Analysis Of A Steel Structure Considering Braced And Unbraced Eccentric Condition Using ETABS

Sujit Kumar[1], Hitesh Kodwani[2]
Civil Engineering Department
[1] M.Tech Scholar, SAM college of engineering and technology, Anand nagar, Bhopal, Madhya Pradesh 462001, India
[2]Assistant Professor, SAM college of engineering and technology, Anand nagar, Bhopal, Madhya Pradesh 462001, India

Abstract- *In modern seismic design, damping devices are used to increase the capacity of structures to dissipate energy. This Project evaluates the efficiency of using a passive friction damper system in a structure compared with typical structures and the influence of the damper's capacity on the structural response. The analysis concludes that dampers with lower capacity slip more times during earthquake than dampers with bigger capacity but the acceleration result increases.*
The main objective of this research is to assess the seismic performance of Eccentrically Braced Frames of different configurations. Modelled Eccentrically Braced Frames subjected to both linear and nonlinear analysis in ETABS. The linear analysis gives an insight to mode shapes and mass participation ratios.

Keywords*: Seismic Analysis, Storey Drift, Base Shear, Storey Displacement, ETABS*

I. INTRODUCTION

Earthquake is a wavering which is produced by powers underneath the lithosphere, traveling through the asthenosphere. It very well may be expressed as the vibration which happens due to energy delivered in the asthenosphere. The arrival of the energy is the consequence of the quick interruption or the definite eruption of a piece of the outside layer, or even because of the human mediations brought about by blasts. This issue has been a critical subject of thought for specialists. At last numerous analysts and researchers recommended the utilization of supporting frameworks for the viable opposition of the seismic burdens.

Brace System

A Fundamental concept in engineering – bracing – involves added additional elements to a frame in order to increase its ability to withstand lateral loads. There are two main varieties of braced frames – concentric and eccentric.

- Concentric Bracing

Concentric propping comprises of slanting supports situated in the plane of the edge. The two finishes of the support join toward the end points of other outlining individuals to shape a bracket, making a firm edge.

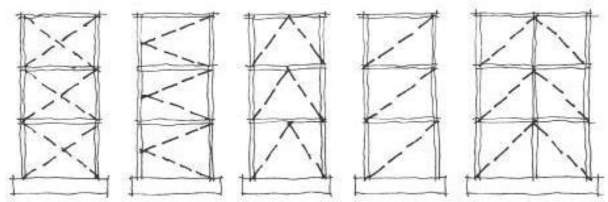

Fig 1: Common types of concentric bracing

- Eccentric Bracing

Eccentric bracing comprises of corner to corner supports situated in the plane of the edge where one or the two closures of the support don't join toward the end points of other outlining individuals. The framework basically joins the elements of a second casing and a concentrically propped outline, while limiting the disservices of every framework.

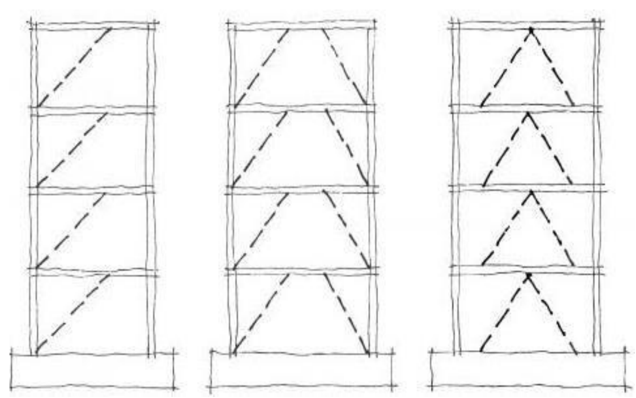

Fig 2: Common types of eccentric braced framing

Damping System

Damper systems are planned and fabricated to safeguard underlying honest characters, control primary harms, and to forestall wounds to the occupants by engrossing seismic energy and lessening distortions in the construction. Seismic dampers grant the design to oppose serious information energy and diminish hurtful diversions, powers and speed increases to designs and inhabitants. There are a few kinds of seismic dampers to be specific gooey damper, erosion damper, yielding damper, attractive damper, and tuned mass damper.

ETABS

ETABS is the shortening of " Expanded 3D Investigation of building Framework". ETABS is a result of PCs and Designs, Inc. which is perceived worldwide as the spearheading pioneer in primary designing examination and plan programming for underlying and tremor designing. They have presented ETABS with the accompanying section.

