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Comparative Study on the Seismic Behavior of Asymmetrical Steel Structure using Lateral Load Resisting Systems

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Abstract: Non structural component are delicate to huge ground movement which produces floor accelerations, velocities, and displacements. During an earthquake the structure creates this movement, resulting in peak floor accelerations higher than the peak ground acceleration. In this way earthquake ground motion can cause huge or serious structural damages. Consequently the requirements of structural response control system increases worldwide. In this study steel structures are taken for seismic performance evaluation. The steel buildings are modeled with different structural control system such as base isolator, damper and bracing with use of ETABS software. After that to evaluate structural response of building various ground motion data is applied. Equivalent static analysis is carried out for building model with each control system and the result of the seismic response of each control system is compared with other control system.
Keywords: Seismic Performance, Conventional Bare Frame, Cross Bracing, Lead Rubber Bearing, Damper, Equivalent Static Analysis

I. INTRODUCTION

Generally the reason for elevated structure is to exchange the primary gravity load securely. The common gravity loads are dead, live load. Likewise the structure should withstand the lateral load brought about by earthquake, blasting, and wind depending upon terrain categories. The lateral load decreases stability of structure by creating sway moments and induces high stresses. So in such cases stiffness could easily compare to strength to resist lateral loads.

There are various ways of providing lateral load resisting system, for example, bracing, base isolation, damper, to improve seismic performance of structures. Base isolations is a passive vibration control system that does not require any outer power sources for its task and uses the movement of the structure to build up the control force. The upside of this method is to keep the structure basically versatile and along these lines guarantees security among enormous earthquake. Viscous damper are hydraulic devices that disseminate the kinetic energy of seismic occasions and pad the effect between the structures. They are flexible and can be intended to permit free movements just as controlled damping of a structure to protect from wind load, thermal motion or seismic event. The improvement of bracing made the construction of high rise structure possible. Bracing are strong in compression. At the point when bracings are put in steel outline it acts as diagonal compression strut and transmits compression force to another joint. Variety in the column stiffness can impact the method of failure and lateral stiffness of the bracing.

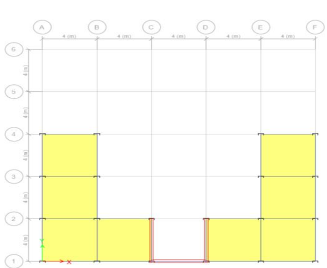

Fig. 1 A: Typical Floor Plan

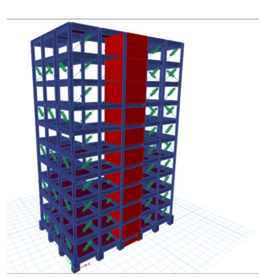

Fig.2: 3D Modeling of structures with friction damper

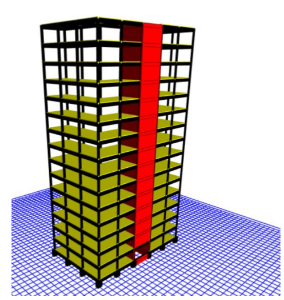

Fig.3: 3D Modeling of structures with bare frame.

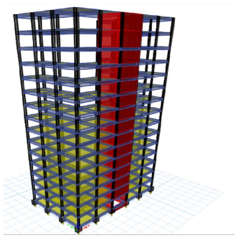

Fig.2: 3D Modeling of structures with lead rubber bearing

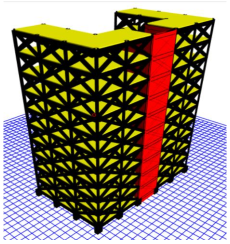

Fig.2: 3D Modeling of structures with cross bracing

Table 1: Data of Structure

SECTION MODEL	DIMENSIONS
Beam	ISMB 600
Column	ISMC 400
Plan	10, 15, 20 storey model
Column Spacing	4m in both direction
Floor height	3 m
Steel section	Fe345
Slab thickness	100mm M25 grade
Shear wall thickness	200 mm
Bracing (X)	ISMB 450
Damper type	Friction Damper
Base isolation	Lead Rubber Bearing
Live Load	3.5 KN/ m^ 2
Superimposed Dead Load	1.5 KN/ m^ 2
Live Loads on Roof	1.5 KN/ m^ 2
Seismic Zone	V
Seismic Factor	0.36
Soil Type	Medium type 2
Importance Factor	1.5
Reduction Factor	5
Earthquake Load	X and Y Direction
Floor Finish	1 KN/ m^ 2
Unit Weight of Steel	78 KN/ m^ 3

