FEA on Energy Dissipation in Seismic Mitigation of Braced Frame Structures using Cost Effective Dampers

Jinsa C Hameed[1], Sreeja S[2]

[1]*M.Tech Scholar, Dept. of Civil Engineering Ilahia College of Engineering and Technology,Mulavoor*
[2]*Assistant Professor, Dept. Civil Engineering Ilahia College of Engineering and Technology,Mulavoor*

---***---

Abstract –*In this paper, x shaped damper (XPD) is introduced in real frame structure of a multistoried building. The aim of this paper is to find out optimum size of damper by Conduct parametric study by nonlinear pushover analysis in frame. Lateral load is applied at beam column joint. Then find out the seismic analysis for optimized multistory frame with XPD under time history analysis. Comparing the energy dissipation and performance with conventional frame without XPD.*

Key Words: X shaped damper (XPD), Bare frame (BF), Finite element analysis (FEA), Energy dissipation (ED)

1. INTRODUCTION

1.1 General

In order to control the vibration response of high rise buildings during seismic events, energy absorbing passive damping devices are most commonly used for energy absorption. Dampers are usually installed between two load bearing elements (walls or columns) in new buildings. An effective damping system can result in higher levels of safety and comfort, and can also lead to considerable savings in the total cost of a building.

In this paper, X-shaped damper is introduced and examined in the full scale frame. Damper is made through welding two oppositely positioned pipe halves to form a X-shape shown in figure 1. Ductility, optimum size of XPD and energy absorption capacity of XPD frame was studied in full scale frames. Study is carried out in real frame structure with diagonal braces.

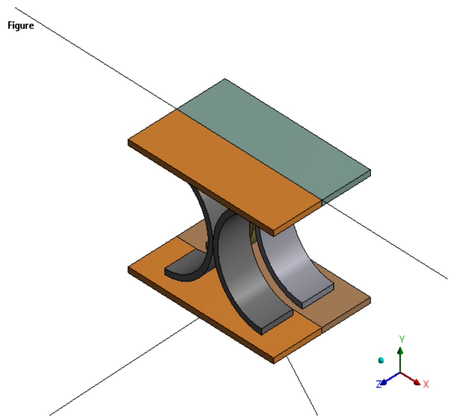

Fig -1: X Shaped Damper

2. FINITE ELEMENT MODELLING

2.1 General

To investigate optimum size of damper in real frame structure by non linear pushover analysis and also to compare energy absorption capacities of XPD frame and bar frame. Finite element modeling was developed using ANSYS 19.0. Solid 186 elements were used to model damper.

2.2 Geometry and material properties

The whole structure consist of two columns, one beam , diagonal bracings and XPD damper is modeled. Damper is placed between the diagonal bracings. A single frame of a six storey building is taken for analysis. Size of the column is HE340,beam size is IPE 600.Size of bracing is 219.1x8 mm ,span of frame is taken as 7 m, height of frame is 4m [2]. For damper, diameter of pipe is 133 mm and thickness is 5 mm [1]. Element type used for damper is solid 186 and element type used for beam ,column and bracing is beam 188.Figure 2 shows geometric model of XPD in real frame.

Fig –2: Geometric model of XPD in frame

2.3 Meshing

This model of XPD was developed by finite element software to demonstrate behavior property. Figure 3 shows meshing of XPD so that, solid model with given dimensions is formed in to a finite element model. Meshing size provided is 50 mm. Element type used is solid 186 with hexahedron shape.

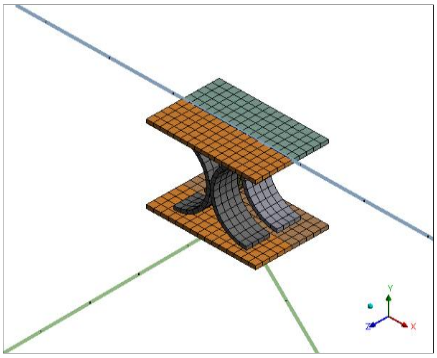

Fig -3: Meshing of XPD

2.4 Boundary conditions

Figure 4 shows boundary condition of XPD damper in real frame structure. A and B are fixed support 1 and 2. C is the lateral load applied. D, E, and F are the lateral support 1,2,3. Cyclic displacement load is applied to beam column joint.

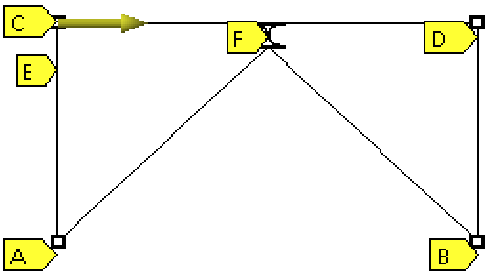

Fig-4: Boundary condition

A SUPPORT 1
B SUPPORT 2
C LATERAL LOAD
D LATERAL SUPPORT 1
E LATERAL SUPPORT 2
F LATERAL SUPPORT 3

3. Analytical result and discussion

Ductility is an important factor that affects the seismic behavior of buildings. In order to find the optimum size of damper, first we have to study four basic damper size as preliminary step. Size of dampers taken are133x40x5, 266x80x10, 399x120x15and 532x160x20.Initially bar frame without bracing is analyzed .Then bar frame with bracing is analyzed, it have high load carrying capacity but it fails at very low displacement. Stiffness of structure is improved by providing bracing. Higher stiffness show higher resistance, but failure occurs initially. In this case ductility is very low. Then each of the above specimen is analyzed by changing its length and thickness by considering deflection, load and ductility. The effective size of specimen obtained is 399x130x20.Damper having size 399mmx130mmx20mm more effective in load carrying capacity sown in table 1, thereby improve its seismic behavior. Maximum deflection is also occurring in this size.