II. LITERATURE REVIEW

Srushti Bagal et.al (2020) in the exploration paper, a multistoried exposed and supported steel outlines was examined by Execution Based Seismic Plan (PBSD) technique in STAAD Expert High level following nonlinear static examination. Outline parts (bar, sections, and so forth.) was continuously changed in accordance with represent nonlinear versatile plastic conduct under consistent gravity loads and gradually expanding sidelong loads. The outcomes were dissected as far as uprooting, shear powers, plastic pivots and limit bend.

Results presumed that propped steel outline at ideal position expands the shear limit of construction and performs well, most extreme in LS level. No breakdown of part is seen here after gradual parallel burdens. Weakling investigation is effectively executed to concentrate on non direct way of behaving of design under seismic tremor stacking.

Shaik Mohammad et.al (2019) creator examined the exhibition of a 6 celebrated steel outline working with knee supporting framework and contrasted and exposed outline. Weakling examination, comparable static investigation, Reaction Range investigation, Time history examination is acted in ETABS in light of IS 1893:2002 (section 1) rules. The manual computation was finished based on Identical static examination and Reaction range investigation to figure out base shear for establishment and parallel power for every story deck section and contrasted the qualities and exposed outline. Results expressed that the knee propped outline framework is vital for decrease the impact on parallel relocation by unearthly speed increase (Sa). The inside story float in Y-heading is far contrasted with admissible float proportion according to IS 1893:2002 (section 1). Subsequently, the knee supporting edge underlying inside story float is adequate by IS 1893:2002 (section 1).

III. METHODOLOGY

Step 1 New model quick template is defined on the first step, as here in this case, G+9 storey structure was considered, with number of storey as 10, typical storey height of 3.2m and the bottom storey was locked at 3m.

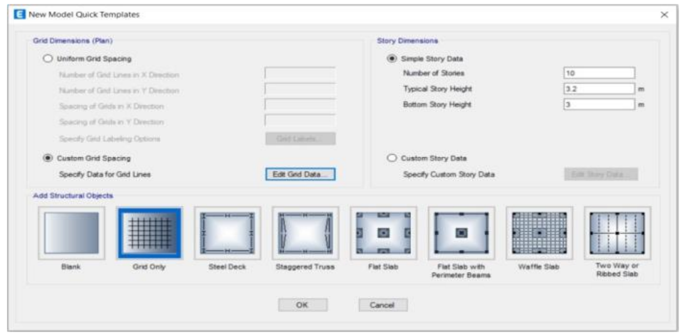

Fig 3 : New Model Quick Template

Step 2 Defining Grid System, this leverage is available in ETABS where the structure can be predefined on parameters of grid system defining them in X and Y direction by naming grid ID in x direction as A,B, C,....... and 1, 2, 3, 4…..in y direction.

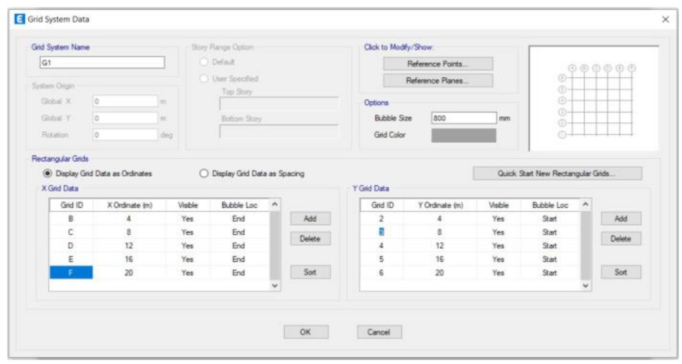

Fig 4 Defining Grid System Data for X and Y Direction.

Step 3 Defining Material Properties as M30 grade of concrete and HYSD500 grade of steel is considered for beam, column shear wall and slab.

