International Journal of Engineering Innovation & Research
Volume 3, Issue 4, ISSN: 2277 – 5668

Evaluate the Effectiveness of the use of, Viscoelastic Damper on the Behavior of Steel Structures

Samaneh Khaksefidi
Faculty, Department of Civil Engineering,
University of Zabol
Email: samaneh112@yahoo.com

Hossein Ali Rahdar
Faculty, Department of Civil Engineering,
University of Zabol
Email: rahdar@uoz.ac.ir

Mohsen Rezaee
Faculty, Department of Civil Engineering,
University of Zabol
Email: m59_rezaee@yahoo.com

***Abstract* – Today, the use of seismic dampers to control vibrations of the structure against earthquake forces, as depreciated energy systems, while concentrating inelastic deformations, during an earthquake, in these systems, ease finds, as well as the repair and rehabilitation of structures. In this method, be used as a method of controlling structures.**

So, to review the results of using this method, the performance of steel structures, steel building, is modeled on the 12 floor, and a three-dimensional, and the increase in viscoelastic damper, the structural analyzes of is, in terms of time histories, acceleration, and displacement of the roof, and the relative displacement stories, have been investigated. The results show that, this method has caused reductions roof displacement. Comparison of all results is presented in the context of this paper.

***Keywords* – Accelerogram, Relative Displacements, Structural Control, Viscoelastic Damper.**

I. Introduction

Among the methods that have been considered in recent years to strengthen the structures, is used in energy absorbing systems, without a significant increase in the stiffness of the system increases, the energy dissipation capability set, a lot. For this purpose, a variety of energy-absorbing systems, have been developed and introduced, among which we can mention the steel dampers, friction, viscous liquid, and viscoelastic. By doing this means, is that, with the transmission mechanism of energy dissipation in the plastic hinges that are created, the main structural member to a second member, causing reduced, the plastic deformation on the structure and damage applied to it.

II. Introduction of Structural

Buildings surveyed is a 12-storey building which is modeled in the form of a simple steel frame, with a brace of vestibule, two central span of perimeter frames, and an intermediate frame with 6 span 6 meters, 4 span 4.5 meters.

II.I. Parameters used in the modeling and design

1. User Type of Construction: Residential
2. Building up zone: an zone with very high seismicity
3. Types of soil: the soil type Π
4. Type of lateral backer system: a simple frame with vestibule bracing
5. Buildings affected Tabas earthquake time history has been analyzed.
6. Roof porter system type: Concrete slab

II.II. loading and material properties

Loads on the structure and material properties, are given in Tables 1 and 2.

Table 1: Profile of loads on structure [1] ,[2]

Load / Story	Roof Dead Load	Partition Load	Total Dead Load	Dead Load Minus the Weight of the Slab, and Pseudo-Ceiling	External Wall load	Live Load
Stories	470	130	600	360	300	200
Roof	550	75	625	385	300	150

Table 2: Specifications of materials consumed [1]

Concrete		Steel	
Mass per unit volume	$245\ {kg}/{m^3}$	Mass per unit volume	$795\ {kg}/{m^2}$
Weight per unit volume	$2400\ {kg}/{m^2}$	Weight per unit volume	$7800\ {kg}/{m^2}$
Modulus of elasticity	$2.18\times10^5\ {kg}/{m^2}$	Modulus of elasticity	$2.06\times10^6\ {kg}/{m^2}$
Poisson's ratio	0.2	Poisson's ratio	0.3
Compressive strength of concrete	$280\ {kg}/{m^2}$	Yield stress of steel	$2400\ {kg}/{m^2}$

International Journal of Engineering Innovation & Research
Volume 3, Issue 4, ISSN: 2277 – 5668

Yield strength of longitudinal bars	$4000\ {kg}/{m^2}$	The ultimate strength of steel	$3600\ {kg}/{m^2}$
Yield strength Stirrup	$3000\ {kg}/{m^2}$		

III. Viscoelastic Dampers

The dampers, first time used in the towers of the World Trade Center in New York City, to deal with the vibrations caused by the wind. The use of dampers, controlling the seismic response of structures, has been in recent years. In this case, a greater increase in mortality, compared with the case of wind power is needed. To describe the dynamic behavior of these materials is provided, numerous mathematical models. In this regard, we can mention two common models of Maxwell, and Kelvin-. Model Maxwell, consists of a spring and a linear damper, in series. This model is used for fluid viscous dampers. The mathematical model Kelvin, viscoelastic material, is considered to be a spring and a linear damper, in parallel. This model is suitable for describing the behavior of solid viscoelastic dampers. A typical viscoelastic damper, is shown in the following figure.

