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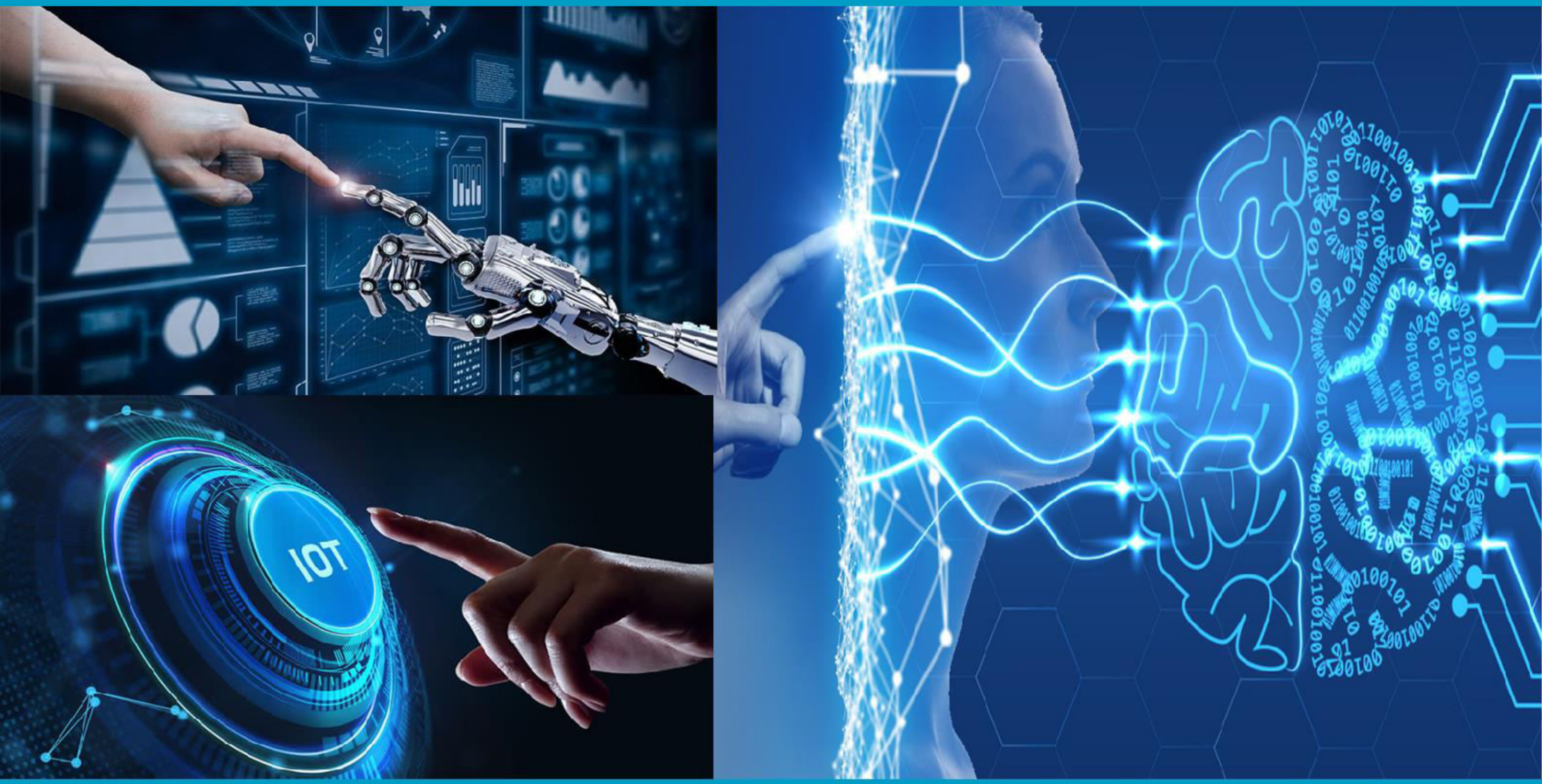

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Dynamic Analysis of Industrial Steel Structure by Using Bracings and Dampers under Wind Load and Earthquake Load

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ABSTRACT*:* The structural system of the building has to support the lateral loads due to earthquake and wind in addition to gravity loads. A lateral load develops high stresses and produces sway causing vibration and drift. If the industrial steel structures are not designed to resist the lateral loads, then they may be collapse resulting into the loss of life or its content. The objective of this research is to propose simple but innovative and effective LLRSS or structural technology and methodology for the seismic control which can be used in new as well as old industrial steel structures. In spite of increasing popularity, analytical study of braced industrial steel structure and its detailed requirement to control the seismic responses limited in India. Also, industrial steel structure involves heavy dead load due to large member size which intern is more prompt for seismic loss. The research work dealswith the parametric study of response of Non-linear time history analysis (NLTHA) of 3D industrial steel structure braced withdifferent bracing configurations and dampers with different massratios using software (Sap-2000) under earthquake. The bracing configuration used are X-bracing, Modals with x bracing and damper with mass ratio 2% arefound to improve the performance of the building under earthquake load and wind load.

