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Review Article

INVESTIGATING AND BEHAVIOR OF FRICTION DAMPERS IN IRREGULAR STEEL STRUCTURES

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ABSTRACT
Structures inactive control method toward earthquake is used as proper replaced way instead of traditional methods. Today among these methods using frictional dampers has found considerable status. Frictional dampers could be used for reducing earthquake damages reduction on structures. The main purpose of this research is to evaluate the steel structures seismic behavior by frictional dampers and comparing them with steel brace. The used model in this research is in two types of two dimensional frames with 3, 5, 8 steps that one time it was without brace and other time with frictional dampers and then the steel braces are evaluated. One of the main points in steel brace modeling is these braces buckling. Through none-linear dynamic analysis by open sees software, the modeling structures responses were evaluated. The applied earthquake records in this research are about 10 quantities that are forced to the structure. It should be noted that the used records in this research is about PGA = (0.6) g and forced to the structure. The result of evaluations showed that the rate of steps displacement in structures with frictional dampers is reduced compared to structures with typical structures with braces.

Keywords: *Frictional Damper, Buckling, None-Linear Dynamic Analysis, Steps Partial Displacement*

INTRODUCTION

During the intensive earthquake, the great amount of kinetic energy is forced to the structure and pushed it with the forced energy relevant to the domain to forward and backward. All building regulations verify that due to economical condition using elastic materials to come up with shaking energy is not possible unless the intended structure has high importance that the number of these structures is really low. If we could reduce the shaking energy to mechanical energy in great scale, the structure response is controllable without happening damages. One of the methods to achieve this aim is the use of frictional dampers. The philosophy behind using these instruments is to change forced kinetic energy to the structure and thermal energy that occurs during the frictional energy overcoming and the hysteresis energy due to the force-location variation curve in the damper. By the little number of frictional dampers we can make considerable protection toward made damages. In contrast to other shaking control instruments, these dampers do not have maintenance cost and they don't need to have repairing during the structure live and even if the high amount of energy is observed and by incapacitation after high shakings we can change them easily (Nims, 1993).

One of the oldest frictional dampers what made by metal Somitomo industries in Japan, the frictional damper used for many years for observing energies due to put stresses to the rail ways. Since 1980 these dampers efficiency was evaluated about the structures and earthquakes engineering. The Techton Company made similar frictional dampers that contained simple elements than Somitomo type. These dampers includes a series of adjustable screws that by tuning them we can control the vertical force to the frictional dampers surface and as the result the damper friction force that occurs during the slipping, figure 4. This damper was designed in 199 by Rinhon and coworkers by the purpose if frictional damper construction cost reduction.

Rinhon *et al.,* (1991) presented other type of frictional damper that operated as the controlling tool for location changing for bridge structure which has the slipping support including the brass and steel. This damper could be tuned for providing the required resistance and stable energy amortization in frequent cycles, figure 1 (Cherry and Filliatrault, 1993).

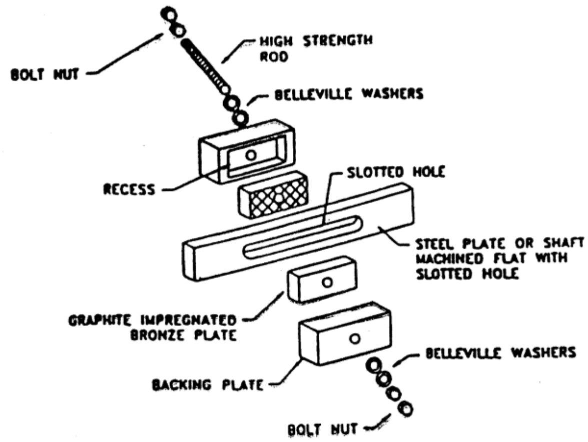

Figure 1: Details of Controlling the Displacement

EDR or energy dissipation restraint damper is other type of frictional dampers that has more complicated mechanism comparing to other amortizing factors. This tool was tested and suggested by the Daniel flour company in 1993 and it has the capability to provide to return to its primary position after load removing by the internal spring and the last brace distance providing.