Hard plastic is calculated using equation (1) [3-4]:

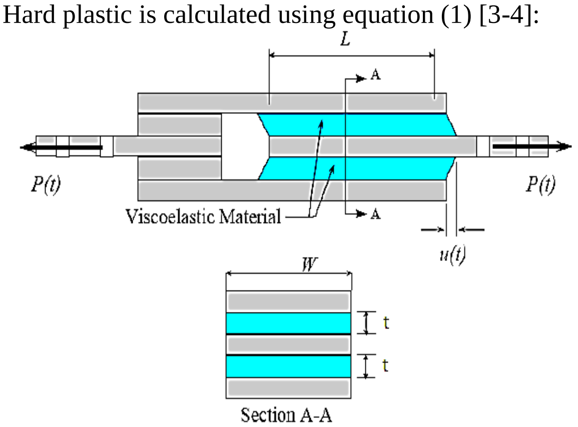

Fig.1. Geometry of a viscoelastic damper

In that case, the viscoelastic damper, placed in the structure, the control is created visible by the damper, as follows:

$$F_d = C_d \dot{u} + k_d u \quad (1)$$

In this regard, the parameters C_d and K_d, are calculated as follows depending on the damper characteristics.

$$c_d = \frac{n_v \eta G_1 A_v}{\omega h_v}, k_d = \frac{n_v G_1 A_v}{h_v} \quad (2)$$

Force where, η is the loss factor, the $\eta = \frac{G_2}{G_1}$, G_1 and G_2, are respectively, the shear storage modulus, loss modulus and shear viscoelastic material, n_v, is the number of layers, the viscoelastic damper, and finally A_v and h_v respectively, the cross-sectional area and thickness of each layer. Also, ω, is the frequency of the excitation. The standard linear model, is composed of a linear spring, the series, is connected to the Kelvin model [5-6].

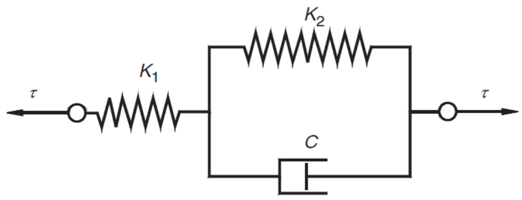

Fig.2. The standard linear material models

The relationship between stress and strain, in this case, can be expressed by the following equation:

$$\tau + p_1 \dot{\tau} = q_0 \gamma + q_1 \dot{\gamma} \quad (3)$$

τ And γ ,respectively, are the shear stress and strain. Also, p_1 , q_0 and q_1 are dependent coefficients, the damper characteristics. Here, used the theory of heat - the equivalent frequencies for all values G_1 and η [8]

$$G_1 = \left(q_0 + p_1 q_1 \alpha_T^c \omega^c\right) \Big/ \left(1 + p_1^2 \alpha_T^c \omega^c\right) \quad (4)$$

$$\eta = \left(q_1 - p_1 q_0\right) \alpha_T^d \omega^d \Big/ \left(q_0 + p_1 q_1 \alpha_T^{2d} \omega^{2d}\right) \quad (5)$$

$$\alpha_T = 10^{-\frac{12(T - T_0)}{[525 + (T - T_0)]}} \quad (6)$$

The relationship between the force-displacement of viscoelastic damper, are oval, which corresponds to the equation, as follows [7].

$$\left(\frac{F_d - K_{dl} u_d}{\eta K_{dl} u_0}\right)^2 + \left(\frac{u_d}{u_0}\right)^2 = 1 \quad (7)$$

