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Seismic Performance of Energy Dissipation Beam in Braced Steel Building

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Abstract
The aim of this paper is to study the performance of Energy Dissipation Beam (EDB) by varying cross section. The software used for the study is ETABS 2019. The model is analysed using time history analysis. In this investigation, the horizontal ground motion records of the RSN:753, Loma Prieta::Corralit from PEER ground motion data base have been selected for performing the nonlinear dynamic TH (Time History) analysis. The EDB acts as a shear fuse. It is implemented in a G+3 storey 3D steel building with V bracing. Four models are created for the study purpose.
Keywords: *Energy Dissipation Beam, Time history analysis.*

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I. INTRODUCTION

During last two or three decades, the reduction of structural response caused by dynamic effects has become a subject of intensive research [5]. Many structural control concepts have been evolved for this purpose, and quite a few of them have been implemented in practice [5]. They include reduction of undesirable vibrational levels of flexible structures due to unexpected large environmental loads, retrofitting existing structures against environmental hazards, protecting seismic equipment and important secondary systems and provision of new concept design of structures against environmental loading [5].

The braced frame (BF) has sufficient rigidity and safety performance under standard working conditions [1, 2]. In contrast, under extreme earthquakes, the BF shows reasonable ductility and energy dissipation capability that is why EBF becomes widely used in earthquake-prone areas [1, 2]. During the earthquakes, the BF system mainly dissipates seismic energy inputted to the structure through the inelastic deformation of the energy dissipating beam (EDB), so that the EDB is prone to yield before other members in the structure [1, 2].

Shear type energy dissipating beams (SEDBs) has been used as a key component of the energy dissipation capacity system in various BF structures as it plays a significant role in resisting seismic loads[1, 2].

1.1 MODELLING OF BUILDING

1.1.1 Building description

The study is done in a G+3 storey 3D steel building under time history analysis in ETABS 2019. It has 3 bays in both longitudinal and transverse directions at 5m spacing. The beam is of ISMB 200 and column ISMB 225 with steel grade Fe345. All storeys are of 3m height. Slab has thickness of 150 mm and concrete grade of M20. The design considerations used are live load 5kN/m, self weight is explicitly captured using steel density of value Fe 345 grade steel in ETABS 2019, design code-IS1893 (part 1): 2016, special moment resisting frame, importance factor-1 and seismic zone – zone III [5].

Figure1: Plan

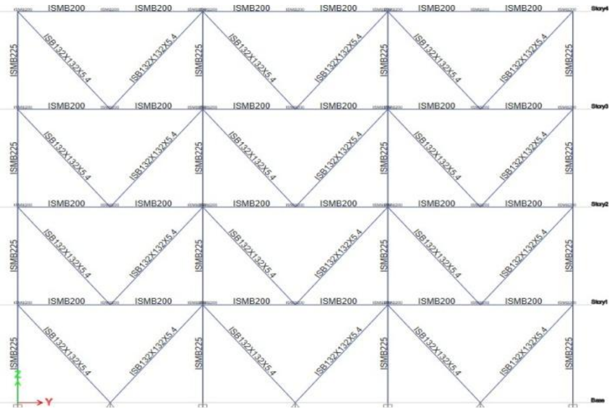


Figure 2: Section of steel building showing V shaped bracing

V bracing is provided as shown in the above figure externally in 4 sides of building.

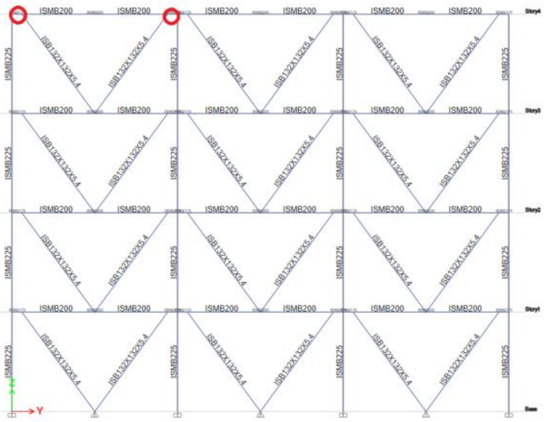


Figure 3: Section of steel building showing V shaped bracing and EDB in corners.

