Performance of profiled I shaped dampers as energy dissipation system for braced steel structure

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Abstract -*During an earthquake, severe damages may occur in the structural elements. In order to reduce the damages by earthquakes, dampers are used in the structures. It controls earthquake induced vibrations on buildings. Dampers absorb a significant amount of seismic energy to the structure and which is dissipated by them. In this study, I shaped profiled damper (IPDs) are used. The IPDs as ductile element in concentrically braced frame systems which is responsible for energy absorption and energy dissipation. Dampers are easily replaceable and economically feasible which controls the seismic mitigation on steel structure. The main objective of this study is to perform the lateral loading testing on a braced steel frame with and without damper. The parametric study is carriedout by changing the parameters of the IPD dimensions to find the optimum size that is bests suited for the seismic performance of the structure. This study also focus on obtaining hysteresis performance and the energy dissipation capacity byplacing IPD damper in a different bracing system. It is expected that using IPD damper in braced steel frame, the energy dissipation capacity is improved avoid buckling of bracing and the output parameters like stiffness, total dissipated energy, and hysteresis behavior are compared. The complete analytical model and extensive parametric studies will be carried out usinga ANSYs software.*

***Key Words*: I profiled dampers (IPDS)**

1.I NTRODUCTION

The focus of research over the past few decades has been on methods to save the main structural components and localize damage to a few particular components so that the structure's responses to powerful earthquakes may be managed. Three classifications of structural control are generally used: active, semi-active, and passive control. The hydraulic jacks, sensors, and power supply that the active and semi active systems may use to adapt the structural reactions to the imposed loads require specialized infrastructure, which raises the cost of construction. The cost of construction for passive systems, however, is determined by the complexity and material of the damper and is not dependent on the applied forces. These kinds of systems' major purpose is to dissipate or reduce the transmitted input energy into the structure via the passive control devices in order to avoid the formation of plastic hinges into the fundamental structural elements. As passive control devices, all forms of dampers are considered, including metallic, friction, tuned mass, and base isolations.

The Concentrically Braced Frame (CBF) is one of the structural systems that, despite being used extensively worldwide, exhibits unsuitable behaviour when subjected to seismic pressure. As a result, scientists have worked very hard to modify this system's behaviours. Researchers put forth various design standards for CBFs (in line with EC8). Their findings demonstrated that the recommended design parameters enhance CBFs' earthquake performance. The buckling of the compression elements decreases the ductility and energy wasted by the system, despite the fact that it has a higher lateral stiffness than other lateral load resisting systems like Moment Resisting Frames (MRF) and Eccentrically Braced Frames (EBFs). Additionally, the expense of system rehabilitation is expensive due to the plastic hinges' transformation into the diagonal braces.

Even while reducing the slenderness ratio enhances CBF performance, deterioration of stiffness and strength and a correspondingly considerable drop in energy absorption remain grave problems. This has caused researchers to consider the use of dampers in CBFs. Metallic dampers are more capable and cost-effective than other types of dampers for use in CBFs and to improve the capacity to dissipate energy. Despite their simplicity, these dampers have unique qualities including lower construction costs, simplicity of installation, increased energy absorption, and localization of damages to a particular portion. Additionally, the manufacture of these dampers does not require specialized tools or cutting-edge technology, which lowers the cost of metallic dampers. Additionally, metallic dampers' straightforward design and numerical simulation lower the design cost.

Metal dampers have the ability to transfer input energy using a variety of methods, including bending, shear, torsion, or a combination of them. The shear process, however, results in a high elastic stiffness and an ideal capacity for energy dissipation. These dampers can be divided into two groups: those that are added directly to the diagonal systems and those that can be installed on the diagonal systems. Examples of the first category include axial, shear, comb-teeth, slit, pre-bent strips, and ADAS dampers. The high-quality construction and high price of these dampers make their use problematic even though they exhibit suitable seismic performance. The most well-known dampers in the second category are the U-shaped dampers attached to the diagonal braces and the Buckling-Restrained Brace (BRB). Despite having acceptable seismic performance, these dampers are more expensive due to the manufacturing costs and unique facilities.

