

# Assesment Of Seismic Response Of Building Frame With Base Isolation

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**ABSTRACT:** Use of base isolation devices in the foundation of critical structures as a mean of seismic design has attracted considerable attention in the recent years, however the shear wall frame interaction system is commonly adopted in high seismic zone. Shear wall interaction system provides large stiffness thereby decreasing the ultimate deflection. Providing isolator is the other way of making earthquake resistant frame which offers more flexibility to the building. The base isolation is adopted to make the frame more flexible and thus increasing the fundamental time period of building. In this paper seismic performance of three framing systems namely bare frame, shear wall frame and bare frame with base isolation are compared and presented in terms of seismic response parameters. The response spectra analysis and nonlinear modal time history analysis was performed on the building. The plug lead rubber bearing was adopted as a base isolator. The results show that the base isolated frame is most flexible and shear wall frame is the stiffest frame. The response parameters such as displacement, drift, time period and column forces are presented. The study is particularly useful in proper selection of type of seismic resistance system.

**KEYWORDS:** Base isolation; Shear wall; bare frame; Time history; SAP

## I. INTRODUCTION

The shear wall is supposed to carry large amount of lateral forces and is a primary defence to the earthquake forces. The column and shear walls are main lateral load resisting elements and share the earthquake forces based on their stiffness's. The base isolation is opposite to shear wall frame interaction system and makes the entire building more flexible with large deformation, however due to isolation of base of structure the overall drift will be less and thus seismic resistance is considerably improved. In this paper the performance of these two earthquake resistance systems are compared and presented. The study is mainly concentrated for high rise buildings situated in high seismic zone ie Zone IV and V

## II. METHODOLOGY

As stated earlier the aim of this study is to compare the performance of two main earthquake resistance systems. The high rise building frame situated in seismic zone IV is considered for the study. The study is performed on following three models.

**Model CM (Control Model):** Fixed base building with bare frame system (Beam and column system) without base isolation.

**Model M1:** Fixed based building with shear wall frame interaction system without base isolation.

**Model M2:** Building with rubber isolator as a base isolation

The controlled model (CM) is a bare frame building with beams and columns only. For this building the basic earthquake analysis was performed using approximate fundamental time period of the building. The equivalent static analysis and design of elements was carried out using finite element software SAP 14. The main objective of performing equivalent static analysis is to fix preliminary sizes of the member. The design of elements was carried out adopting the load combinations for strength as per IS 456:2000. After fixing the preliminary sizes of columns and

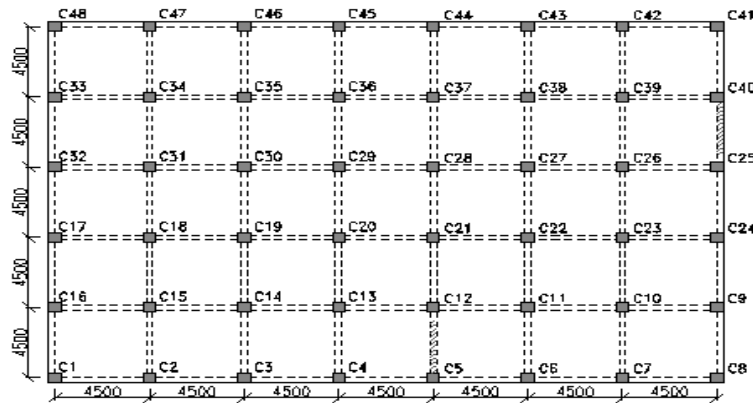
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**Vol. 7, Special Issue 3, March 2018**

beams model M1 and M2 are prepared as base isolation and shear wall frame interaction system. The Plug lead rubber bearing is adopted as base isolation. All the models are then subjected to response spectra and time history analysis.