The following relationship, are established, the damper characteristics and the geometry

$$K_{dl} = \frac{F_1}{u_0}, G_1 = \frac{F_1 h_v}{n_v A_v u_0}, \eta = \frac{F_2}{F_1} \quad (8)$$

$$G_2 = \eta G_1, E = \frac{\pi n_v A_v G_2 u_0^2}{h_v} \quad (9)$$

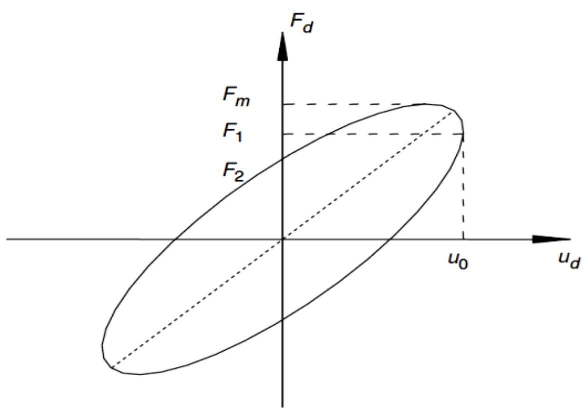

Fig.3. The hysteresis cycle of force - displacement [7]

The viscoelastic properties of the material used should be introduced. Here is a selection of the material damping ratio will result in greater difficulty. Hence, the material advantage is 9050A. The material properties are as follows.

$q_0 = 2.7405E6, q_1 = 3.3825E5, P_1 = 0.0048$

C=1.34, d= 0.58, $T_0 = 94^{oc}$

The design of dampers, the damping of both modes of the structure, where the first and third modes have been selected for the damper structure, based on the value of the damping coefficients α and β, are available. It can be seen that the most suitable distribution dampers, so that the damping of the motion of the structure from top to bottom, gradually increased, until, on the second floor, to reach its maximum value, and the first floor, slightly decrease. According to what was said, several categories of damper are used in stories.

Table 2: Profile dampers used in building

Type of damper	Type 1	Type 2
Effective stiffness	**51366.40**	**34244.27**
Damping	**66081.29**	**44054.19**
The primary stiffness	**490771.27**	**490771.27**
Cross section	**39600.00**	**39600.00**
Number of Layers	**6.00**	**6.00**
The thickness of each layer	**30.00**	**45.00**
The maximum displacement of damper	**10.00**	**10.00**
All values are written in terms of N-mm		

Table 4: Kind of damper used in stories

Type of damper	Damper Type 1	Damper type 2
Story	First to sixth	Seventh to twelfth

IV. Survey Results

The results of the analysis of the structures controlled by the viscoelastic damper, is given in the following figures, in these curves, partial displacement, and displacement of stories in both the longitudinal and transverse directions, and the history of roof displacement and acceleration roof for structures without damper and structures with viscoelastic damper, is compared.

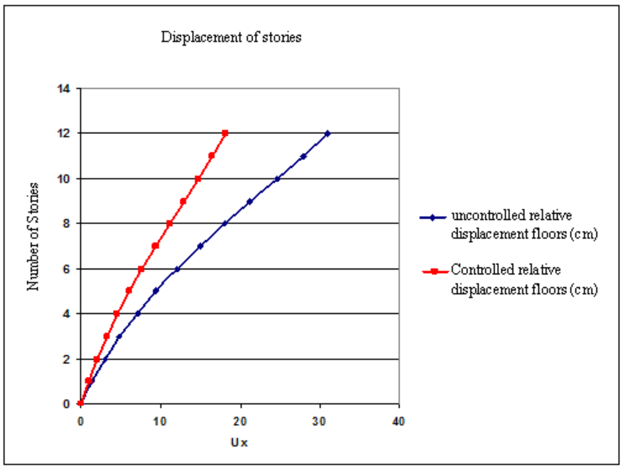

Fig.4. Displacement stories in the longitudinal direction

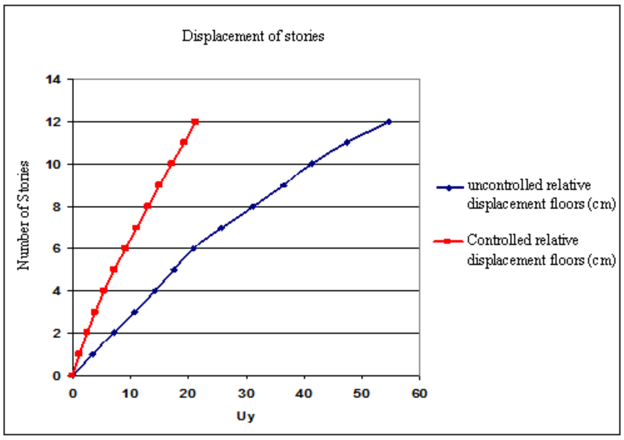

Fig.5. Displacement stories in the transverse direction

Use the damper, has led to reduced displacement of stories, so that, at the level of the roof, for both longitudinal and transverse directions, this reduction is more than 70 percent. At the middle stories, the rate of decrease was smaller, so that, for the sixth floor, the rate of decrease has been about 50%, and at the lower stories, this value is lower.

