Seismic optimization of an I shaped shear link damper in EBF and CBF systems

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Abstract – *Most of the steel structures that are constructed in earthquake prone areas are susceptible to frequent damages. Hence variegated types of results were introduced as a part of reducing the threat of damages. One of the main solutions to impart sufficient flexibility to steel framed structure is the installation of dampers. To improve the seismic energy dissipation capacity of braced frames, an I shaped shear link damper can be effectively used. As a part of the study, a single-story single span frame in concentrically braced frame (CBF) system with I-shaped damper was evaluated and analytically treated to lateral seismic load. The main ideal of the study is to identify the optimum size of this I shaped shear link damper which enhance both max loads bearing capability and resilience of the frames.*

***Key Words*: CBF, pushover analysis, ANSYS, lateral load, EBF, damper, frame**

1. INTRODUCTION

In structural integration, diagonal divination can be used as a basic system, while multi-component integration can be a more complex one. The structure's configuration and appearance can determine whether bracing is necessary. In general, concentrically braced frames and eccentrically braced frames (EBF) are most common. A conventional EBF is characterized by eccentrically coupling the braces to the beam, and the bridge is the beam section between the brace and beam. [1,2]

In concentrically braced frames, two braces intersect at a common point in the beam. Basically, these frames are strong enough to provide a permissible range of relocation. Due to buckling of the bracing and insufficient ductility, this type of system has poor performance and incorrect behavior in terms of energy absorption during intense earthquake loads.[3,4]In order to keep the diagonal member from buckling, using energy dissipating dampers can restrict the damage to the dampers as a result, other parts of the structure stay elastic, which could also improve their serviceability.[5] The usage of an I-fashioned shear hyperlink damper in metallic frames improves seismic performance at the same time as being cost-effective. Furthermore, these dampers are without problems replaceable in the occasion of an earthquake. [6]

2. OBJECTIVES

- To create a full-scale model of a steel structure that is braced and unbraced.

- To determine the optimum size of the damper in a full-scale model using nonlinear push over analysis in CBF to increase seismic energy dissipation capacity.

3. METHODOLGY

The study's major goal is to improve seismic performance in terms of ductility and maximum load carrying capacity by optimizing the size of the damper for a concentrically braced structure of certain dimensions. As part of the study to examine seismic performance, a single-story single bay frame with and without bracing is investigated. The CBF is then fitted with an I-shaped shear link damper of various damper proportions, and a pushover study is performed to determine the appropriate damper size. An EBF with these dampers is subjected to pushover study in order to determine the appropriateness of optimum sized damper in such systems. Complete analysis is performed using the ANSYS WORKBENCH software.

4. NUMERICAL STUDY

4.1 Modelling of frames

The indirect response of a single-story steel frame is tested. ANSYS WORKBENCH is used to carry out the entire analysis. The bay's columns are allowed to curve on their own axis, with a 4- meter story height. The columns and beams are made of steel I sections. The beam, which spans 9 meters, is braced by steel bracings with round cross sections Details of each individual component are listed in Table 4.1. 345 MPa, 345 MPa, and 317 MPa are the yield stresses of the beam, column, and bracing, respectively. [7]

The damper is designed as an I section with a web and flanges. The I-shaped damper is likewise made of steel. Steel is 7850 kg/m^3 dense and has a Young's modulus of 200000 MPa. It has a Poisson's ratio of 0.3 as well. The damper has a yield stress of 370MPa.[6] The proposed damper can be seen in Figure 1.

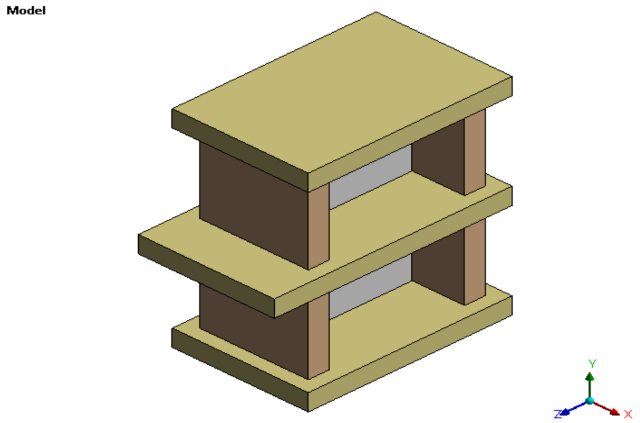

Fig -1: I-shaped shear link damper

Table-1: Frame component specs

Component	Specification
Braces	HSS9.625×0.500
Beams	W33×241
Columns	W14×311

Dampers with various web thicknesses, flange thicknesses, and depths were evaluated as part of seismic optimization. Table 4.2 shows the details of the various damper dimensions.

