Evaluation of Seismic Response of Braced Base Isolated RC Structure

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Abstract - *Base isolation is most effective technique for protecting structure against earthquake forces. The performance can be further improved by bracing the structure to achieve high stiffness, which increases the detuning between fundamental period of superstructure and the effective period of isolated system and also limits deformations within structure itself. The seismic response of 20 and 35 storey braced base isolated structure subjected to the N-S component of 1940 EL Centro earthquake input is evaluated and compared with fixed base, braced fixed base and base isolated structure using SAP2000 software. The comparison shows that displacement of braced base isolated structure is reduced as compared to fixed base, braced fixed base and base isolated structure.*

***Key Words*: Base isolation, Bracings, Storey Drift, Base shear, Lead Rubber bearing.**

1. INTRODUCTION

Base isolation of structures is one of the most popular means of protecting structures against earthquake forces. It is a passive control device that is installed between the foundation and the base of the building. For bridges, the base isolators are installed between the deck and the pier, as with bridge bearings. In buildings, the base isolator protects the structure from earthquake forces in two ways: (i) by deflecting the seismic energy and (ii) by absorbing the seismic energy. The seismic energy is deflected by making the base of the building flexible (instead of fixed) in lateral directions, thereby increasing the fundamental time period of the structure. As buildings with longer time periods attract less seismic force, the isolation system deflects the seismic energy. In particular, high energy in the ground motions at higher mode frequencies are deflected. The seismic energy is absorbed by the isolator because of its non-linear response to earthquake excitation. The (internal) force–displacement curve of isolators under sinusoidal excitation exhibits hysteretic behavior and, therefore, much of the input energy to the isolators is lost in the hysteresis loop. Because of these two properties of the isolators, they have become very attractive passive control devices to be used in the control of seismic response of structures, especially the building structures. Generally, the base isolators can be grouped under (i) laminated bearings, and (ii) friction bearings. Among the laminated bearings, laminated rubber bearing (LRB), and New Zealand (NZ) rubber bearings are used extensively in practice. Of the friction type, elastic sliding bearings, friction pendulum systems (FPS), resilient friction systems (R-FBI), and pure friction (P-F) systems are popular.

The performance can be further improved by bracing the structure to achieve high stiffness, which increases the detuning between fundamental period of superstructure and the effective period of isolated system and also limits deformations within structure itself. Bracing provides stability and resist lateral loads.

2. LITERATURE REVIEW

Pan, T. C., Ling, S. F., Cui, W. [1] presented a seismic design concept of segmental building. A constrained optimization method is used to determine the design parameters of the vibration isolation systems so as to minimize the mean square maximum acceleration response of the segmental building subjected to the N-S component of the 1940 El Centro earthquake and compared with the responses of the corresponding fixed-base and conventional base-isolated buildings. Segmentation of superstructure has reduced the base displacement while keeping the acceleration response of superstructure at a low level. The segmental building possesses the same ability as the base isolated building to decouple the building from the harmful horizontal earthquake ground motions.

Praveen J V1, Govardhan B R2, Naveen K3 [2] has done the work on the performance of RC building with different bracing systems like X, V and inverted V using ETABS software. It is concluded that storey displacement increases, storey drift reduces and also acceleration reduces for base isolated stuctures.

Prof.R.B.Ghodke, Dr.S.V.Admane [3] has done work on performance of base isolated MR frame using nonlinear time history and compared the results. The result shows that displacement is reduced for MR frame with base isolation as height increases.

Ajay. G. Singh, Ajay k. Lohar, Ashish T. Yadav, S. R. Awad [4] has done work on G+6 RCC building with base isolation and the braced building is compared using linear time history analysis. From results it is concluded that base isolation increases the flexibility at the base of the structure and horizontal flexibility helps to minimize lateral earthquake force which is being transmitted through the building hence base isolation reduce seismic force as compared to the braced structure.

3. OBJECTIVE

In present study the seismic response of 20 and 35 storey structure without and with base isolation using X type bracing carried out.

1. To carry out analysis for 20 and 35 storey structure with fixed base (FB), braced fixed base (BFB), base isolated (BI) and braced base isolated (BBI) using SAP2000.
2. To explore effect of earthquake ground motion.
3. To compare the results of time period, base shear, displacement, storey drift, absolute acceleration, relative acceleration.