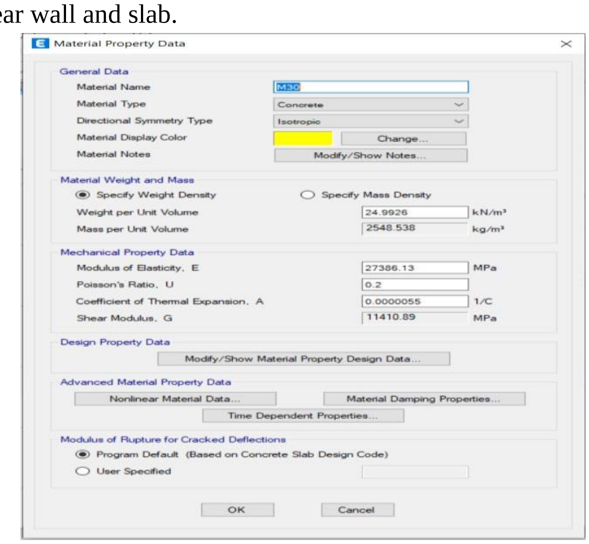

Fig 5: Defining Property of concrete for M30.

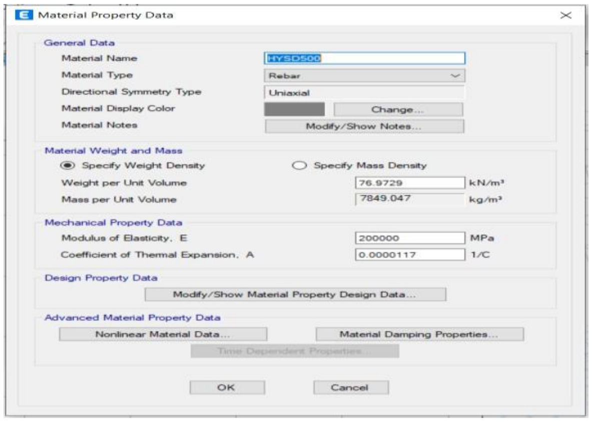

Fig 6: Defining Properties of Rebar

Step 4 Defining Section properties for beam as 450x300mm, column 500x500mm, properties of wall 200mm.

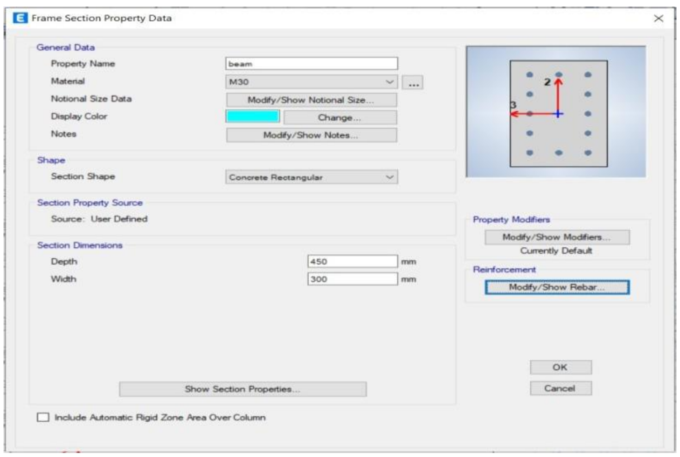

Fig 7: Defining Section Properties of Beam

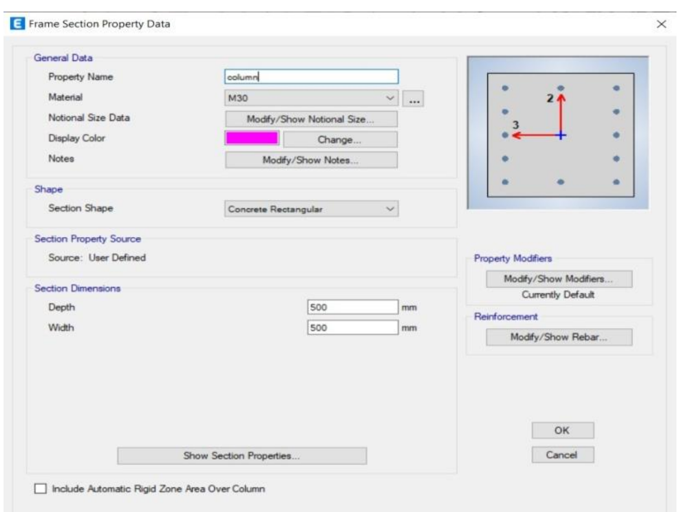

Fig 8: Defining Section Property for column

Step 5 Assigning Fixed Support at the bottom of the structure in X, Y and Z direction.