1.2 Objectives and scopes

The primary goals of the study are lateral load testing on braced frames with and without dampers, modelling and analysis of profiled dampers, finding the best size of damper for performance, and assessing the hysteresis performance and energy dissipation capacity when a profiled damper is installed in a braced system.

Through the employment of an energy dissipation system and I-shaped dampers in the bracing, the study will be used to reduce the effects of seismic control and buckling elimination. damper system that controls seismic mitigation on steel structures is easily changeable and financially viable. The models are created using nonlinear static analysis in Ansys Workbench (2022).

2. LATERAL LOADING TEST ON BRACED FRAME WITH AND WITHOUT DAMPER

This chapter deals with modelling of a full scale model for steel structure with braced configuration without damper and with damper. After modelling lateral loading test is carried out on the braced frame with and without damper. Three models are created using ANSYS software as per AISC provisions. The different models are barced frame, braced frame with flat damper, braced frame with profiled damper. Material properties of the beams are Young's modulus 2×10^5 Mpa, 3, Density 2400 kg/m^3 and material properties of steel tube is Young's modulus 2×10^5 Mpa, Poisson's ratio 0.3, Density 7850 kg/m^3 .Profiled damper; Flat web is replaced with corrugated web.

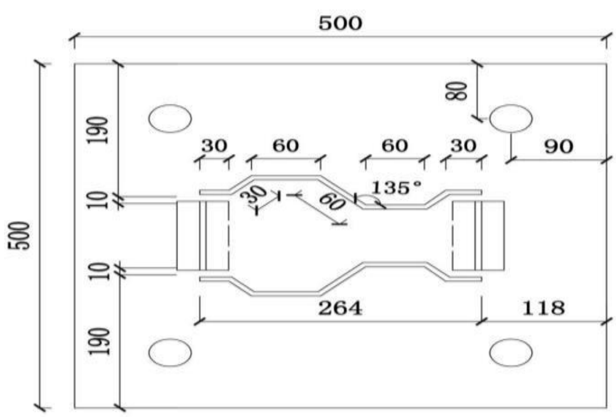


Fig 1 Geometric dimension of corrugated web

2.1 Modelling

These specimens are modelled in ANSYS software with different specimen dimensions like FD 200x6x140mm and PD 200x6x140mm. Modelling is done by using element type SOLID 186. Values are referred from journal (Experimental Investigation of the Seismic Behavior of Low-Yield-Point Corrugated Steel Plate Dampers, Seismic response of dual concentrically braced steel frames with various bracing configurations -2022).

