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SEISMIC RESISTANCE OF STEEL STRUCTURE EQUIPPED WITH DUAL PIPE DAMPER

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Abstract: In this paper, a new passive earthquake energy dissipative device, called the dual-pipe damper (DPD), is used to study the percentage of improvement of the seismic capacity of a rigid connection steel structure. Different mechanisms such as yielding of metals, phase transformation of metals, friction, deformation of viscoelastic materials and fluid orificing have been used by researchers to develop several passive energy dissipation devices during the last four decades. Among these mechanisms, yielding of metals is one of the most effective, simple and economical mechanisms to dissipate earthquake input energy. DPD fabricated of two horizontal mild steel pipes in contact welded to each other. The frame with DPD seemed to 70percentage more ductility compared to the frame without DPD. The parameters such as diameter, thickness and length changed by different combination and the optimum pipe size are determined.

Index Terms **- Dual Pipe Damper, Earthquake load, Energy Dissipation, ANSYS.**

1. INTRODUCTION

When designing a structure for seismic load, it is assumed that the part of seismic input energy will absorb by the structure elements through the plastic deformation or hysteretic behaviuor. The formed plastic hinges in beams of rigid frames, concentric braces and shear wall are the examples of these plastic energy absorbing elements. But in severe earthquake the strength and stiffness of the elements will degrade and collapse of the structure will takes place. In addition rigid frames undergo a large inter storey drift which cause considerable damage to structural and non-structural elements. Due to these limitations the concept of structural control system was developed. It includes semi active, active and passive control systems. Semi-active and active-control systems the motion of the structure modified by the action of an external energy supply. But passive control systems increase the energy dissipation capacity of the structure by absorbing the seismic input energy. There by it reduces the force, displacement demand and damage to gravity load carrying members. It does need any external power source like semi active and active control system. It increases the lateral stiffness and strength of the structure. Mechanisms such as yielding of metals, friction, deformation of viscoelastic material, phase transformation of metals and fluid orificing have been used by researchers to develop several passive energy dissipation devices. Among these mechanisms one of the most effective, simple and economical mechanism to dissipate earth quake energy is yielding of metals. The idea of applying this mechanism to dissipate earthquake energy is introduced in early 70s. Many hysteretic energy dissipating devices have been invented. The researchers named Maleki and Bagheri invented a new passive energy dissipation device called pipe damper and verified the effectiveness of the shear loaded pipes as an energy dissipating device through cyclic tests. The test result was excellent for the energy dissipation capacity and hysteretic behaviour. The initial stiffness and maximum strength of the pipe damper was low when comparing with some commercially available energy dissipating devices. This was compensated by using more than one pipe damper at the same level. This was not economical issue since the pipes were inexpensive. Finally in this research a new passive earthquake energy dissipative device called Dual Pipe Damper (DPD) is introduced.

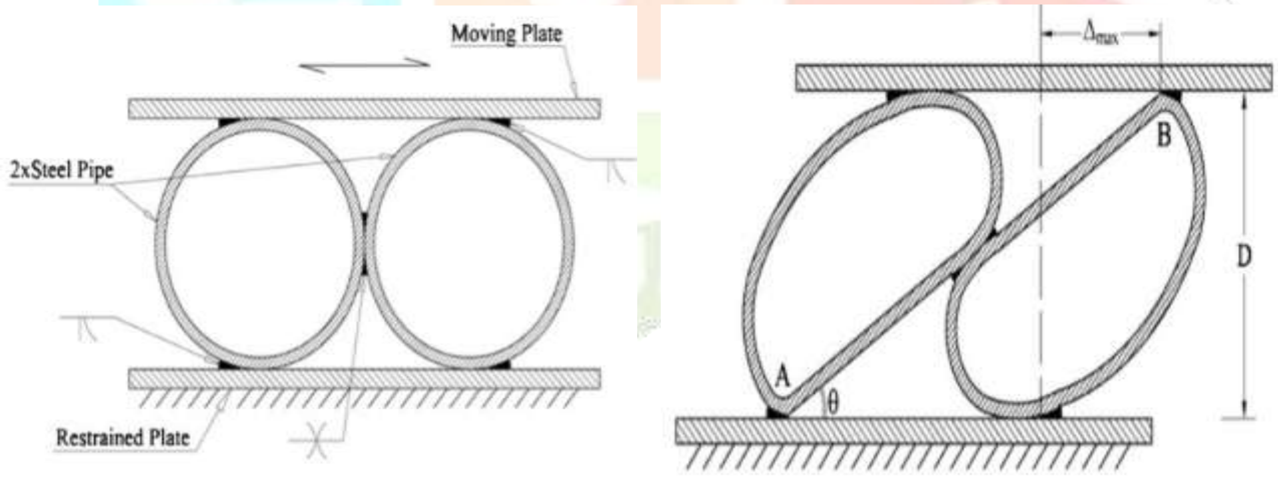
1.1 Objectives of the Project

- To study the seismic behavior of DPD in a steel frame with bracings
- To make a comparative study of a bare frame with frame with DPD and frame with bracing only
- To find out best model based on parameters diameter, thickness, and different lengths of the pipe