KEYWORDS: LLRSS, bracings, dampers, time history analysis, time period, base shear, lateral displacement, EARTHQUAKE, SAP 2000 software.

I. INTRODUCTION

The statics of a building must also withstand lateral loads from wind and earthquakes in addition to gravitational loads. High strains and oscillations brought on by side loading result in vibration and drift. Industrial steel structures that are not built to bear lateral loads run the risk of collapsing, which could result in the loss of people or property. Thus, it is crucial that the structure of the be both sturdy enough to endure lateral stresses and stiff enough to withstand gravity. The Project aims to investigate how bracings and dampers affect industrial steel structures subjected to earthquake and wind loads. This study's primary objective was to ascertain how different bracings, dampers with variable mass ratios, and height to width ratios would affect various dynamic metrics. The study of why and where earthquakes occur comes under geology. The main aim of all kinds of structural system in a building is to transfer the gravity load effectively and thus assure safety of the structure. Apart from these vertical loads, structure is also subjected to lateral loads which can develop high stress which will cause, sway of the structure. Buildings are usually subjected to different types of loads i.e. Lateral load due to wind and earthquake and vertical loads due to gravity (Dead + Live load on the structure). So the structure should be such that it should be strong enough which can resist all types of loads. When structures are subjected to lateral loads especially tall structures, these structures show large displacement and to reduce this displacement and drift moment resisting frames along with different types of lateral load resisting structural forms are available. The most popular lateral load resisting systems are shear walls and braces. Tall reinforced concrete constructions cannot withstand significant displacements in earthquake-prone zones. Buildings' vulnerability to drifts and significant displacements that could harm them and result in fatalities can be greatly decreased by adopting bracing systems. Finding the best bracing configuration to lessen the structure's response to seismic excitation is the main goal of the current effort.

II. LITERATURE REVIEW

[1] Dynamic Analysis of Industrial Steel Structure by Bracings and Dampers under Wind Load and Earthquake Load (2018) - The structural system of the building has to support the lateral loads due to earthquake and wind in addition to gravity loads. A lateral load develops high stresses and produces sway causing vibration and drift. If the industrial steel structures are not designed to resist the lateral loads, then they may be collapse resulting into the loss of life or its content. Therefore it's important for the structure to have not only. Hence there is a need to study the LLRSS or technology suitable for a particular breadth of building. The objective of this research is to propose simple but innovative and effective LLRSS or structural technology and methodology for the seismic control which can be used in new as well as old industrial steel structures.. In spite of increasing popularity, analytical study of braced industrial steel structure and its detailed requirement to control the seismic responses limited in India. Also industrial steel structure involves heavy dead load due to large member size which intern is more prompt for seismic loss.

[2] Dynamic Analysis of Steel Structure with Bracings and Dampers under Wind and Earthquake Loads (2020)- In India residents are increasing gradually and the necessary land for living. It is a key requirement to survive anywhere. For that reason multi story building are best choice for construction in Metro cities where a smaller amount of property is presented. As designer knows multi story structure provides large floor area in small area and it is beneficial also. Hence, it is required to assemble high rise structure. If high rise structures are constructed than many structural troubles come to pass, such as lateral load effect, lateral displacement and stiffness etc. Normally for high rise structure wind and earth quake load effects are prevailing. In the present study, a 15-storey building is considered. The structure is subjected to both wind and dynamic loadings. The Modelling and analysis are carried out using ETABS software. The structure is further stabilized by providing the Bracing system and Viscous Dampers. The performance of these structures is studied and compared using various parameters such as displacement, storey drift, base shear and time period. The results are extracted and conclusions are drawn. From the static Analysis, it is found that, the displacement values are higher in case of model M1 with bare frame, however, it is reducing up to 31% and 37% by providing bracings and dampers respectively.