Also the maximum power in damper is equivalent to the location variation that most of dampers don't have this specification. The force- position changing curve for EDR damper on the X figure as it provides the energy observation capability. The figure 2 has the details for this damper (Cherry and Filliatrault, 1993)18-19.

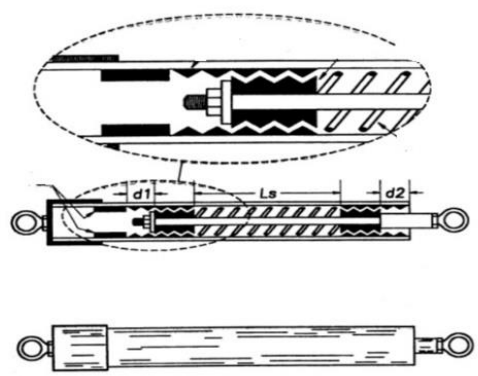

Figure 2: EDR Frictional Damper

Gerald (1989) suggested other type of frictional damper by application of grooved screw connections in the same axis braces. The energy amortization n this type of dampers is provided due to the made friction on the steel surface that slip on the direction of braces.

Pall (1970) invented a tool to amortize the input energy to the structure due to the land movement or earthquake by friction. Pall was inspired to invent such damper by the car brake system damper. He believed that the cars braking action is totally similar to the building movement stop during the land quake.

As the frictional braking is observed by the car movement kinetic energy, the building movement also could be controlled by the energy amortization due to the friction. The frictional damper was invented in 1982 by two Canadian researchers called pall and marsh (Nims, 1993).

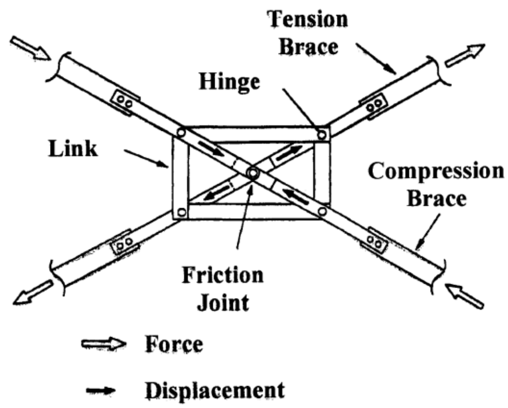

Figure 3: Pall Frictional Damper

Pall frictional damper basically includes a series of metal plates which are connected to each other by steel high resistant screws together and allowed to slip under the predetermined load. During earthquake, the frictional dampers for the determined load is slipped before the frame damaging, this matter allows that the earthquake general part s amortized with friction. Actually structures are remained in the elastic limit and they are capable to stand high seismic forcers (Nims, 1993).

If the structure braces are designed not to be buckled in pressure, a simple grooved frictional complex is possible to be installed to amortize some of the input energy by the friction. In this way each of slipping loop which operates independent from other. Of course the loop slipping load should be lower than the braces frequent load but this method is not economical pressure bracing designing, on the other hand if braces are weak and designed only for extension effectiveness, the simple grooved frictional loop is only slipped in extension.

In other word during the force direction variation from extension to pressure, the brace is deformed and if the frictional loop could not slip to backward, as shown in figure 4, the frictional loop is not slipped to the time the brace is not extended more than the previous length enhancement and as the result the energy absorption is weakened.