2. SPECIMEN DESIGN

2.1 Design and working of Dual Pipe Damper

Dual Pipe Damper is fabricated of two pipes welded to each other horizontally. To optimize the performance of DPD a top and bottom supporting plates are welded to it. Six lines of weld are used in the fabrication of dual pipe damper. That is, four flare bevel groove weld between the pipes and supporting plates and two flare V-groove weld between the pipes. The material for the pipe should be mild steel with minimum 25% elongation in tensile coupon test to guarantee ductile behaviour.



(a) (b)

Fig -1: Model of DPD (a) Before Deformation (b) After Deformation [8]

When the structural suffered by the seismic events, the DPD are very easy to be yielded in a to and fro motion corresponding to the seismic wave and dissipate the energy of seismic events sufficiently. And also with its high elastic stiffness, it can prevent the primary structural being damaged by the seismic events sufficiently. Due to its geometry it has maximum displacement limit. Energy dissipation in DPD is based on plastic deformation of steel pipe mainly in flexure form. At relatively large displacement a tensile-flexural form of displacement was seen in the part of the device, which gradually increases the secondary stiffness and strength of the DPD to a much higher value. This behaviour enhances the performance of the DPD in structures subjected to heavy earthquake. When reaches the maximum displacement the tension side of the central X-shaped part become straight and more displacement will only be tolerated by material plastification. Maximum theoretical displacement of DPD is 0.26 times of the diameter of the pipe and it increases up to 0.36 times of the diameter of the pipe due to material plastification.

2.2 Design of the Models

Firstly a single bare frame, single frame equipped with DPD and a single frame equipped with bracings only are designed to make a comparative study of these three frame models. After that for finding the optimum dimensions of the DPD's pipe a total number of 16 models having different combinations of pipe diameter, thickness and length were designed and tested under pushover analysis. The frame is designed as per IS SP 6:1964. Column used is ISWB 450 with a full height of 5m. Beam is ISMB400 with 4m span length, and the used bracing is a steel tube with size of 100mm X 100mm X 5mm. In this paper different combinations of diameter, length and thickness combinations of pipe were studied using ANSYS 16.2. Table 1 shows the all the 16 models. In set 1 there are 4 models of 10mm thickness and 25mm length with pipe lengths of 400mm, 300mm, 200mm and 100mm. And so on the other 3 sets.

Table -1: Dimensions of DPD Models

	Set 1 (10mm thick& 25mm length)	Set 2 (10mm thick& 50mm length)	Set 3 (20mm thick& 25mm length)	Set 4 (20mm thick& 50mm length)
Diameter (mm)	400	400	400	400
	300	300	300	300
	200	200	200	200
	100	100	100	100

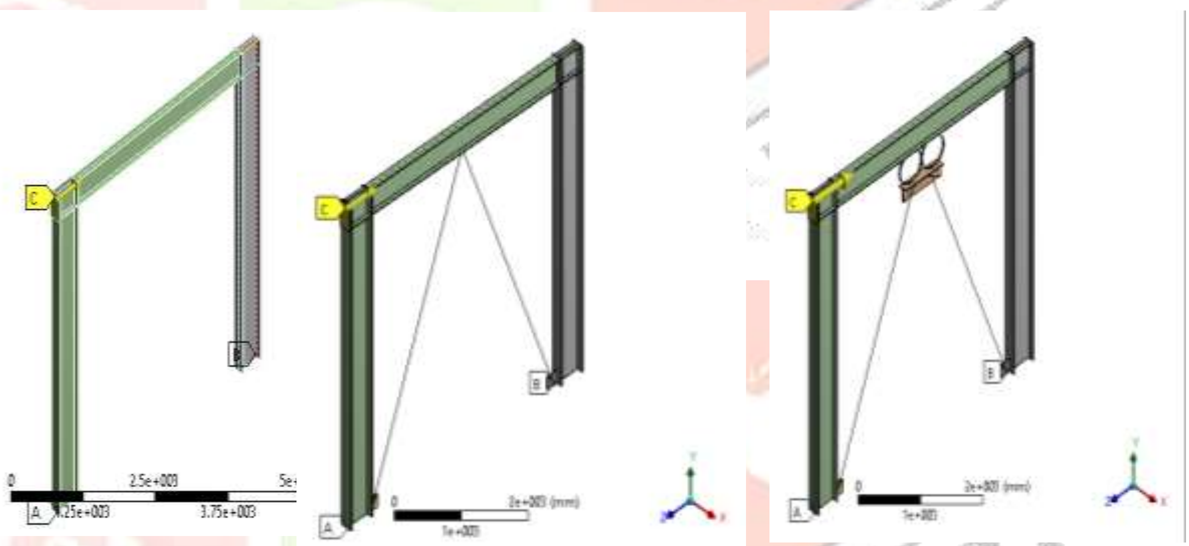
3. MATERIAL PROPERTIES

Table -2: Material Properties

Steel
Yield strength- 345 MPa
Young's modulus- 200 GPa
Poisson's ratio- 0.3
Bi linear property