[3] Dynamic Response of Steel Structure with Bracings and Pendulum Tuned Mass Dampers (2023)- In this work the Dynamic response of Steel Structure with Bracings and Pendulum Tuned mass damper (PTMD) are studied. Bracings are added to the structure to provide additional stiffness and strength. PTMD is a device that consists of a mass which is connected to the structure by means of a spring and a damper. The mass is tuned to vibrate at the different frequency as the structure, which allows it to cancel out the vibrations of the structure. G+5, G+15 and G+25 Storeyed steel structure models with the different combinations of Bracings and PTMD are considered in this study. Following which the FE Analysis involving the Modal, Equivalent static and Response spectrum analyses are performed and results are obtained in terms of Time period, Base Shear, storey displacement and Storey drift.

[4] Dynamic Analysis of Industrial Steel Structure by using Bracings and Dampers Under Wind Load and Earthquake Load (2016)- The structural system of the building has to support the lateral loads due to earthquake and wind in addition to gravity loads. A lateral load develops high stresses and produces sway causing vibration and drift. If the industrial steel structures are not designed to resist the lateral loads, then they may be collapse resulting into the loss of life or its content. Therefore it's important for the structure to have not only sufficient strength against gravity loads but also the adequate stiffness to resist lateral forces. Literature review reveals that LLRSS (Lateral load Resisting structural system) is provided in the form of devices like base isolation and dampers which controls the seismic vibration and lateral drift. But these devices are very costly and effective only for high rise buildings. Hence there is a need to study the LLRSS or technology suitable for a particular breadth of building. The objective of this research is to propose simple but innovative and effective LLRSS or structural technology and methodology for the seismic control which can be used in new as well as old industrial steel structures.. In spite of increasing popularity, analytical study of braced industrial steel structure and its detailed requirement to control the seismic responses limited in India. Also industrial steel structure involves heavy dead load due to large member size which intern is more prompt for seismic loss. Hence, it is proposed to study the response of steel buildings/frames with different types of steel bracings configurations and dampers as a LLRSS to control the vibration lateral displacement and storey drift. The structural response parameters selected for the study are time period, natural frequency, and roof displacement. The research work deals with the parametric study of response of Non-linear time history analysis (NLTHA) of 3D industrial steel structure braced with different bracing configurations and dampers with different mass ratios using software (Sap-2000) under Bhuj earthquake.

[5] Seismic Analysis of Industrial Structure Using Bracings and Dampers (2019)- Resistance of structures against earthquake plays an extensive role in construction industry. A structure should consist of strength, stability and ductility to accommodate both horizontal and vertical loadings. Horizontal loading leads to the production of sway and further results in vibration and storey drift. Strength and stiffness are two major keys for any structure to resist gravity and lateral loads. Provision of bracings or dampers to any structure contributes to lateral stability. After assigning dampers or bracings, the general system changes to lateral load resisting system (LLRS). However, this involves high economy, it is only suitable for high rise, important buildings which are suspected to be affected by lateral load and structures damaged by lateral load. The present work involves in proposing the suitability of type of damper or bracing for controlling the seismic activity on industrial structures in respective seismic zones III and V of India. Industrial structures also associate high dead load as it provides residence to heavy sized members. Therefore, this is necessary to investigate seismic response of buildings with various bracings and dampers to control vibration, lateral displacement and storey drift. Natural time period, frequency, roof displacements are the major parameters considered for observing response of structures. Response spectrum analysis of 3D industrial structure with distinct concentric bracings and dampers using SAP 2000 and ETABS is carryout in this research under respective base shear.

III. OBJECTIVES

1. Examine the placement of bracings and dampers at various areas that are subject to wind and earthquake load.
2. The design of wind load was calculated based on IS 875 (Part-3) and the earthquake load obtained using IS1893(Part-1):2002.
3. To understand the performance of steel structure for bracing system and damper.
4. The positioning of dampers and bracings for minimising lateral displacement and drift is assessed.
5. The SAP-2000 software program is selected to perform analysis.

IV. PROPOSED METHODOLOGY

4.1 INDUSTRIAL STEEL STRUCTURE DETAILS

In the current study's environment, a steel structure is taken into account, and the analysis is performed in accordance with Indian norms. This structure won't be an exact replica of a real one that has already been constructed or is being considered. The building is thought to be in India's zone 5. However, the building's proportions, general design, and other features have been chosen to be an example of one for which the employment of bracings and dampers would be an appropriate option. Here, studies on steel structures with various height to breadth ratios have been carried out.In the present study, dynamic analysis of industrial steel structure using dampers and bracings under wind load and earthquake load is investigated. Considering steel structure keeping height constant the breadth of the structure has been varied (H/B RATIO 1, 2 and 3). The dampers mass ratio has been varied by 1%, 1.5% and 2%. The research work deals with the parametric study of response of Nonlinear time history analysis (NLTHA) of 3D industrial steel buildings braced with different bracing configurations and dampers using software (Sap-2000) under Bhuj earthquake.