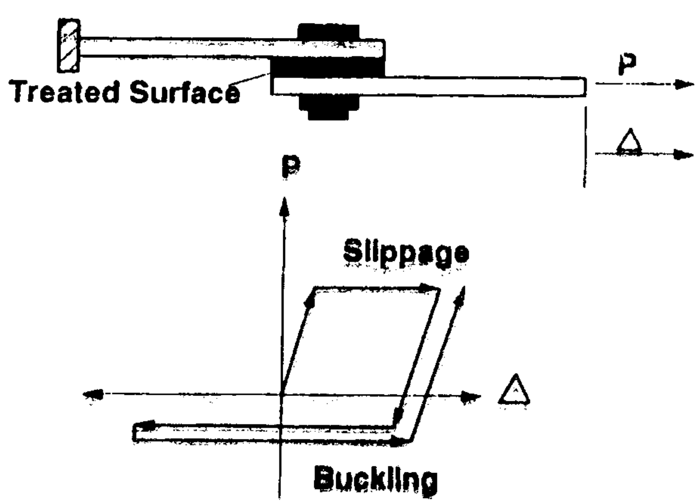

Figure 4: The Simple Grooved Frictional Loop and Related Hysteresis

By the use of damping mechanism in pal frictional system, there is possibility to improve the energy absorption. By connecting this mechanism in the braces conjunction, the possibility for simultaneous slipping is made for extension and pressure. According to figure 5, braces are connected to the frictional damping mechanism. While an extension occurs in one of the braces, the loop s slipped and four elements are become active an as the result this available loop in the brace forced to slip.

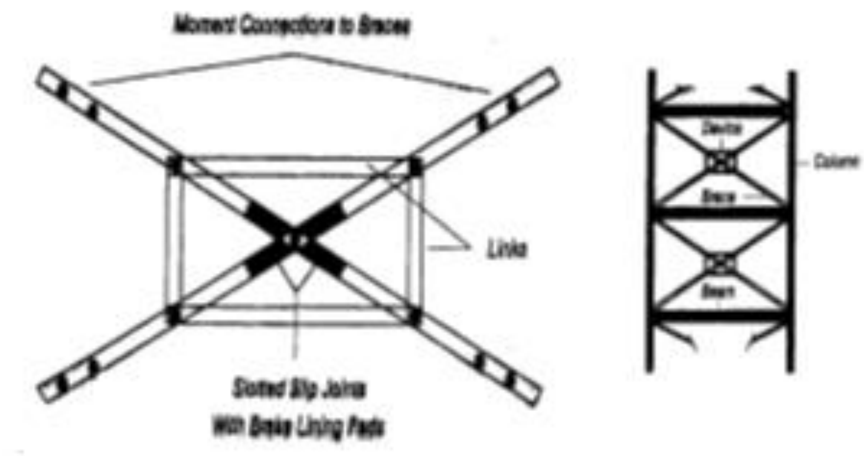

Figure 5: The Pall Frictional Damper Detail and its Application Method n Structure (Wolf, 1994)

For modeling the pall frictional damper in DRAINED-2D software, the structural model was presented but due to much accessibility to such behavior it is not possible, as the result such model could not properly explain this tool efficiency, in other word, the obtained rates from this model is in the reverse direction of security and assurance.

The other model was suggested by Shry and Filyatrout that includes more details about this damper. As expected the obtained results has differences with the first model at least in 30% differences.

As it was seen this differences is reduces by increasing the input actuation, the made force in braces is as big as to activate the frictional loops to make the imagined behavior, therefore to evaluated the efficiency of these dampers in intensive earthquake, using the first model has the proper accuracy that is defined in exchange for lower freedom degrees and as the result the required time for computer analysis is fewer.

The laboratory studies for modeled frames on the shaking table confirm the proper efficiency of frictional damper frames toward intensive earthquake.

In some of these studies it was observed that even earthquake with PGA=0.9g also could lead to system destruction; also the results showed that the frictional damping could control the partial rushing properly and the structure steps acceleration (the structures destruction most important mechanism).

Also the frictional tools efficiency is become well by increase of PGA (input earthquake great quake) because in this condition due to the more slipping (under the slipping fixed force) they are capable to amortize energy more.

In this research the openSees software was used for none-linear dynamic analysis and it is the criterion for steps comparative displacement evaluation.

The Modeling Hypothesis

According to the main target of this research that is evaluation and comparison of frictional damper behavior, it has been attempted that the used models being the representation for typical buildings with middle stature.