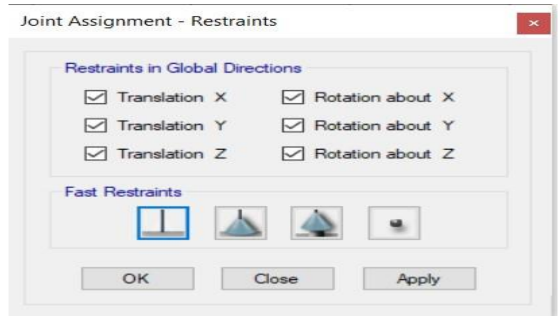

Fig 9: Assigning Fixed Support

Step 6 Defining Properties for friction dampers

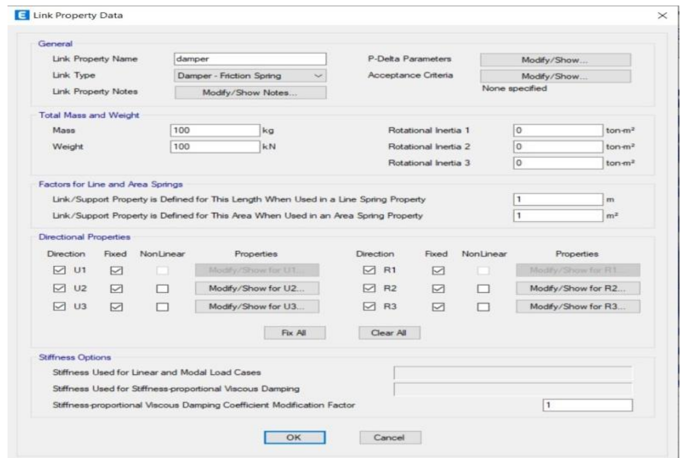

Fig 10: Defining Link Property Data for damping system

Step 7 Defining Loading conditions for dead load, live load and earthquake load.

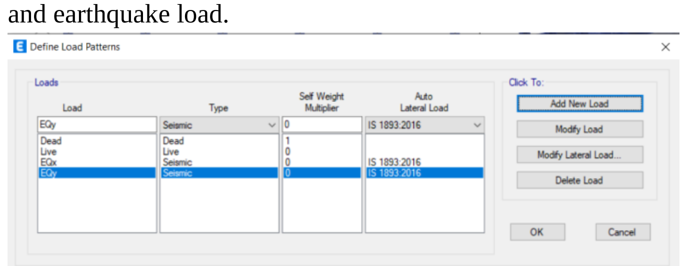

Fig 11: Defining Load Pattern

Step 8 Defining Seismic load data for different seismic zones.

