Lateral Resisting Performance of X Shaped Pipe Damper in Inverted V Bracings

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Abstract – *In today's scenario, steel frame structures play an important role in the construction industry because they are efficient, sustainable, durable, flexible and safe. To analyze the structure subjected to seismic loads, the deformed geometry and the non-linear behavior of the structure must be considered. Therefore, to determine the performance of the structure, non-linear or a pushover test is performed. The thrust test was performed on two frames, namely bare frame and steel reinforced frame. Steel braced structural frame is one of the structural systems used to resist earthquake loads in multistoried buildings. Bracings are required to inhibit lateral buckling the members For the better performance of brace frame in building x shaped pipe damper is installed in brace beam connection to enchance the seismic performance. So this study deals with the study of the inverted V-type bracing system with X shaped Pipe Damper(XPD) in steel constructions. Push over analysis is the preferred analysis procedure for seismic performance evaluation. The objective of this paper is to evaluate the response of bare frame and braced frame with XPD subjected to seismic loads and to identify the suitable size of XPD in brace frame for resisting the seismic load efficiently. From the study it is obtained that brace frame with XPD provide better seismic performance than brace frame in terms of ductility, yield displacement, ultimate displacement and ultimate load*

Key Words: X Shaped Pipe Damper, Bracing, Lateral Buckling, Steel Structure

1.INTRODUCTION

Steel frames play important role in the construction industry because they are profitable, sustainable, durable, flexible and sure. Recently, the need for structural remediation of civilian infrastructure around the world is well known and a lot of research is being done in this field. Whenever new technologies are developed they are changes in factors contributing to the structure, such as increased load required, deterioration due to corrosion exposure to aggressive environments, changes in functionality, potential damage caused by mechanical and environmental effects, increased strength and durability of the material. Today steel frame system with beams and columns becomes the conventional building structure in the construction world. Structural design and structural analysis are both of the criteria needed to create a structure that is safe perform its function of producing structures in stable conditions. The main advantage of steel structure is that it exhibit post-elastic behaviour.

In general, ground movement due to an earthquake can occur anywhere in the world and special attention must be paid to the danger related to buildings, especially under strong seismic forces. While reinforcement is provided in the structural system in the construction of the structure, the location of the bracing must be in an effective position to make the building more rigid. Most of the steel braces used are X, V, inverted V, etc. Introduction of pipe damper in bracing will enchance the seismic performance. So this pipe deals with the study of the inverted V-type bracing system with X shaped Pipe Damper(XPD) in steel constructions. Push over analysis is the preferred analysis procedure for seismic performance evaluation purpose and it also gives post elastic behaviour. Analyse and evaluate seismic Performance of bare frame and brace frame with XPD is done with help of ANSYS software .

1.1 XPD

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 circumferential welds. The XPD (X-shaped Pipe Damper) 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 [1]. The production process of XPD is simple and the pipes are easy to obtain. So, XPDs as in cooperate with brace frames will provide more seismic resistant structure.

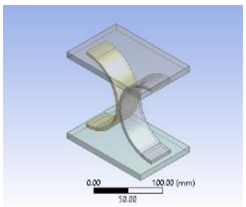

Fig -1:Modelling of XPD in Ansys Software

The objective of this paper is to evaluate the response of bare frame and braced frame with XPD subjected to seismic loads and to identify the suitable size of XPD in brace frame for resisting the seismic load efficiently.

2. ANALYSIS AND RESULTS

The units used in modeling the steel structure are in millimeters. The height of frame 4000 mm and the section length is 8000 mm. The columns are fixed to the base with welded connection, the joints between the beams and columns are joined with a combination of welds and nuts and bolts. In the end, a terminal can be assumed for the connection of the pins. The 3D view of the steel bare frame is designed as shown in Fig. 2 and another steel frame is designed with mounted V-shaped brace stiffeners as shown in Fig.3.

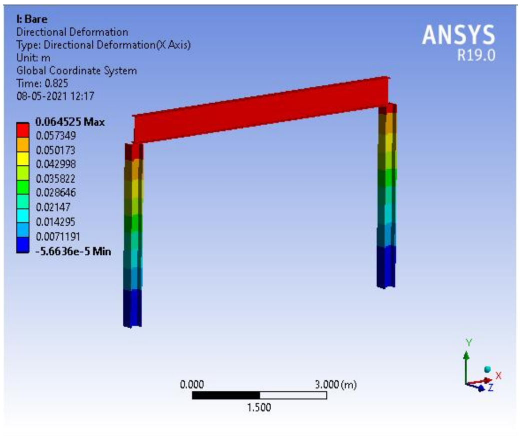

Fig -2: Directional Deformation of Bare Frame

Steel frame is designed with inverted V-shaped bracing equipped with the XPD steel dampers as shown in Fig 3.

