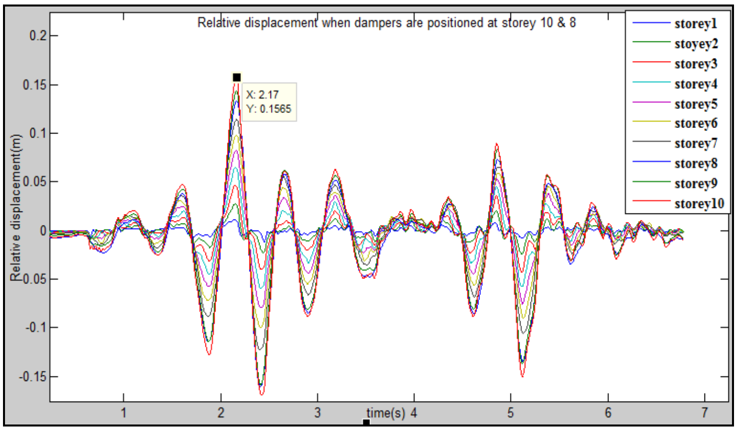

Chart 3: Case 3-Damper positioned at 10th and 8th storey

International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056
Volume: 04 Issue: 05 | May -2017 www.irjet.net p-ISSN: 2395-0072

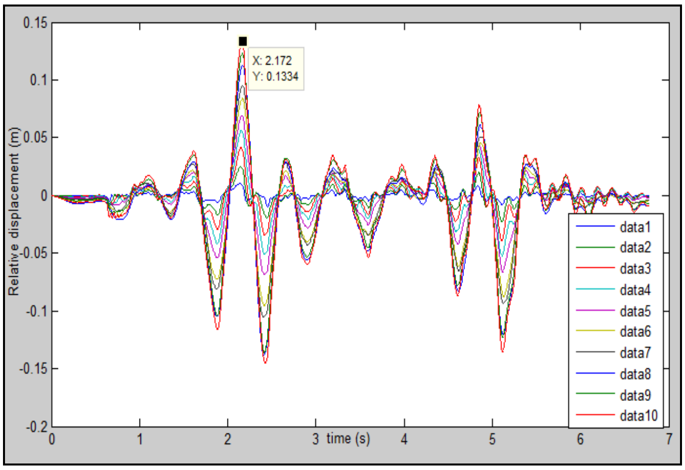

Chart 4: Case 4-Damper positioned at 10th, 8th and 6th storey

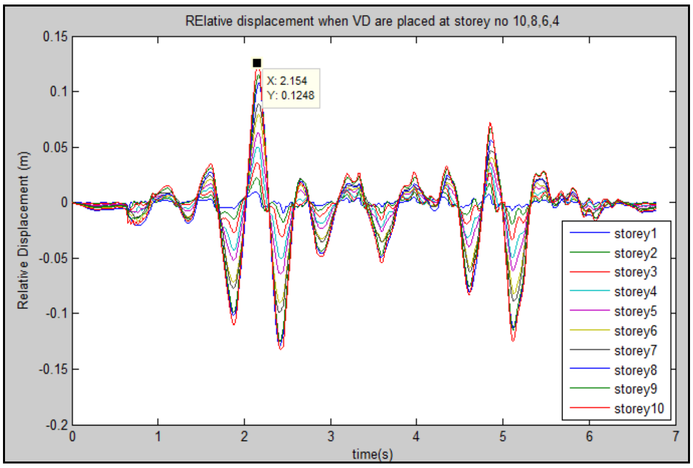

Chart 5: Case 5-Damper positioned at 10th, 8th, 6th storey and 4th storey

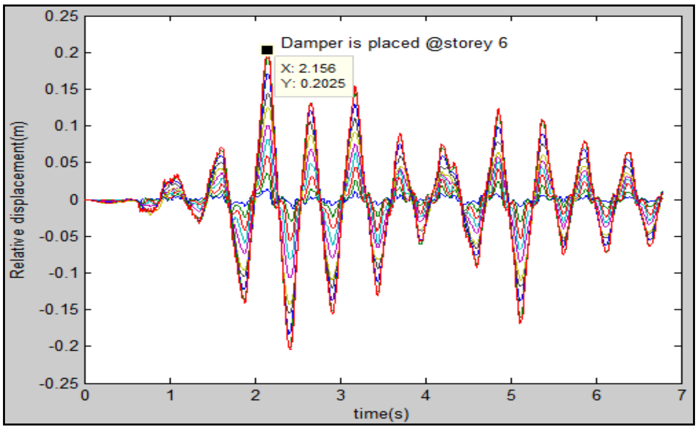

Chart 6: Case 6-Damper positioned at 6th storey

4. RESULTS AND DISCUSSIONS

4.1 Tabulations of Results

Table 1: Maximum Relative Displacement in meters using viscous damper under locations