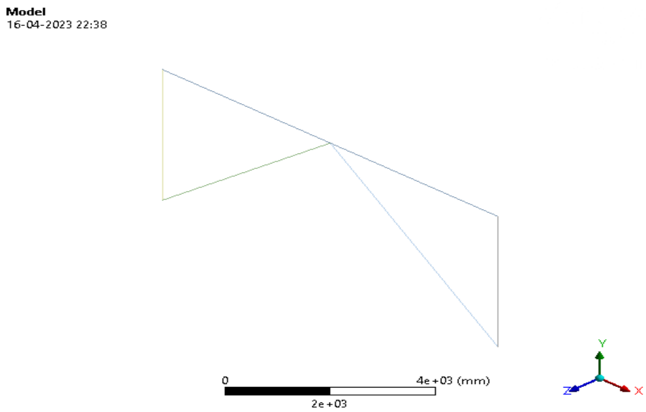


Fig -1: Model of braced frame

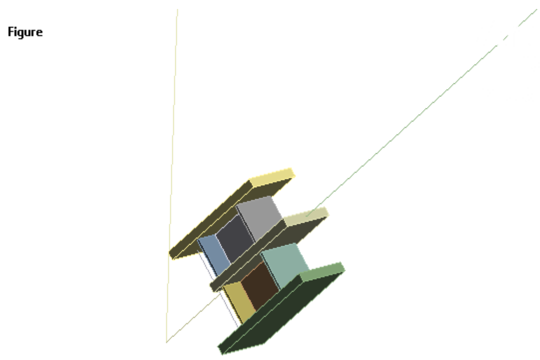


Fig 3 model of flat damper

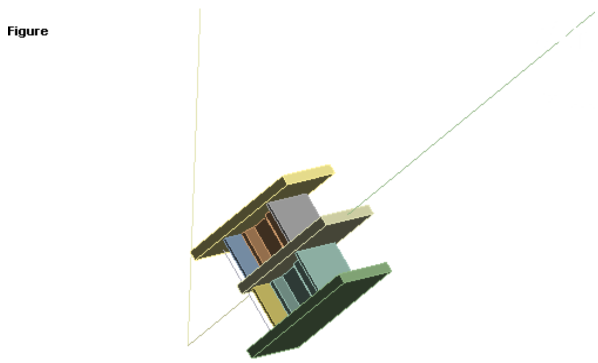


Fig 4 Model of profiled damper

2.1.1 Meshing and loading

The specimens is modelled using hexahedral which is a 20- noded mesh. Programme controlled coarse mesh is adopted for meshing the models. Load is applied as displacement of 11.2 mm according to displacement convergence method.

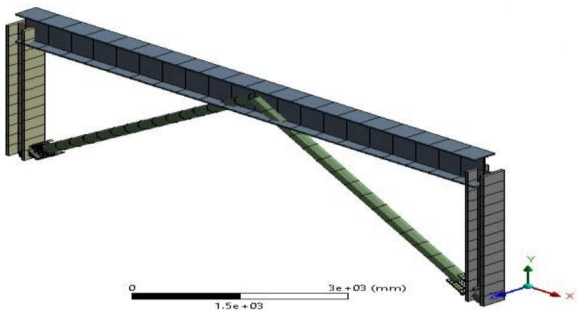


Fig -5: meshing of braced frame

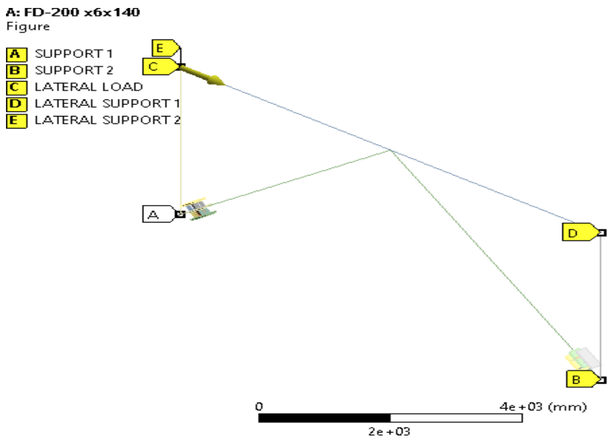
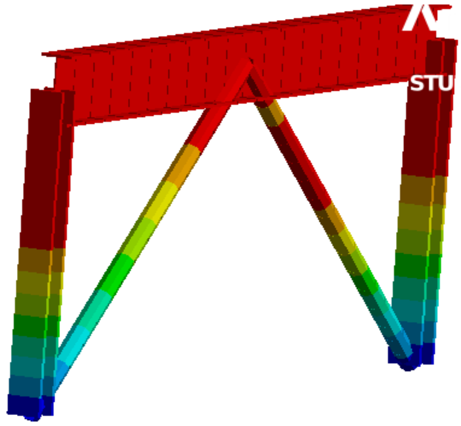


