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A study of performance of seismic steel bending frame equipped with frictional damper and diametrical member

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Abstract

One of the methods for reduction of dynamical response of structure against the seismic loads is to use the frictional dampers which, today, very extensive application of these dampers have been expanded greatly in designation of new building and/ or resistant-making of the available building. In these dampers, mechanism of performance is in such a way that value of input energy into the structure is absorbed and depreciated. Thus, this tool has an appropriate influence on the seismic behavior of the structure. In the current research, using analysis of non-linear time history, a 8- story structure equipped with frictional dampener and diametrical member is to be modeled in the Opensees software through two- dimensional form and compared with lack-of- dampener structure. Finally, the results suggest appropriate influence of the frictional damper on decrease of the lateral displacement of the structure and reduction of the knots/nodes against the lack- of- damper frame.

Keywords: Frictional damper;seismic optimization; seismic parameters; analysis of time history

1. Introduction

For the purpose of structural designation of the buildings, in addition to loading resulted from the gravity force, environmental forces, including wind, waves and earth quake are exerted on the structure as well. In a lot of buildings, the force resulted from earth quake is a determinant factor in designation of the structures.

By combination of the factors such as hardness, these buildings show plasticity in the limits of the elastic behavior and resistance in the limits of the plastic behavior as well as a mechanism for energy damping against the earth quake force. Quantity of damping is very low in the common building. Therefore, the energy dampened in the limits of elastic behavior is negligible. While occurrence of the strong earth quakes, these buildings are gone out of the limits of elastic behavior and show much displacements, and a great quantity of the earth quack energy is depreciated by the topical

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destructions in the lateral resistant system of the structure.

In the recent decade, the depreciator tools of the energy have been taken into consideration specially which one of these tools is to use frictional dampeners. These dampeners were invented for the first time by Pall et al. in 1980. Due to lack of requirement for special materials and technology, these dampeners are counted as one of the best ways for promotion of the seismic behaviors of the structures which these dampeners are employed in three passive inactive, half active and active states.

In the inactive/ passive control, vibrating kinetic energy of the building is depreciated in various mechanisms, and more than one mechanism participates in the damping phenomenon. In these mechanisms, damping phenomenon occurs due to internal friction and/ or heating phenomena resulted from going -back and forth- elastic bowings of the materials. By these descriptions, it is noted that definition of a mathematical relation for each one of the above phenomena is impossible in model of a real building [2].

Idea of equipping the structure with devices of inactive/ passive control, in order to obsorb the huge quantities of input energy of earth quake has been presented for the first time by Klay et al. [3]. Today, there are various varieties of energy controlling devices in the world which can supply an extensive spectrum of hardness and damping used by designers of structure using various materials. Different varieties of common dampeners have been studied by consideration in order to decrease effects of earth quake. The systems protected against the environmental forces in the modern building can be divided into three groups. Seismic separator system, in order to filter the input energy of earth quake and increase flexibility of the structures, has been used extensively, and it is usually placed in the level/ balance of the structure's foundation before that the energy is able to transfer to the structure, this system converts a part of the input energy of earth quake into heat and sends back another part.

In the active and half- active control, movement of the structures is controlled to protect the structures or moderated through controlling system.

This controlling system influences on the structure through a lot of external energy source. However, half- active control only requires a little quantity of energy to moderate the mechanical characteristics of system and, contrary to the active control, is not able to exert a great energy to the structure [1].

1.1. Passive control of structures:

It is a control method in which the structural system, in order to control and protect itself against the environmental factors, has not access to data/ information and, also, additional external energy to protect itself after designation and making of the structure.

1.2. Half- active control of structures:

It is a method in which the structural system, in order to control and protect itself against the environmental factors, has enough data/ information, but enough external energy has not been put at its disposal.