Table -1: Effective size of damper

Specimen size	399x130x20
Δy (mm)	14.52
Δu (mm)	190.78
Pu (kN)	1996.80
Ductility (μ)	13.14

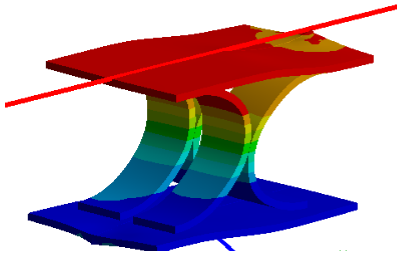

Fig -5: Maximum deformation

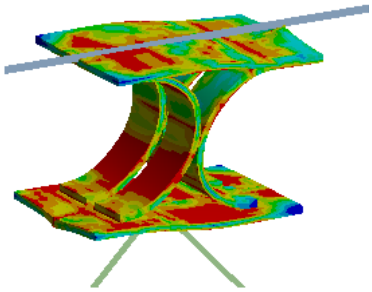

Fig -6: Maximum stress distribution

Cyclic analysis is carried out for XPD frame and bar frame. Load deflection curve for bare frame and xpd frame was obtained from analysis. Cyclic analysis should be based FEMA protocol. Lateral load is applied at beam column connection. Energy dissipation of frames can be obtained with the help of ORIGIN 2018 software. Energy dissipation of bar frame and XPD frame is directly obtained. Total number of cycles applied for both frames is 40.Results are shown in table 2. XPD dissipates more energy than bar frame. Out of 40 cycles, 37 cyclic loading steps were acted for XPD frame and bare frame takes only 21 cyclic steps. Figure below shows the load deflection curve of bar frame and XPD frame.

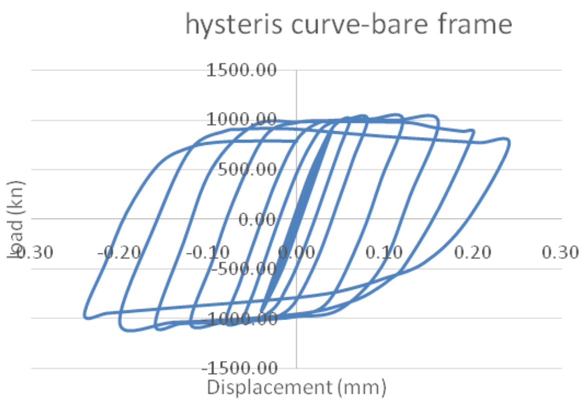

Fig -7: Load deflection curve of bar frame

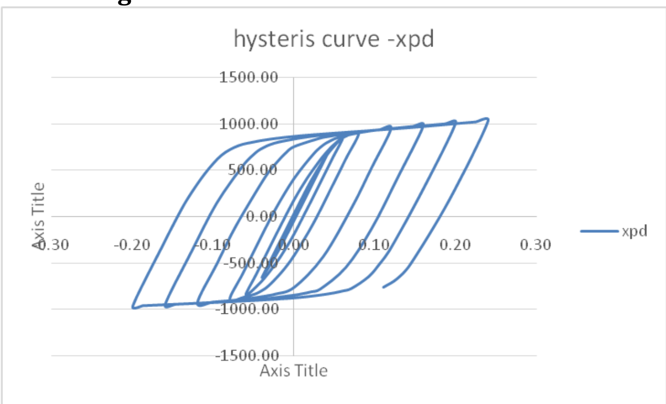

Fig -8: Load deflection curve of XPD frame

Table -2: Comparison between XPD frame and bare frame

	Energy dissipation	Cyclic steps
Bare frame	101.18	21/40
XPD	1429.03	37/40

4. CONCLUSION

Optimum size of XPD for a full size steel frame was obtained as 399mm x130mm x20mm. Cyclic analysis of multi-storey frame with XPD and without XPD was carried out .The result shows that frame with XPD is much more better in energy dissipation and load carrying capacity.

REFERENCES

[1] Yang Wang,Wei Guo,Shu Li, “Experimental study of a steel damper with X-shaped welded pipe halves” Journal of Constructional Steel Research,(2020).

[2] Silvia Costanzo, Mario D’Aniello⁎, Raffaele Landolfo “Influence of moment resisting beam-to-column connections on seismic behavior of chevron concentrically braced frames ” (2018).

[3] J.Lee,J.Kim,“Development of box shaped steel slit dampers for seismic retrofit of building structures”,(2017).

[4] K Deng,P. Pan,Y.Su, “Shape optimization of U shaped damper for improving its bi-directional performance under cyclic loading”,(2015).

[5] S.Maleki, S.Bagheri, “pipe damper”,(2010).