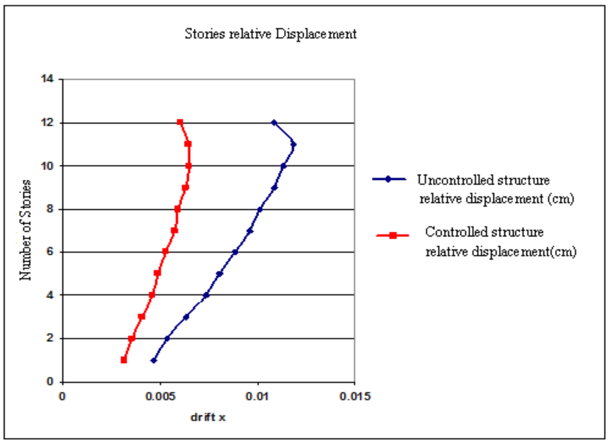

Fig.6. The relative displacement stories in the longitudinal direction

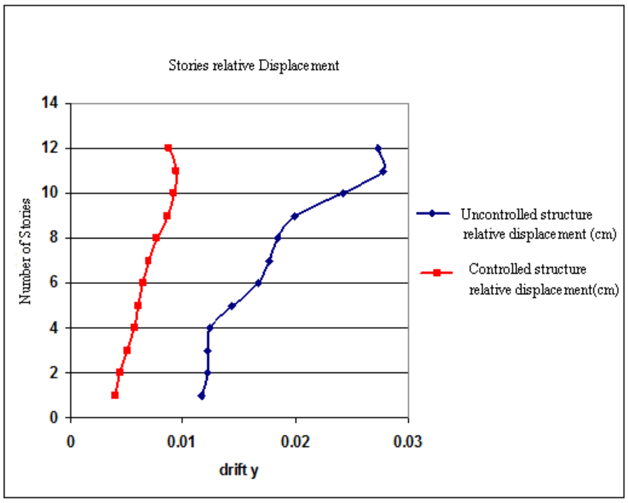

Fig.7. The relative displacement stories in the transverse direction

The use of viscoelastic damper, has led to the displacement of stories, reduced to a large extent, the reduction in the transverse direction is higher