Table-2: Damper dimensions

Damper	h (mm)	tw (mm)	tf (mm)	bf (mm)	B (mm)
200 ×6×10	140	6	10	160	200
200 ×8×10	140	8	10	160	200
200 ×10×10	140	10	10	160	200
200 ×15×10	140	15	10	160	200
200 ×20×10	140	20	10	160	200
200 ×15 × 15	140	15	15	160	200
200 ×15×20	140	15	20	160	200
300 ×10×20	140	10	20	160	300
300 ×10×25	140	10	25	160	300
300 ×15×25	140	15	25	160	300

4.2 Boundary conditions and loading

Stiff connections exist between the beam, columns, and bracings. Displacement is applied at top end of column based on displacement control method. In order to avoid torsional buckling, supports are provided at beam level in braced frames.

5. RESULT AND DISCUSSIONS

All the specimens modelled were subjected to lateral load analysis and Figure 2 to 6 represents the deformation results of specimens.

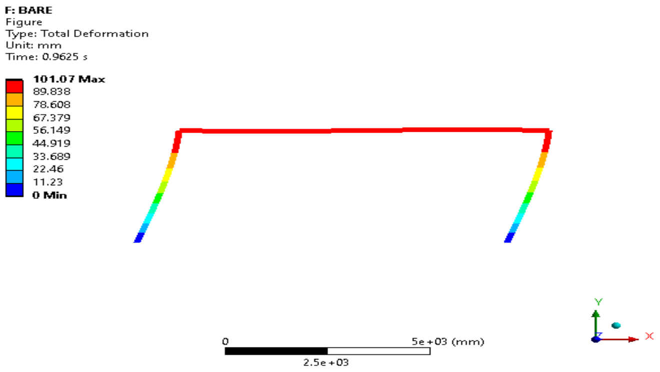

Fig -2: Deformation of bare frame without bracings

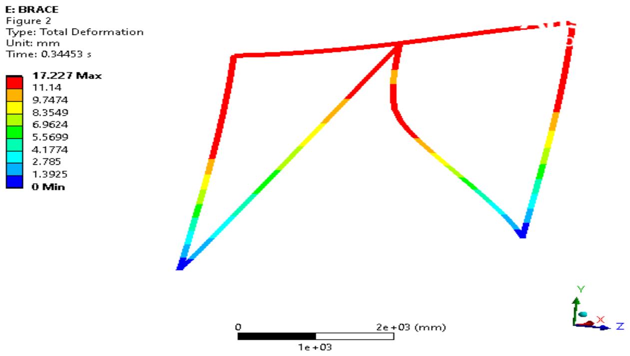

Fig -3: Deformation of braced frame (CBF)

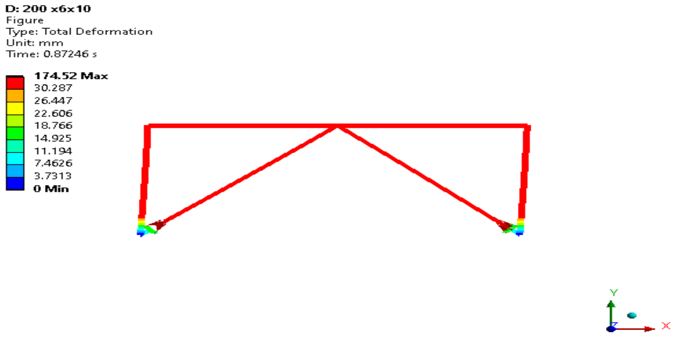

Fig -4: The distortion figure of CBF with damper

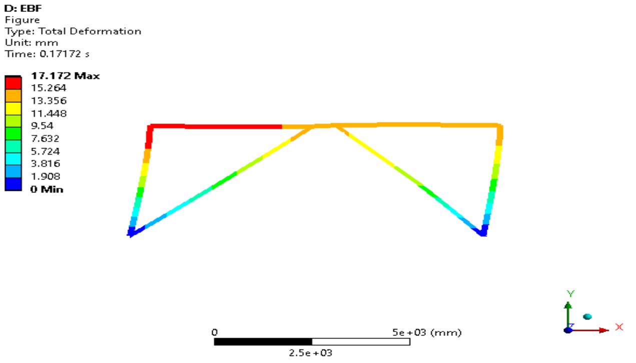

Fig -5: Deformation of EBF

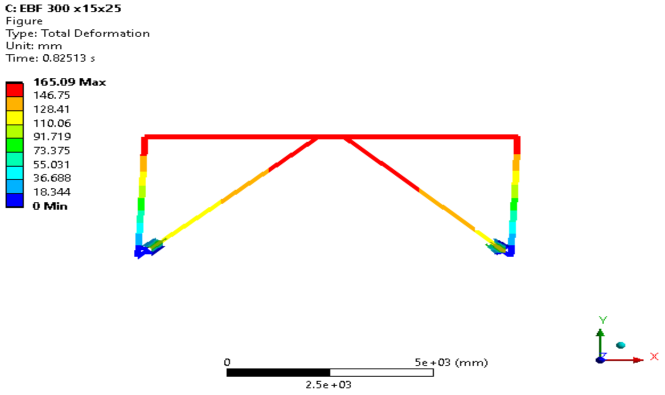

Fig -6: The actual deformation of the EBF with optimum sized damper

Table 3 gives the pushover analysis results of each model tested.