4. ANALYSIS OF THE MODELS

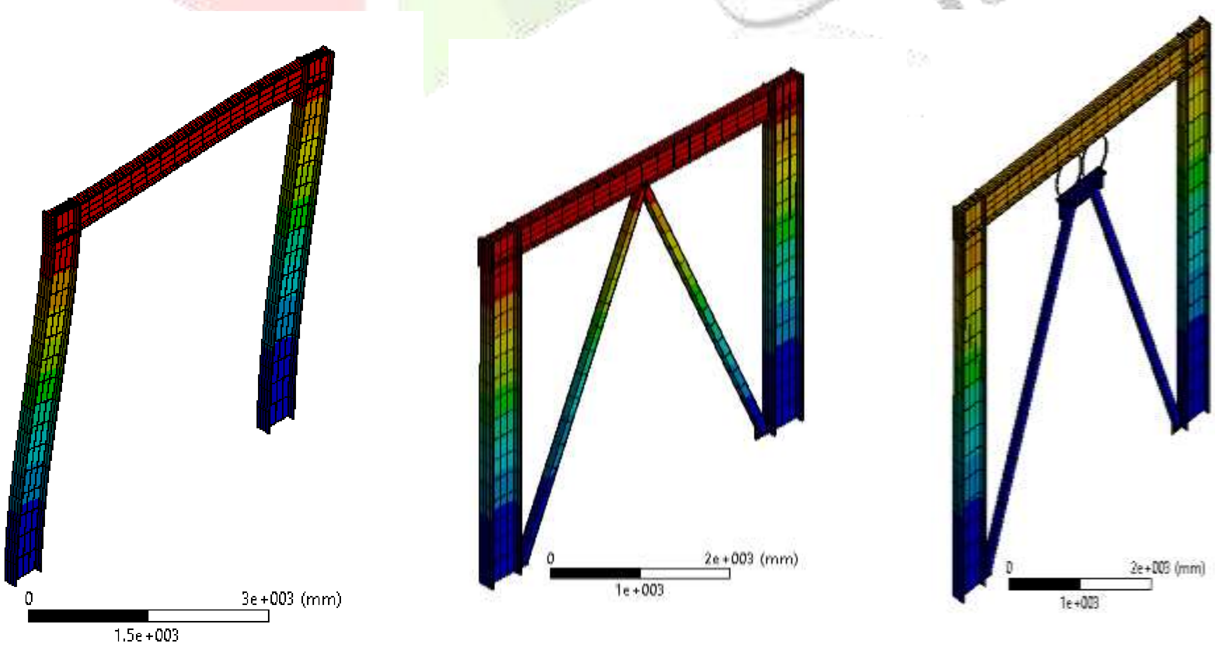
Ansys workbench 16.1 was used to develop the two dimensional steel structure model. The comparative study of the single frames with DPD, without DPD and bracing only is done. And the parametric study of the damper is done with various 16 models. The ANSYS 16.1 software was used to model all the specimens for nonlinear analysis. SOLID 186 from ANSYS library was used for 3-D finite element modeling of the steel frame model comparison of the DPD equipped frame and bare frame, parametric study o DPD and comparison of three different patterns of DPD arrangement and a bare frame were studied using ANSYS 16.1 through push over analysis.



(a)

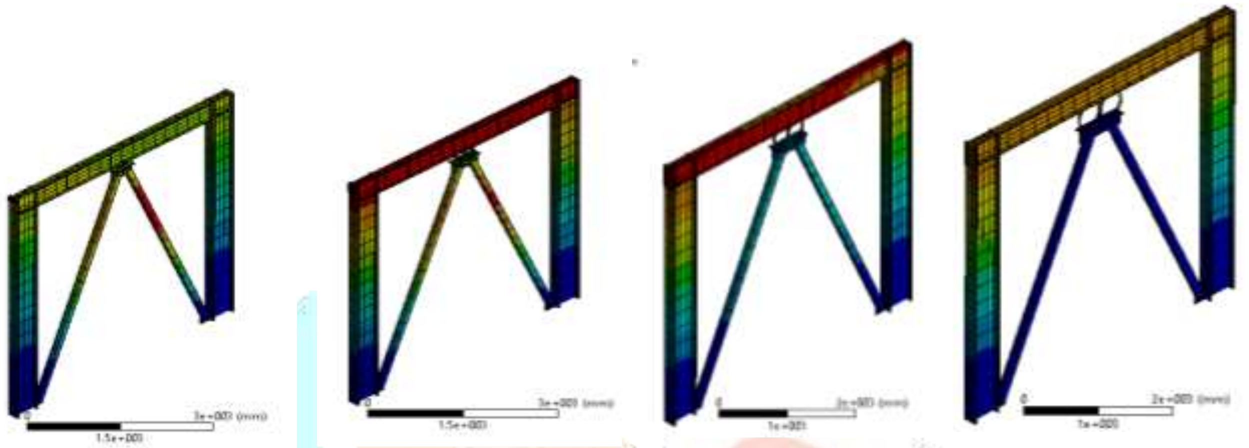
(b) (c)