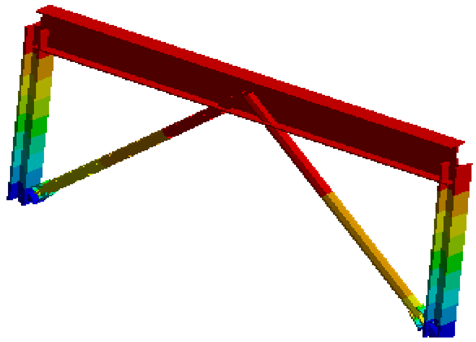
Fig -6: Loading condition

2.2 Analysis

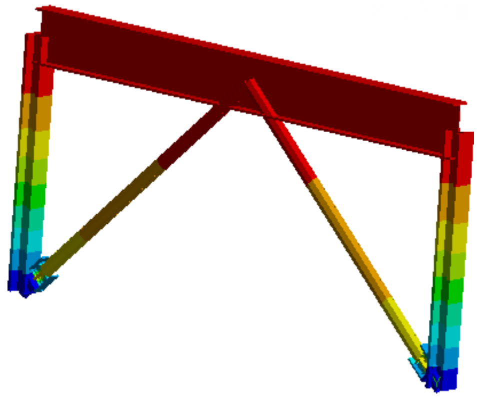
Analysis is carried out to study the lateral loading testing on the braced frame with and without damper. Nonlinear static structural analysis is carried out in ANSYS software. Deformation and load carrying capacity is studied.



Deformation of braced frame



Deformation of flat webbed damper



Deformation of profiled damper

Fig -7: Deformation diagram

2.3 Result and discussion

The result obtained from the lateral load testing of the braced frame with flat damper and braced frame with profiled damper is then compared with the result obtained from the braced frame. From that load deflection curve is taken for each model. The load deflection curve is compared.

Table -1: Comparison of result

Model	Deflection (mm)	Load (kN)	Ductility	% decrease of load
Brace	17.352	4471.6	1.732	1
FD 200x6x 140	177.75	2551.4	17.775	42.942
PD 200X6X 140	179.85	2542.7	12.846	43.136

The load and deflection obtained are compared.

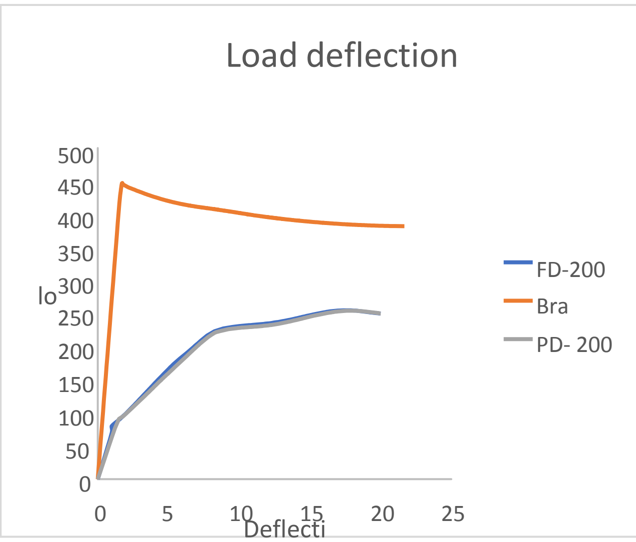


Chart -1: Load deflection comparison

Lateral load testing of full scale braced framed is carried out successfully, it has high stiffness. Braced frame has a low ductility of 1.732 and have high strength of 4471.6 kN. By introducing flat damper and profiled damper to the braced frame the ductility of the frame is increased. By introducing flat damper and profiled damper to the braced frame the ductility of the frame is increased. Braced frame with flat damper has a ductility of 17.775 and have strength of 2551.4 kN. Braced frame with flat damper has a ductility of 17.775 and have strength of 2551.4 kN. Braced frame with profiled damper has a ductility of 2542.7 and have strength of 2542.7kN. Braced frame with damper does not have us much strength as the braced frame, hence further parametric studies are needed to carried out to determine the optimum size of the damper which give better performance

