SEISMIC PERFOMANCE OF CONCENTRATED BRACING WITH DUAL- PIPE DAMPER

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Abstract–: Dual pipe damper is a special device having dissipation energy capacities. Braced structures are one of the most common resistant systems used widely in steel buildings due to their high stiffness and lateral strength. However, when these structures are subjected to moderate and severe earthquakes, their weakness is being understood. Under these earthquakes, the structure enters the inelastic zone and the braces that lead to failure to of the structure. This makes it impossible to use the full capacity of braces in the force exerted on the structure. To improve load carrying capacities and durability of bracing dual pipe damper is applied in it. This study examines the structural performance of concentrated bracing with dual pipe damper. Dual pipe damper with varying parameter are selected for this study. Out of these, best model is applied in an 8 storey building as per IRC recommendation and analyzed against ELCENTRO FOR PGA DATA. Non-linear finite element (FEM) model was developed using ANSYS 16.1 to study structural performance of these special bracing with dual pipe damper.

Keywords: *Concentrated bracing system (CBS), Finite Element Analysis (FEA),*

1. INTRODUCTION

Braced structures are one of the most common resistant systems in steel buildings due to their high lateral strength and high stiffness. These systems have a good performance under mild earthquakes that behave in the elastic range. However, when these structures are subjected to moderate and severe earthquakes, their main weakness is being revealed, the structure enters the inelastic zone and thus the braces that are pressurized begin to buckle. This makes it impossible to use the full capacity of braces in the dissipations of energy exerted on the structure. Generally in a frame failure is occurring in the end region of the brace. That cause less durability to the structure. So in order to transfer the failure occur at the end region ,that is the failed section is transferred in to the centre, that will help to increase the strength of bracing comparing to that of conventional bracing system. This type of arrangement is known as concentrated bracing system. In concentrated bracing system, the centre region convert in to more ductile, so failure occur is transfer in to the centre. Results from these investigations and damage of bracing during past earthquakes have raised some concerns with respect to the drift capacity of braces due to damage incurred as they deform in elastically while subjected to strong ground motions. To notice this issue, many scholars have attempted to found various special-shaped bracing. It has been understand that a simple concentrated bracing cannot meet the requirements of high-rise steel housing construction in terms of resistance to seismic performance, drift ratio, energy absorption capacities.

In this study, structural performance of concentrated bracing with dual pipe damper is assessed. A dual pipe damper is an energy dissipation device which is provided at the middle of the bracing. During an earthquake the failure load is completely take by the damper place at the middle section and is suitably transferred in to the further part of the bracing. The dual pipe damper is replicable.

2. FINITE ELEMENT MODELLING

2.1General

To investigate structural performance of dual pipe damper in bracing, finite element models were developed using ANSYS 16.1. SOLID186 s used as the element type and it is a higher order 3D element exhibiting displacement in x, y, z directions.

2.2 Scope

The work is limited to modeling and analysis of bracing with dual pipe damper by using ANSYS. The study includes the model with varying parameter i.e., diameter, pipe length, and thickness. From this load, ductility, deflection is find out. The best preformed dual pipe damper is selected and checks it in to a building recommended by specified journal. Seismic Performance towards ELCENTER FOR PGA DATA is carried to obtain frequency vibration of building, and compare result to the time with acceleration, deflection and force reaction.

2.3 Geometry

Dual pipe damper selected for the analyses having varying parameter like diameter, pipe length and thickness. Multi linear isotropic hardening is used to reproduce plastic behavior of material. Yield strength for steel is selected as 345N/mm², poisons ratio as 0.3 and young's modulus as 2.05x105N/mm². Material of finite element models was kept constant in all cases. Spot weld used for welding. The building properties selected for the analysis are described in the table1.

Table -1: Properties steel building

Building name	Plan in x&y direction	Storey height	Beam size	Column size
IS-III-8	L=5@4m B=7@4m	5meter.	ISMB400	ISWB450

The combination selected for the analysis of dual pipe damper is following. The varying parameter selected for analysis is diameter, pipe length and thickness of pipe. Here diameter is measured from outer core to centre of damper and, pipe length is defined as linear distance from inner core of clamp to center diameter of pipe. Clamp is C shape section seen in the dual pipe, and size is50mmX100mm, and the brace have the dimension of 150x150x10mm.Table show combination of damper.