Fig -2: Ansys Models (a) Bare frame, (b) Frame with Bracings Only, (c) Frame with DPD

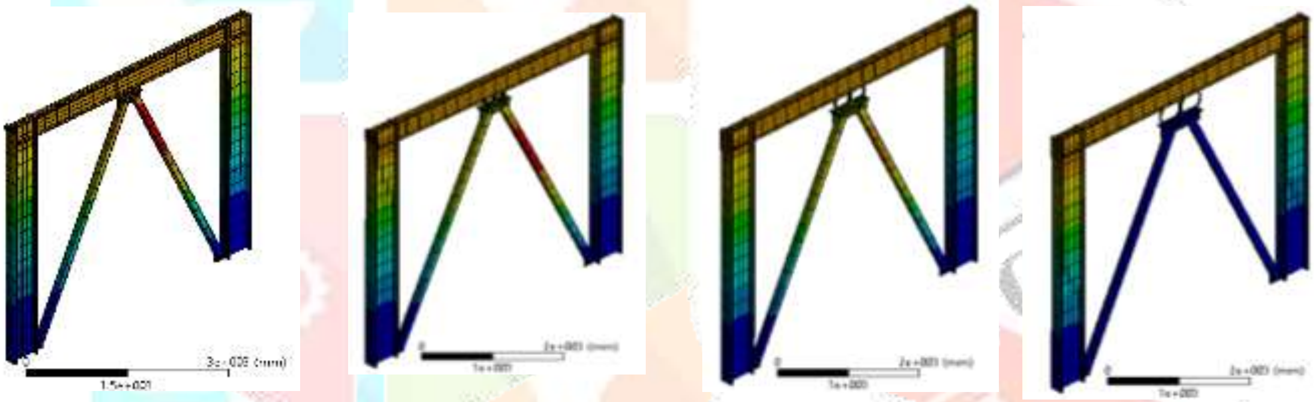


(a) (b) (c)

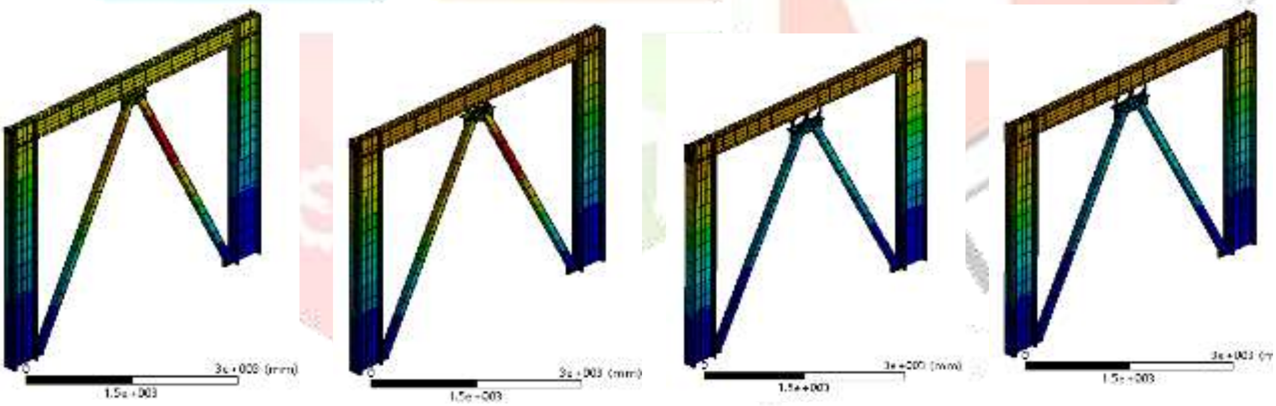
Fig -3: Total Deformations of (a) Bare frame, (b) Frame with Bracings Only, (c) Frame with DPD