II. DETAILS OF LEAD RUBBER BEARING (LRB)

Lead rubber bearing are made up of a standard elastomeric laminated rubber bearing the rubber compound can be natural or chloroprene rubber. The shape can be round or rectangular. The calculations for the design of LRB are as per the provisions of UBC-97.

Table 2: Detail of LRB Base isolator

Effective Stiffness	1065 KN/ m
Horizontal stiffness	350
Vertical Stiffness	180
Yield Force	20 KN
Stiffness Ratio	0.1
Damping	0.05

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III. DETAILS OF FRICTION DAMPER

In these kinds of damper the energy is consumed by surfaces with frictions between them scouring against one another.

Table 3: Detail of friction damper

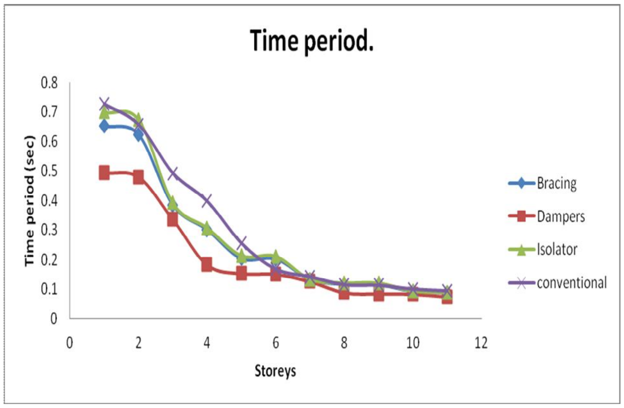
Link Type	Plastic (Wen)
Mass (Kg)	222.07
weight (KN)	2.18
Effective Stiffness (KN/m)	152500
Yield Strength (KN)	450
Post Yield Stiffness Ratio	0.0001
Yield Exponent	10
Effective Damping (KNs/m)	0

IV. RESULTS AND DISCUSSIONS

Lateral loads resisting systems are used to reduce the seismic effect of the structure which is subjected to the earthquake load. The frames with base isolation, LRB and cross bracing are modeled according to the properties of structure which are explained in the work. The model is subjected to analysis for gravity load i.e. dead load and live load and seismic loads. The seismic behavior of the steel structure is judged by observing the time period and base shear.

Table 4: Time period Value for G+10 Storey

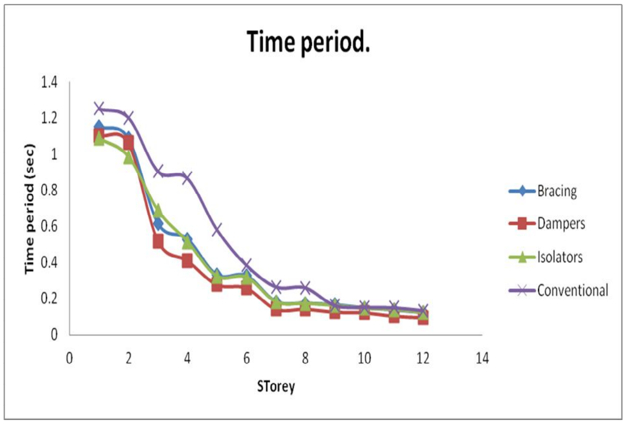
Sl. No	Modes	Time period (sec)			Time period (sec) conventional bare frame
		Bracing	Dampers	Isolators	
1	1	0.654	0.495	0.699	0.726
2	2	0.624	0.481	0.674	0.656
3	3	0.385	0.336	0.392	0.493
4	4	0.301	0.183	0.307	0.398
5	5	0.204	0.153	0.214	0.256
6	6	0.203	0.151	0.212	0.169
7	7	0.133	0.126	0.134	0.143
8	8	0.116	0.088	0.122	0.116
9	9	0.115	0.084	0.121	0.114
10	10	0.092	0.083	0.094	0.101
11	11	0.089	0.074	0.09	0.095
12	12	0.083	0.061	0.089	0.09