Table- 2: Combination of dual pipe damper

150mm,model combination	200mm,model combination	250mm,model combination
150X50X5	150X50X5	150X50X5
150X100X5	150X100X5	150X100X5
150X150X5	150X150X5	150X150X5
150X50X10	150X50X10	150X50X10
150X100X10	150X100X10	150X100X10
150X150X10	150X150X10	150X150X10
150X50X15	150X50X15	150X50X15
150X100X15	150X100X15	150X100X15
150X150X15	150X150X15	150X150X15

The combination selected as per the Diameter X Pipe length X Thickness. Geometry of bracing with dual pipe damper is shown in figure1.

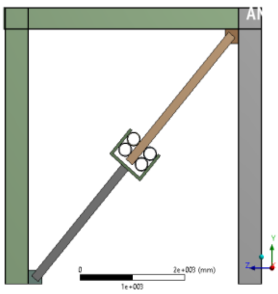

Fig- 1: Bracing with dual pipe damper

The gap form from clamp to dual pipe damper is fuse length. It should be minimum half of the diameter.

2.4 Meshing.

Meshing is the process of dividing the whole component into a finite number of elements so that whenever the load is applied on the component, it distribute load uniformly. The size of element should be small to get better result.Innorder to get accurate result total number of element is large as possible.

2.5. Loading and Boundary conditions

To obtain the real condition fixed support is provided at the base. Axial and lateral support are provided at the top. Boundary conditions of different methods of beam column connection are shown in Figure 2.

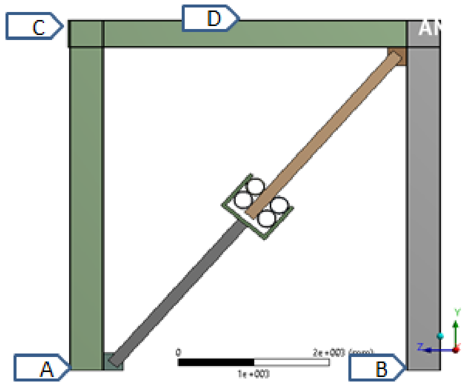

Fig -2: Boundary conditions of bracing with dual pipe damper

3. EXPERIMENTAL PROCEDURE AND ANALYTICAL RESULT

3.1 Push over analysis

To analyze the performance of structure, non linear or push over analysis is perfomed.The main advantage of steel frame is that elastic behavior occur only in itself. The push over analysis is carried to determine the response of the frame by applying horizontal force at the top corner of frame using ANSYS software. After installing dual pipe damper at the frame analytical study is carried. Figure 3 show the push over analysis of the structure.

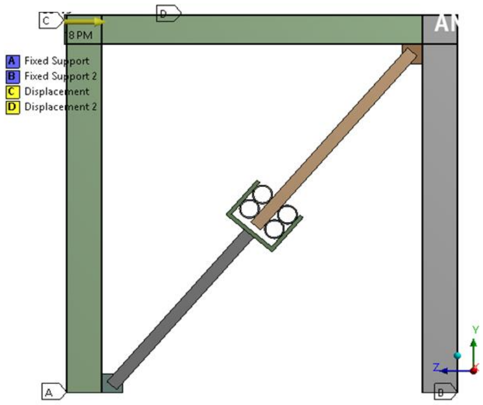

Fig- 3: Push over analysis

3.2 Selection of best model

Specimens were analyzed for different parameter like thickness, pipe length, diameter etc. Chart1 represents load-displacement comparison of 150 mm diameter damper having 5mm thickness and varying pipe length.

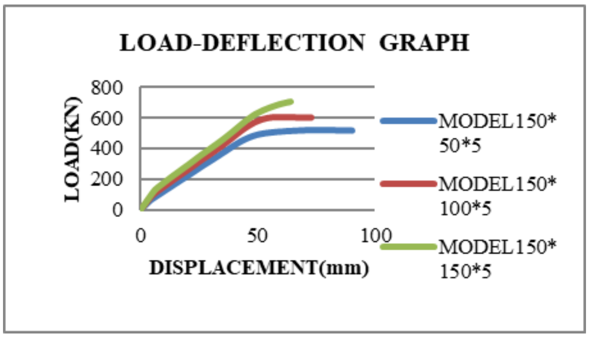

Chart -1: Load – Deflection curve of 150 mm diameter and 5mm thickness

Chart.2 represents load-displacement comparison of 150 mm diameter damper having 10mm thickness and varying pipe length.