### III. MODELING AND ANALYSIS

The modeling of building is carried out using one of the most efficient software SAP 14. The beams and columns are modeled as two noded element with six DOF at each node. The slab is modeled as four noded area element with six DOF at each node. The shear wall is modeled using shell element. For modeling of plug lead rubber bearing type isolator first the properties are calculated for linear and nonlinear analysis from book titled “Design of seismic isolated structure” by F. Naeim and J. M. Kelly.

Table 1: Plan of building frame

Frame type	Special moment resisting frame
Building	G+20
Storey height	3.2m
Depth of foundation	2.0m
Plan dimension	31.5mX22.5m
Unit weigh of RCC	25 KN/m <sup>2</sup>
Unit weight of masonry	18 KN/m <sup>2</sup>
Live load intensity on floor	3.0 KN/m <sup>2</sup>
Live load intensity on roof	3.0 KN/m <sup>2</sup>
Weight of floor finish	1.5 KN/m <sup>2</sup>
Water proofing load on roof	2.0 KN/m <sup>2</sup>
Height of parapet	1.0m
Importance factor	1.5
Response reduction factor	5
Soil Type	Medium
Seismic Zone	IV
Thickness of shear wall	200mm

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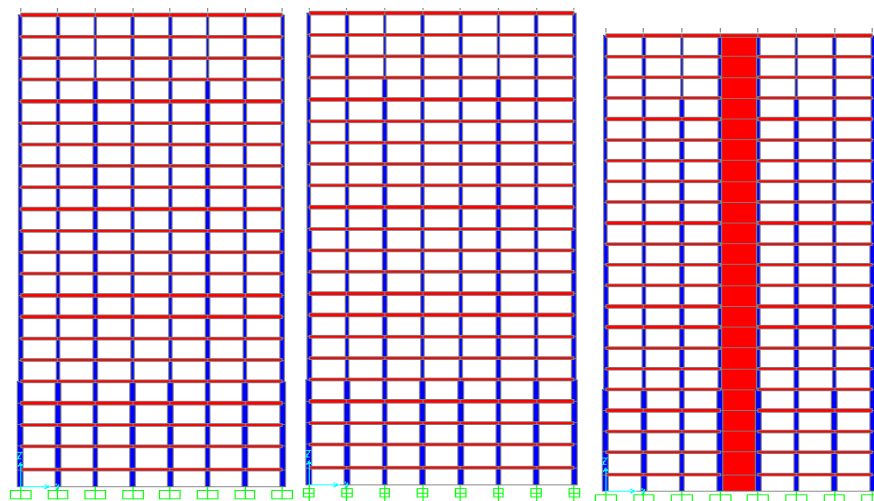
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**TABLE 2: DETAILS OF TIME HISTORY**

Earthquake	El Centro
Date & time	18/05/1940
Station	Imperial Valley
Hypocentral distance	12.12 Km
Earthquake component	N 75 E
Peak acceleration	341.69 cm/s/s
No of acceleration data points recorded	1559
Unit	g
Time interval	NA
Magnitude	6.9
Scale factor for SAP	9.81

**Table 3: Calculated properties of plug lead rubber isolator**

Sr. No	Property	Value
1	Fundamental period	3.197 Sec
2	Damper design period	3.197 Sec
3	Effective stiffness	2824.24 KN/m
4	Vertical stiffness	1004489KN/m
5	Horizontal stiffness	2824.24 KN/m
6	Yield strength	196.45KN
7	Post yield stiffness ratio	0.1
8	Damping	5%



i) Model CM                      ii) Model M1                      iii) Model M2

*Figure 2: Building Mathematical Models*

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## 1) Modal Analysis

The modal analysis is carried out on the models using Ritz vector. The total number of modes considered for analysis is 50, however the results are presented for first 30 modes only. The first three modes are considered to be governing modes and first mode will give the fundamental natural period of the building