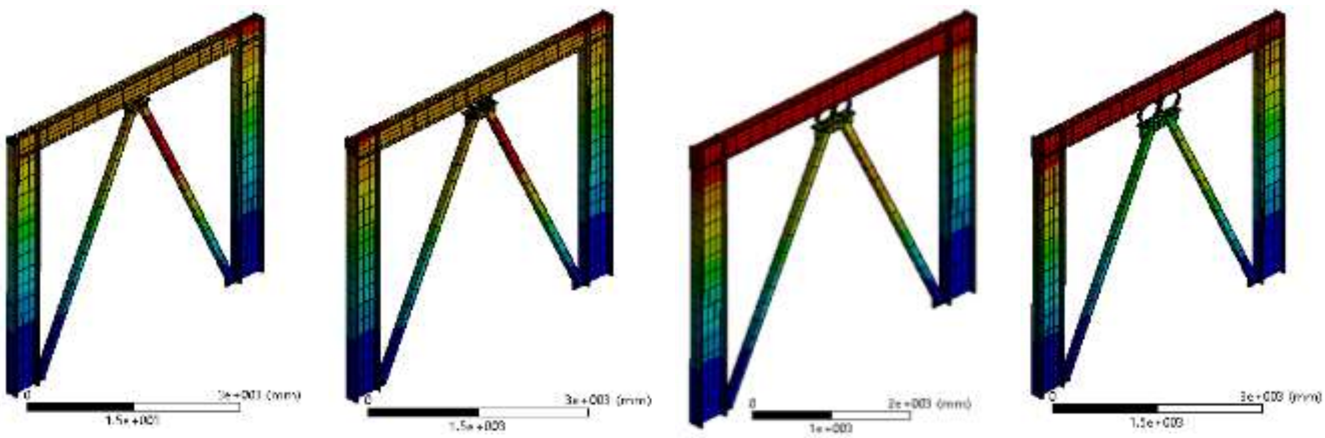
Set 1



Set 2



Set 3



Set 4

Fig -4: Total Deformations of Set 1, Set 2, Set 3 and Set 4

5. LOAD VERSUS DEFLECTION

Chart -1 shows the load deflection curve for bare frame, frame with DPD and the frame with bracings only. From this study we got the ductility is more to the frame with DPD. Ductility is very less to the frame with bracing only. But it has more stiffness compared to the other two models.