The building is modeled by giving V bracing externally in its four sides along With EDB in corners which connecting the bracing and the main beams. The EDB is provided in all beams in the external 4 sides as shown in figure 3. The section used for v bracing is ISB 132×132×5.4. The EDB is studied in three different cross sections box, I and circle sections. The section property data used for EDB with I section, circle section and box section is shown in figure 4, 5 and 6. These sections were selected by keeping the area constant as same as ISMB 175. The length of the EDB is taken as 300 mm by considering ISMB 175 and this length is selected as per the design criteria in AISC code.

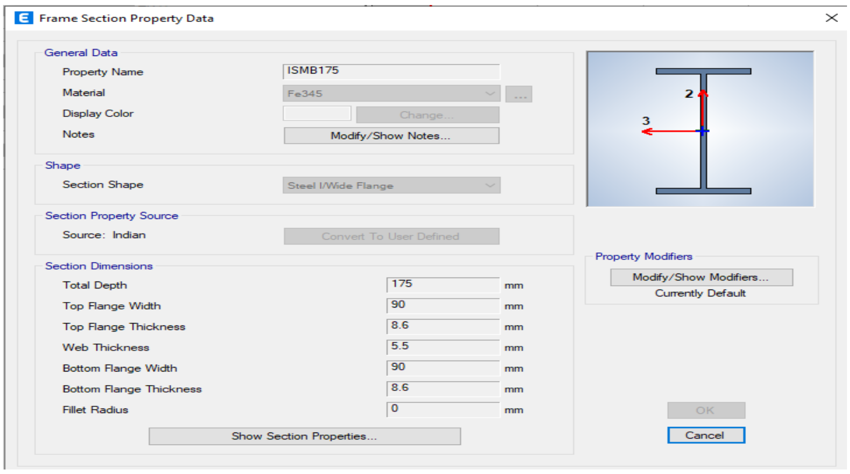


Figure 4 :Section property data of I section

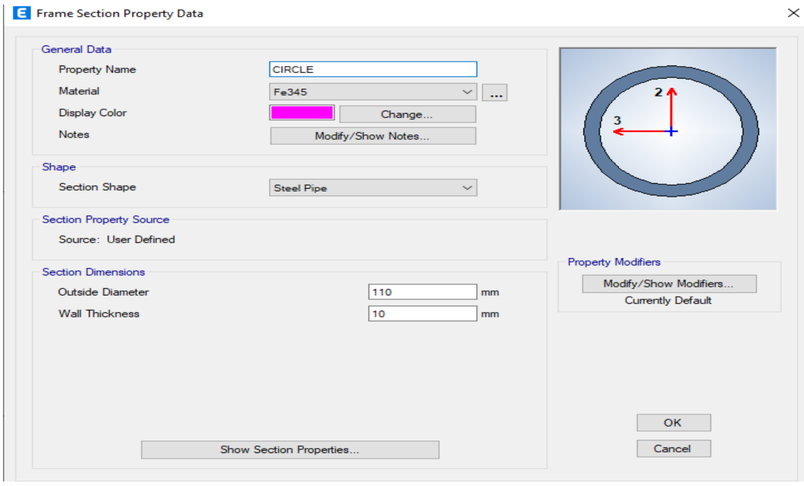


Figure 5: Section property data of circle section

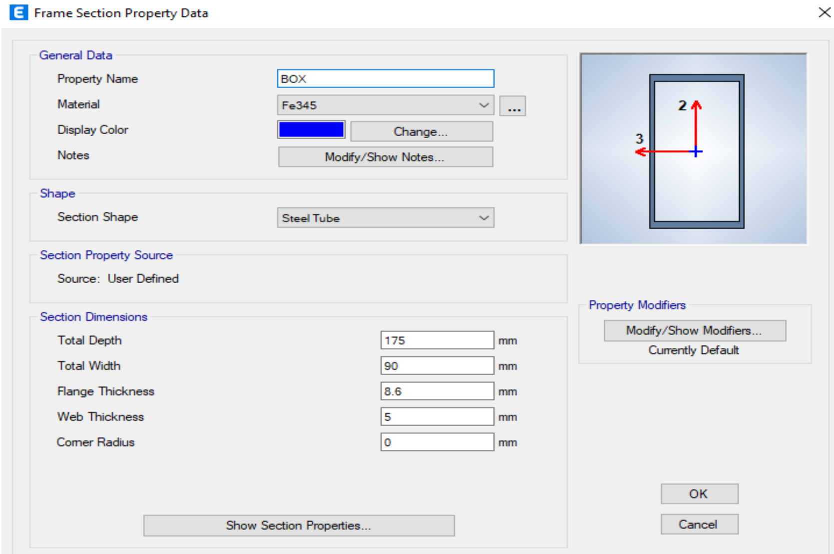


Figure 6: Section property data of box section

1.1.2 Time history (TH) function definition

In this study, G+3 storey 3D steel building under time history analysis in ETABS 2019 for studying the effectiveness of seismic response in the form of base shear, storey displacements drift and time period. In this investigation, the horizontal ground motion records of the RSN: 753, Loma prieta :: Corralit from PEER ground motion data have been selected for performing the nonlinear dynamic TH analysis.