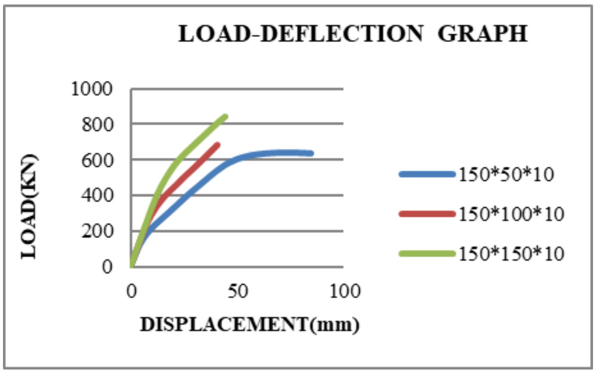

Chart - 2: Load deflection curve of diameter 150 mm and thickness 10mm

Chart.3represents load-displacement comparison of 150 mm diameter damper having 15mm thickness and varying pipe length.

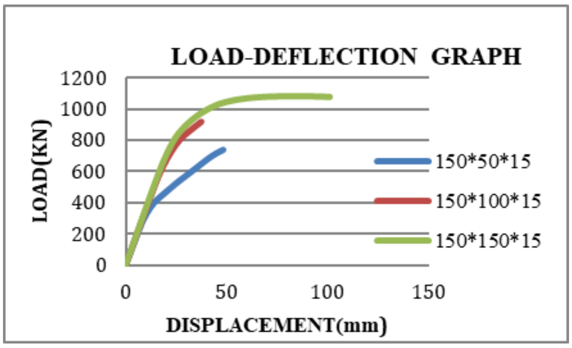

Chart -3: Load deflection graph of damper diameter150 mm and thickness 15mm.

Chart.4 represents load-displacement comparison of 200 mm diameter damper having 5mm thickness and varying pipe length.

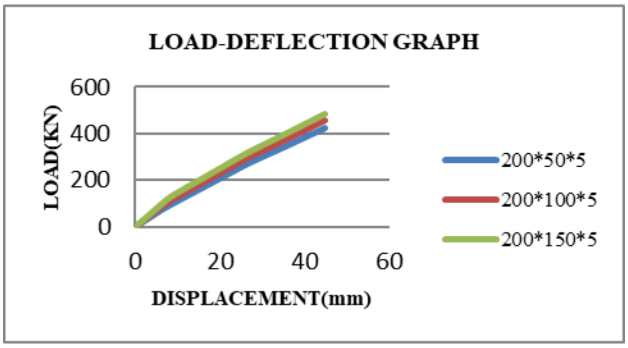

Chart - 4: Load – Deflection curve of 200 mm diameter and 5mm thickness.

Chart.5 presents load-displacement comparison of 200 mm diameter damper having 10mm thickness and varying pipe length.

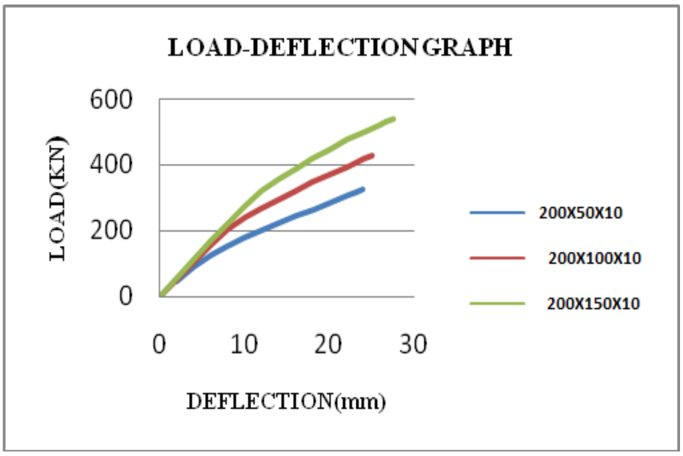

Chart - 5: Load – Deflection curve of 200 mm diameter and 10mm thickness

Chart.6represents load-displacement comparison of 200 mm diameter damper having 15mm thickness and varying pipe length