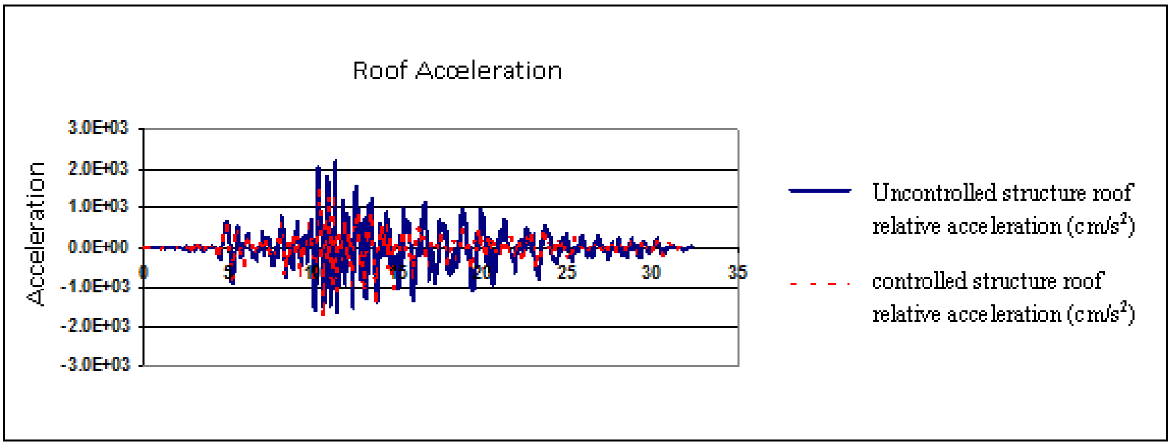

Fig.8. History of roof acceleration

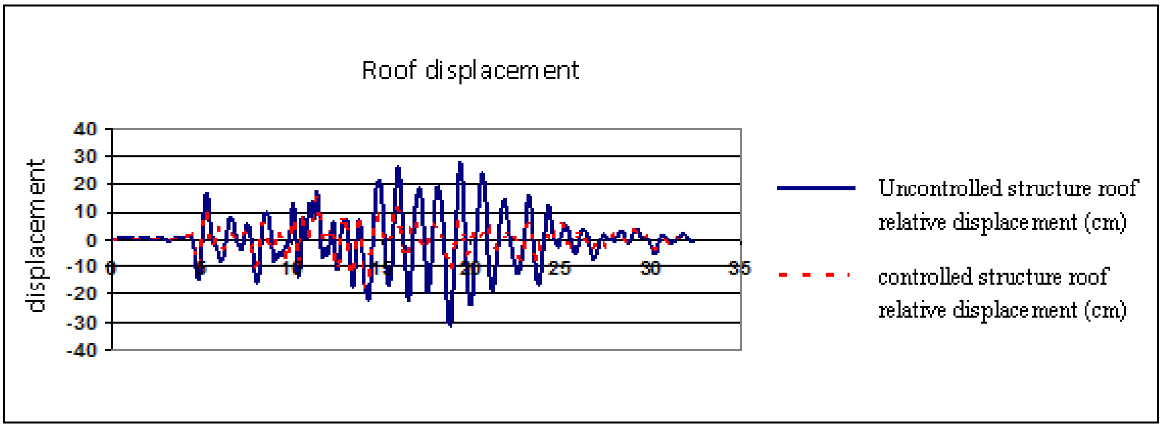

Fig.9. History of roof displacement

The use of viscoelastic damper, has led to a decrease in the peak of the roof acceleration time history and displacement, the displacement of the roof, the decrease for the peak in the mid-second acceleration time Accelerogram, much more has been reduced and , up 50 percent.

Conclusion

Curves obtained from the study, the analysis of steel structures, and time history analysis of structures by accelerogram of Tabas earthquake, the following results were obtained:

In general, control structures, has led to a reduction of roof displacement, and displacement stories

Use the damper, has led to reduced displacement at stories, so that, at the level of the roof, for both longitudinal and transverse directions, this reduction is more than 70 percent. The middle stories, this reduction are less, so that, for the sixth floor, the rate of decrease has been about 50%, and the lower stories, this value are lower.

The use of viscoelastic damper, has led to the displacement of stories, significantly reduced, the rate of decrease in the transverse direction is higher.

The use of viscoelastic damper is triggered, decreasing at the peak of time history of acceleration and roof displacement, for roof displacement, the decrease for the peak in the mid-second accelerograms is much higher, and has been decreased to 50 percent.

Dampers, in both directions, as well as reduce the relative displacement, and makes up, drift, are more uniform in height

References

[1] "Loads on buildings (the sixth issue of National Building Regulations)," Building and Housing Research Center, Department of Housing and Urban Development, 2013.

[2] "Regulations for seismic design of buildings (2800), Third Edition," Building and Housing Research Center, Department of Housing and Urban Development, 2005.

[3] De La Llera, J. C. Almazan, J. L. Vial, I. J. Ceballos, V. and M. Garcia, "Analytical and experimental response of asymmetric structures with friction and viscoelastic dampers," Proceeding of 13th World Conference on Earthquake Engineering, Vancouver, B.C., Canada, 2004, paper No. 531.

[4] J. C. De La Llera, I. J. Vial, J. L. Almazan, and E. C. Fighetti, “Balanced design of asymmetric buildings with energy dissipation devices,” Proceeding of the 8th National Conference on Earthquake Engineering, San Francisco, California, USA, 2006, Paper No. 1670.

[5] D.G. Lee, S. Hong and J. Kim, “Efficient seismic analysis of building structures with added viscoelastic dampers,” Engineering Structures 24, 2002, pp 1217–1227.

[6] S. T. Semih, U. Ozan, “Reduction of earthquake response of plane frame buildings by viscoelastic dampers,” Engineering Structures 25, 2003, pp 1755–1761.

[7] K. W. Min, J. Kim and S. H. Lee, “Vibration tests of 5-storey steel frame with viscoelastic dampers,” Engineering Structures 26, 2004, pp 831–839

[8] Z. D. .Xu, H.T. Zhao, A. Q. “Optimal analysis and experimental study on structures with viscoelastic dampers,” Journal of Sound and Vibration 273, 2004, pp 607–618.