3. MODELLING AND ANALYSIS OF PROFILED DAMPER AND FINDING THE OPTIMUM SIZE OF THE DAMPER

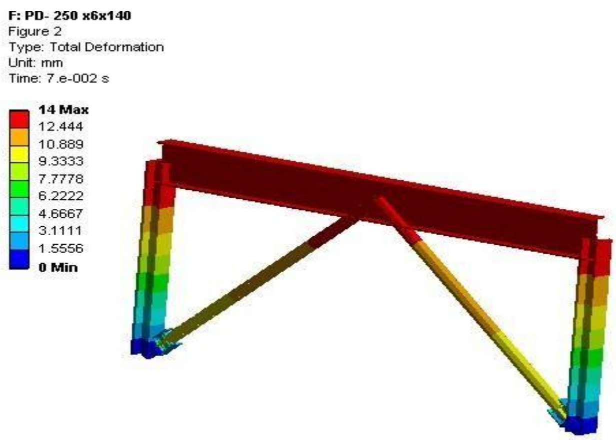
This study is deal with the determination optimum size of the damper in a full-scale damper. These profiled dampers are modelled and analysed. For this study various parametric studies have been carried out. Parametric studies are such as effect of length ratio, effect of web thickness ratio and effect of profile depth. Various model are analysed by considering the parametric conditions. These models have analysed by using ANSYS software.

3.1 Modelling

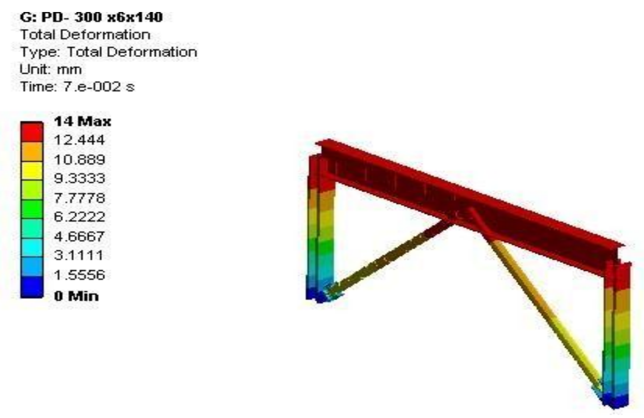
The parametric studies are conducted by changing the web height ,web width and thickness. The specimens are PD 200X6X140, PD 250X6X140, PD 300X6X140, PD 350X6X140, PD 350X6X100, PD 350X6X110, PD 350X6X120, PD 350X6X130, PD 350X8X140 to PD 350X18X140.
Note; PD profiled damper

3.2 Analysis

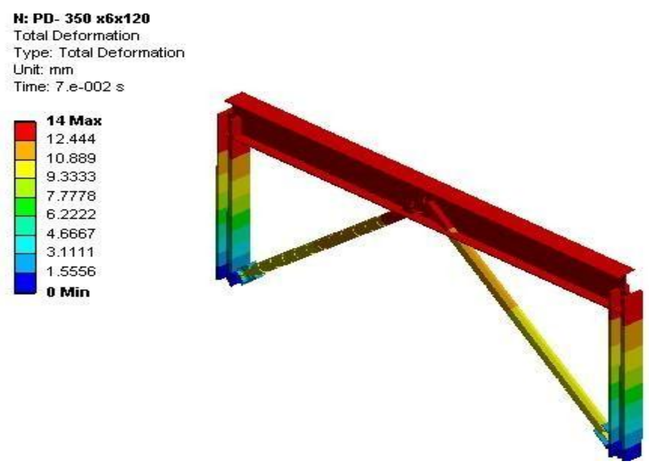
Analysis is carried out to determine the optimum size of the profiled damper which gives the better performance. Non linear structural analysis is carried out in ANSYS software. Deformation and load carrying capacity is studied.