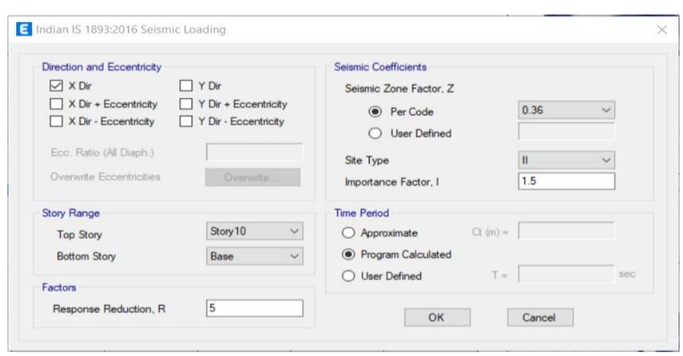

Fig 12 : Seismic Zone Data for Zone V

Step 9 Shell Assignment floor meshing option

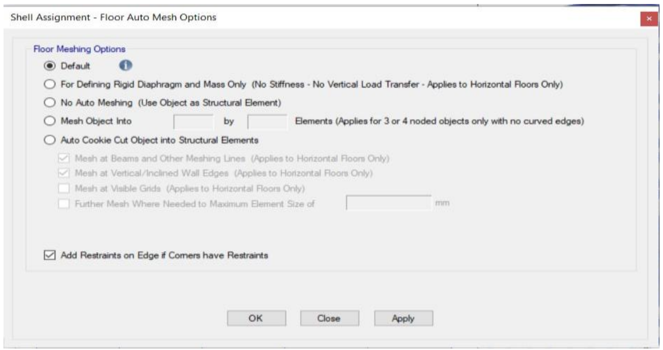

Fig 13: Shell Assignment for Meshing

IV. PROBLEM IDENTIFICATION

Building configuration for structure	
Building configuration	G+9
Structure Type	Steel Structure
Plan Dimension	25mx25m
Number of Bay in X-direction	5
Distance between bays in X-direction	4m
Distance between bays in Y-direction	4m
Number of Bay in Y-direction	5
Height of the structure	31.8m
Bearing capacity of soil	200 KN/m2
Slab Thickness	150mm
Storey Height	3.2m
Bottom Storey Height	3m
Wall Thickness	150mm
Parapet Wall	150mm
Section of Beam	450mmx300mm
Section of Column	500mmx500mm

Table 1: Building configuration

Grade of Concrete	M30
Weight per unit Volume	24.9926 kN/m3
Mass per Unit Volume	2548.538 kg/m3
Modulus of Elasticity, E	27386.13 MPa
Poisson's Ratio, U	0.2
Coefficient of Thermal Expansion, A	0.0000055 1/C
Shear Modulus, G	11410.89 MPa

Table 2: Properties of Concrete

Material Name	HYSD500
Material Type	Rebar
Weight per unit Volume	76.9729 kN/m3
Mass per Unit Volume	7849.047 kg
Modulus of Elasticity, E	200000MPa
Coefficient of Thermal Expansion, A	0.0000117 1/C

Table 3: Properties of Rebar

Material Name	Fe345
Weight per unit Volume	76.9729 kN/m3
Mass per Unit Volume	7849.047 kg
Modulus of Elasticity, E	21000MPa
Poisson's Ratio, U	0.3
Coefficient of Thermal Expansion, A	0.0000117 1/C
Shear Modulus, G	80769.23 MPa

Table 4: Properties of Steel

Loading Condition

The gravity loads and earthquake loads will be taken for analysis. As per IS 1893 (Part1): 2016 Clause no: 6.3.1.2, the following load cases have to be considered for seismic analysis:

1. 1.5 DL
2. 1.5(DL+ IL)
3. 1.2(DL+IL + EL along X direction)
4. 1.2(DL+IL + EL along Y direction)
5. 1.2(DL+IL - EL along X direction)
6. 1.2(DL+IL - EL along Y direction)
7. 1.5(DL + EL along X direction)
8. 1.5(DL + EL along Y direction)
9. 1.5(DL - EL along X direction)
10. 1.5(DL - EL along Y direction
11. 0.9DL + 1.5EL along X direction
12. 0.9DL + 1.5EL along Y direction
13. 0.9DL - 1.5EL along X direction
14. 0.9DL - 1.5EL along Y direction

Following loadings are adopted for analysis:-

1. Self weight: Dead load of materials

2. Dead Load: Calculated by software using density and sectional data of the structural members.

A. 25.K.N/m^3 X 0.20 m

B. 5.0 K.N/ m^2

Floor finishing = 1.625KN/ m^2

Total Weight of slab = 5.0 KN/ m^2 + 1.625KN/ m^2
= 6.625 KN/ m^2

3. Live Load: It is calculated as per IS-875 (Part II): 1987Live load on floors = 4KN/ m^2

4. Earthquake Load: It is calculated as per IS-1893 (Part I): 2016.

Vb = Ah x Weight of the building Ah = (Z/2) x (Sa/g) x (I/R).
Calculation for Sa/g

Ta = 0.075 $h^{0.75}$ [IS 1893 (Part 1):2016, Clause 7.6.1]

= 0.075 x $(15)^{0.75}$ = 0.571 sec.

Zone factor, Z = 0.36 for Zone V, IS: 1893 (Part 1):2016, Table 2 Significance factor, I = 1.5 (building)
Delicate soil site and 5% damping Sa/g = 1.36/0.571 = 2.381
According to I.S.: 1893 (Part 1): 2016.

Case Study

Case I- A Conventional G+9 storey structure.