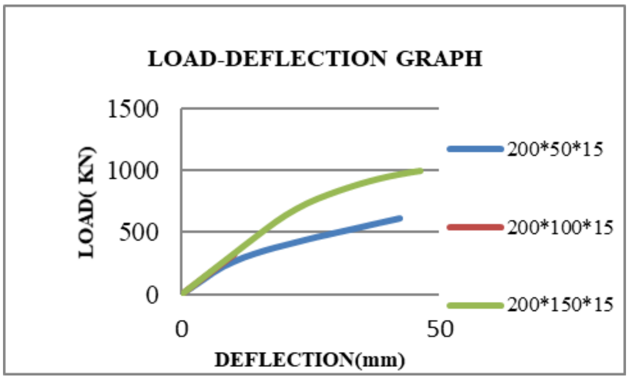

Chart - 6: Load deflection graph of damper diameter200 mm and thickness 15mm

Chart.7 represents load-displacement comparison of 250 mm diameter damper having 5mm thickness and varying pipe length.

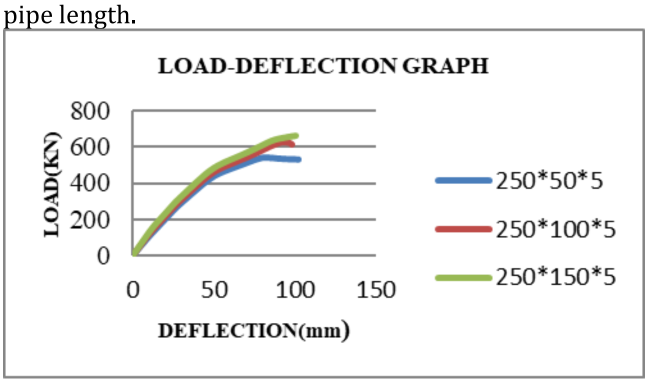

Fig-7: Load deflection graph of damper diameter250 mm and thickness 5mm

Chart.8 represents load-displacement comparison of 250 mm diameter damper having 10mm thickness and varying pipelength.

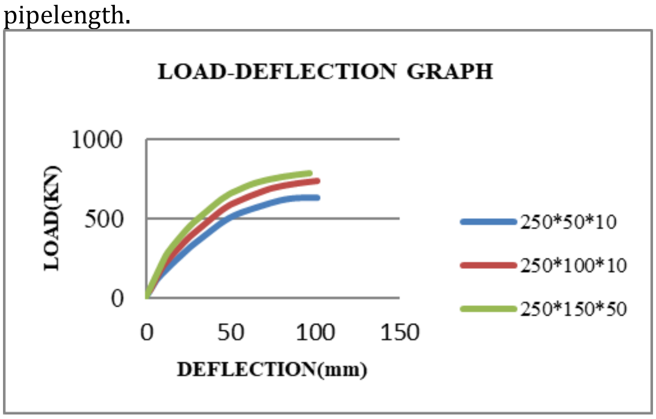

Chart -8: Load deflection graph of damper diameter250 mm and thickness 10mm

Chart.9 represents load-displacement comparison of 250 mm diameter damper having 15mm thickness and varying pipe length

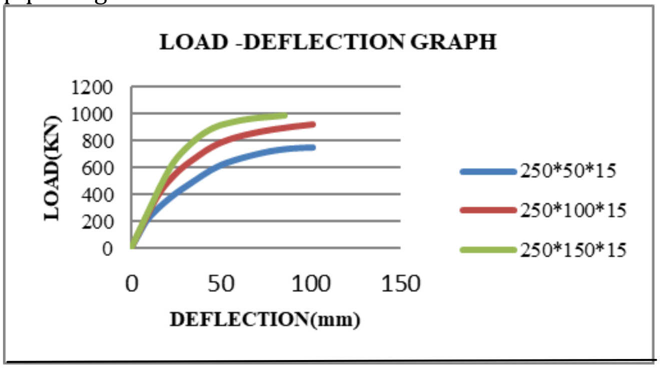

Chart -9: Load deflection graph of damper diameter250 mm and thickness 15mm

The comparison of ductility of the models are shown in the following table. From this it's clear that load carrying capacity increase when the diameter of the section increase and also best performance shown by the section are combination of different diameter with same pipe length and thickness. Hence on comparing each models of different diameter, ductility factor high for that. Here the values arranged as in the base of same diameter and pipe length with varying thickness. Ductility is the main factor to define the better properties of the sections.

