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EVALUATION OF RESPONSE OF MULTI-STOREY STRUCTURE THROUGH NON-LINEAR ANALYSIS USING STRUCTURAL FUSES

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Abstract*— Research and development of passive energy dissipation devices for structural applications have roughly a 25-year history. The basic function of passive energy dissipation devices when incorporated into the superstructure of a building is to absorb or consume a portion of the input energy. The passive energy dissipation devices that are chosen for investigation include metallic bracings which are used as structural fuses. Structural fuses are supplemental energy dissipating devices that are fabricated into the structure to ensure safety of primary structural members. They are installed in the second and third bay of building. Three different type of bracing(X,V,IV) and X-plate metallic damper are used. The analysis is carrying out for modeled 8storey building by ETAB-2016 software and designed according to IS1893:2002 code specification. The static pushover analysis is carried out. Interstorey drift, storey displacement, shear force and moment proved to be the key constraints in accessing the performance of the building structure.

Keywords*— X-Bracing, V-Bracing, Inverted V-Bracing, Metallic Damper, pushover Analysis.

1. INTRODUCTION

This paper presents summary of current practice and recent developments in the application of structural fuses for protection of the structure. This philosophy has led to the development of a seismic design codes featuring lateral force methods and more recently, inelastic methods. Ultimately, with these approaches, the structure is designed to resist an equivalent static load and results have been reasonably successful. Even an approximate accounting for lateral effects will almost certainly improve building survivability. As a result, from the statical point of view, new and innovative concepts of structural protection system advanced and are at various stages of development. For application of structural fuses bracings & metallic damper taken as structural fuses.

A. *Bracing System*

The lateral force resisting systems employed to resist these forces include rigid frames, steel plate shear walls and bracing systems. Bracing systems can be constructed in many different configurations, often established by specific clearance constraints or to behave in predetermined fashion. These systems may be designed and detailed as concentrically or eccentrically braced frames.

B. *Metallic Damper*

Metallic dampers are one of the most effective mechanisms available for the dissipation of energy, input to a structure during an earthquake, is through the inelastic deformation of metallic substances. A metallic damper or a metallic fuse is capable of sustaining many cycles of stable yielding deformation resulting in high level of energy dissipation. The metallic damper also called Structural or Metallic fuse. The concept behind this device comes from the fuse of an electric circuit.

2. LITRATURE REVIEW

Vargas and Bruneau [1] carried out an experimental project on the structural fuse concept. A design approach which was proposed in the past that a structural fuse is self-sacrificial and easy to repair material was evaluated experimentally. When this element (i.e. structural fuse) is installed into the structure, it behaves in-elastically leaving the primary skeletal structure in the elastic region with minor cracks and damage. The structural fuse element is of rectangular shape mounted on inverted V brace element. For evaluation stiffness ratio (α) and maximum displacement ductility (μ_{max}) are considered as key parameter. Results were accessed in form of dimensionless charts normalized with respect to key parameters. The experimental concluded that system having stiffness ratio less than or equal to 0.25 require large sized fuse and also systems having maximum displacement ductility less than equal to 5 need large sized fuse. Using rectangular shaped plate as fuse does not provide uniform yielding therefore X shape plate should be used.

Tremblay *et al.* [2] worked on the concept of Self Centering Energy Dissipative Steel Braces (SCED). For carrying out the program 2, 4, 8, 12 and 16 storey steel frame building which were assumed to be located in Los Angeles and California. Evaluation of the structures took place through Incremental Static Analysis (i.e. Pushover Analysis). The

study demonstrated that the system with Self Centering Energy Dissipative Steel Braces (SCED) proved to be superior to the Buckling Restrained Brace System. Results of pushover analysis are approximate therefore to study actual behavior buildings with SCED nonlinear dynamic time history analysis should be performed.
Symans *et al.* [3] summarized the current practices and recent development that took place in the field of passive energy dissipation devices (PED's) that are used to reduce the seismic hazard level in the building structure. Their main focus was that how these devices works when they are implemented into the structure. The passive energy dissipation devices that were studied include Viscous Fluid Damper, Viscoelastic Solid Damper, Metallic Damper and Friction Damper. Relating to the PED's they gave information about basic principal of energy dissipation system, Description of mechanical behavior and mathematical modeling of these devices.