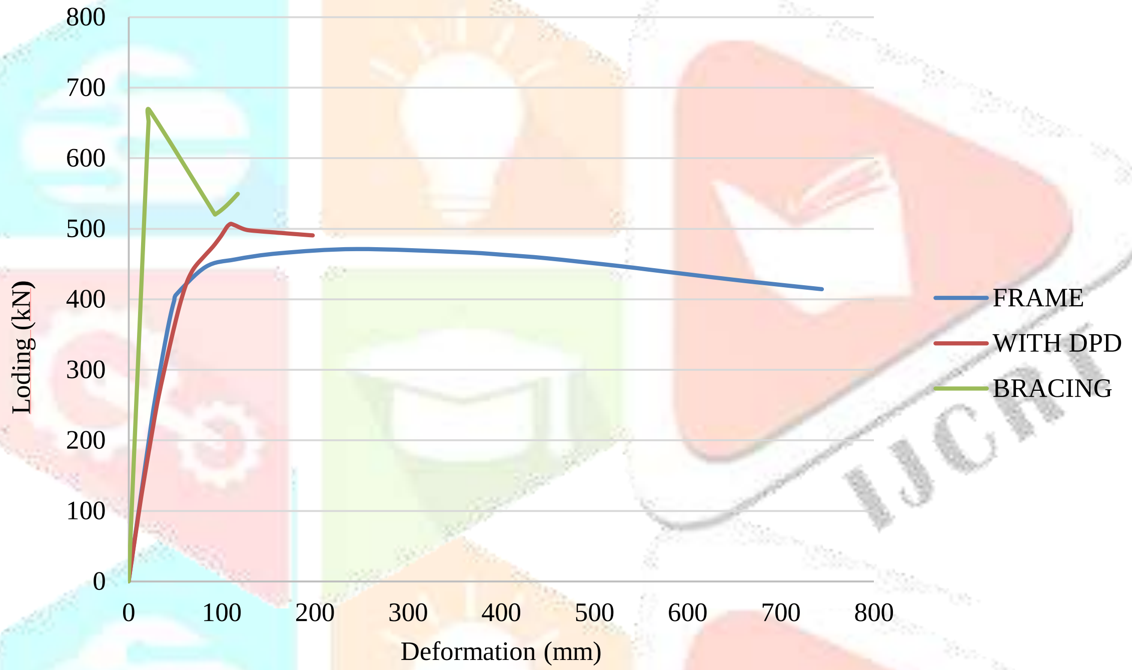


Chart-1: Load Deflection Curve of Three Models

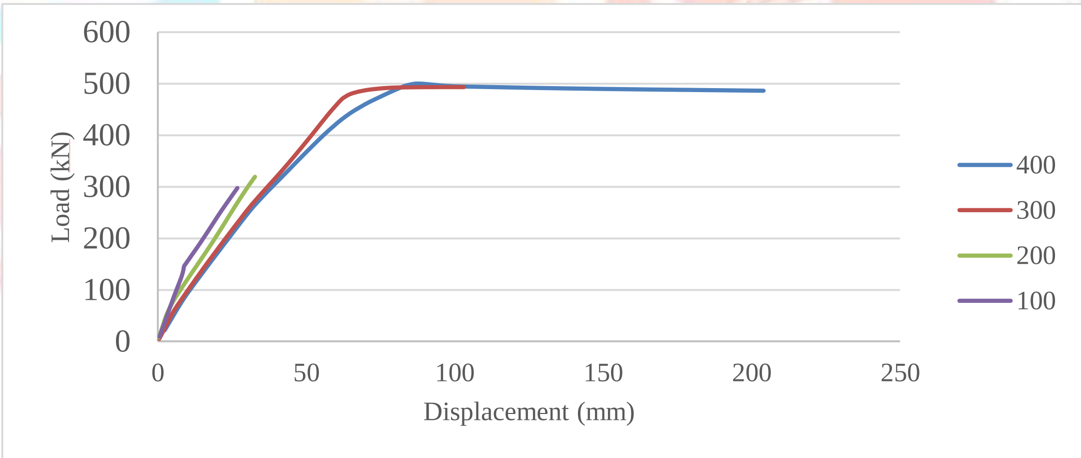


Chart-2: Comparison Plot of 10 mm Thick and 25 mm Length

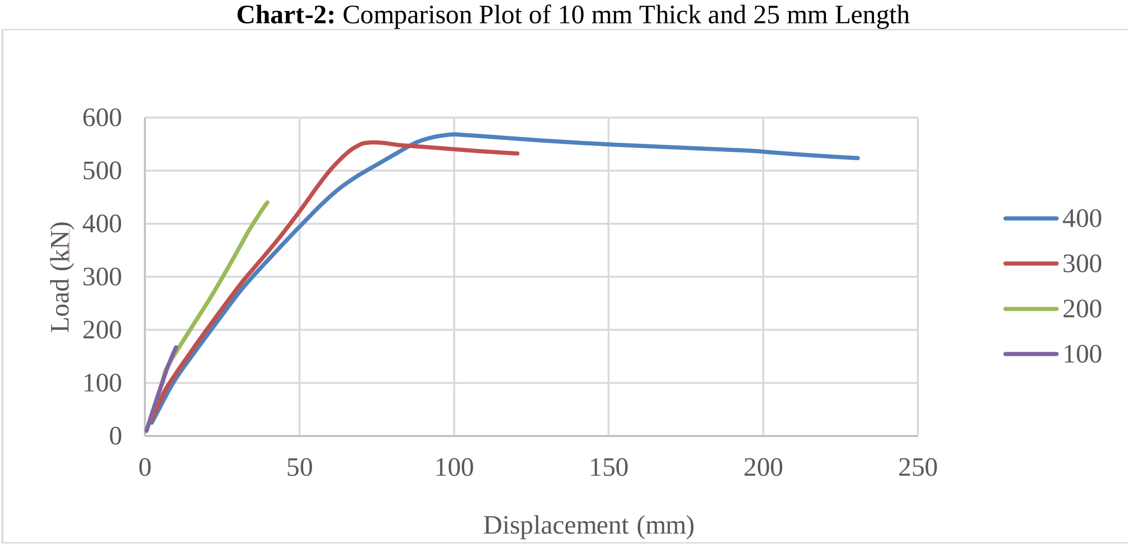


Chart-3: Comparison Plot of 10 mm Thick and 50 mm Length

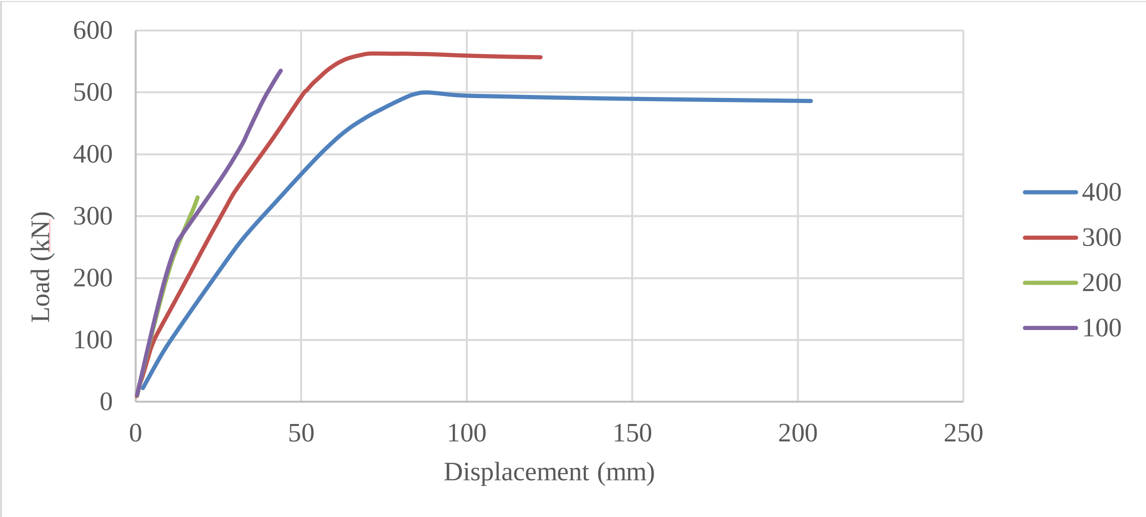


Chart-4: Comparison Plot of 20 mm Thick and 25 mm Length

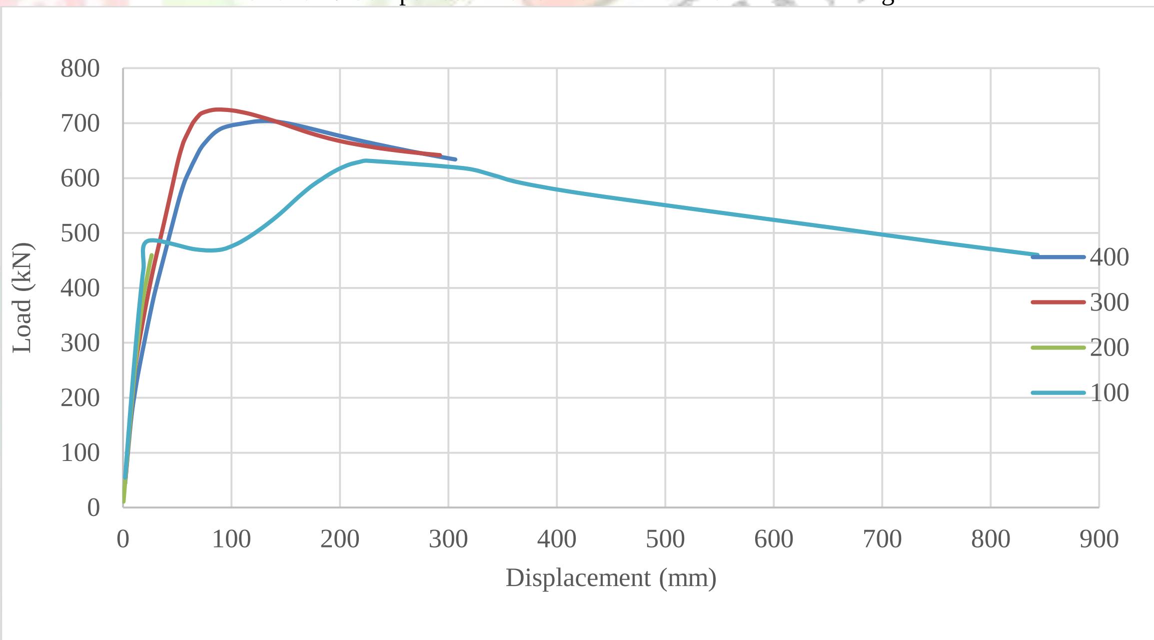


Chart-5: Comparison Plot of 20 mm Thick & 50 Mm Length

From the charts the optimum diameter for the pipe is obtained is 400mm. All the comparison charts shows that 400mm diameter taken more load and more deformation, that is the stiffness of the pipe is more for the diameter 400mm. For ensuring the perfect parameters for the pipe we have to determine the stiffness and the ductility of the models. By analyzing these 16 models we got yield stiffness, ultimate stiffness, ductility and dissipated energy of each frame.

$$\text{Yield stiffness, } Y_s = \frac{Yl}{Yd} \qquad (1)$$

Where Y_l is the yield load and Y_d is the yield displacement.

$$\text{Ultimate Stiffness, } U_s = \frac{Ul}{Ud} \qquad (2)$$

Where U_l is the ultimate load and U_d is the Ultimate displacement.

$$\text{Ductility, } \mu = \frac{Ud}{Yd} \qquad (3)$$

$$\text{Dissipated energy, } E = 0.015\ L.\ t^{1.77} \qquad (4)$$

Where D is the diameter, L is the length and t is the thickness of the damper.

6. ANALYTICAL RESULTS

Table -3: Analytical Results of Each model

Model	Y_d (mm)	Y_l (kN)	Y_s (kN/mm)	U_d (mm)	U_l (kN)	U_s (kN/mm)	μ
Frame only	24.29	224.81	9.17	244.66	471	1.92	9.98
Frame with bracing	12.04	368.66	30.61	22.07	668.43	30.27	1.83
Frame with DPD	6.81	60.74	8.91	109.2	506.96	4.64	16.02

From this study we got the ductility is more to the frame with DPD. Ductility is very less to the frame with bracing only. But it has more stiffness compared to the other two models.