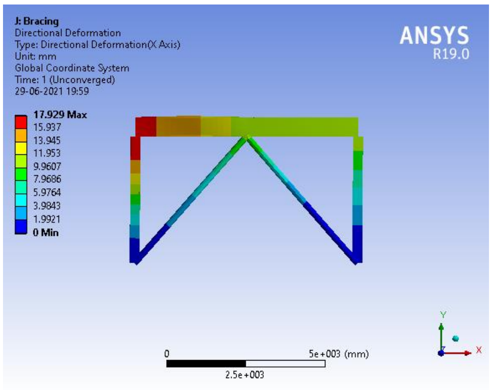

Fig -3: Deformation of brace frame

Here the X shaped Pipe Damper is installed in beam brace connection. Analysis results of deformation of various damper sizes used in brace frame from ANSYS are shown in figures below

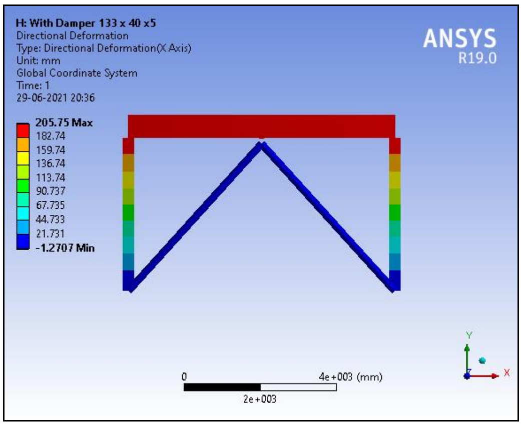

Fig -4:Deformation of damper size133 x 40 x 5 mm in brace frame

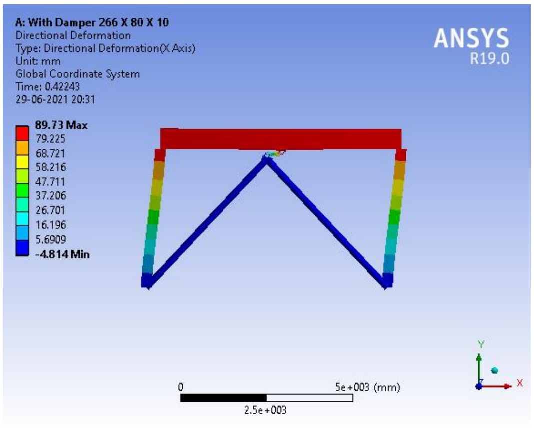

Fig -4 : Deformation of damper size : 266 x 80 x 10mm in brace frame

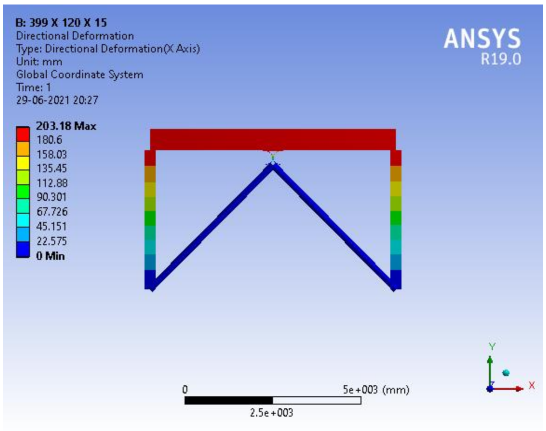

Fig -5 : Deformation of damper size : 399 x 120x 15mm in brace frame

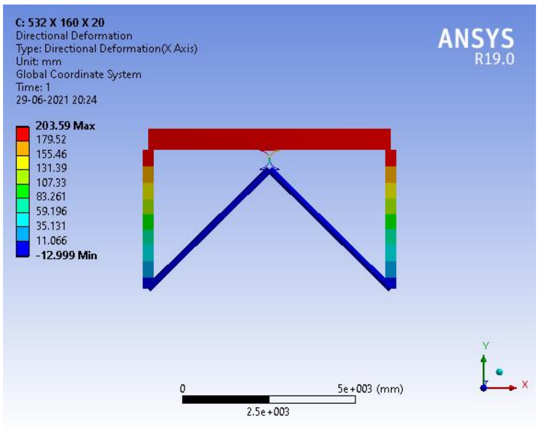

Fig -6: Deformation of damper size:532 x 160 x 20mm in brace frame

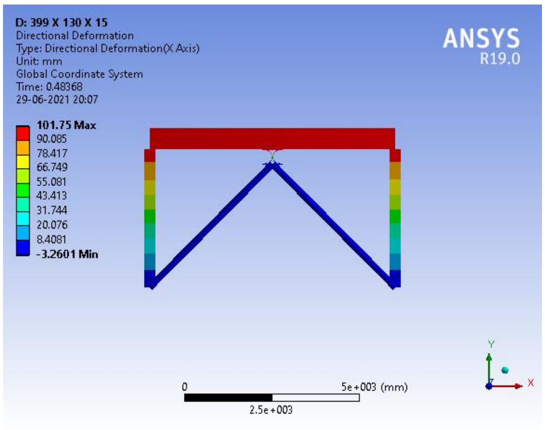

Fig -7: Deformation of damper size: 399 x 130 x 15mm in brace frame.

