International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 09 Issue: 07 | July 2022 www.irjet.net p-ISSN: 2395-0072

Seismic mitigation evaluation on steel connections with multi tubular dampers

Fathima Shahul[1], Kiran Jacob[2]

[1]Mtech, Structural engineering, Ilahia college of engineering and technology, Muvattupuzha, Kerala, India
[2]Assistant Professor, Ilahia college of engineering and technology, Muvattupuzha, Kerala, India

---***---

***Abstract** – Seismic forces are the one of the destructive forces acting on the building. The seismic forces adversely affect the building. Many researches are going on to reduce the adverse effect of seismic forces on the building.one of the method adopted to mitigate the seismic forces are the installation of seismic dampers. This paper mainly focuses on the installation of multi tubular dampers on beam column joint to mitigate the seismic forces. Rigid connections are considered in this study. ANSYS software is used for the analysis of models. Parametric study is conducted on models to find the effective size of the damper. Studies are conducted on various shapes of dampers like ellipse, oval, x shape, circular to find effective shape. Also, studies are conducted on various materials of damper to find damper of better performance. Then the effective damper is installed in a five storied building frame and analyze the building frame to find base shear and storey displacement.*

Key Words: Dual pipe dampers, Seismic forces, Building frames, Kobe earthquake, cyclic loading

1. INTRODUCTION

An earthquake is the shaking of the surface of the earth resulting from a sudden release of energy in the earth's lithosphere that creates seismic waves. The seismicity, or seismic activity, of an area is the frequency, type, and size of earthquakes experienced over a particular time period.

Earthquakes are one of the most destructive natural hazards that cause huge amount of loss of life and property. Therefore, the reduction of the irreparable damage of this natural hazard at the lowest cost has always been the ultimate goal of researchers and practitioners in the earthquake engineering field [3].

One of the methods adopted to reduce the effect of seismic forces on building is the installation of dual pipe dampers. By installing these dual pipe dampers in building, it absorbs the seismic forces coming in to the building and maintain the building in an elastic state. Amir Masoumi Verki , Adolfo Preciado[3] proposed experimental and analytical investigations of enhanced semi-rigid connections with dual pipe dampers. In this study, an experimental and analytical study of a semi-rigid connection with DPDs is evaluated. The studied models in this research have a beam connection to two steel columns with DPDs with a semi-rigid connection. Also, ABAQUS® software is used to perform finite element analysis. In the next step, one of the available laboratories has been used to perform experimental tests. Then, the results between FEM and tested results models have been compared.

Hossein Akbari Lor, Mohsen Izadinia, Parham Memarzadeh[4] proposed experimental and numerical study of I-shape slit dampers in connections . In this study, the proposed damper is installed and tested under cyclic loading. Based on the experimental results, the connection has high seismic performance and rotational capacity more than 0.04 radians. Also, the slit damper connection has more moment capacity than other common connections and indicates a good hysteretic behavior. Also, local buckling didn't occur on the flanges and web of the beam. The column and beam remain in elastic state. Some numerical models were made in ABAQUS software. Analysis results had good agreement with experimental results and showed high energy dissipation and ductility in the proposed connection.

Jie Zheng, Chunwei Zhang [6] proposed experimental Investigation on the Mechanical Properties of Curved Metallic Plate Dampers. In this study, proposes a curved steel plate damper to improve the seismic performance of structures. The theoretical analysis of the curved plate damper was carried out deriving formulas of key parameters of the curved plate damper including elastic lateral stiffness, yield strength, and yield displacement. Moreover, a cyclic loading test of four sets of specimens was conducted, and the hysteretic performance, ductility, energy dissipation performance, and strain of the specimens were studied. The results showed that the initial stiffness of the damper was large, no obvious damage was observed, and the hysteresis loop was full.

AliAshasi-Sorkhabi n, HadiMalekghasemi, AmirrezaGhaemmaghami b, OyaMercan[7] proposed experimental investigations of tuned liquid damper-structure interactions in resonance considering multiple parameters. In this study, tuned liquid dampers (TLDs) are cost effective and low maintenance vibration absorbers that can be used to suppress structural vibrations. A TLD dissipates energy through liquid boundary layer friction, free surface contamination, and wave breaking. In this paper, using a state-of-the-art experimental testing method, namely real-time hybrid simulation (RTHS), a comprehensive parametric study is conducted to investigate the effectiveness of TLDs. During RTHS the TLD response is obtained experimentally while the structure is modeled in a computer, thus capturing the TLD-structure interaction in real-time. By keeping the structure as the analytical model, RTHS offers a unique flexibility in which a wide range of influential parameters can be investigated without modifying the experimental setup.