1.3. Active control of structures:

It is control method in which the structural system, in order to control and protect itself against the environmental factors, has enough external data/ information and energy. Today, considering how to distribute mechanical energy in the structures, some methods with various viewpoints differing from resistant- making methods have been taken into constantino [4] which a number of them includes visco- elastic dampeners, viscous- liquid dampeners, frictional dampeners and surrendering dampeners. By possession of the unequal dynamical characteristics, these dampeners have a various performance against input energy of earth quake, including characteristic of visco- elastic dampeners and viscous dampeners which they can depreciate the input energy of earth quake against an extensive spectrum of the stimulation frequencies [5]. Instead, frictional dampeners take action to depreciate energy only when the slippage force exceeds the allowed limit, but when we combine these dampeners with one another and use them in the structure, the structure will have an effective performance against the low and high frequencies of earth quake [7,8].

2. Modeling

For the purpose of designation and analysis of the frictional dampener, Open sees software was used, which Truss element has been used. By allocation of viscous single- axial materials to pillar element, this element can be considered for tone/ melody of bowing-down changes and used as a dampener in the structured [6].

In the structures, the depreciated energy depends greatly on the value of slippage force (Minimum force quantity which is required so that two dampener plates are displaced against each other) and displacement established between the two plates. If value of slippage force is very high, value of the depreciated energy will be equal to zero because two plates related to dampener cannot move against each other, and exertion of structure work like an ordinary braced structure.

In the opposite direction, if slippage force is very small, amount of displacement between two plates is high, and exertion of quantity of the depreciated force will be equal to zero which it can be supposed that the structure behaves like an ordinary curving frame. Among the two mentioned limiting states, there will be existed a low quantity of the slippage force which, considering that quantity, the depreciated energy in the structure will be maximum. This quantity of the slippage force is known as maximum slippage force. The maximum slippage force is to be obtained from equations (1), (2) and (3) as following (7):

$$T_g = \frac{2\pi}{65-7.5M_l}$$

$$\alpha = \frac{(-1.24NS-0.31)T_b}{T_u} + 1.04NS + 0.43$$

$$\beta = \frac{(-1.07NS-0.1)T_b}{T_u} + 1.01NS + 0.45$$

Where Tg, Mt, Tb, Tu and Ns is dominant period of earth vibration, greatness of earth quake, period of the braced structure, period of initial structure and number of the plates, respectively.

The considered model is a two- dimensional model with bending frame A in the steel story and with orifice of 5 meters and story hight in the size of 3.20 meters. And, considering type of land (III) and base acceleration of a_g=0.53, quantity of dead and alive load is equal to 600 kg/m^2 and 200 kg/m^2 which loading on this structure was exercised linearly. The sections considered for the columns are IPB and these considered for the beams are IPE. In order to design the structure, E-tabs V9.7 software with 2800 standard and, also, URSD method has been used which value of relative displacement controlled in the lack-of-dampener structure. In this frame, the time history analysis, under 7 even numbers of the accelerogram, has been used to analyze according to characteristics of table No2 it is required to mention that the units are based Newton/ meter.

Table 1: The sections used in the beams, columns and braces.

Section of braces	Selection of beam	Section of column	Story
BOX 120*120*8	IPE 500	IPB 550	**1**
BOX 120*120*8	IPE 500	IPB 450	**2**
BOX 120*120*8	IPE 500	IPB 450	**3**
BOX 120*120*8	IPE 500	IPB 360	**4**
BOX 120*120*8	IPE 450	IPB 360	**5**
BOX 120*120*8	IPE 450	IPB 340	**6**
BOX 120*120*8	IPE 400	IPB 280	**7**
BOX 120*120*8	IPE 330	IPB 220	**8**

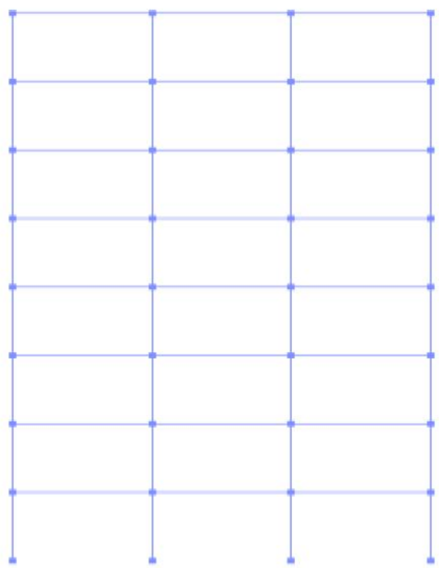

Figure No (2): A view of frame without frictional damper.