Table-3: Ultimate loads and deflection of different models

Specimen	Yield deflection Δy (mm)	Ultimate deflection Δu(mm)	Ultimate load, Pu (KN)	Ductility μ
Bare frame	4.9	174.52	2553.5	35.62
Braced frame (CBF)	15	17.352	4471.6	1.16
200 ✕6✕10	21	101.07	1333.7	4.81
200 ✕8✕10	14.7	183.85	2755.1	12.51
200 ✕10✕10	14.7	141.99	2953.3	9.66
200 ✕15✕10	14.7	141.51	3187.4	9.63
200 ✕20✕10	14.7	101.88	3200.2	6.93
200 ✕15✕15	14.7	121.61	3297.8	8.27
200 ✕15✕20	14.7	98.629	3352.2	6.71
300 ✕10✕20	14.7	181.82	3990.1	12.37
300 ✕10✕25	14.7	136.98	4325.4	9.32
300 ✕15✕25	14	147.02	4856.6	10.50
EBF	9	17.172	4372.8	1.91
EBF (300 ✕15✕25)	14	165.09	4945.8	11.79

Chart 1 to 3 shows the load deflection response curves of different models.

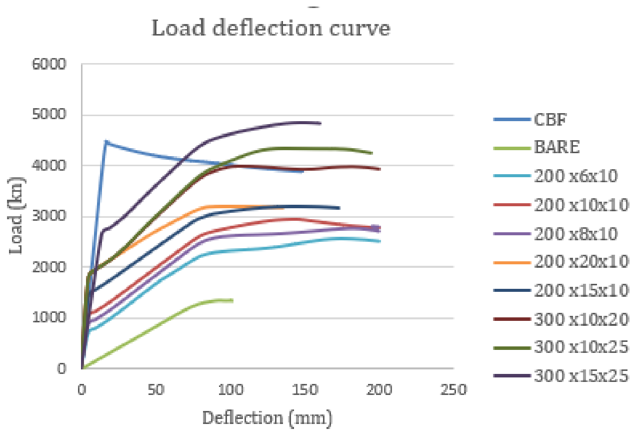

Chart -1: Load deflection response of CBF with and without dampers

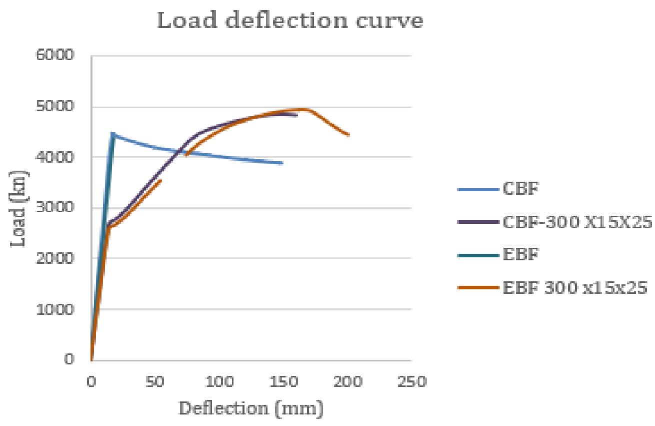

Chart -2: EBF and CBF force displacement reactions with optimally sized dampers

A frame must have suitable flexibility and maximal load bearing capability in order to be erected in seismically dangerous locations. When the findings were compared, it was discovered that none of the bare or CBF materials possessed sufficient ductility to improve the seismic performance. And it is also found that,CBF's ultimate load carrying capability cannot be obtained only with the installation of a specific sized damper.

When comparing the ductility and ultimate load comparison graphs, CBF with a damper size of 300 x15x25 outperforms CBF with other damper size as seen in chart 1. As a result, an I shaped shear link damper measuring 300 x15x25 can be regarded the optimum size.

It is obvious from these graphs that the optimally sized damper improves both EBF and CBF performance. However, when compared to CBF, the percentage improvement in ultimate load carrying capacity in EBF is significant.

6. CONCLUSIONS

Numerical analysis is conducted to evaluate the load bearing capabilities and stiffness of diverse moment resistant frameworks with dampers and bracings. After conducting the research, the following findings were obtained:

- When bracing was added in the bare frame, the load carrying capability of the moment resisting frame increased by 70.1%, while the ductility decreased by 63.82%.
- When the braced frame has occupied with a damper ,the ductility has improved about 95.11% while the load carrying capacity reduced by 42.9%. The reduction in loading bearing capacity is substantially due to deduction of stiffness of bracing due to the installation of damper.
- It was observed that when dampers of various sizes were used in a braced frame (CBF), I shaped shear link damper with dimensions of 300 x15x25 proved to be the most helpful in stimulating the ultimate load bearing capacity and rigidity of braced frames.
- In both EBF and CBF, characteristics such as ultimate load carrying capacity and ductility have improved by a significant amount when utilizing the optimal sized damper.

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