4. PROBLEM DESCRIPTION

20 storey structure details

Height of story	-	3 m
Modal damping ratio	-	5 %
Plan area	-	25 m x 25 m
Grade of concrete	-	M30
Grade of steel bracing	-	Fe250
Grade of steel bracing	-	Fe250
Size of Beams	-	0.3 m x 0.6 m
Slab thickness	-	0.150 m
Live load on slab	-	3 kN/m^2
Brace section	-	ISA 150 x 150 x 18
Size of Column		
1st to 10th floor	-	0.45 m x 0.45 m
11th to 20th floor	-	0.4 m x 0.4 m

35 storey structure details

Height of story	-	3 m
Modal damping ratio	-	5 %
Plan area	-	25 m x 25 m
Grade of concrete	-	M30
Grade of steel bracing	-	Fe250
Reinforcing bar	-	HYSD 500
Size of Beams	-	0.3 m x 0.6 m
Slab thickness	-	0.150 m
Live load on slab	-	3 kN/m^2
Brace section	-	ISA 200 x 200 x 15
Size of Column		
1st to 7th floor	-	0.6 m x 0.6 m
8th to 14th floor	-	0.55 m x 0.55 m
15th to 21st floor	-	0.5 m x 0.5 m
22nd to 28th floor	-	0.45m x 0.45 m
29th to 35th floor	-	0.4 m x 0.4 m

Base shear, displacement, storey drifts, absolute accelerations and relative acceleration in the middle column are taken into consideration as the comparison criteria.

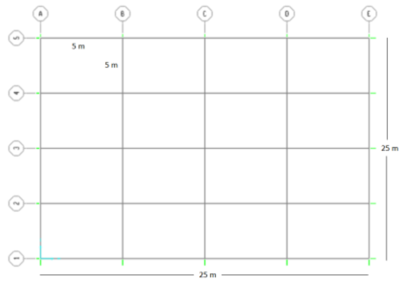

Fig -1: plan of 20 storey and 35 storey structure

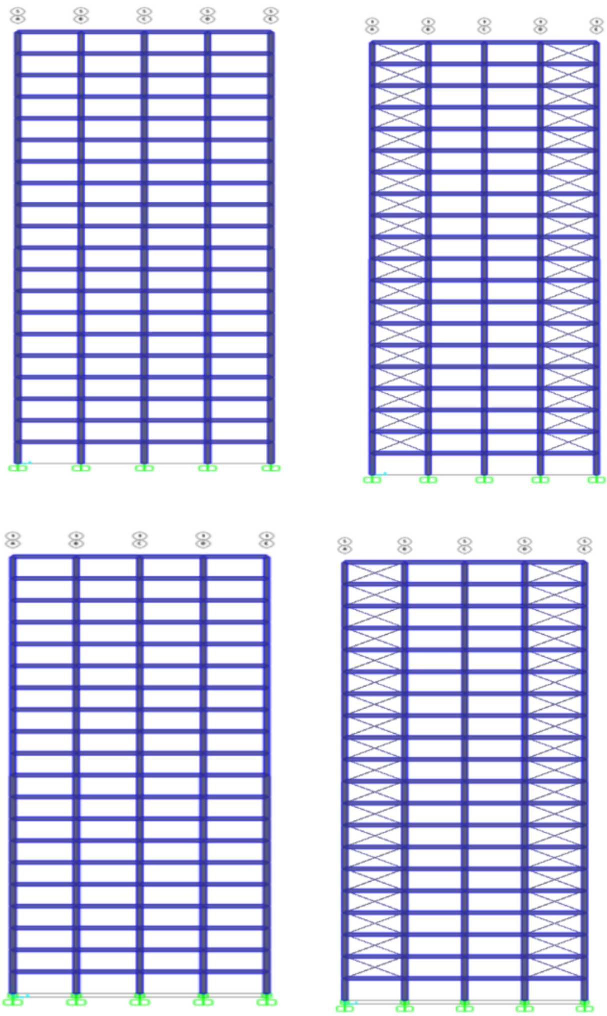

Fig -2: elevation of 20 storey structure fixed base, braced fixed base, base isolated and braced base isolated structure

Properties of lead rubber isolator for 20 storey:

Effective stiffness U1	-	180000
Effective stiffness U2 & U3	-	600
Nonlinear Effective stiffness U2	-	600

& U3

Yield Strength U2 & U3 - 40

Post yield stiffness ratio U2 & U3 - 0.1

Properties of lead rubber isolator for 35 storey:

Effective stiffness U1 - 350000

Effective stiffness U2 & U3 - 1000

Nonlinear Effective stiffness U2 & U3 - 1000

Yield Strength U2 & U3 - 70

Post yield stiffness ratio U2 & U3 - 0.1

5. RESULTS

Natural time period

Table -1: Time period of 20 storey

Mode shape	Type of Structure			
	Fixed base	Braced fixed base	Base isolated	Braced base isolated
1	2.43	1.89	4.55	4.38
2	2.43	1.89	4.55	4.38
3	2.15	1.26	4.01	3.72
4	0.83	0.59	1.25	1.10
5	0.83	0.59	1.25	1.10