Mohammad Mahdi Javidana, SeunghoChunb and Jinkoo Kim [5]proposed experimental study on steel hysteretic column dampers for seismic retrofit of structures . In this study, the seismic performance of a steel column damper is evaluated using cyclic loading tests of two one-story one-bay reinforced concrete (RC) frames before and after retrofit. The theoretical formulation and design procedure of the damper are explained first and then the details of the tests are described. The seismic performances of the test frames are evaluated in terms of hysteretic behavior, energy dissipation, crack pattern, failure mechanism, and damper behavior. The analytical model of the damper is established and verified using the experimental data. The seismic performance of the structure is evaluated and compared before and after retrofit in detail using pushover, nonlinear time-history, and fragility analyses. The results show that the presented damper can efficiently reduce inter-story drifts and damage of the structure. The details of modeling techniques and simulations given in this study can provide guidelines and insight into nonlinear analysis and retrofit of RC structures.

Rongqian Yang 1 and Xuejun Zhou 2[8] proposed experimental Research and Theoretical Analysis of the Seismic Behavior of Prefabricated Semirigid Steel Frame with X-Shaped Braces. In this study, three semirigid connections which are convenient for prefabrication have been proposed in this paper. Based on them, the quasistatic test was conducted on three prefabricated semirigid steel frames with X-shaped braces in order to investigate their hysteresis behavior, bearing capacity, energy dissipation capacity, and failure mechanism. A comparative analysis of the semirigid connections was made to analyze their advantages and disadvantages. A numerical simulation was carried out via using ABAQUS to verify the test results, and the causes of the errors were analyzed. The results showed that the prefabricated semirigid steel frames with X-shaped braces had good seismic behavior, the braces cooperated well with the steel frame in resisting lateral load, and the braces failed before the steel frame, which meant the structure had two seismic fortification lines.

Wei Guo XingyeWang , Yujie Yua,Xueyuan Chen , Shu Li a, Wenbin Fanga, Chen Zenga,YangWang a, Dan Bud[9] proposed experimental study of a steel damper with X-shaped welded pipe halves. In this study, a new steel damper named X-shaped pipe damper (XPD), is proposed and examined. The proposed damper is made through welding two oppositely positioned pipe halves to forma X-shaped core, and connecting the X-shaped core to side plates with fillet welds or circumferential welds. The XPD damper provides the lateral resistance and energy dissipation behaviors initially through flexural bending of pipe plates, and latter through the tensile stretching at composite pipe halves. Theoretical derivations of initial stiffness and yielding properties were conducted, and the nonlinear working mechanisms and seismic performance were investigated through cyclic quasi-static tests. Effect of welding methods and pipe configurations on the stiffness, strength, ductility and energy absorption efficiency of the XPDs were studied.

1.1Dual pipe dampers

Dual-pipe damper is fabricated of two horizontal pipes in contact welded to each other and to a top and bottom supporting plate at certain locations to optimize the performance. Six lines of weld are used in the fabrication of DPD — four flare bevel groove welds between the pipes and supporting plates and two flare V groove welds between the pipes. The pipe material should be mild steel with a minimum of 25% elongation in tensile coupon test to guarantee ductile behavior. Fig 1 shows a model of dual pipe damper.

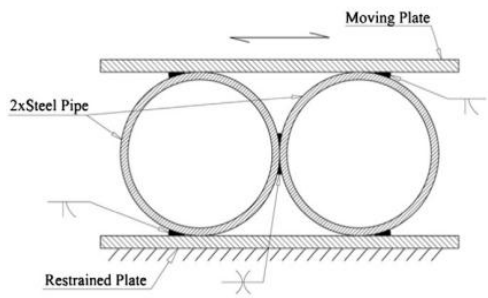

Fig 1 Model of a dual pipe damper.

1.2 Objectives

The main objective of this paper is to identify the seismic performance of joint with a and without damper. Parametric investigations for size optimization of the damper in the beam column joint by varying diameter, width, thickness and number of the dampers and finding optimum performance. To investigate the cyclic performance of the pipe connection under cyclic analysis to evolve it ultimate load, moment capacity, drift, ductility, energy absorption capacity.

1.3 Scope

The study is focused mainly on the rigid connections

2.ANALYSIS OF BEAM COLUMN JOINT WITHOUT DAMPER

The geometric modelling is carried out in ANSYS software. Bare frame is modelled in ANSYS software. The beam (B)and column (C) dimensions [8] are given in the table1

	Depth (mm)	Flange width (mm)	Web thickness (mm)	Flange thickness (mm)
B	600	220	12	19
C	310	288	18.5	33

Table 1 Beam column dimensions

2.1 Modelling of beam column joint without damper

Geometric modelling of beam column joint without damper is done using ANSYS software. Fig 2 shows a model of beam column joint without damper.

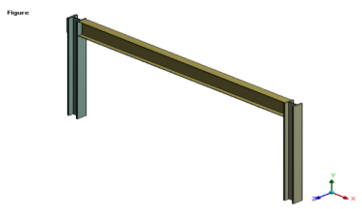

Fig 2 Model of beam column joint without damper.

2.2 Meshing and loading

After modelling, meshing is done as rectangular mesh which is a 4 nodded mesh. Here a mesh size of 10 mm is adopted. The load is applied to the beam column joint.

