Experimental and numerical study using NSD metal damper has been used in concrete moment frames

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ABSTRACT

One of the most widely used structural systems in existing buildings are reinforced concrete moment resisting frames that offer high ductility and acceptable strength when lateral loads are applied. But test concrete buildings need to be reinforced due to operational problems in many older buildings. In recent years, the simultaneous use of steel braces and dampers in strengthening and improving the behavior of concrete frames has always been of interest to researchers. In the present paper, a laboratory and numerical study of the effect of using non-uniform gap (NSD) dampers in concrete flexural frames has been performed. In the present study, 2 models including a simple frame and a frame with a damper were examined. The reference concrete flexural frame is modeled in a 1: 3 scale, the lengths of beams and columns in the laboratory sample were 1.45 and 1 m, respectively, and the dimensions of beam and column sections were 150 by 150 mm. Reinforcement of the concrete frame was done in such a way as to provide medium torque resistance conditions in the frame. Displacement control loading was used. To study the behavior of the studied samples, force-displacement diagrams of the models were extracted. The results showed that deep cracks were created at the junction of the beam to the column and the structure was damaged. Also, at the junction of the column with the foundation of the structure, it has undergone irreversible deformations and major damage. The study of the effect of NSD damper on deformation and failure showed that the damper can reduce the damage in the concrete frame by absorbing permanent deformation. Also, due to the stresses, the concrete beam underwent plastic deformation. The final strength of the concrete frame with the damper was recorded more than three times the final strength of the frame without the damper. The results showed that the stresses and deformations of the plastic are concentrated in the damper and the frame performance is almost linear and without damage.

KEYWORDS

Metal damper, concrete moment frame, retrofit, NSD damper.

1. Introduction

Non-uniform Slit yielding dampers (NSD) have attracted a great deal of attention from researchers for reasons such as low material cost, easy installation, no need for specialized personnel to install, operate and replace them after a severe earthquake. The performance of this type of damping is such that by its early submission during an earthquake, it causes the energy loss to be concentrated in the dampers and ultimately the demand for energy loss in the main parts of the structure (beams, columns and braces) is reduced.

In conventional concrete moment frame structures, generally in severe earthquakes, the application of lateral loads causes deformation in the beam and column and as a result the stress is concentrated in the connection of the beam to the column and as a result the main elements of the structure suffer serious damage. Oh et al. (2009) introduced a new type of slit Damper was used at the junctions of steel structures. These types of dampers are activated after deformation in the connection (Rotate the connection), absorb some of the energy and apply less force to the column [1]. Saeedi et al. (2016) evaluated the TADAS damper seismically. The results of their incremental load analysis show that the addition of a TADAS damper to the frame significantly increases the frame capacity curve. After performing the analyzes and displacement the purpose of each model, the parameters of strength and stiffness of the structures equipped with this type of damper were investigated without it [2]. Tahamouli et al. (2018) investigated concrete structures equipped with ADAS dampers and TADAS experimental studies. The use of yield dampers in concrete frames can also show good behavior and significantly improve the seismic behavior of the structure. The variables of these researchers included the number of sheets as well as the type of sheets, which were considered in both ADAS and TADAS. The results showed that these dampers can improve all the seismic parameters of the frame to a desirable level [3]. Pan et al. (2020) modeled a type of shear yield element. After applying force to this attenuator, a tensile force is created and yielding. Their model variables were the cross-sectional area of these dampers, which after periodic analysis, the results of increasing load analysis show that with increasing the cross-sectional area of these elements, the frame capacity also increases [4].

In the present paper, two laboratory models of concrete frames with and without NSD yield dampers are modeled and analyzed under laboratory conditions and then the behavior of the two frames is compared.

2. Research Methods

In the present study, 2 models including simple frame and frame with NSD damper were investigated. The reference concrete moment frame is modeled on a 3:1 scale, the length of beams and columns are 1.45 and 1 m, respectively, the dimensions of beam and column sections are 150 x 150 mm. Laboratory tests of the present study were performed in the structural research laboratory of Islamic Azad University, Kermanshah branch. Two examples of medium reinforced concrete moment frames were constructed and subjected to cyclic displacement-quasi-static control cyclic loading. The effect of reinforcement of reinforced concrete frames by yield dampers was investigated by evaluating the seismic parameter of the final strength and evaluating the damage in the samples by testing laboratory samples. In this regard, two moment reinforced concrete frames were constructed, the first of which was a reinforced concrete moment frame without the use of yield dampers, and in the second sample, NSD yield dampers were added to the reinforced concrete frame. The results of the tensile test of steel rebar are shown in Table 1. Figure 1 shows a structural model of a concrete frame without dampers made in the laboratory. Figure 2 shows a model of a frame structure with an NSD yield damper.