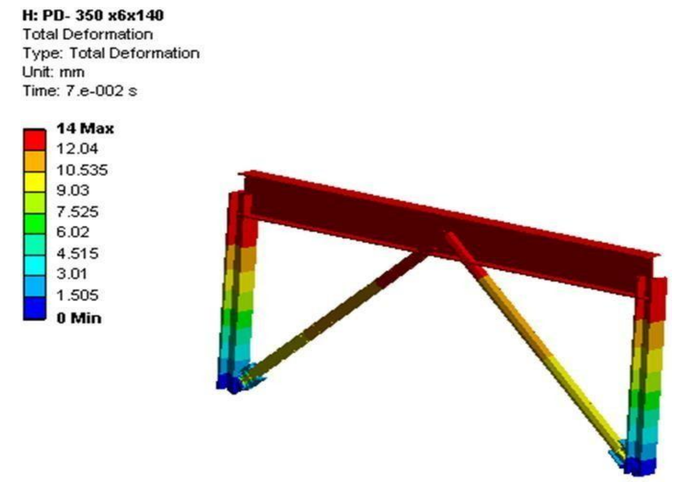
Deformation of PD 250X6X140



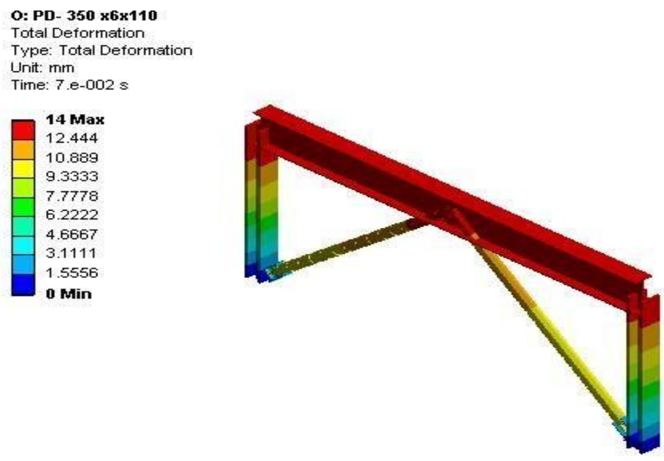
Deformation of PD 300X6X140



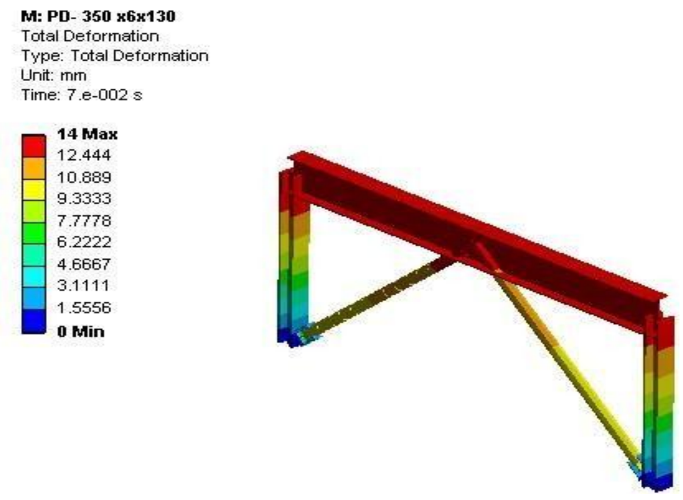
Deformation of PD 350X6X120



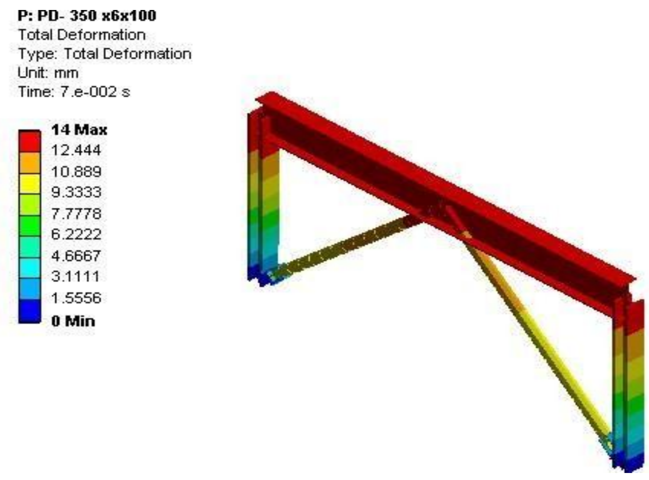
Deformation of PD 350X6X140



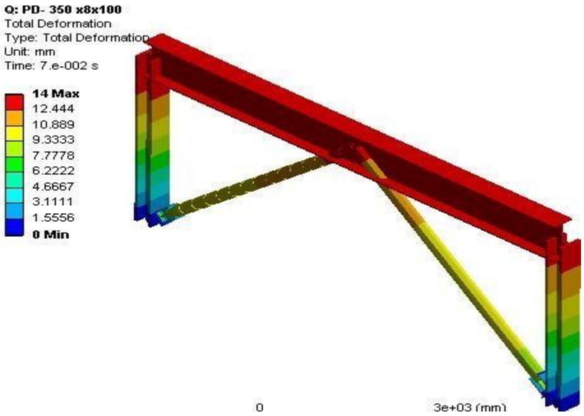
Deformation of PD 350X6X110



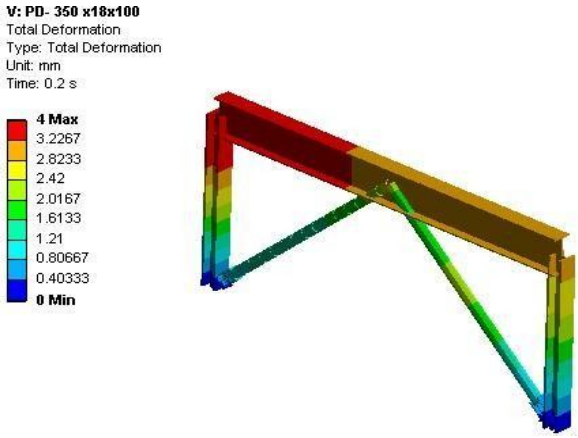
Deformation of PD 350X6X130



Deformation of PD 350X6X100



Deformation of PD 350X8X100



Deformation of PD 350X18X100

Fig -8: Deformation diagram

3.3 Result and discussion

The result obtained for each of the above mentioned models are compared with the braced model. Different parametric conditions are considered such as web height, height and thickness. Load deflection curve is plotted for each specimen. The load and deflection obtained is compared.

Table -2: comparison chart by changing web height

Changing height	Model	Deflection(mm)	Load (kN)	Ductility	% decrease of load
	PD 250X6X140	182.06	2600.6	37.15	41.84
	PD 300X6X140	102.44	2496.7	14.63	44.16
	PD 350X6X140	93.319	2623.4	31.55	41.33