2.3 Analysis

Nonlinear static analysis is carried out to find out the maximum load carrying capacity by using ANSYS software. Fig 3 shows the total deformation diagram of beam column joint by the application of load.

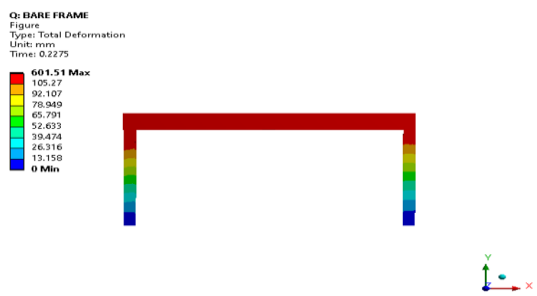

Fig. 3 Total deformation diagram

3.ANALYSIS OF BEAM COLUMN JOINT WITH DAMPER

3.1 parametric study

The geometric modelling is carried out in ANSYS software. Frame with damper is modelled in ANSYS software. The beam (B)and column (C) dimensions are same as given in the table1

3.1.1 Modelling of beam column joint with damper

Model1:150x5x120

Fig 4 shows the model of frame with damper. Fig 5 shows the loading diagram and fig 6 shows the total deformation diagram

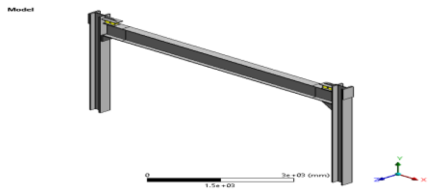

Fig 4 Model of frame with damper

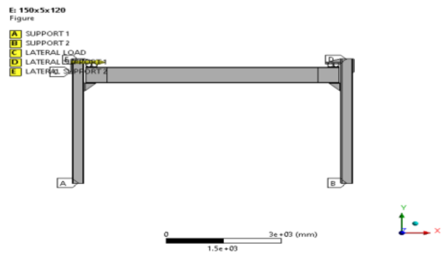

Fig 5. loading diagram

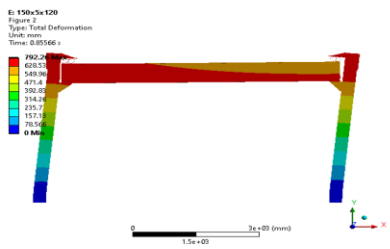

Fig 6 Total deformation diagram

Model 2:150x10x120

Fig 7 shows the model of frame with damper and fig 8 shows the total deformation diagram.

Fig 7 Model of frame with damper

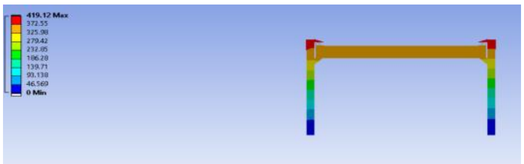

Fig 8 Total deformation diagram.

Model 3:150x15x120

Fig 9 shows the model of frame with damper and fig 10 shows the total deformation diagram.

Fig 9 Model of frame with damper

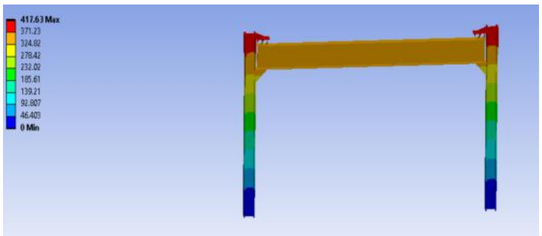

Fig 10 Total deformation diagram

Model 4:150x15x80

Fig 11 shows the model of frame with damper and fig 12 shows the total deformation diagram.

Fig 11 model of frame with damper

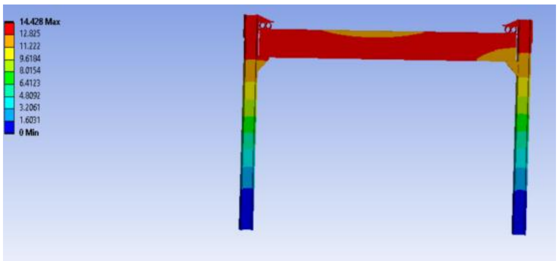

fig 12 Total deformation diagram

Model 5:200x5x120

Fig 13 shows the model of frame with damper and fig 14 shows the total deformation diagram.

Fig 13 Model of frame with damper

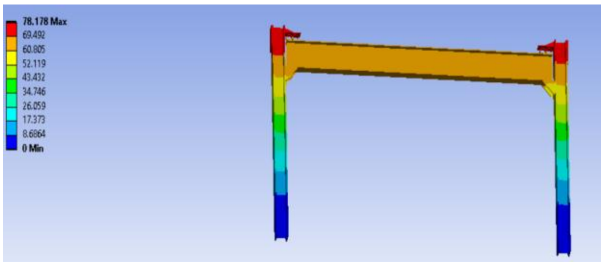

Fig 14 Total deformation diagram.