Hence the main model is shown in figure 6 for a three dimensional structure with 3, 5 8 steps and with 3 inputs. The weight loading of structure is done based on the national regulation sixth discussion. The shaking loaded basis is the third edition 2800 standard.
Hence by identification of structure the main frequency is obtained and then by assuming the structure location in Tehran and establishment on the type 2 soil, the steps lateral forces is obtained.

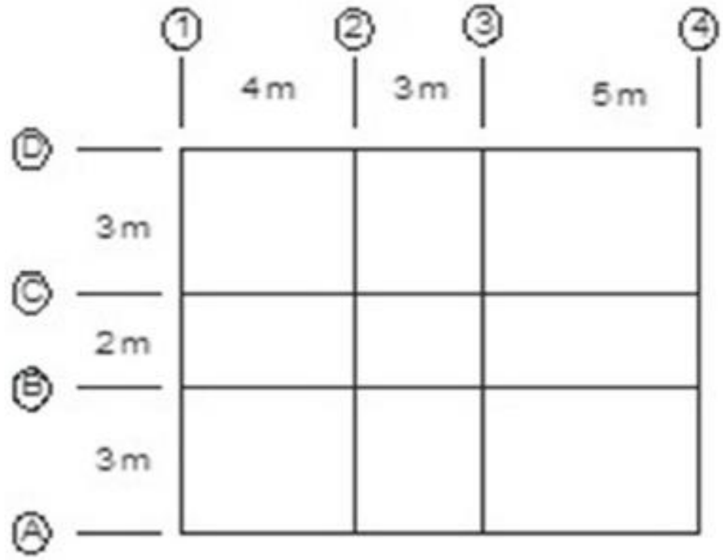

Figure 6: Models Steps Type Plan

The element designing is done as the tension ratio in them remains more than 0.8 and lowers than 1.10. Also in between steps rushing designing and also building's roof displacement that is not controlled based on the regulation and more than definite limitation. The displacement limitation maximum is put on the supplementary dampers duty at primary designing.
IPE section is used for square profile columns and for beams. The reason of using the profile section for columns is the bending similar resistance in two directions in order to make lateral stiffness in two X and Y directions. In all structures one type of beam is identified, for 3 stairs structures the 2IPE160 section and for 5 stairs structure, the 2IPE180 section and for 8 stairs structure, the 2PE200 sections have been used. The similarity of beams in two direction of X and Y due to weight cross sectional distribution at the bed, as it is mentioned n previous section, in the structures primary designing, the related limitations of structure is not obeyed in stairs displacement to put this duty on the braces duty. Therefore the steel braces are designed on a way that the displacement rates between stars are lower than mentioned rates in regulation.
After primary designing and clarification of structure elements, it was the time for dynamic analysis and then we study the parametric elements, open sees Ver 2.4 is the main software used for analysis. The steel is being modeled by the tension- deformation curve in this software that the used model in this research is the steel 02 model. One of the unipolar materials used in this research is the elastic perfectly plastic type that will be model by frictional dampers. Pall and Marsh suggested frictional damper for modeling that an artificial surrounding rate was considered for brace material extension behavior that is corresponding with the tension in extending brace at the time of slipping in damper. Therefore, in the open sees software the truss element is used. By regarding truss element accompanied with unipolar material, only the tension- strain effect is considered and therefore we can model the elastic-plastic behavior easily as above.
Because the purpose of this research is to evaluate the frictional dampers in the none-linear limitation, the most proper element for beams modeling is the none-linear element. By the use of fiber section and its

attribution to the none-linear column element, the plastic specification is developed and it is considered not only as the beginning rather at the end.

The point that should be explained is the buckling capability. So we should refer to the Mr. Ouriz article in which he used the buckling feature of steel braces that the model of this brace is including elastic elements with high stiffness and they are none linear columns and they are connected to each other through exit from the mentioned centrality.