Figure7: PGA of corralit from PEER

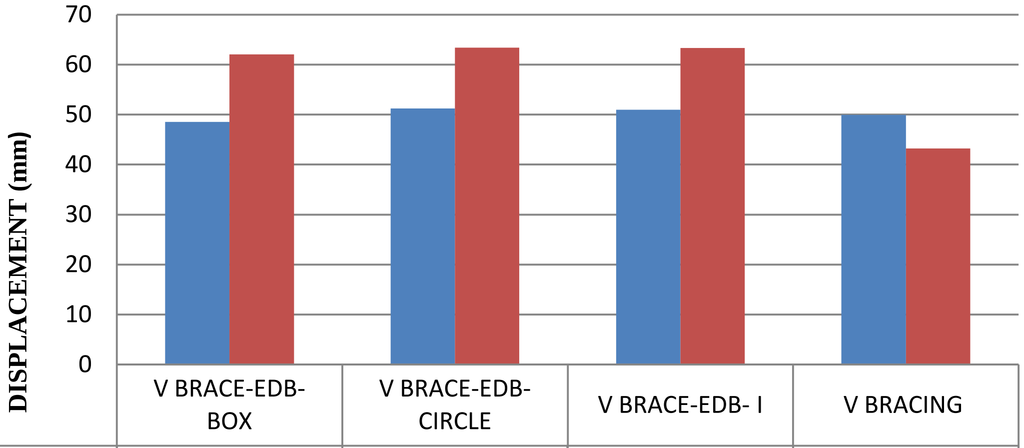
II. RESULT AND DISCUSSION

For the study of seismic performance of EDB 4 different models are created, they are listed as follows:

(i) V braced model
(ii) V braced model with EDB- 300 mm-I section
(iii) V braced model with EDB- 300 mm-Circle section
(iv) V braced model with EDB- 300 mm-Box section

The study is done by comparing the performance of models with EDB to the model with V bracing alone. The maximum value of their drift, displacement, base shear and time period results are taken after time history analysis in both x and y direction.

2.1 Displacement results

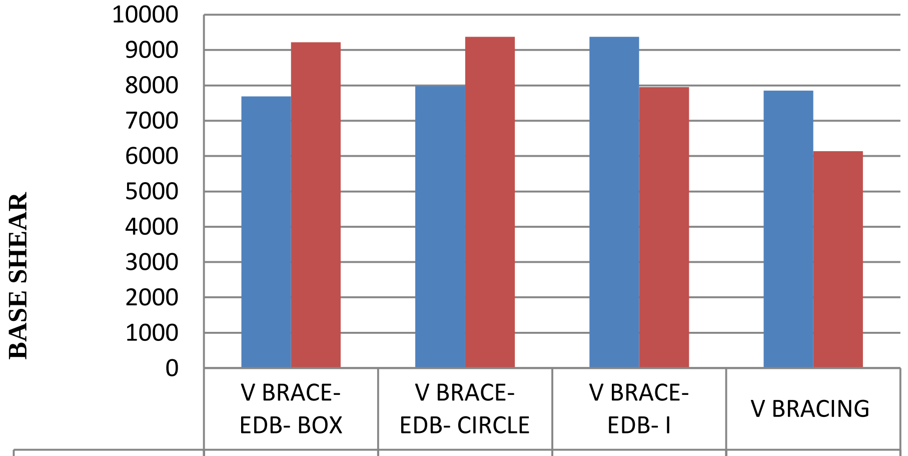


	V BRACE-EDB-BOX	V BRACE-EDB-CIRCLE	V BRACE-EDB- I	V BRACING
DISPLACEMENT X	48.536	51.24	50.99	49.983
DISPLACEMENT Y	62.066	63.418	63.368	43.239

Figure 8: Displacement- V braced model with different cross sections of EDB

The displacement of V bracing with EDB having box section has the lowest value among models. There is only negligible difference in the displacement values of models.