Model6:200x15x120

Fig 15 shows the model of frame with damper and fig 16 shows the total deformation diagram.

Fig 15 Model of frame with damper

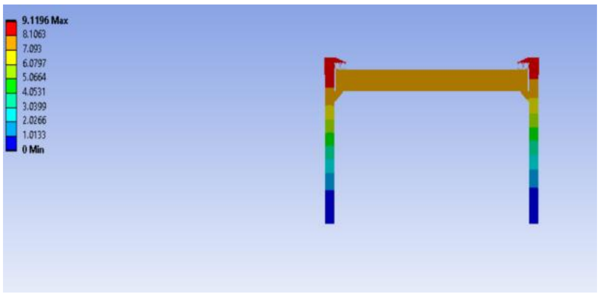

Fig 16 Total deformation diagram.

Model 7:200x15x80

Fig 17 shows the model of frame with damper and fig 18 shows the total deformation diagram.

Fig 17 Model of frame with damper

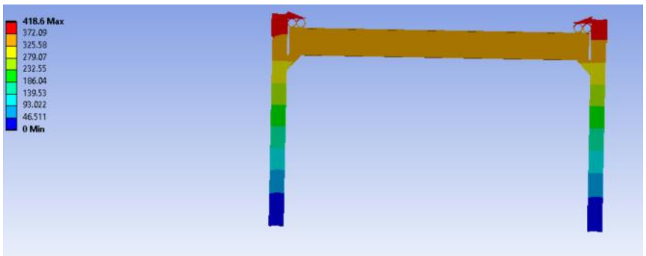

Fig 18 Total deformation diagram.

3.1.2 Results and comparison

Fig 19 shows the graph of comparison of various sizes of dampers

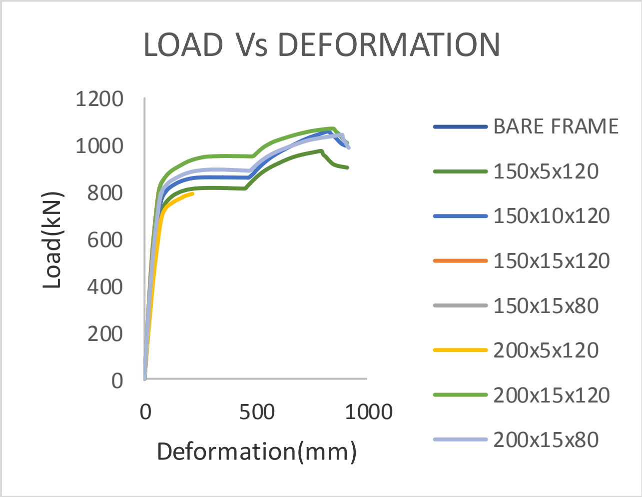

Fig 19. parametric study on dampers

From the above models, the model 200*15*120 have more ductility and load capacity. So, the effective size of damper is 200x15x120.

3.2 Damper with various shapes

Model 1: elliptical shaped damper

Frame is modelled with same dimensions and elliptical damper is installed in beam column joint. Fig 20 shows the model of elliptical damper. Fig 21 shows the deformation diagram of elliptical damper.

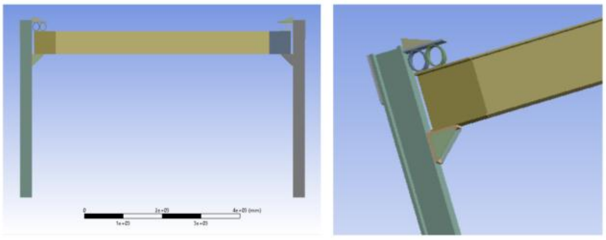

Fig 20. Model of elliptical damper

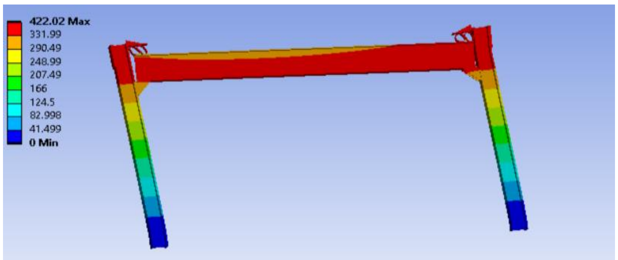

Fig 21. Deformation diagram of elliptical damper

Model 2: oval shaped damper

Frame is modelled with same dimensions and oval shaped damper is installed in beam column joint. Fig 22 shows the model of oval damper. Fig 23 shows the deformation diagram of oval damper.