Graph 1: Comparison of time period value for G+10

Table 7: Time period Value for G+15 Storey

Sl.No	Modes	Time period (sec)			Time period (sec) conventional bare frame
		Bracing	Dampers	Isolators	
1	1	1.15	1.102	1.085	1.250
2	2	1.086	1.06	0.986	1.201
3	3	0.615	0.519	0.686	0.906
4	4	0.529	0.411	0.514	0.867
5	5	0.33	0.278	0.323	0.582
6	6	0.326	0.259	0.318	0.387
7	7	0.182	0.142	0.181	0.266
8	8	0.172	0.142	0.172	0.261
9	9	0.164	0.126	0.161	0.163
10	10	0.146	0.122	0.145	0.152
11	11	0.135	0.104	0.139	0.15
12	12	0.12	0.095	0.121	0.134



Graph 2: Comparison of time period value for G+15

Table 8: Time period Value for G+20 Storey

Sl.No	Modes	Time period (sec)			Time period (sec) conventional bare frame
		Bracing	Dampers	Isolators	
1	1	1.435	1.485	1.574	1.585
2	2	1.405	1.45	1.493	1.574
3	3	0.730	0.698	0.761	0.865
4	4	0.714	0.560	0.761	0.785
5	5	0.416	0.325	0.646	0.652
6	6	0.430	0.410	0.565	0.598
7	7	0.252	0.295	0.269	0.450
8	8	0.216	0.266	0.236	0.320
9	9	0.212	0.185	0.228	0.280
10	10	0.201	0.156	0.209	0.250
11	11	0.149	0.143	0.162	0.180
12	12	0.148	0.136	0.161	0.171

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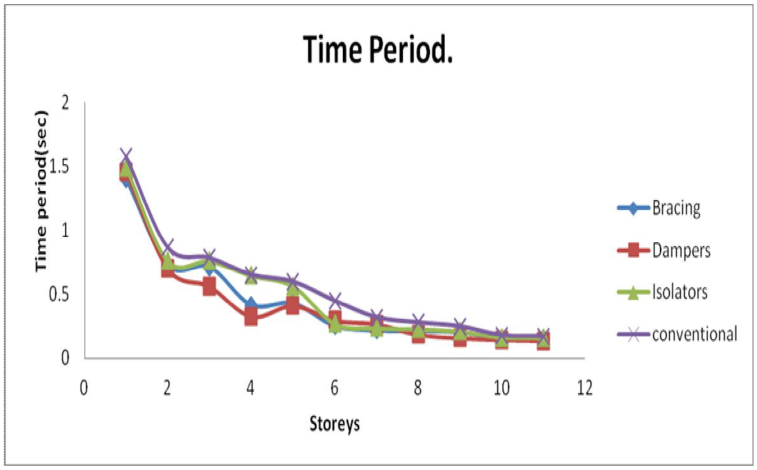


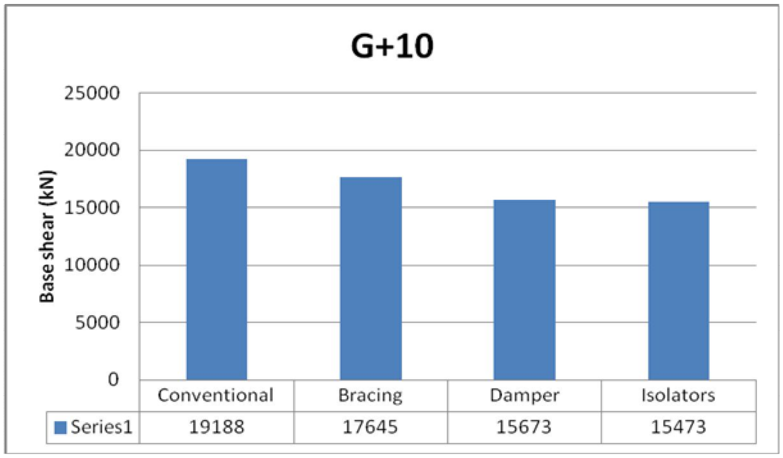
Graph 3: Comparison of time period value for G+20