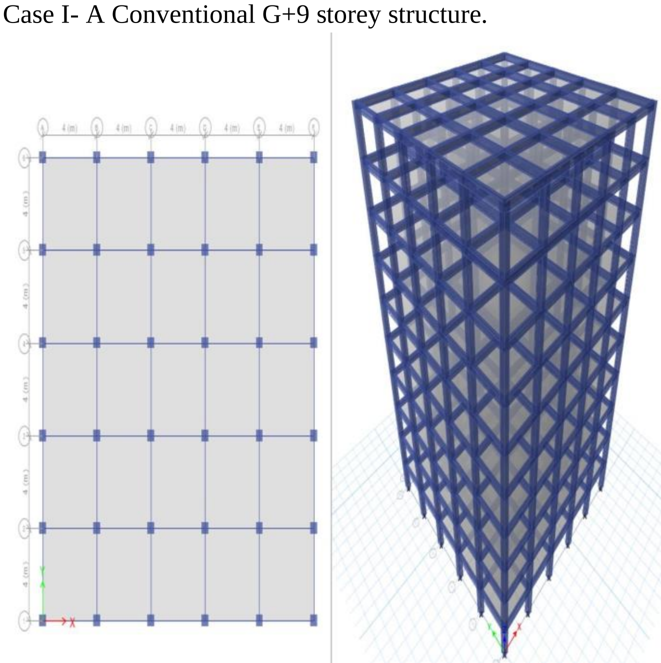

Fig 14: G+9 Conventional Structure

Case II- Centric brace structure

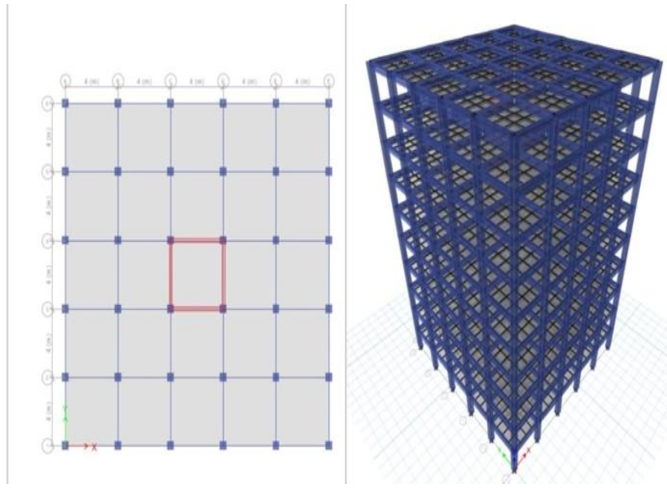

Fig 15: G+9 Centric Brace Structure

Case III- Eccentric brace structure

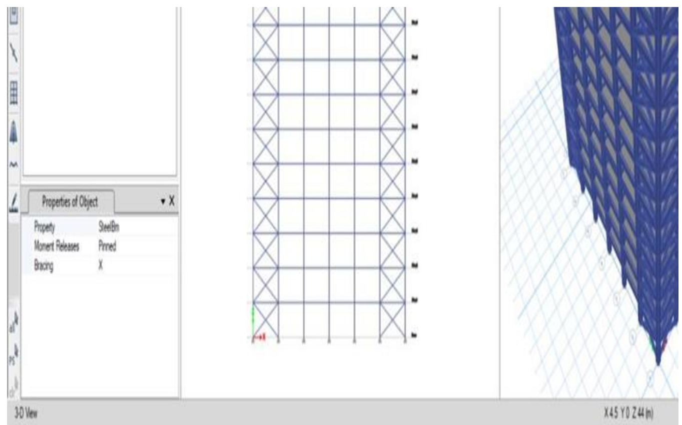

Fig 16: Eccentric brace structure

Case IV- Frictionally damped

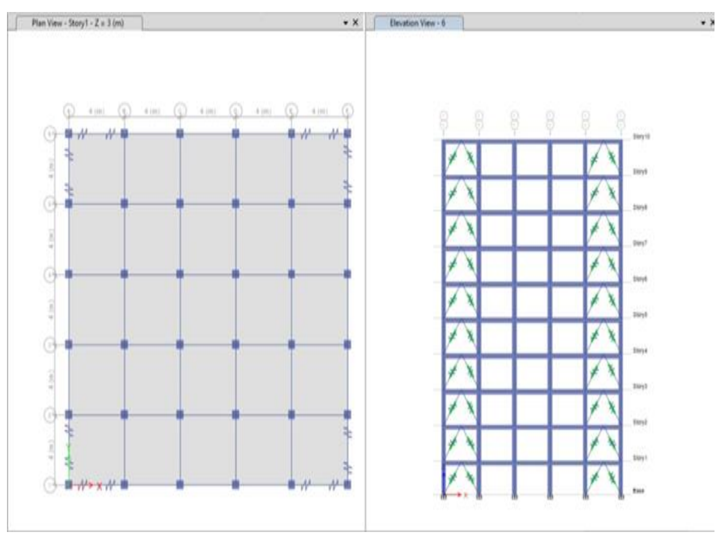

Fig 17 : G+9 Structure with Friction Dampers

V. RESULTS AND DISCUSSION

Lateral Displacement

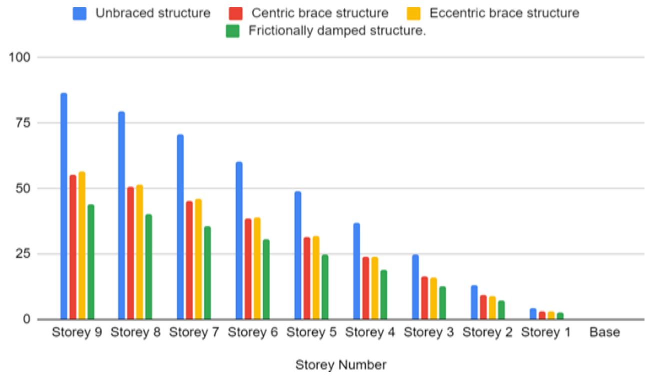