Sarno and Elnashi [4] studied the seismic performance of steel moment resisting frame and frame with bracing system. Three types of bracing system used are Special Concentrically Braces (SCBF's), Buckling Restrained Braces (BRB's) and Mega Braces (MBF's).Retrofitting of the structure was carried out with the help SCBF's, BRB's and MBF's. An inelastic time history analysis was carried out to access the performance of the modeled structure. Comparative results were accessed in the form of plastic rotation of the member, interstorey drift and roof storey displacement. Results concluded that the roof storey displacement of the Mega Brace Frame is 70% lower than Moment Resisting frame and 50% lower than Special Concentrically Brace Frame. Further investigation stated that Buckling Restrained Mega Brace Frame is superior than Mega Brace Frame.

3. OBJECTIVES

1) To study the effect of bracing and metallic damper through non-linear static analysis.
2) To compare the behavior of different types of bracing with metallic damper.
3) To study the response of building with and without bracings and Metallic damper.

To study the above objective using pushover analysis with the help of using ETABS 2016 software considering the parameters such as natural time period, drift, displacement and base shear, moment.

4. MODELLING

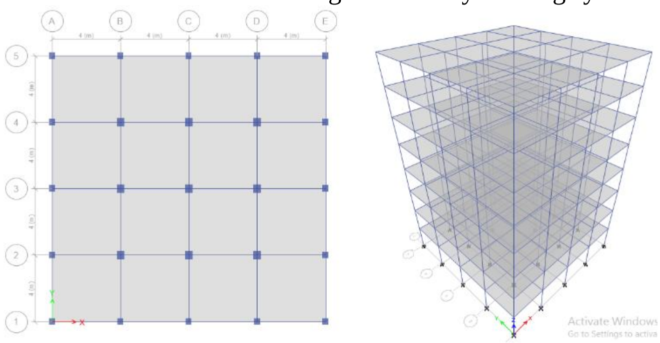
The analysis of regular structures (8 storeys) have been analysed for lateral loads. ETABS v9.7.4 has been used for the modelling and to carry out the analysis. The analysis results are obtained for seismic zone IV.

A. Model Data

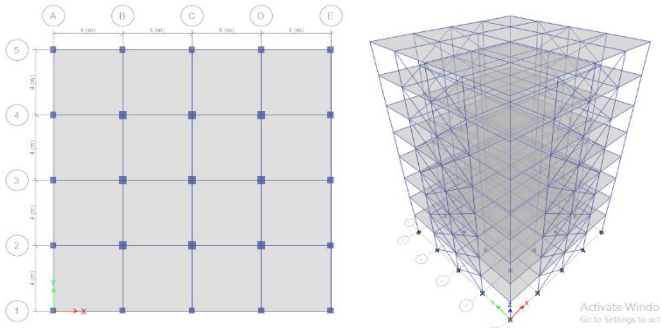
Plan dimension	16m x 16m
Storey height	3m
Bay width along X direction	4m
Bay width along Y direction	4m
Grade of steel	Fe415
Grade of concrete	M20
Size of beams	300mm x 350mm
Size of columns	350mm x 400mm
Density of concrete	$25kN/m^3$
Floor finishes	$1kN/m^2$
Live load	$3kN/m^2$

B. Building Modeling

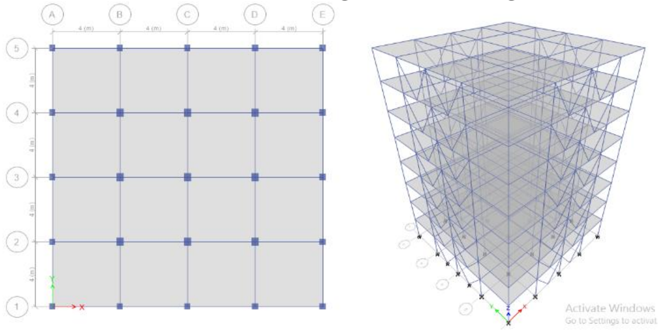
Model I: Base Model Building without any Bracing system