In this research 10 records were used for tem historical analysis that all of these records are registered for type 2 soil with slicing speed of lower than 750 meter in second and more than 375 meter in second. According to the purpose of this research for comparing the different braces earthquake behavior, 0.6 g acceleration was used for analysis performance and all used records in this article are normalized.

Conclusion and Resulting

As mentioned in previous chapter, to study the frictional damper shaking behaviors in steel structures two type of different systems are added to the steel bending frame. So three steel bending frames as steel bending frames, steel bending frame with steel braces and steel bending frame with steel bending were modeled by the open sees software for frictional damper and then analyzed in dynamic none linear method. In this chapter the results were evaluated and different parameters were analyzed. For each group of models with the same steps first the structure response without brace was compared to similar structure with the brace in the same material.

T should be noted that in all graphs the blue lines are identified with bending frame structure special circle and red lines are identified with Special Square related to the steel brace and the green lines are the special triangle signs for frictional dampers.

In this section we proceed to run a parametric study in order to evaluate the structure response variation by the use of obtained results from 10 introduced earthquakes in previous chapter and acceleration definition for the earth moving at (0.6)g.

It should be noted that the X graphs related to the A frame in the X direction and related to the last points on the axis No.4. The Y graphs also are related to the frame 1 in Y direction and on the D axis. The XY graph also is the combination of both frames transformation in A1 common column.

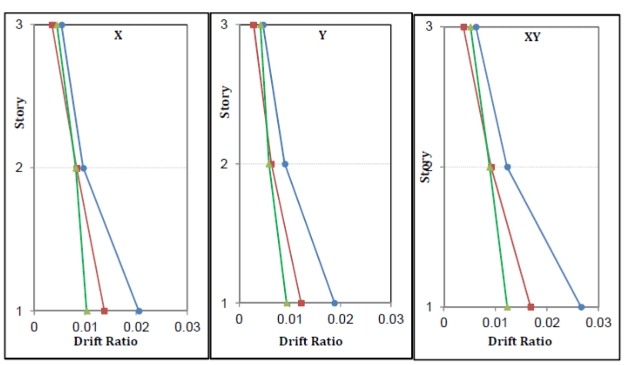

Figure 5-1- Three Stairs Structures Response Average for Earthquake with PGA=0.6g

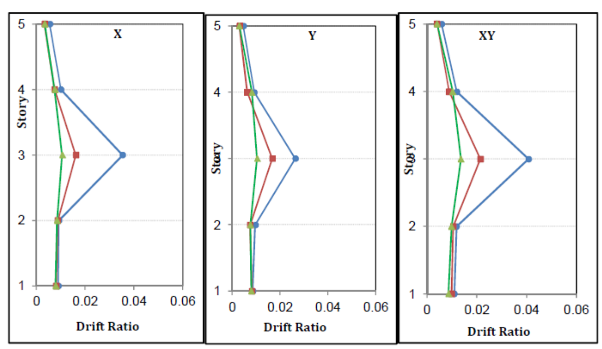

Figure 5-2—Average of 5 Steps Structures Response for Earthquakes with PGA=0.6g

After evaluation of related results about the lateral transformations in three stairs structures in this section we will analyze the 5 stairs structures lateral transformations. As it will be observed in next graphs, the lateral transposition in 5 stairs models occurs in third stair; therefore reduction of transposition has high importance.

After none linear analysis on the 8 stairs structures the modeling results show that the most transposition has occurred in the sixth stair. The last results related to the 8 stairs structures is presented below

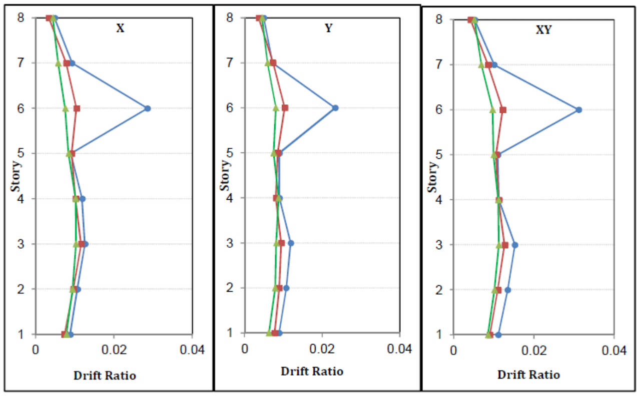

Figure 5-3- The 8 Stairs Structures Response Average for Earthquakes with PAG=0.6g

