DSTA 2021 dys-ta.com
16th INTERNATIONAL CONFERENCE
Dynamical Systems – Theory and Applications
December 6-9, 2021, On-line

Seismic response of adjacent steel frames linked by friction dampers

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Abstract: The simplest way for the elimination of earthquake-induced pounding that occurs between two adjacent structures is to have a proper gap between the two structures. However, this method is not applicable in all cases, and we should search for methods that can reduce the pounding effects. Linking the two adjacent structures with different elements like friction dampers (FDs) is one of the applicable strategies that can be studied. A friction damper (FD) absorbs energy by friction, and the slip force is the most important factor in these dampers. In this study, the effect of pounding on adjacent frames with different heights and also the effect of considering friction dampers with optimum slip force that are distributed uniformly in the stories, have been discussed. It is concluded that the pounding results in decreasing the responses of the low-rise frame and in increasing the responses of the high-rise frame. It is revealed that linking dampers does not reduce pounding effects in all cases, and their performance in reducing or increasing the responses of the frames belongs to the characteristics of the adjacent frames and the acceleration time history.

Keywords: impact, friction damper, damage index, non-linear dynamic analysis, adjacent frames

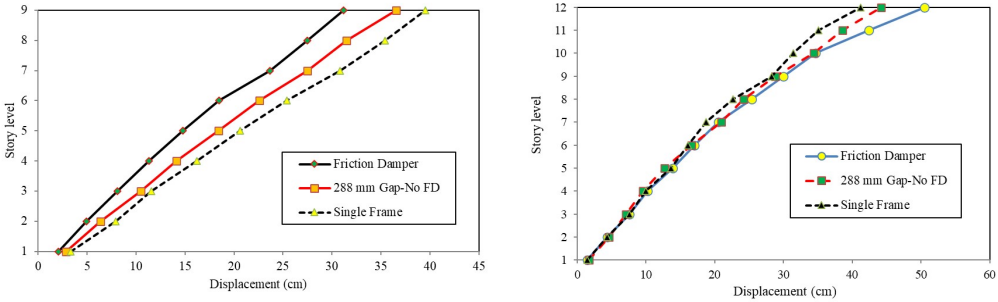
1. Introduction

An earthquake has always endangered human life and property as one of the most dangerous natural disasters. By observing the past seismic events, it can be known that one of the phenomena caused by earthquakes and which intensifies the damage is the impact phenomenon. Impact refers to the collision of two structures that have different dynamic properties and therefore vibrate non-simultaneously. Lack of sufficient gap between the two structures is another condition that is necessary to create a collision. This phenomenon has been observed in recent decades with the increase in the value of urban lands and cost of buildings, and in several earthquakes has caused various damages, including the destruction of walls, failure of collided columns, and complete collapse of buildings. Researchers have always been looking for a way to eliminate or reduce the damage caused by this phenomenon. The simplest way to eliminate impact is to create enough gap between the two structures so that they do not collide with each other due to non-phase vibration. But this method is not always applicable and is also an uneconomical method. Therefore, a solution must be provided to reduce the effects of this phenomenon. Among these, methods such as filling the space between two structures with shock-absorbing materials or connecting two buildings with high-strength beams in the form of two pin ends were proposed [1]. Another method proposed by the researchers is to use

dampers between two structures that are subjected to impact [2]. Since a few research has been done on how friction dampers affect impact responses in adjacent tall and short buildings under an earthquake, more research is needed. In this study, the effects of friction dampers (FDs) on the seismic behavior of steel buildings are investigated.

2. Results and Discussion

In this study, the pounding effect on two adjacent 9-story and 12-story frames is investigated under the Landers earthquake (component ABY090 seismic record). The displacement of the floors in the case of the gap distance is zero, sometimes increased and sometimes decreased compared to the single case, with a maximum change of 4%, which is not a considerable value. In the distance of 72 mm and 144 mm, the response due to impact is severely reduced by 45%. A 31% reduction in displacement at a distance of 288 mm indicates that the effect of the impact has decreased with increasing the distance between two frames. By connecting the two frames per each floor level with friction dampers at a distance of 72 mm, an increase in displacement can be seen compared to the case where there is no damper between the two frames, which in the maximum case increases by 24%. At a distance of 144 mm, the displacement of the floors with the dampers sometimes decreased and sometimes increased, which can be reduced by 38.9% and increased by 25%. Placing the dampers at a distance of 288 mm causes the displacement to be significantly reduced under the seismic record with a maximum value of 47%. At a distance of 144 mm, in most cases, there was an increase in response, which averaged 8.2%. By increasing the distance to 288 mm, the damage index decreases by an average of 0.4%.



(a) 9-story (b) 12-story

Fig. 1. Distribution of floor lateral displacements with and without friction dampers under the Landers earthquake in (a) 9-story and (b) 12-story frames

3. Concluding Remarks

By increasing the distance between the two frames, the friction dampers are able to absorb more energy by being able to displace more and have a better performance at reducing the responses. When the distance between the two frames is zero, the responses are always close to the single state, and a little change is observed in them. By examining the effect of impact, it was concluded that the impact between buildings with a different number of floors reduces all responses in the shorter building and increases them in the taller building.

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