2.2 Base shear results

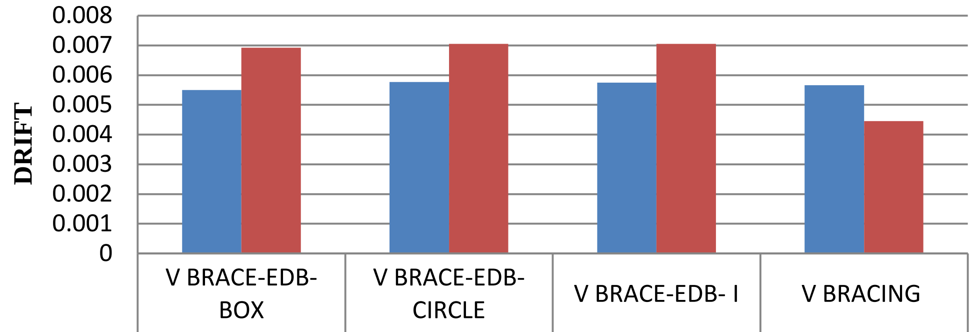


	V BRACE-EDB- BOX	V BRACE-EDB- CIRCLE	V BRACE-EDB- I	V BRACING
BASE SHEAR X	7689.8279	7976.3498	9370.4108	7854.5662
BASE SHEAR Y	9218.8094	9377.3767	7950.0965	6138.678

Figure 9: Base shear- v braced model with different cross sections of EDB

The base shear value is lowest for V bracing with EDB box section among all the models.

2.3 Drift results

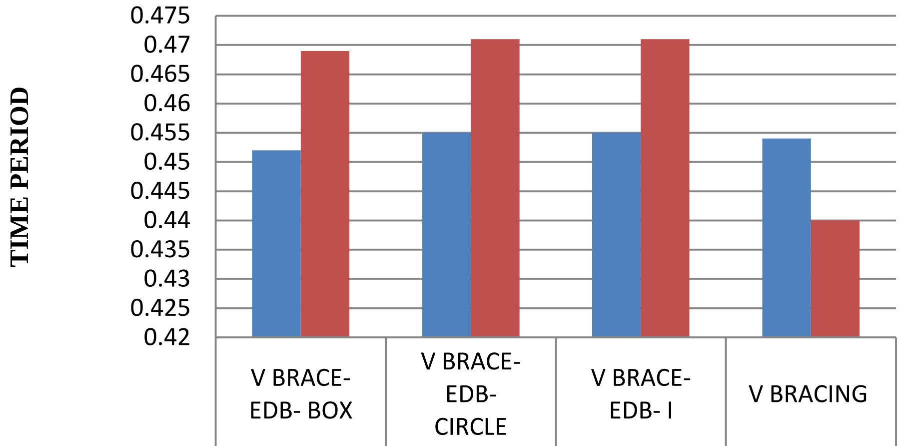


	V BRACE-EDB-BOX	V BRACE-EDB-CIRCLE	V BRACE-EDB- I	V BRACING
DRIFT X	0.005503667	0.005767	0.005747667	0.005663
DRIFT Y	0.006921667	0.007046333	0.007046333	0.004458

Figure 10: Drift-V braced model with different cross sections of EDB

The drift is lowest for V bracing with EDB of box section. All the models have almost similar values.

2.4 Time period results



	V BRACE-EDB- BOX	V BRACE-EDB-CIRCLE	V BRACE-EDB- I	V BRACING
TIME PERIOD X	0.452	0.455	0.455	0.454
TIME PERIOD Y	0.469	0.471	0.471	0.44

Figure 11: Time period- V braced model with different cross sections of EDB

The time period value is lowest for V braced model with EDB of box section. All the models have same values there is no big difference seen in the values. The difference is negligible.

III. CONCLUSION

It was observed that the displacement, base shear, drift and time period values of V braced model with box section gives better values. The displacement has reduced by using box section. The time period is also reduced. The base shear value is also lowest for box section. The better performance is given by V braced model with box section.

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