Storey No	Maximum Relative Displacements At Different Stories (m)					
	Case 1	Case 2	Case 3	Case 4	Case5	Case 6
10	0.244	0.221	0.163	0.134	0.130	0.200
9	0.237	0.206	0.143	0.123	0.125	0.195
8	0.217	0.189	0.132	0.113	0.129	0.170
7	0.172	0.159	0.114	0.095	0.097	0.169
6	0.146	0.129	0.097	0.084	0.088	0.143
5	0.119	0.105	0.082	0.069	0.061	0.100
4	0.0960	0.084	0.063	0.056	0.0497	0.082
3	0.066	0.058	0.046	0.042	0.0352	0.059
2	0.038	0.034	0.027	0.025	0.0221	0.035
1	0.0162	0.013	0.011	0.0104	0.0096	0.013

Table 2: Percentage Reduction of the response for different cases using state space method

Percentage Reduction (%) Of Response For Different Combinations Using State Space Method			
Different Combinations	**Relative Displacement**	**Relative Velocity**	**Increase in Damping Force**
Case1	-	-	-
Case 2	11.37139	76.015	11.4
Case 3	34.94959	94.065	25.4
Case 4	44.45003	94.316	36.1
Case5	44.65114	95.773	41.5
Case6	13.51859	92.996	15.7

4.2 Discussions

1. The 10 storey structure considered in the problem statement, initially this problem is analyzed without any damper and obtained the response.
2. Reduction in relative displacement response for case2, case3, case4 case5 and case6 is 11.37%, 34.95%, 44.45% 44.65% and 13.52 % respectively compared to without any damping case.
3. Reduction in relative velocity response for case2, case3, case4 case5 and case6 is 76.015%, 94.06%, 94.316% ,95.773% and 92.996 % respectively compared to without any damping case.
4. Increase in damping force for case2, case3, case4 case5 and case6 is 11.4%, 25.4%, 36.1%, 41.5% and 15.7 % respectively compared to without any damping case.

5. From all the cases we can conclude that there is reduction in response of the structure as number of dampers are increased. If only damper has to be placed than the effective location would be on storey six. Since when damper is placed on storey six it reduces responses much effectively compared to the responses obtained when damper is placed on storey 10.
6. It can be concluded that viscous dampers are more effective over semi-active friction dampers considering pros and cons of each.

5. CONCLUSIONS

From the above results and discussion it is seen that dampers can be used effectively in controlling the seismic vibration during an earthquake. They can be used in tall structures which are prone to earthquake and wind induced vibrations. Their effectiveness depends on design parameters of the dampers selected. One has to master the knowledge of dampers in order to decide the exact location, type of damper required and number of dampers to achieve the required results. In these project out of two dampers considered viscous damper proved to be best. They can be used to control both wind and seismic induced vibrations

REFERENCES

1. Alka Y. Pisal and R. S. Jangid," Seismic Response Of Multi-Story Structure With Semi-Active Multiple Tuned Mass Friction Dampers", International journal of computational engineering research, vol,03, issue 8, pp 53-78.
2. Ashish A. Mohite, G.R. Patil, et al. "Earthquake Analysis of Tall Building with Tuned Mass Damper" IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), e-ISSN: 2278-1684, p-ISSN: 2320 334X, PP 113-122.
3. Frahm, H., Device for damping of bodies. US Patent No: 989,958, 1911.
4. IS 875 (Part 1) – 1987; "Code of Practice for Design Loads (Other Than Earthquake) for Buildings and Structures – Dead Loads"; Bureau of Indian Standards, New Delhi.
5. IS 875 (Part 2) – 1987; "Code of Practice for Design Loads (Other Than Earthquake) for Buildings and Structures – Imposed Loads"; Bureau of Indian Standards, New Delhi.
6. Jangid, R.S. "Seismic response of isolated bridges", Bridge Engineering, Vol.9, No.2, pp. 156- 166(2004).
7. Kwok, K.C.S., and Samali, B. (1995). "Performance of tuned mass dampers under wind loads." Eng. Struct., 17 (9) , 655-667
8. Li, C. (2002). ―Optimum multiple tuned mass dampers for structures under the ground acceleration based on DDMF and ADMF.‖ Earthquake Engineering Structural Dynamics, 31(4), pp 897–919.
9. Li, C. (2003). ―Multiple active-passive tuned mass dampers for structures under the ground acceleration. Earthquake Engineering Structural Dynamics, 32(6), pp949–964.
10. Lin, Chi-Chang, et al. "Vibration control of seismic structures using semi-active friction multiple tuned mass dampers." Engineering Structures 32.10 (2010): 3404-3417.
11. Muhammed Murad.K And Lavanya.G, "Dynamic resistance of tall buildings by using tuned mass damper's (TMD'S)",International Conference on Current Research in Engineering Science and Technology (ICCREST-2016).
12. Ormondroyd, J. & Den Hartog, J.P., The theory of dynamic vibration absorber. Trans., ASME, 50, pp. 9-22, 1928

BIOGRAPHIES

Yedulla Jyothi
Post-Graduate Student,
Department of Civil Engineering,
KLS Gogte Institute of Technology,
Belagavi, India- 590008

Prof. Kanchan B Kangali
M.Tech (Structural Engineering), B.E (Civil),
Assistant Professor,
Department of Civil Engineering,
KLS Gogte Institute of Technology,
Belagavi, India- 590008