As the results related to the 5 and 3 stairs structures, we see the in the 8 stairs structures that in steps in which the transposition of structure is high that the dampers transformation reduction effects is increased and this dampers present their effect better. The main reason of this event could be assumed as the braces buckling that due to the strains and tension in the brace, will lead to the increase of stair partial transformation rate and reduce the efficiency of these braces but it does not occur in frictional dampers. In order to compare the transposition reduction rate results properly, below graphs are presented for structures stairs partial transpositions.

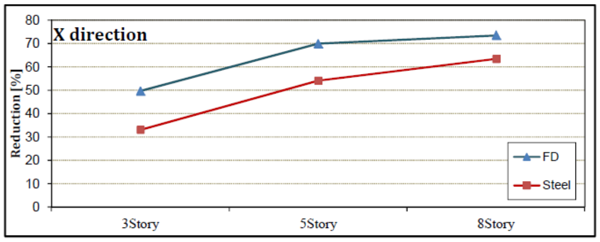

Figure 5-4- The Stair Partial Transformation Maximum Reduction Rate Comparison in X Direction

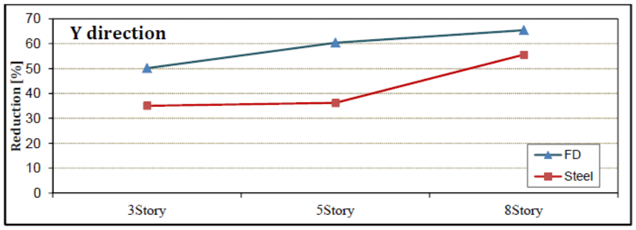

Figure 5-5- The Stairs Partial Transformation Maximum Reduction Rate Comparison in Y Direction

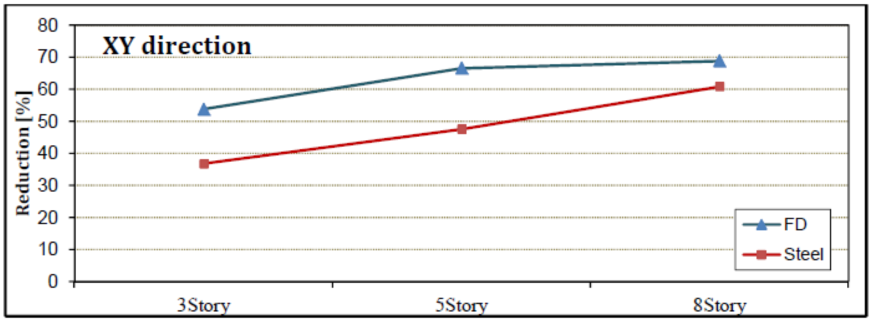

Figure 5-6- Stairs Partial Transformation Maximum Reduction Rate Comparison in XY Direction

Therefore, if briefly we evaluate the results we can say that in this research after the primary evaluation of results in order to make a correct model in open sees software and also the study and comparing the frictional dampers seismic behavior under the main time historical analysis, we proceed to construct three main models. The differences between these categories are in the structures systems. The first type is the elementary structure with steel buckling structure. The second type is the buckling framed braces with added cross steel typical braces and the third type is the usual braces from frictional dampers for phase control and structure transformation.

In every category by changing the number of stairs, the evaluation extension is also increased then each of structures are tested under 10 earthquakes records. In this study by comparing the results we can deduct below results:

By increase of structure lateral transposition, the frictional dampers reduce the lateral transpositions more than steel braces. This issue is observed in critical stairs response. The reason of this matter could be considered as the tension and strain which are available in steel braces behaviors.

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