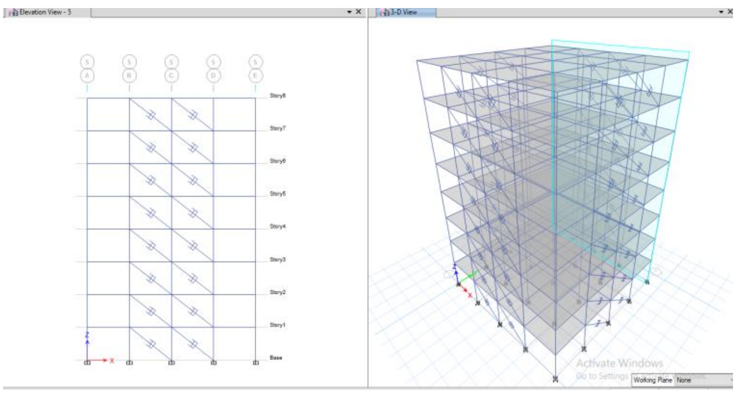


Model II: Building with X Bracing



Model III: Building with V bracing





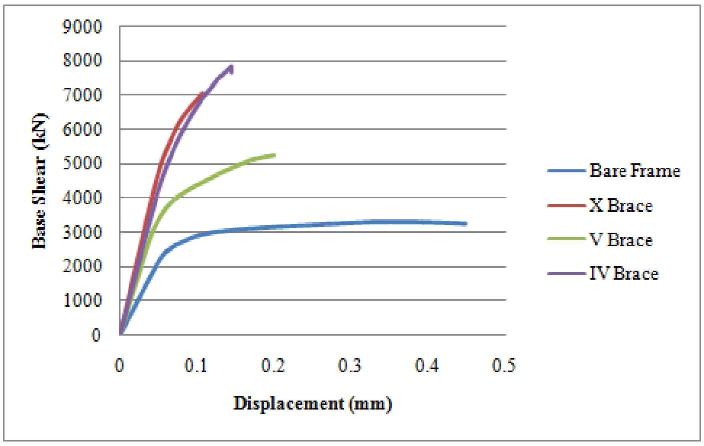
Model V VI VII : With 10xpd, 15xpd, 20xpd

5. RESULTS

A comparative study is presented between the performances of different bracings and metallic damper for the application of non linear static analysis.

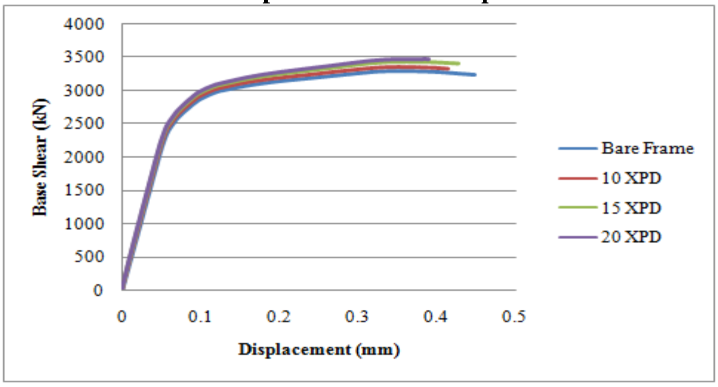
Effect of Bracing on Various Properties of Structure

Sr. No.	Properties	Bare Frame	X Brace	V Brace	IV Brace
1	Yield Shear (kN)	3102.38	5635.48	3923.92	5430.67
2	Yield Displacement (mm)	70.1	57.7	53.9	63
3	Target Shear (kN)	3262.31	7030.323	5236.734	7676.1
4	Target Displacement (mm)	422	110	192	137
5	Ductility Ratio	6.877	1.858	3.865	2.237



Pushover Curve for Model I, II, III and IV

Effect of X Plate Damper on Various Properties of Structure



Pushover Curve for Model I, V, VI, and VII

6. CONCLUSIONS

In present work nonlinear analysis is carried out i.e. static for studying the performance of bracings and metallic damper. Results were assessed in form of storey displacement, storey drift, nonlinear time history analysis. The conclusions of these results are discussed in this chapter.

1. X brace, V brace and inverted V brace increased the yield shear capacity of building by 44.95%, 14.56% and 41.31% respectively.
2. The target displacement reduced by 73.93%, 54.50% and 67.35% for X,V and Inverted V brace system respectively.
3. 10XPD, 15XPD and 20XPD curtailed the target displacement by 4.97%, 10.42% and 23.22% respectively.
4. 10XPD dissipated 22.87% input energy through hysteretic behavior where as 15XPD and 20XPD dissipated 29.69% and 35.4% input energy.
5. X bracing system proved to the most effective system in curtailing response due to ground motions.
6. All the plates in X-Plate Damper have yielded well and dissipated considerable amount of energy.

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