1) *Time Period:* From the graphs it is shown that the time periods of building with damper are less than bracing & isolator as compared to normal conventional building. The building with bracing shown time period of 31.8% greater than the damper and 11% greater than the isolator.

a) Base Shear

Table 9: Base shear for G+10 Storey

Sl. No	Storey	Base shear kN			Base shear for conventional bare frame KN
		Bracing	Dampers	Isolators	
1	Base shear	17645	15673	15743	19188



Graph4: Comparison of base shear value for G+10

Table 10: Base shear for G+15 Storey

Sl. No	Storey	Base shear kN			Base shear for conventional bare frame KN
		Bracing	Dampers	Isolators	
1	Base shear	23948	25643	22623.22	40964

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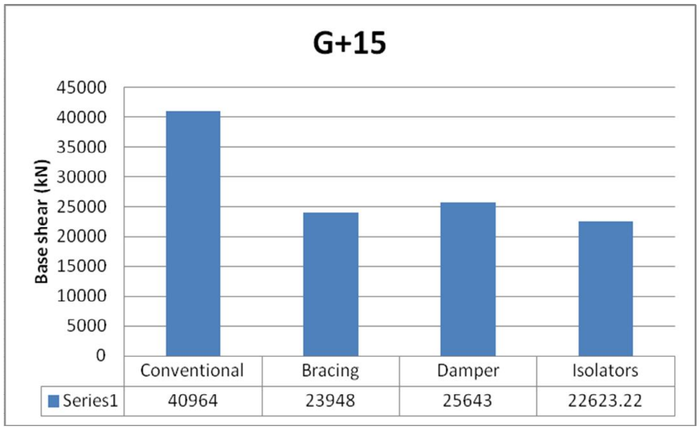
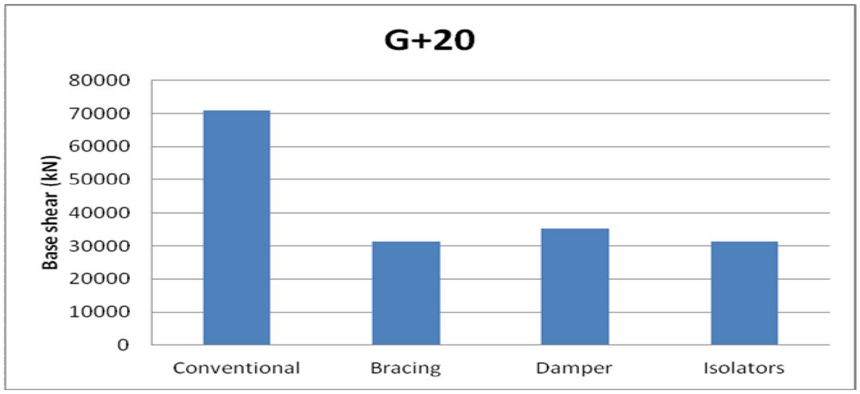


Graph 5: Comparison of base shear value for G+15

Table 11: Base shear for G+20 Storey

Sl. No	Storey	Base shear kN			Base shear for conventional bare frame KN
		Bracing	Dampers	Isolators	
1	Base shear	31417	35216	29754	70884.2



Graph 6: Comparison of base shear value for G+20

V. CONCLUSION

After carrying out results by using ETABS software for buildings with various heights, the parameters like time period and base shear for different lateral load resisting systems are compared. Following conclusion is made.

A. From the analytical studies it is concluded that the maximum time period can be achieved with conventional bare frame compared to bracing, LRB isolator and friction damper.
B. It has been found that time period of the structure got decreased with the presentation of the damper. Structure with full damper in all bays has most reduced time period when contrasted with supporting isolator and conventional bare structure.
C. By the analysis result shown in graph (4, 5, 6) it is concluded that the maximum base shear are for the building with conventional bare frame compared to bracing, LRB isolator, and friction damper.
D. It has been found that base shear value can be reduced by providing proper LRB isolators to the normal frame structure.