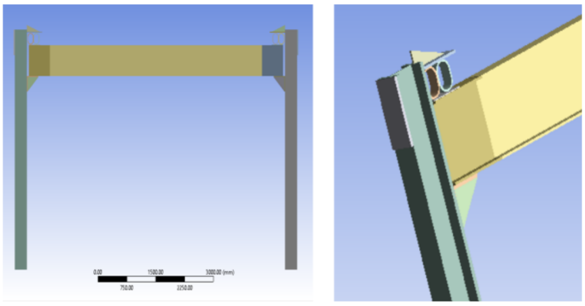

Fig 22. Model of oval damper

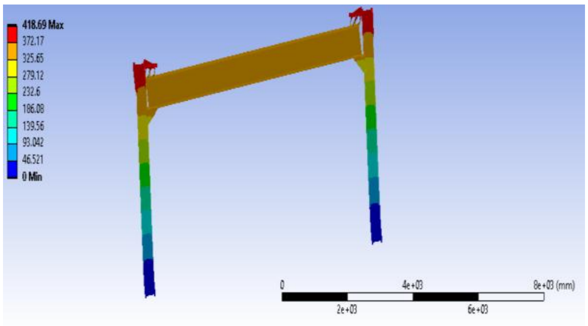

Fig23. Deformation diagram of oval damper.

Model 3: X shaped damper

Frame is modelled with same dimensions and X shaped damper is installed in beam column joint. Fig 24 shows the model of X shaped damper. Fig 25 shows the deformation diagram of X shaped damper.

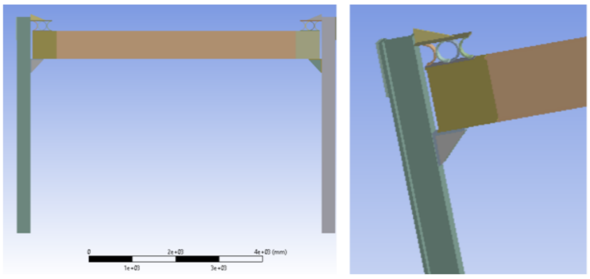

Fig 24. Model of X shaped damper

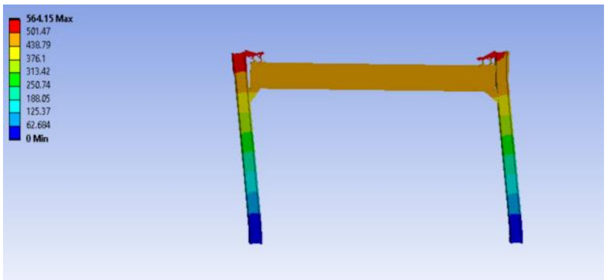

Fig 25. Deformation diagram of X shaped damper

Model 3: circular shaped damper

Frame is modelled with same dimensions and circular shaped damper is installed in beam column joint. Fig 26 shows the model of circular shaped damper. Fig 27 shows the deformation diagram of circular shaped damper.

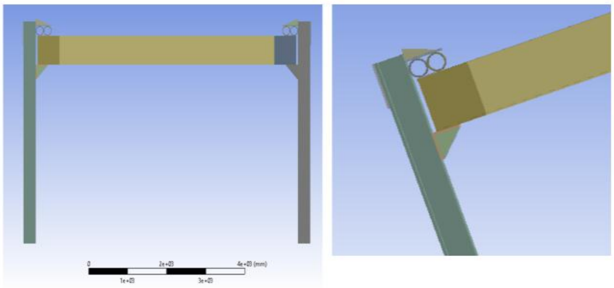

Fig 26. Model of circular shaped damper

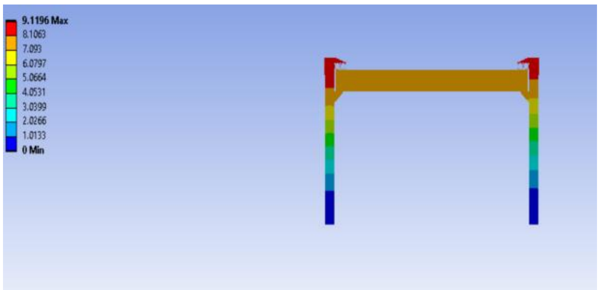

Fig 27. Deformation diagram of circular shaped damper

3.2.1Results and comparison

Fig 28 shows the graph of comparison of different shapes of damper

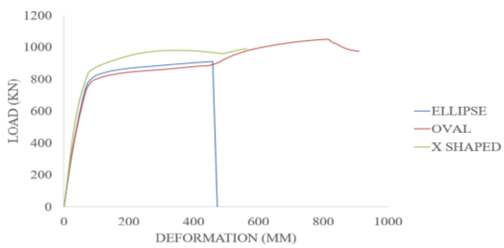

Fig 28. Graph of comparison of different shapes of damper

International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 09 Issue: 07 | July 2022 www.irjet.net p-ISSN: 2395-0072

Various shapes of models like ellipse, oval, x shape, circular is modelled in ANSYS software. From the above models, the circular shaped damper shows more load carrying capacity and ductility.