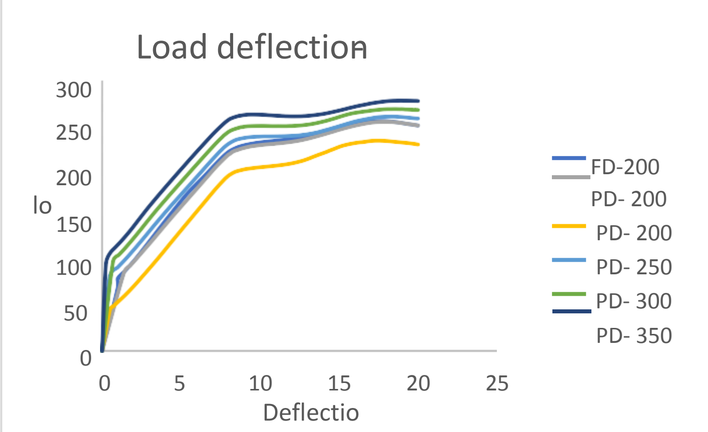


Chart 2 Load deflection curve

Table -3: Comparison of results

Model	Deflection (mm)	Load (kN)	Ductility	% decreasein load
PD 350X8X 100	159.9	3216.6	32.632	28.06
PD 350X10X 100	159.03	3371.3	3245	24.60
PD 350X12X 100	91.288	3556	13.04	20.47
PD 350X14X 100	93.505	3997.5	23.37	10.602
PD 350X16X 100	92.004	4317.4	23.00	3.44
PD 350X18X 100	90.004	4630.1	22.501	-3.54

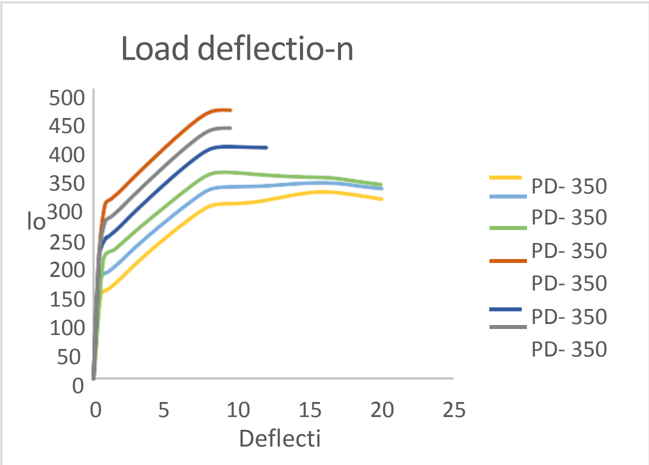


Chart 3 Load deflection curve

Various parametric studies have been conducted to determine the optimum size of damper which give better performance and high strength. By increasing the web height from 200 mm to 350 mm, strength is increased to 2623.4 kN But it will not acquire the strength as much the braced system. By keeping the web height constant the web width is increased from 140 to 180 mm and deceases from 140 to 100 mm. Decreasing the web thickness causes the increase in strength of the structure. Width of 100 mm gives a strength of 2934.7 kN. Decreasing the web width keeps the ductility as same as the braced system. Again by fixing the web height as 350 mm and web width as 100 mm the thickness is increased from 6 mm. At a thickness of 18 mm the profile damper (PD) attains the strength more than the braced system ie 4630.1 kN. At this point it has a ductility of 22.40. Therefore the effective size of the damper for the structure is 350 X 18 X100mm.

4. CONCLUSIONS

In this study an innovative I profiled damper is displayed. This damper is used to improve the performance of these structures because CBFs have weakness in their ductility and energy absorption. Main benefits of this damper are its inexpensive cost of production and assembly, quick installation and lack of need for special tools. Numerous parametric studies have been carried out in order to research and create this damper .The ideal damper size that provides improved performance has been determined through a variety of parametric experiment. If damper is added to a braced frame frame , performance will be improved.

- Full scale model of a steel structure with braced configuration is studied. It gives a load of 4471.6 KN and ductility of 1.73 and have high stiffeness.
- As compared to ordinary braced frame here a I shaped profile damper is introduced . in this frame flat damper and profiled damper is introduced. Flat damper gives a load of 2551.4 kN and profiled damper gives a load of 2542.7 KN.
- Various parametric studies have been conducted in the profiled damper by changing various parameters such as wed height (from 200mm to 350mm) , web width (140 to 100mm), thickness(6 to 18mm)
- From the analysis it is found that the profiled damper of size 350x18 x100 give better load and have great strength, which is the optimum size of damper. Maximum load obtained is 4630.1 KN and a ductility of 22.50.

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