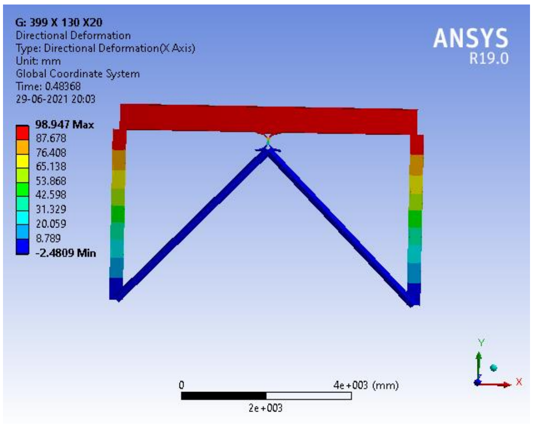

Fig -8: Deformation of damper size 399 x 130 x 20 mm in brace frame

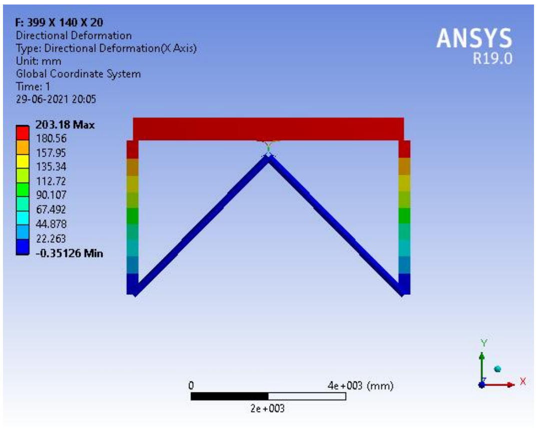

Fig -9: Deformation of damper size : 399 x 130 x 15 mm in brace frame

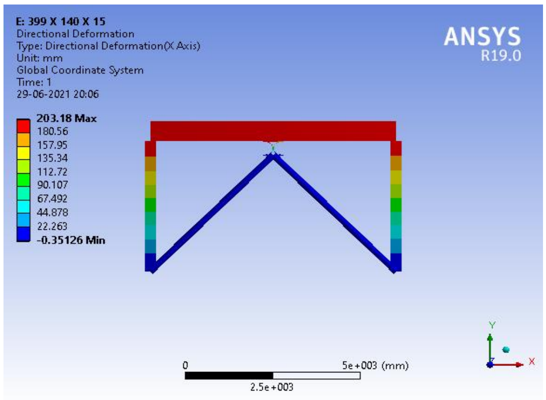

Fig -10: Deformation of damper size: 399 x 140 x 15mm in brace frame

2.1 Results of X damper in brace Frame

Results of X damper of various sizes are tabulated in table 1 shown below. The initial XPD of size 133 x 40 x 5 mm is taken because it is experimentally proved to be effective in seismic performance[1].

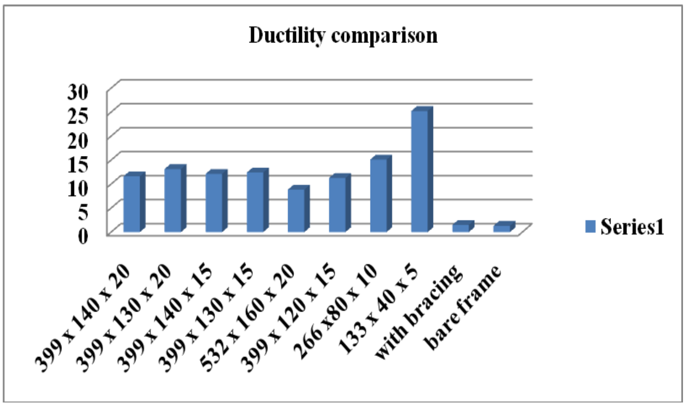

Chart -1:Ductility comparison

Ductility and ultimate load comparison of various dimensions of dampers in brace frame are plotted in the chart 1and 2 respectively.