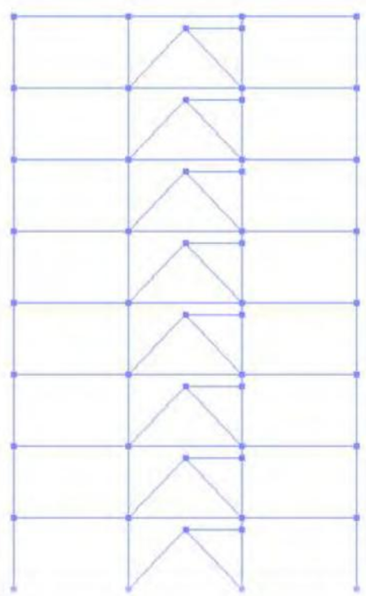

Figure No (1): A view of the frame with frictional damper

Table 2: Specifications and name of acceletograms

Name of accelero-gram	year	Name of component	PGA
Imperial Valley	1979	IMPVALL/H-E11140	0.364
		IMPVALL/H-E11230	0.38
Kocaeli	1999	KOCAELI/DZC180	0.312
		KOCAELI/DZC270	0.358
Loma Prieta	1989	LOMAP/G03000	0.555
		LOMAP/G03090	0.367
Morgan Hill	1984	MORGAN/G04270	0.224
		MORGAN/G04360	0.348
Northridge	1994	NORTHR/LOS000	0.41
		NORTHR/LOS270	0.482
Westmorland	1981	WESTMORL/WSM090	0.368
		WESTMORL/WSM180	0.496
Whittier Narrows	1987	WHITTIER/A-EJS048	0.426
		WHITTIER/A-EJS318	0.443

3. Discussion and study of results

Comparison value of the Drift's decrease in the lack-of- dampener structure and with- dampener structure has been shown which suggests decrease of Drift in the structure.

3.1. Lateral displacement of nodes

As it is observed in the following table, usage of visoelastic damper and frictional damper is effective on the relative displacement of knots/ nodes which, of course, it is required

to mention that value of displacement of roof is different in the earthquakes and diagram/ curve of decrease of displacement in the roof of three accelerograms has been shown.

Table 3. Deformation

Name of accelerogram	Component of accelerogram	Displacement of roof (BAM) with dampener	Displacement of roof (BAM) without Dampener	Decrease percentage
Imperial Valley	IMPVALL/H-E11140	1.50E-01	2.16E-01	30.55%
	IMPVALL/H-E11230	1.72E-01	2.70E-01	36.29%
Kocaeli	KOCAELI/DZC180	2.74E-01	3.74E-01	26.73%
	KOCAELI/DZC270	4.13E-01	5.25E-01	21.33%
Loma Prieta	LOMAP/G03000	1.03E-01	1.48E-01	30.40%
	LOMAP/G03090	2.91E-01	3.53E-01	17.27%
Morgan Hill	MORGAN/G04270	1.62E-01	2.71E-01	40.22%
	MORGAN/G04360	1.08E-01	1.86E-01	41.93%
Northridge	NORTHR/LOS000	2.79E-01	3.05E-01	8.52%
	NORTHR/LOS270	2.45E-01	2.72E-01	9.92%
Westmorland	WESTMORL/WSM090	3.64E-01	3.80E-01	4.21%
	WESTMORL/WSM180	2.32E-01	2.51E-01	7.56%
WhittierNarrows	WHITTIER/A-EJS048	3.95E-01	4.59E-01	13.94%
	WHITTIER/A-EJS318	7.25E-02	9.94E-02	27%

4. Conclusion

Usage of this type of dampers is very desirable due to low cost and simple enforcement. Usage of the frictional dampers in the structure leads to decrease of the nodes' displacement which, considering the whole accelerograms, this value is 20\5 on the average. The frictional dampeners lead to decrease of the storys' drift which this decrease is different in the various earth quakes.

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