TABLE- 4: show the Comparison of ultimate load, ultimate deflection, ductility

model	Ultimate load(KN)	Ultimate deflection (mm)	Yield deflection	ductility
150x50x5	519.9	80.939	2.014	40.21
150x50x10	641.23	73.091	2.004	36.4
150x5015	735.4	47.818	4.03	11.86
150x100x5	599.5	68.435	2.0091	34.06
150x100x10	844.03	40.727	4.016	10.14
150x100x15	919.77	37.257	6.07	6.131
150x150x5	703.58	63.91	2.008	31.81
150x150x10	844.02	44.017	4.026	10.93
150x150x15	1077.6	39.27	4.325	9.23

Table-5: show the Comparison of ultimate load, ultimate deflection, ductility

Model	Ultimate load(KN)	Ultimate deflection (mm)	Yield deflection(mm)	ductility
200x50x5	521.2	86.484	2.031	42.5
200x50x10	648.83	78.947	2.065	38.1
200x5015	651.22	49.56	4.0148	12.3
200x100x5	610	75.563	2.0315	37.3
200x100x10	687.3	45.928	2.0079	22.8
200x100x15	693.45	39.621	4.269	9.43
200x150x5	639	80.27	2.0133	39.2
200x150x10	643	59.36	4.03	14.7
200x150x15	907	36.25	4.007	9.4

Table-6: show the Comparison of ultimate load, ultimate deflection, ductility

Model	Ultimate load(KN)	Ultimate deflection (mm)	Yield deflection (mm)	ductility
250x50x5	632.27	101.00	2.009	50.0
250x50x10	631.7	84.73	2.03	41.5
250x5015	745.33	71.96	4,.016	17.9
250x100x5	625.22	93.609	2.0314	46.0
250x100x10	735.21	91.69	2.014	45.5
250x100x15	916.78	100.72	6.02	16.7
250x150x5	660.32	100.83	2.026	49.7
250x150x10	786.97	96.916	6.025	16.0
250x150x15	983.52	85.448	6.022	14.1

From the investigation of 27 model, in the first group, specimen,150x50x5 and, in second200x50x5 and in thrd 250x50x15 are taken as best for the further study due to its behavior towards ductility. From the table it's clear that diameter is important factor while considering design of damper, and best model selected for checking seismic performance in 8 storey building is 250x50x5.

3.3 Time –history analysis

In time history analysis ELCENTRE PGA DATA is applied on the structure, seismic acceleration is provided in terms of load and check the performance towards time. The time taken for the analysis is 54 sec. From the analysis time with base shear, deformation, acceleration of building are found. Figure show the bracing with dual pipe damper applied an 8 storey building having plan L=5@4m in X direction and L=7@4m in Y direction.

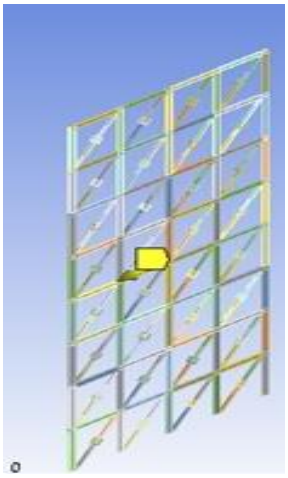

Fig-4: Application of dual pipe damper in an 8 storey building frame.

Chart.10 represents the comparison of base shear of bare system with time towards brace system.

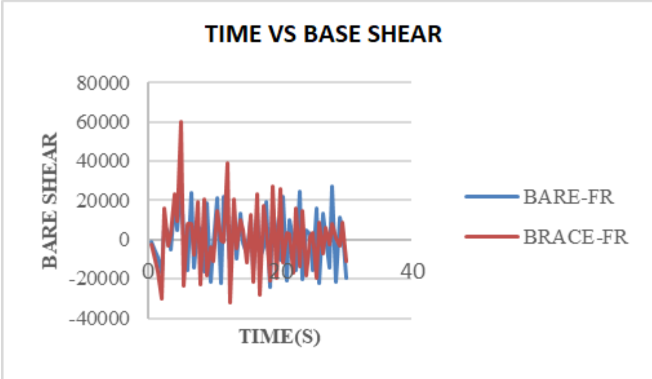

Chart-10: Time vs. base shear graph of brace and bare system.