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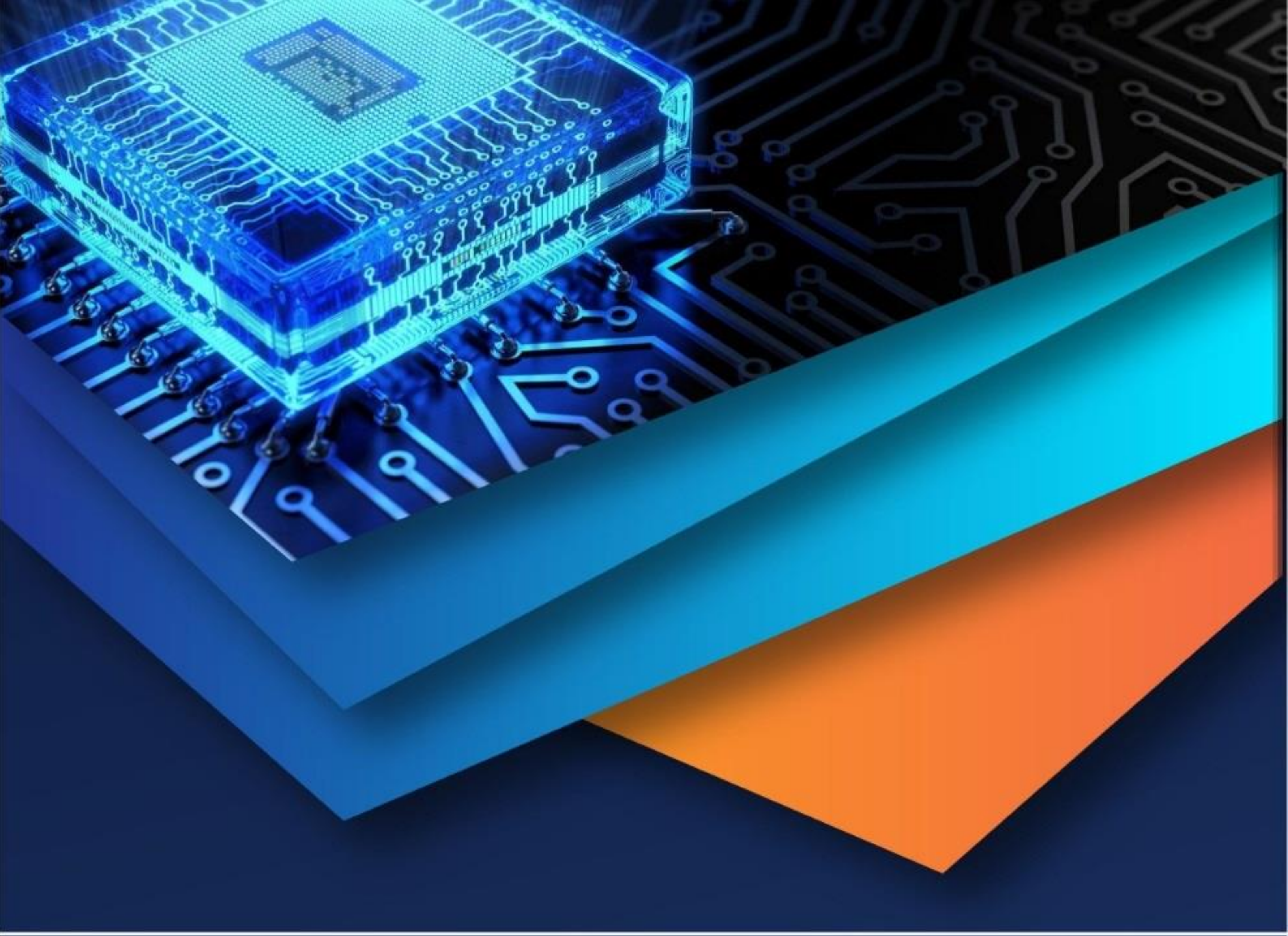

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