The modal considered for the study is a 12.6m height steel structure. The plan of the structure is 57.6 x 86.4m, 57.6 x 100.8m, 57.6 x 129.6m , 57.6 x 172.8m with column spaced at 7.2m centre to centre. a building is assumed to be located at zone 5 of India.

Table 4.1: Description of steel structure

No of bays	X direction	Y direction
Model 1	8	12
Model 2	8	14
Model 2	8	18
Model 4	8	24
Height of frame	12.6	
Yield strength of steel	Fe 500	
Grid to grid spacing in x direction	7.2 m	
Grid to grid spacing in y direction	7.2 m	

Table 4.2: Wind Coefficient

Coefficients	Values
Basic wind speed	50
Terrain category	3
Structural classes	C
Risk coefficient k1	1
Terrain height and structure size factor k2	1
Topography factor k3	0.85
Design wind speed vz	42.5

To evaluate seismic performance, structural analysis of mathematical model is recommended for finding the force and displacement demands of a structure. For predicting the seismic demands of a structure, elastic and inelastic analysis of a structure is required. In this present work a series of frames with bracings and dampers were designed.

Table 4.3: Sectional properties of steel structure

All Dimensions in mm	Outside height (In mm)	Flange width (In mm)	Flange thickness (In mm)	Web thickness (In mm)
Beams				
ISMB 225	225	110	11.8	6.5
Rafter				
ISMB 225	225	110	11.8	6.5
Purlin Intermediate				
ISMB 225	225	110	11.8	6.5
Purlin At Ends				
Pipe	Dia= 30 mm			
Bracings	Outside horizontal leg	Outside vertical leg	Horizontal and vertical leg thickness	
BR1-CA225x225x30	225	225	30	

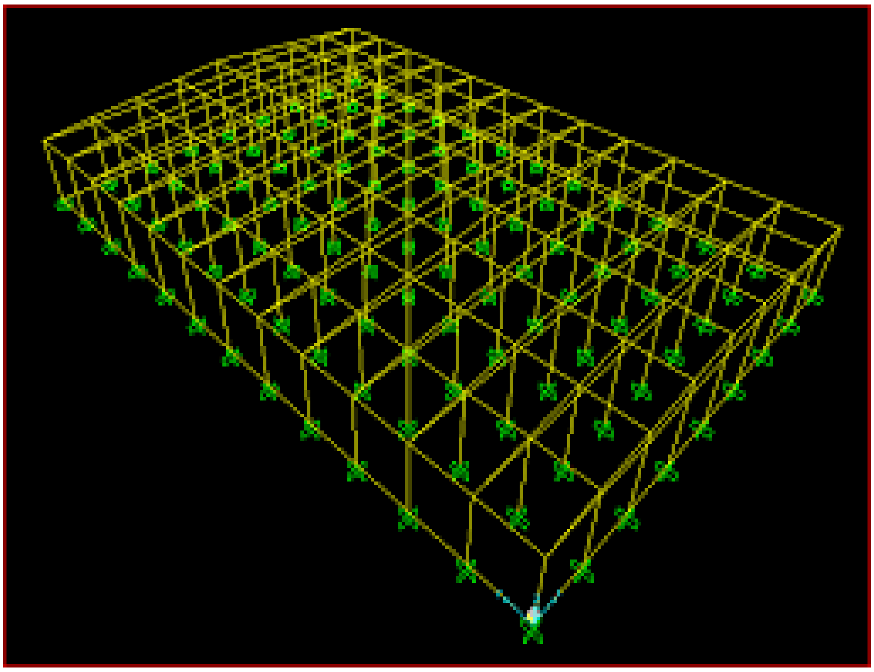
Table 4.4: Seismic Coefficients

Coefficients	Values
Response reduction factor R	5
Importance factor I	1
Zone factor Z	0.36
Time period T	0.568