Figure 1. Model of concrete frame structure without damper

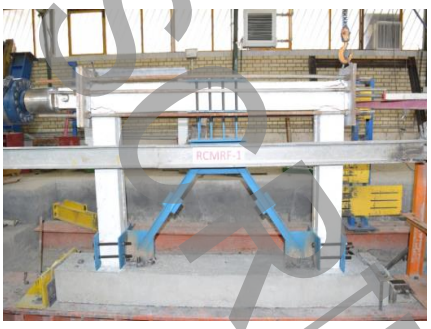

Figure 2. Model of frame structure with NSD yield damper

Table 1. Specifications of rebars used in the reference model (MPa)

Rebar size	F yield	F ultimate	Breaking stress
Φ8	411	625	513
Φ10	363	587	518
Φ14	387	526	549

3. Research results

In the sample of concrete frame with damping at the beginning of loading, the hardness of the sample increased more than 3.4 times. From the beginning of the test, the forces required to bring the structure to the protocol displacements were much higher than the first sample, and by passing the 0.005 drift due to the high resistance to displacement of the system, cracks created in the concrete in place the connection of the beam to the columns increased. at drifts above 1%, NSD dampers visibly deformed, and yielding to them increased the Force required by the system. In general, the study of the effect of dampers on deformation and damage in the concrete frame shows that the damper can reduce the damage in the concrete frame by absorbing permanent deformations. Figure 6 shows the model with the proposed damper in the concrete bending frame. Figure 7 shows the damper shape used in the present study. the damper consists of 4 rows, each of which is cut to absorb the plastic deformation.

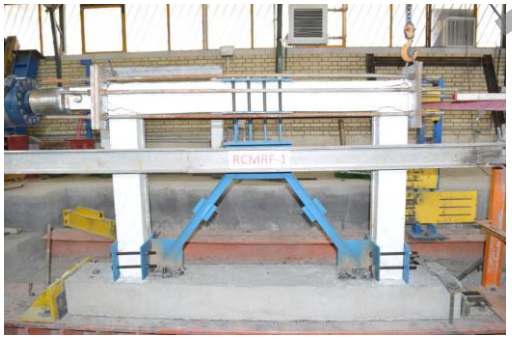

Figure 6 Model with the proposed damper in a concrete moment frame

Figure 7 Image of the damper used in the present study

Figure 21 shows the deformation in a sample with a damper under cyclic loading. The stresses and deformations of the plastic are concentrated in the damper, and the function of the frame is almost linear and undamaged. Also, by adding a damper, plastic deformation occurs in the damper and the beams and columns have a good performance.

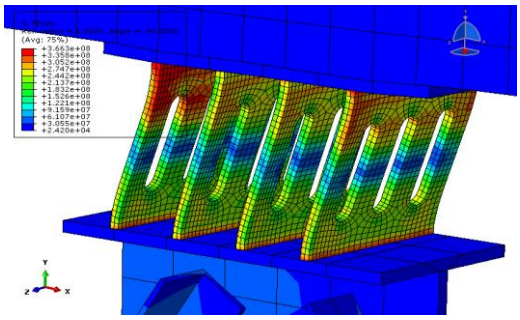

Figure 21 Deformation in a sample with a damper under cyclic loading

4. Conclusions

In this experimental study, two samples of reinforced concrete moment frames with a scale of one third were made, one of which was reinforced by NSD yield dampers. The results showed that:

- The effect of the proposed damper on the performance and energy absorption in the frame is well known. The frame with damper has a higher bearing capacity than the simple frame. Unlike the simple frame where more force is generated in the frame, the different behavior of the frame with NSD damper shows that in this frame, in addition to higher force bearing capacity, the transmission mechanism is also different.
- In general, the results showed that the stresses and deformations of the plastic are concentrated in the damper and the performance of the concrete frame is almost linear and without damage

5. References

[1] S.-H. Oh, Y.-J. Kim, H.-S. Ryu, Seismic performance of steel structures with slit dampers, Engineering structures, 31(9) (2009) 1997-2008.
[2] F. Saeedi, N. Shabakhty, S.R. Mousavi, Seismic assessment of steel frames with triangular-plate added damping and stiffness devices, Journal of Constructional Steel Research, 125 (2016) 15-25.
[3] M. TahamouliRoudsari, K. Cheraghi, M. Habibi, Investigation of retrofitting RC moment resisting frames with ADAS yielding dampers, Asian Journal of Civil Engineering, 20(1) (2019) 125-133.

[4] P. Pan, Y. Cao, H. Wang, J. Sun, Development of double-stage yielding coupling beam damper, Journal of Constructional Steel Research, 172 (2020) 106147.