Fig 18: Lateral Displacement in X-direction.

Storey Drift

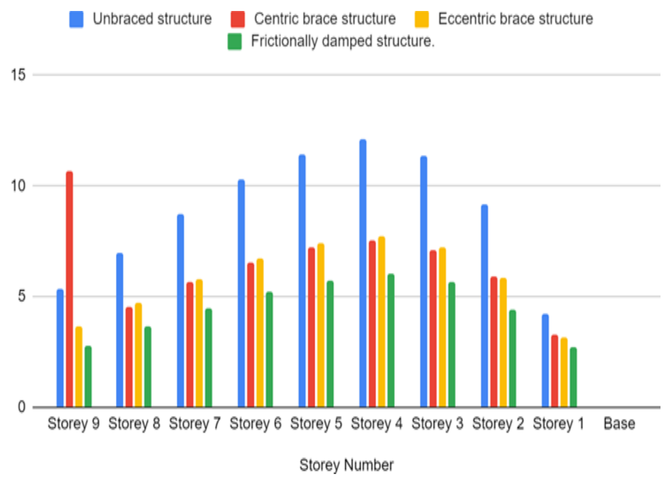

Fig 19: Storey Drift in X- Direction (mm)

Time Period

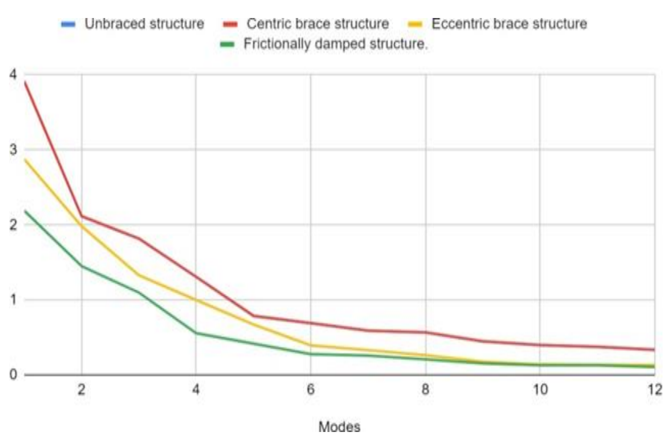

Fig 20: Time Period in sec

Base Shear

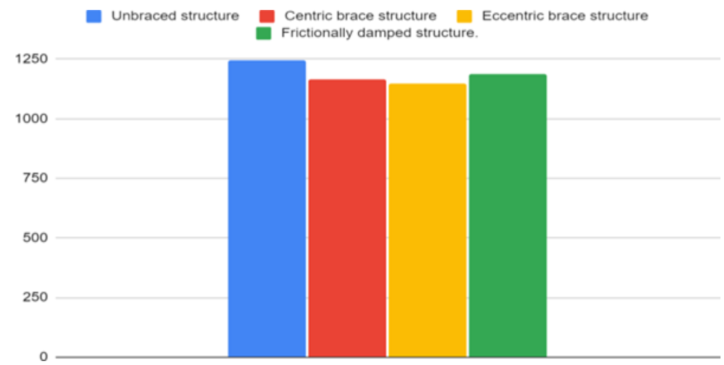

Fig 21: Base Shear in KN

VI. CONCLUSION AND FUTURE SCOPE

The lateral displacement was maximum for unbraced structure which was on the higher side by 37% in comparison to frictionally damped structure.