Chart.11 represents the comparison acceleration of bare system with time towards brace system.

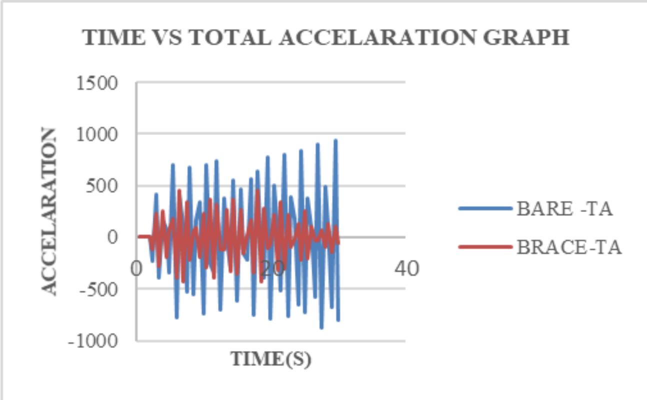

Chart-11: Time vs. acceleration of building graph of brace and bare system.

Chart.12represents the comparison deformation of bare system with time towards brace system

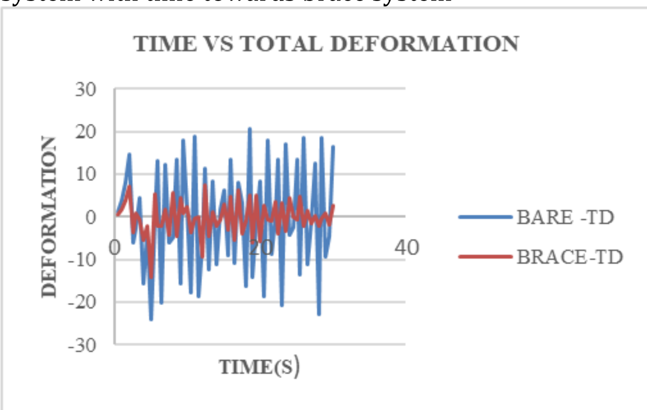

Chart- 12: Time vs. deformation graph of brace and bare system

From the graphs it's clear that base shear taken by the bracing is very too much than normal system. In the case of acceleration graph, the transfer of vibration can be reducing more due to the presence of damper. Hence it shows better performance against seismic force. Also on comparing the deformation of the brace it's very less than that of a brace system. Hence the presence of damper behaves like better fuse section and better devise to resist the seismic force than a normal bracing system.

4. CONCLUSIONS

Structural and seismic performance concentrated beam with dual pipe damper was investigated. Based on results, the following conclusions are drawn.

- Comparing to the normal bracing system a dual pipe damper can withstand more load with less deformation
- When the system exceed ultimate load and turns to failure, dual pipe can be replace.
- Bracing with damper show more ductile behavior can be apply in a building in seismic area.
- From the graph obtained from push over analysis show that load capacity, stiffness is improved in a dual pipe bracing.
- As the pipe length, and thickness increase load carrying capacity is also increases.
- Ultimate load is increased while diameter and pipe length keep constant with varying thickness.
- Ductility comes to more for the combination with 250 mm diameter.
- Diameter is major factor while designing of damper, also combination of 15x5mm of lap length and thickness show better performance for ductility.
- If the number of damper provide in the bracing may be increase, result show further increase of ductility.
- In time history analysis, base shear carried by the brace with damper is more than bare system reveals that, brace with damper take more pressure instead of end region. Hence durability can improved
- The checking of the acceleration time graph show the valuable information is that brace carried by the frequency level cam be reduced with damper. Resistance against seismic force effectively achieved here.
- The deformation against the seismic acceleration force is very low in the system comparing to a bare. Hence the load first take by the damper, after the dissipation of large energy it transfer remain in to the brace. Hence deformation rate also decreases.

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