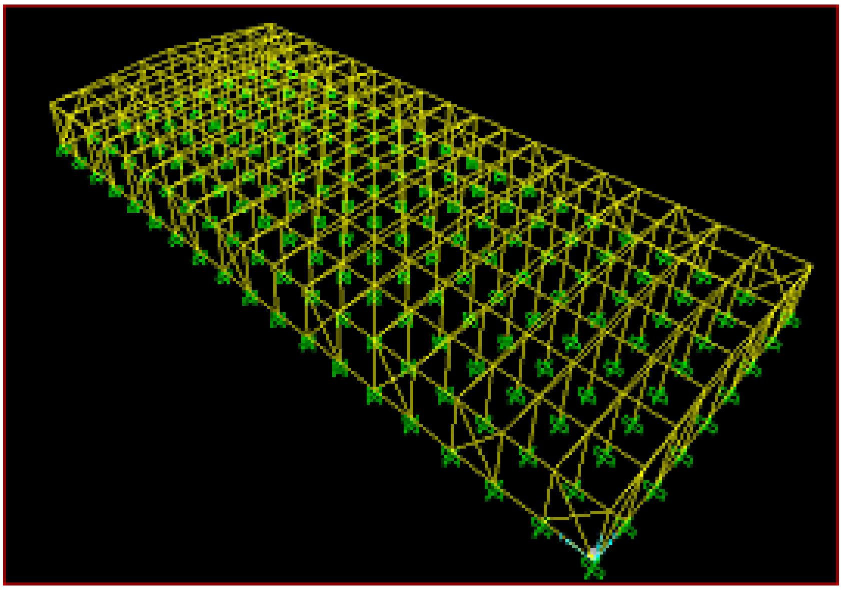
4.2 MODELING

In the present study a total of 4 different arrangements of bracings and 2 models with and without damper are analysed using SAP2000 software are as fallows.

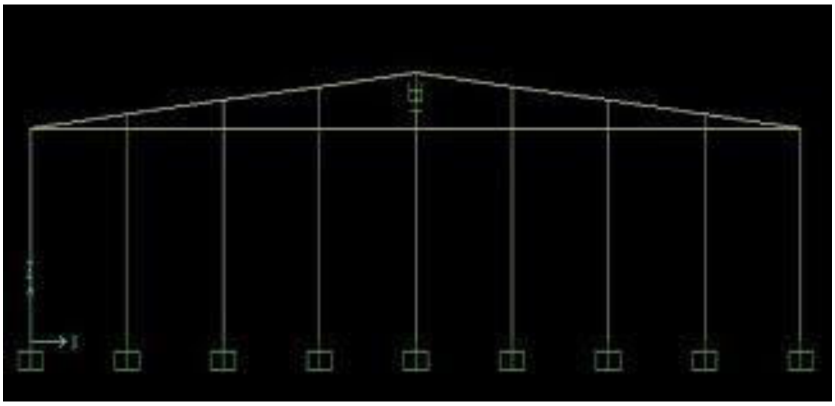
1. Structural modal without bracing.
2. structural modal with X bracing (12 bay)
3. structural modal with diagonal bracing (12 bay)
4. structural modal with eccentric bracing (12 bay)
5. structural modal with X bracing (14 bay)
6. structural modal with diagonal bracing (14 bay)
7. structural modal with eccentric bracing (14 bay)
8. structural modal with X bracing (18 bay)
9. structural modal with diagonal bracing (18 bay)
10. structural modal with eccentric bracing (18 bay)
11. structural modal with X bracing (24 bay)
12. structural modal with diagonal bracing (24 bay)
13. structural modal with eccentric bracing (24 bay)
14. structural modal without damper
15. structural modal with damper.
16. all steel columns are identical that is ISMB225 and the bracings width and length is 0.31m and 12.32m. the tie beam are 0.45m wide and 0.45m deep.
17. the method of analysis carried out here is dynamic analysis. torsional effects are not considered, the material behaviour is in linear elastic range.



[Fig.4.1: 12 bay fixed modal]



[Fig.4.2: :18 bay x bracing modal]



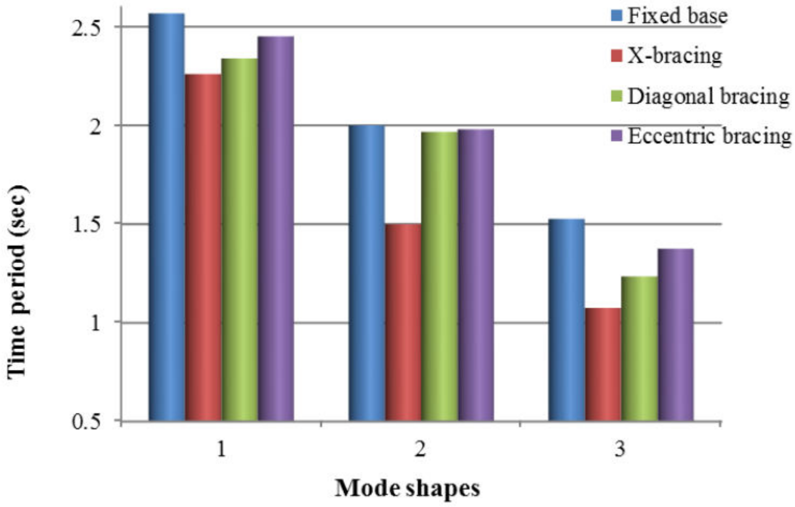
[Fig.4.3: Model with damper]