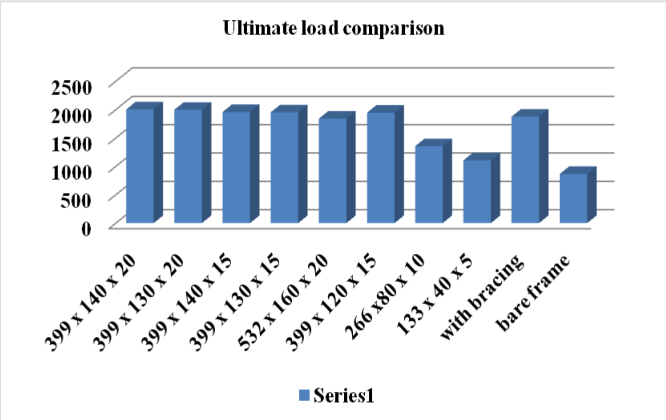

Chart -2: Ultimate load comparison

Chart 2 shows that ultimate load taking capacity of frame increases with increase in damper size. 399x140x20 mm have high ultimate load taking capacity. Variation of ultimate deflection of various dampers is compared in chart 3. From the results obtained from the table 1, it is observed that the ductility and ultimate load increase with increase in length of damper. Suitable size of the X damper in brace frame which gives best performance is found out i.e., 399 x 130 x 20 mm. The ultimate load taken by this damper is effective. i e, 1996.8 N. While ductility value of this damper is also high compared to the other dampers in brace frame. i e, 13.1409285 .Also this size damper is optimum for brace frame from aesthetic appearance point of view. So we can say that this size X damper gives most effective performance in brace frame.

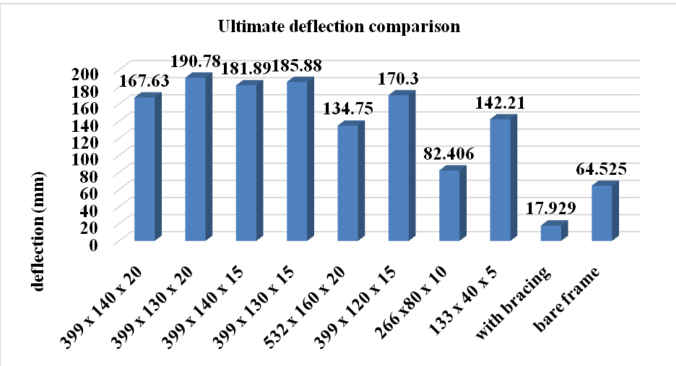

Chart -3: Ultimate deflection comparison

3. CONCLUSIONS

Table -1: Results of the analysis

Specimen size (mm)	Yield displacement Δy (mm)	Ultimate displacement Δu (mm)	Ultimate load Pu (kN)	Ductility µ
399 x 140 x 20	14.437	167.63	2002.9	11.61113805
399 x 130 x 20	14.518	190.78	1996.8	13.1409285
399 x 140 x 15	14.985	181.89	1956.8	12.13813814
399 x 130 x 15	14.982	185.88	1951.3	12.40688827
532 x 160 x 20	15.23	134.75	1840.4	8.847669074
399 x 120 x 15	15.111	170.3	1945.6	11.26993581
266 x 80 x 10	5.4572	82.406	1355	15.1004178
133 x 40 x 5	5.6359	142.21	1104.3	25.23288206
Brace frame	12	17.929	1875.1	1.494083333
Bare frame	49.659	64.525	864.42	1.299361646

Present paper investigates the effect of X Shaped Pipe dampers on the steel structure behavior basements during an earthquake. This study is conducted through push over analysis with the help of ANSYS software. From the push over analysis of various dimensions of XPD in beam brace connection, it is observed that the ductility and ultimate load increase with increase in length of damper. Suitable size of the XPD in brace frame which gives best performance is found out i.e., 399 x 130 x 20 mm. The ultimate displacement and yield displacement of this damper is higher than other dampers in brace frame. The ultimate load taken by this damper is effective .i e., 1996.8 N. While ductility value of this damper is also high compared to the other dampers in brace frame .i.e., 13.1409285. Also this size is optimum for brace frame from aesthetic appearance point of view.The analysis results show that, X Shaped Pipe damper devices are perfectly able to reduce the structural response of steel structures. In summary, XPD can contribute significantly towards minimization of earthquake damages in brace frame with XPD. Maintaining of XPD is much easier than base isolation in terms of cost and ease of installation. Thus, with the use of this replaceable X Shaped Pipe damper, the repair time and cost can be reduced significantly, thereby enhancing the seismic performance of the steel structure than brace frame without XPD.

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