3.3 Damper with various material

Model 1:oval shaped damper

Frame is modelled with same dimensions and oval shaped damper is installed in beam column joint. The material used here is a low yielding steel with yield strength 100 MPa. Fig 29 shows the model of oval shaped damper. Fig 30 shows the deformation diagram of oval shaped damper.

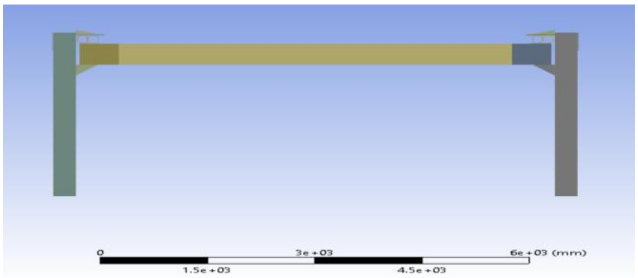

Fig 29. Model of oval shaped damper damper

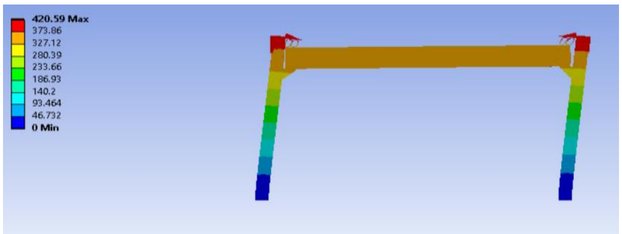

Fig 30. Deformation diagram of oval shaped

Model 2: Elliptical shaped damper

Frame is modelled with same dimensions and elliptical shaped damper is installed in beam column joint. The material used here is a low yielding steel with yield strength 100 MPa. Fig 31 shows the model of elliptical shaped damper. Fig 32 shows the deformation diagram of elliptical shaped damper.

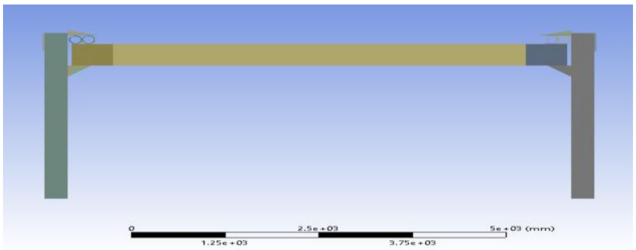

Fig 31.Model of elliptical shaped damper.

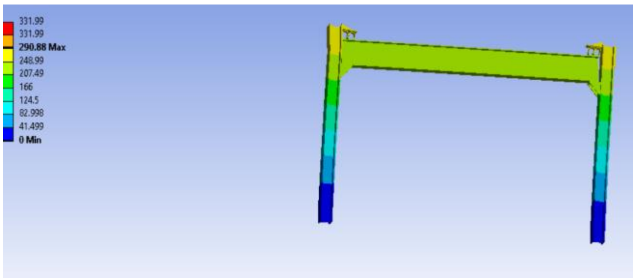

Fig 32.Deformation diagram of elliptical shaped damper

Model 3: X shaped damper

Frame is modelled with same dimensions and X shaped damper is installed in beam column joint. The material used here is a low yielding steel with yield strength 100 MPa. Fig 33 shows the model of X shaped damper. Fig 34 shows the deformation diagram of X shaped damper.

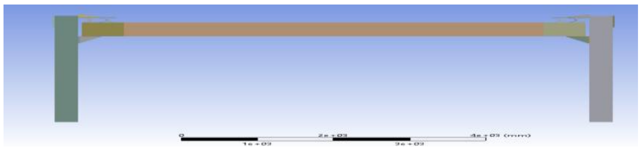

Fig 33 Model of X shaped damper

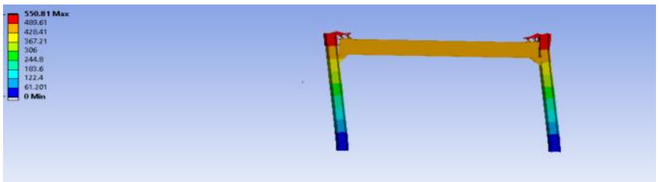

Fig 34. Total deformation of X shaped damper

Model 4: Circular shaped damper

Frame is modelled with same dimensions and Circular shaped damper is installed in beam column joint. The material used here is a low yielding steel with yield strength 100 MPa. Fig 35shows the model of Circular shaped damper. Fig 36 shows the deformation diagram of Circular shaped damper