V. RESULTS

5.1 VARIATION OF NATURAL TIME PERIOD

The variation of natural time period is studied for model with and without bracing, and with and without dampers. The values of natural time period (mode 1, mode 2 and mode 3.

5.1.1 EFFECT OF BRACINGS: The variation of base shear is studied for a steel structure with different number of bays (12,14,18,24) implemented with different bracings is compared with fixed base modal. the values of base shear of a (12,14,18,24) bay modal with and without bracings.



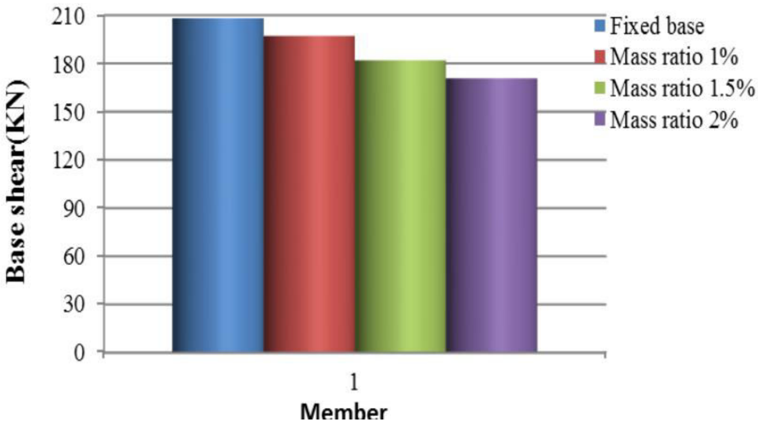
[Fig.5.1: Shows the variation of time period with different bracings]

From the above figure it can be seen that there is decrease in time period with the implementation of bracings and x bracing is found out to be more effective in reducing time period than other bracings.

5.2 VARIATION OF BASE SHEAR

The variation of base shear is studied for model with and without bracing, with and without dampers. the values of base shear of the member.

5.2.1EFFECT OF DAMPERS: The variation of base shear is studied for a steel structure with different number of bays (12,14,18,24) implemented with damper is compared with fixed base modal. the values of base shear of a (12,14,18,24) bay modal with and without dampers.

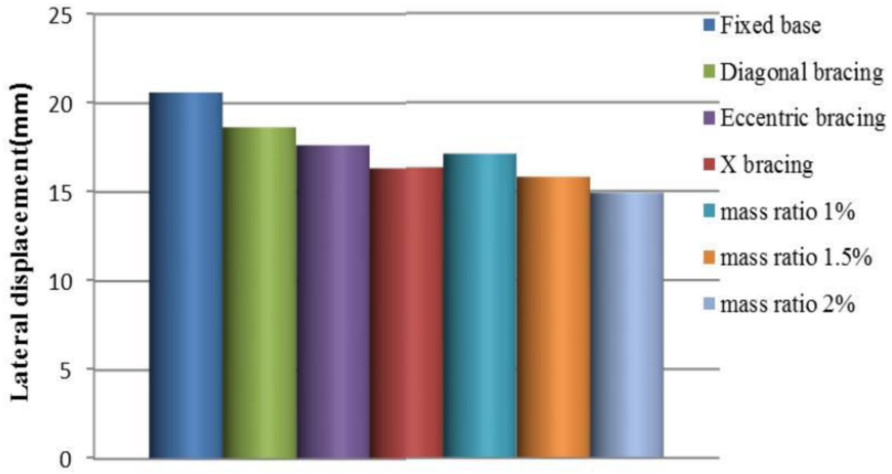


[Fig.5.2: Shows the variation of base shear with different mass ratio]

From the above figure it can be seen that there is decrease in base shear with the implementation of dampers and damper with mass ratio 2% is found out to be more effective in reducing base shear than other dampers with mass ratio (1%,1.5%).