Table -2: Time period of 35 storey

Mode shape	Type of Structure			
	Fixed base	Braced fixed base	Base isolated	Braced base isolated
1	4.04	3.41	5.81	5.48
2	4.04	3.41	5.81	5.48
3	3.4	2.14	4.89	4.25
4	1.39	1.05	1.94	1.77
5	1.39	1.05	1.94	1.77

Base shear

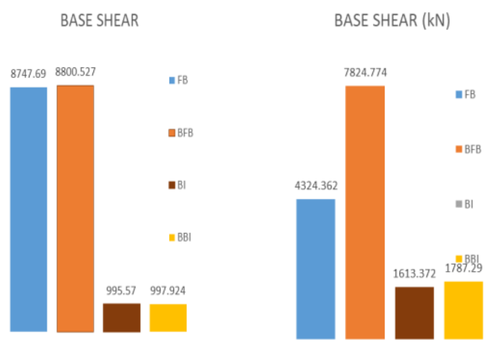

Fig -1: base shear of 20 storey and 35 storey structure

Displacement

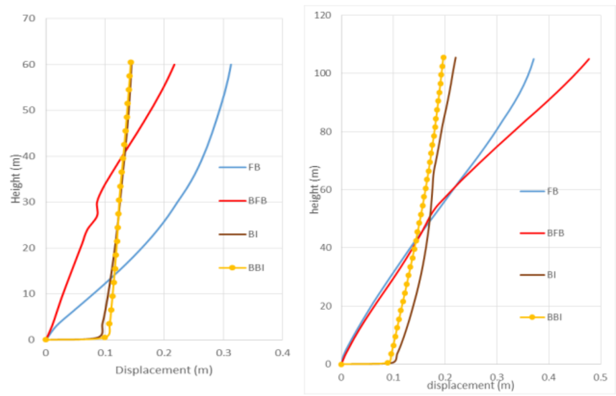

Fig -2: displacement of 20 storey and 35 storey structure

Storey Drift

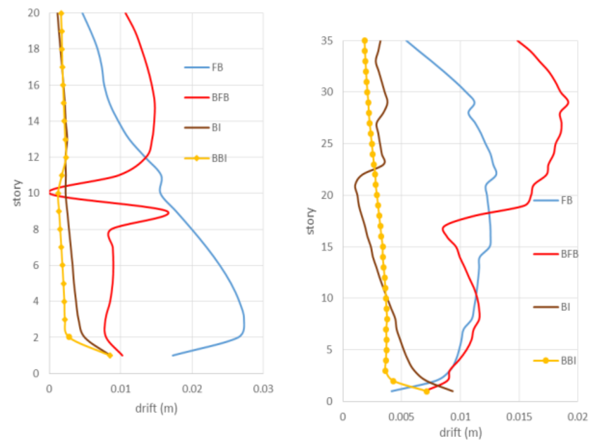

Fig -3: storey drift of 20 structure and 35 story structure

Absolute acceleration

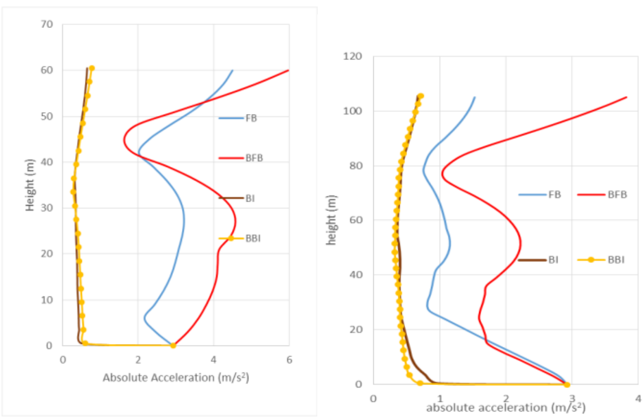

Fig -4: absolute acceleration of 20 storey and 35 storey structure

6. CONCLUSIONS

In this dissertation work an attempt is made to check the performance of RC frame structure with bracing under base isolation. 4 different models of 20 storey and 4 models of 35 storey are considered for the analysis. The analysis results are tabulated and compared.

- For 20 story building base shear is reduced by 88% for base isolated building and for 35 storey building, base shear is reduced 63% for base isolated building compared to fixed base building.
- For 20 story structure displacement is decreased in braced base isolated structure compared to fixed base and base isolated structure.
- Storey drift is reduced in base isolated structure compared to fixed base building.
- Time period of braced structure is also reduced compared to structures without bracing because of its increased stiffness.
- Storey acceleration is also reduced for base isolated structure for both 20 storey and 35 storey structure.

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