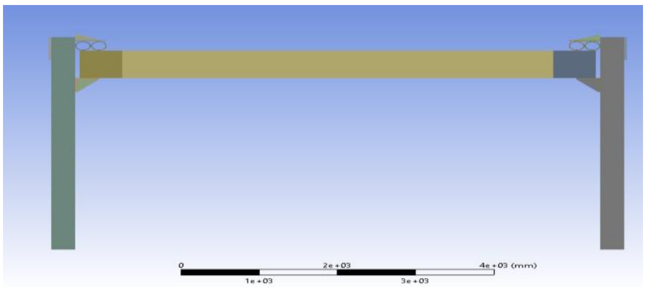

Fig 35. Model of Circular shaped damper

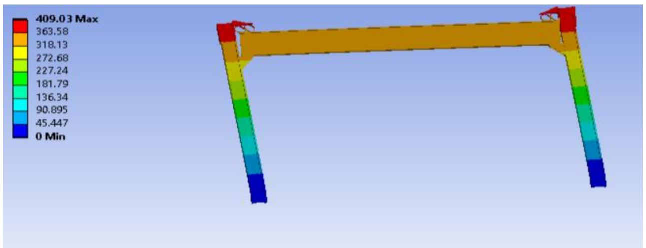

Fig 36. Deformation diagram of Circular shaped damper

3.3.1Results and comparison

Fig 37 shows the comparison of different materials of dampers

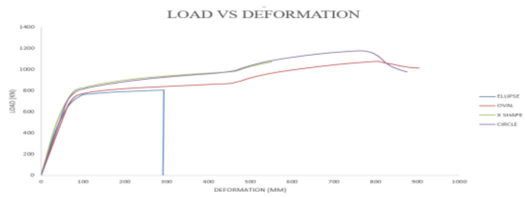

Fig 37. comparison of different materials of dampers

Low yielding materials used in modelling of dampers. By modelling dampers with low yielding material, circular damper shows more load carrying capacity (1177.7 kN) and ductility (12.629).

4 TIME HISTORY ANALYSIS IN MULTISTORY FRAME

4.1Analysis of Building frame without damper

A five storied building frame is modelled in the ANSYS software without damper. Fig 38 shows the model of a building frame without damper.

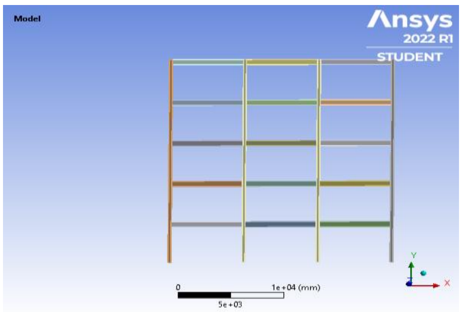

Fig 38. Model of a building frame without damper

4.1.1 Loading

Loading such as Kobe earthquake is applied to the structure. Fig 39 shows the Acceleration Time history of Kobe earthquake. Fig 40 shows the deflection of the building frame.

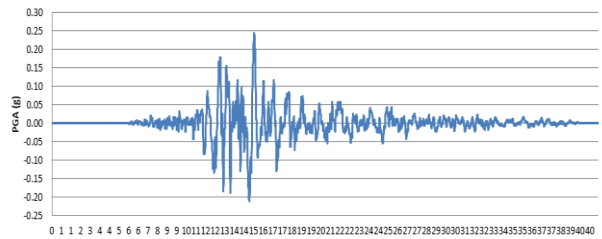

Fig 39. Acceleration Time history of Kobe earthquake

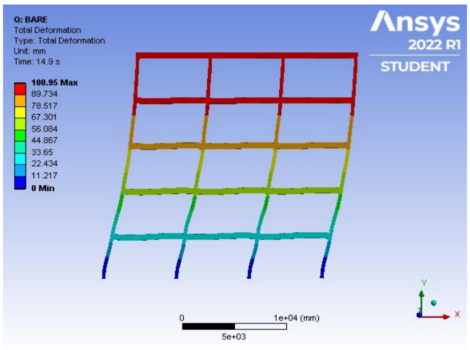

Fig 4Deflection of the building frame.

4.2Analysis of Building frame with damper

A five storied building frame is modelled in the ANSYS software with damper. Fig 41 shows the model of a building frame with damper. Fig 42 shows the total deformation diagram A loading of Kobe earthquake is applied to the building frame.

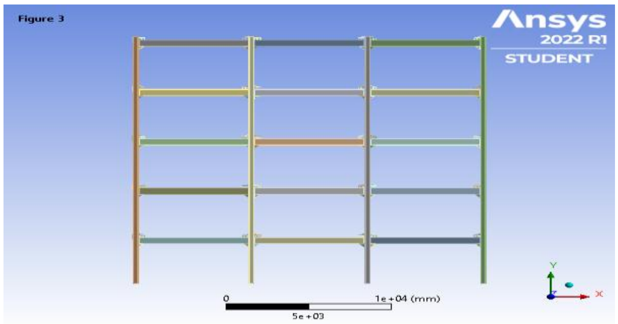

Fig 41. Model of a building frame with damper

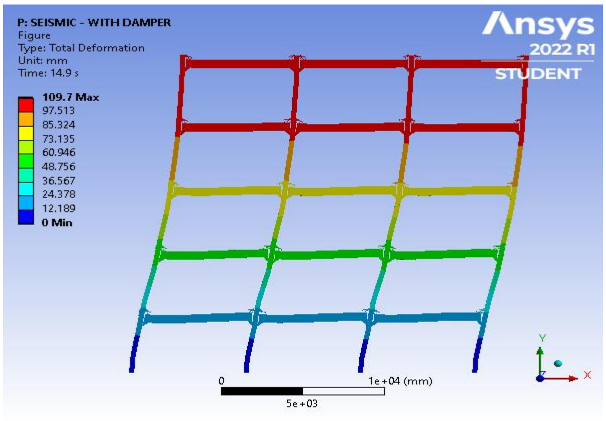

Fig 42 Total deformation diagram

4.3 Results and comparison

Fig 43 shows the graph of base shear comparison of model with and without dampers