5.3 COMPARISION OF LATERAL DISPLACEMENT

The variation of lateral displacement is studied for a steel structure with different number of bays (12,14,18,24) implemented with different bracings and dampers is compared with fixed base modal. the values of lateral displacement of a (12,14,18,24) bay modal with and without bracings and dampers.



[Fig.5.3: Shows the variation of lateral displacement with different mass ratio and bracings]

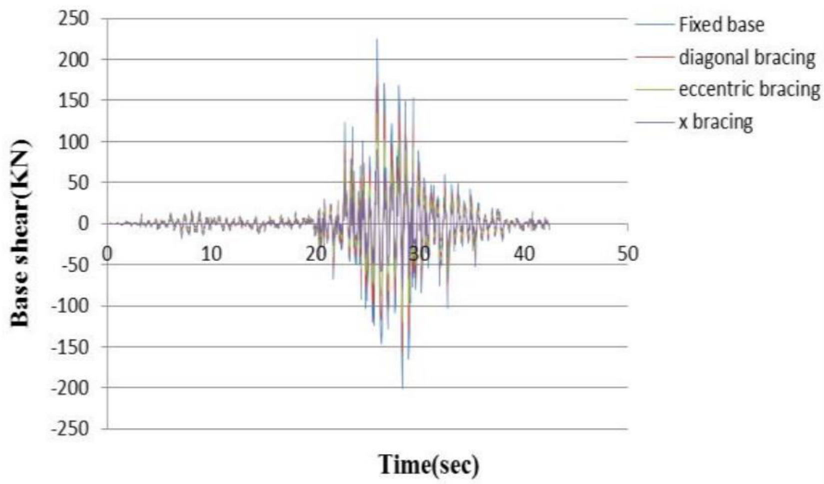
From the above figure it can be seen that there is decrease in lateral displacement with the implementation of dampers and bracings.

5.4 TIME HISTORY ANALYSIS

Analysis of structure, applying data over increment time step as function of acceleration, force, moment or displacement. Earthquake ground acceleration records namely NW bhuj components of bhuj earthquake records have been selected the records are defined for the acceleration points. with respect to a time interval of 0.05secs, time history analysis has been carried out for the modals with fixed base and different bracings(diagonal,eccentric,x) and damper with different mass ratio (1%,1.5%,2%).

5.4.1 EFFECT OF BRACINGS:

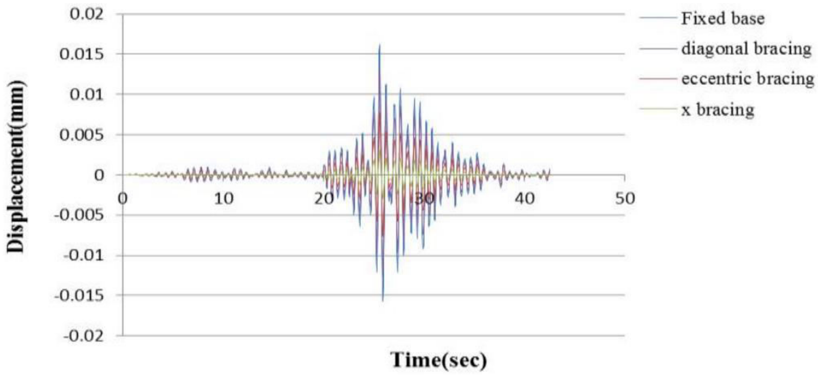
VARIATION OF BASE SHEAR: The variation of base shear is studied for a steel structure with different number of bays (12,14,18,24) implemented with different bracings is compared with fixed base modal and it is subjected to bhuj earthquake data. The values of base shear of a (12,14,18,24) bay modal with and without bracings are showed in below graphs.



[Fig.5.4: Shows the variation of base shear with different bracings]

From the above figure it can be seen that there is decrease in base shear with the implementation of bracings and x bracing is found out to be more effective in reducing base shear than other bracings.