The structure was found stable in all the four cases and favourable results were visible for both eccentric braced structure and frictionally damped structure.

Time period was evaluated with mode 12 where the stable results were visible for frictionally damped structure.

The base shear formula is: V = 0.2 (W) V represents the shear force that will be generated at the base of a building. 0.2 represents earthquake force. W represents the weight of the building. The base shear was least for contric brace structure and maximum for unbraced structure.

FUTURE SCOPE

- The research on the accuracy of fast nonlinear analysis as an alternative to direct integration analysis should be further studied.
- As the modal time-history analysis is especially suitable for structures equipped with energy dissipating devices, this was also performed in this study with friction dampers as a third LFRS.
- Further investigate the behaviour of frictional dampers with soft storey structure.
-

REFERENCES

[1] Emine Aydin, Elif Boru and Mert Gurbuz, [Effects of Diagonal Friction Dampers on Behavior of a Building], Appl. Sci. 2023, 13, 8311.

[2] Shaik Mohammad, N. Raja Nikhil Reddy, Ch. Saipraveen and Vankayalapati Raghu, [Analysis of Steel Frames with

Bracings for Seismic Loads], International Journal of Civil Engineering and Technology (IJCIET) Volume 10, Issue 03, March 2019, pp. 316–329.

[3] Ameena A and Hazni Nizam, [Response Reduction of Highrise Buildings using Friction Dampers], International Journal of Engineering Research & Technology (IJERT), Vol. 10 Issue 06, June- 2021, ISSN: 2278-0181.

[4] Shilpa G. Nikam, S.K. Wagholikar and G.R. Patil, [Seismic Energy Disssipation of a Building Using Friction Damper], International Journal of Innovative Technology and Exploring Engineering (IJITEE) ISSN: 2278-3075, Volume-3 Issue-10, March 2014.

[5] Shubham Jain and Mohd.Adnan, [Structural Analysis of Seismic Friction Dampers], International Research Journal of Engineering and Technology (IRJET), Volume: 06 Issue: 03 | Mar 2019, ISSN: 2395-0072.

[6] Vipul Neeraj Khosla and Dr. Atul. B. Pujari, [Seismic Analysis of Eccentrically and Concentrically Steel Braced Structures], International Research Journal of Engineering and Technology (IRJET), Volume: 06 Issue: 07 | July 2019, ISSN: 2395-0072.

[7] Adithya G. S and H. Narendra, [Performance Evaluation of Friction Dampers under Seismic Loads], International Journal of Research in Engineering and Technology, Volume: 05 Special Issue: 14, Sep-2016.

[8] B Rakesh, Shiva Shankar K M and Navya K S, [Seismic Analysis of Tall Structures by using Dampers in Etabs], International Journal of Innovative Science and Research Technology, Volume 7, Issue 4, April – 2022, ISSN No:-2456-2165.

[9] A.K. Sinha and Sharad Singh, [Seismic Protection of RC Frames using Friction Dampers], International Journal of Civil Engineering and Technology (IJCIET) Volume 8, Issue 2, February 2017.

[10] Kumar Vanshaj, Himanshu Kumar Singh and Abhishek Mishra, [Comparative Study of High Rise Steel Structure with and without Bracing System], International Research Journal of Modernization in Engineering Technology and Science, Volume:04/Issue:03/March- 2022, ISSN: 2582-5208.

[11] Rinu G David and Sarif N, [Seismic performance of eccentrically braced frames], IOP Conf. Series: Materials Science and Engineering 989 (2020).

[12] Vinay V. Gupta, G.R. Reddy and Sandeep S. Pendhari, [Performance- Based Design of RC Structures Subjected to Seismic Load Using a Hybrid Retrofitting Method with Friction Damper and Steel Bracing], Computational Engineering and Physical Modeling 5-1 (2022) 19-35.