Table -4: Analytical Results of Each model

(D/t/L) All in mm	Y_d (mm)	Y_l (kN)	Y_s (kN/mm)	U_d (mm)	U_l (kN)	U_s (kN/mm)	μ	E (kJ)
400/10/25	4.51	43.87	09.70	88.36	499.87	5.65	19.55	
300/10/25	4.44	50.02	11.26	96.99	493.51	5.08	21.83	
200/10/25	1.64	29.36	17.80	32.70	319.04	9.75	19.83	22.08
100/10/25	2.85	46.76	16.36	26.79	297.86	11.11	9.37	
400/20/25	4.51	43.87	9.70	88.36	499.87	5.65	19.55	
300/20/25	3.15	59.19	18.74	74.19	562.70	7.58	23.49	
200/20/25	3.18	72.12	22.63	18.78	330.55	17.60	5.89	75.31
100/20/25	4.58	106.86	23.33	43.90	535.25	12.19	9.58	
400/10/50	4.45	49.25	11.04	100.63	568.53	5.64	22.57	
300/10/50	2.66	29.94	11.25	100.31	493.36	4.91	37.69	
200/10/50	2.79	50.44	18.07	39.62	440.27	11.11	14.19	44.16
100/10/50	3.92	70.74	18.01	10.12	166.87	16.47	2.57	
400/20/50	4.09	88.42	21.57	128.66	703.78	5.47	31.39	
300/20/50	6.60	156.82	23.73	84.65	724.87	8.56	12.81	
200/20/50	6.30	151.82	24.08	26.37	459.54	17.42	4.81	150.6
100/20/50	10.89	272.83	25.03	225.14	631.45	2.80	20.65	

*400/20/50 refers to 400mm diameter, 20mm thickness and 50mm length of the pipe.

Already we have discussed that the pipes with the diameter 400mm takes more loads without failure. After finding the amount of energy dissipated and ductility we concluded that the dual pipe damper with 400mm diameter is more suitable. From the 4 Models of 400mm diameter we find out the optimum parameters of the suitable DPD. From the table 4 we can see that the optimum model is 400/20/50. Ductility and energy dissipated is more for that model.

7. CONCLUSIONS

- From the analysis we can understand that the frame with DPD has more ductility compared with bare frame and frame with bracings.
- The stiffness of the frame with DPD is more when comparing with the frame with DPD and the bare frame.
- Ductility of the frame with DPD has seven times more than the bare frame and frame with bracing only.
- The parametric study of the DPD is done to find out the optimum model size from the 16 models.
- The optimum model size we got is 400mm diameter from the pushover analysis
- After finding the amount of energy dissipated and ductility we concluded that the dual pipe damper with 400mm diameter is more suitable and from the 4 Models of 400mm diameter we find out the optimum parameters of the suitable DPD is20mm thickness and 50mm length.
- The optimum model taken on the basis of the yield stiffness, ultimate stiffness, ductility and energy dissipation capacity

REFERENCES

[1] Amir S. J. Gilani1 and H. Kit Miyamoto (2018) "Design of Structures with Dampers per ASCE 7-16 and Performance for Large Earthquakes". *Structures Congress* 2018

[2] Hessam Shamshiri Dareini and Behrokh Hosseini Hashemi (2011) "Use of Dual Systems in Tadas Dampers to Improve Seismic Behavior of Buildings in Different Levels". *Procedia Engineering* 14 (2011) 2788–2795

[3] Hua Shen, Ruifu Zhang, Dagen Weng, Cong Gao, Hao Luo and Chao Pan (2017) " Simple design method of structure with metallic yielding dampers based on elastic–plastic response reduction curve". *Engineering Structures* 150 (2017) 98–114

[4] Reza Aghlara, Mahmood Md. Tahir and Azlan Bin Adnan (2018) "Experimental study of Pipe-Fuse Damper for passive energy dissipation in structures". Journal of Constructional Steel Research 148 (2018) 351–360

[5] Reza Aghlara and Mahmood Md. Tahir (2018) " A passive metallic damper with replaceable steel bar components for earthquake protection of structures". *Engineering Structures* 159 (2018) 185–197

[6] Ricky W.K. Chan and Faris Albermani (2008) "Experimental study of steel slit damper for passive energy dissipation". *Engineering Structures* 30 (2008) 1058–1066

[7] Saeed Mahjoubi and Shervin Maleki (2016) "Seismic performance evaluation and design of steel structures equipped with dual-pipe dampers". *Journal of Constructional Steel Research* 122 (2016) 25–39

[8] Shervin Maleki and Saeed Mahjoubi (2013). "Dual-pipe damper" *ASCE*. DOI: 10.1061/(ASCE)ST.20113-541X.000117

[9] T.T. Soong and B.F. Spencer Jr (2002) "Supplemental energy dissipation: state-of-the-art and state-of-the practice". *Engineering Structures* 24 (2002) 243–259