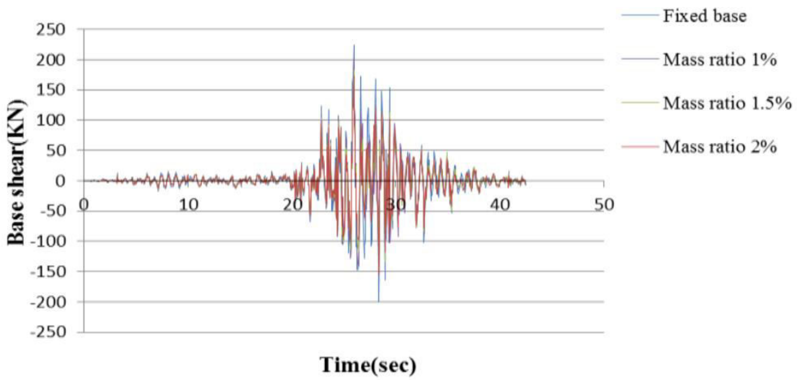
VARIATION OF JOINT DISPLACEMENT: The variation of joint displacement is studied for a steel structure with different number of bays (12,14,18,24) implemented with different bracings is compared with fixed base modal and it is subjected to bhuj earthquake data. The values of joint displacement of a (12,14,18,24) bay modal with and without bracings are showed in below graphs.



[Fig.5.5: Shows the variation of displacement with different bracings]

5.4.2 EFFECT OF DAMPERS

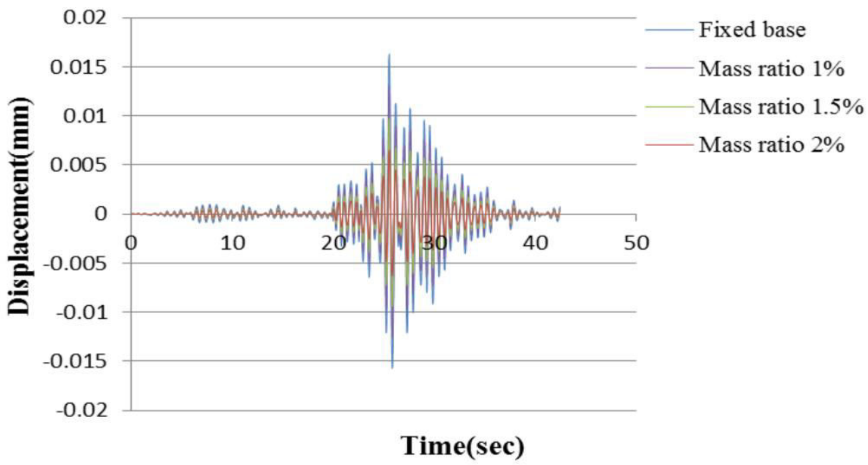
VARIATION OF BASE SHEAR: The variation of base shear is studied for a steel structure with different number of bays (12,14,18,24) implemented with damper is compared with fixed base modal and it is subjected to bhuj earthquake data. The values of base shear of a (12,14,18,24) bay modal with and without dampers are showed in below graphs.



[Fig.5.6: Shows the variation of base shear with different mass ratio]

From the above figure it can be seen that there is decrease in base shear with the implementation of dampers and dam per with mass ratio 2% is found out to be more effective in reducing base shear than other dampers with mass ratio (1%,1.5%).

VARIATION OF JOINT DISPLACEMENT: The variation of joint displacement is studied for a steel structure with different number of bays (12,14,18,24) implemented with damper is compared with fixed base modal and it is subjected to bhuj earthquake data. The values of joint displacement of a (12,14,18,24) bay modal with and without dampers are showed in below graphs.



[Fig.5.7: shows the variation of displacement with different mass ratio]

From the above figure it can be seen that there is decrease in joint displacement with the implementation of dampers and damper with mass ratio 2% is found out to be more effective in reducing joint displacement than other dampers with mass ratio(1%,1.5%).

VI.CONCLUSION

Modals with bracings are more efficient than dampers at lowering structural characteristics. Modals with a damper are more efficient than bracings at lowering systematic parameters. When the damper's mass ratio is 2%, dampers are found to be useful. It is discovered that x bracing is more cost-effective in bracings.

- Time period decreases with the increase in stiffness of building.
- In comparison to the structure with bracing and damper the time period decreases up to 12.06% for bracing and 19.82% for damper.
- Base shear decreases with the increase in stiffness of building.
- In comparison to the structure with bracing and damper the base shear decreases up to 21.82% for bracing and 23.10% for damper.
- Lateral displacement decreases with the increase in stiffness of building.
- In comparison to the structure with bracing and damper the lateral displacement decreases up to 20.72% for bracing and 28.38% for damper.
- Effective stress ratio decreases with the increase in stiffness of building.
- In comparison to the structure with bracing and damper the effective stress ratio decreases up to 71.50% for bracing and 17.30 % for damper.
- Time history analysis (base shear) decreases with the increase in stiffness of building.
- Time history analysis (joint displacement) decreases with the increase in stiffness of building.
- From the study it has been found that Dampers are more economical than bracing.

VII.ACKNOWLEDGMENTS

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