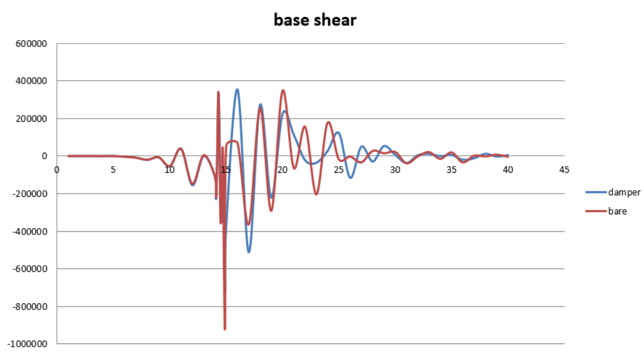

Table 2 comparison of base shear and displacement

MODELS	DISPLACEMENT (mm)	BASE SHEAR(kN)
BARE FRAME	100.95	71643
FRAME WITH DAMPER	108.18	57967

The bare frame has a displacement of 100.95 mm whereas the frame with damper has a displacement 108.18 mm. The bare frame has a base shear of 71643 kN where frame with damper has a base shear 57969 kN.

5. CONCLUSIONS

- Different models are subjected to parametric study with and without damper in beam column joint.
- By analysing the model without damper, it shows a ductility of 4 and the load carrying capacity of 1022 kN
- By conducting parametric study, the model having more ductility and load carrying capacity is selected as effective size (200x15x120). The model with damper shows more ductility and load carrying capacity.
- Various shapes of models like ellipse, oval, x shape, circular is modelled in ANSYS software. From the above models, the circular shaped damper shows more load carrying capacity and ductility.
- Low yielding materials used in modelling of dampers. By modelling dampers with low yielding material, circular damper shows more load carrying capacity and ductility.
- Time history analysis is carried out in multi-storeyed building frame.5 storied building frames with and without damper is analysed in the software. Dampers are installed in the beam column joint of the frame. The model with damper shows more displacement than the bare frame. The bare frame shows more base shear than the model with damper.ie, the model with damper shows less base shear than bare frame. So, the forces coming in to the building reduces to 19%.
- Hence conclude that stability of the building increases when circular dampers are installed in beam column joint of a multi-storeyed building frame.

REFERENCES

[1]. Silvia Costanzo, Mario D'Aniello⁎ , Raffaele

Landolfo "The influence of moment resisting beam-to column connections on seismic behavior of chevron concentrically braced frames" Journal of Constructional Steel Research 188 (2022) 107057

[2].OnurSeker "Seismic response of dual concentrically braced steel frames with various bracing configurations" Journal of Constructional Steel Research 188 (2022) 107057

[3].AmirMasoumiVerki , Adolfo Preciado"Experimental and analytical investigations of enhanced semi-rigid connections with dual pipe dampers" Structures 33 (2021) 3765–3778

[4]. Haifeng Bu, Liusheng He , Huanjun Jiang "Study on steel slit shear walls with different characteristics of hysteretic behavior" Thin-walled structures 128

[5]. Mohammad Mahdi Javidana, Seungho Chunb and Jikoo Kim "Experimental study on steel hysteretic column dampers for seismic retrofit of structures" Steel and Composite Structures, Vol. 40, No. 4 (2021) 495-509

6].Jia Zheng, Chunwei Zhang " Experimental Investigation on the Mechanical Properties of Curved Metallic Plate Dampers" Appl. Sci. **2020**, 10(1), 269.

[7].Ali Ashasi-Sorkhabi ,AmirrezaGhaemmaghami , OyaMercan "Experimental investigations of tuned liquid damper-structure interactions in resonance considering multiple parameters" Journal of Sound and Vibration

[8].Rongqian Yang 1 and Xuejun Zhou 2 "Experimental Research and Theoretical Analysis of the Seismic Behavior of Prefabricated Semi rigid Steel Frame with X-Shaped Braces" Latin American Journals of Solids and Structures

[9]. Wei Guo , Xingye Wang , Yujie Yua , Xueyuan Chen a , Shu Li a , Wenbin Fang , Chen Zeng , Yang Wang , Dan Bu "Experimental study of a steel damper with X-shaped welded pipe halves" Journal of Constructional Steel Research170(2020)