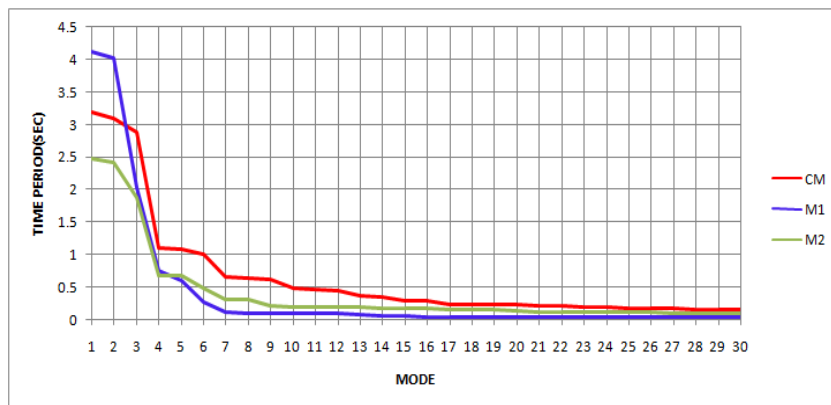


FIGURE 3: MODAL TIME PERIOD

As observed from the modal time period the time period for model with isolator (M1) was found to be maximum where as the model with shear wall (M2) will have minimum time period. Hence the model with isolator will be the most flexible model and the model with shear wall frame interaction will be the stiffest model. The modal time period for fundamental mode for model M1 was found to be 4.123 sec which is about 28% more than control model (Bare frame model).

## 2) Response Spectra analysis

The response spectra dynamic analysis was carried out and results are presented here. The scale factor used for response spectra analysis is 1.472 ( $I_g/2R$ ).

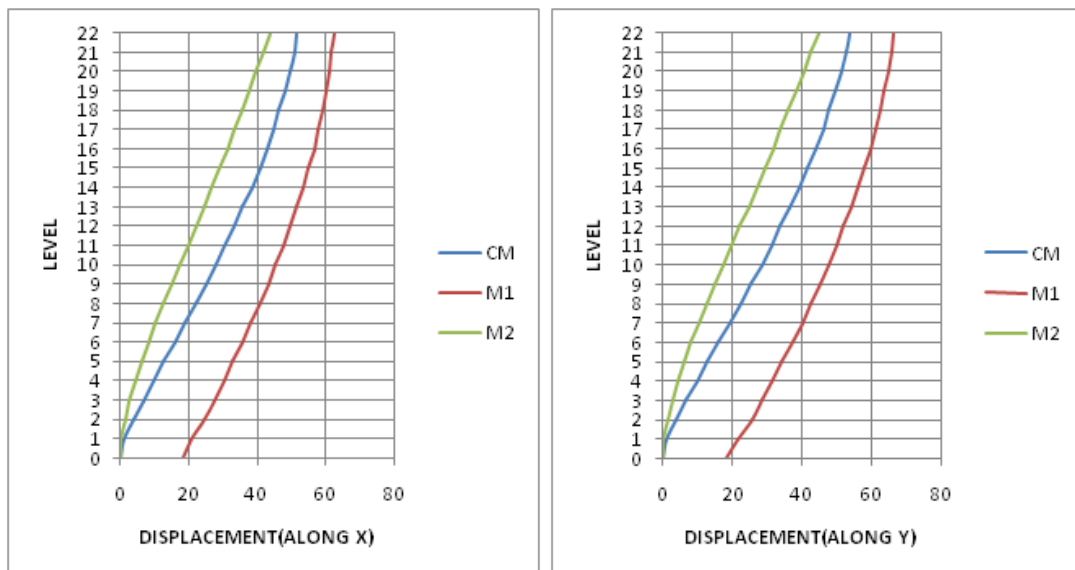


Figure 4: Displacement Profile

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As observed from the displacement profile the model with base isolation gives maximum displacement in both the principal direction. It should be noted that there is the displacement at base of the structure for model with base isolation. This displacement will depend on the stiffness of isolator. The model with shear wall is found to be very stiff and the displacement for this model is found to be minimum.

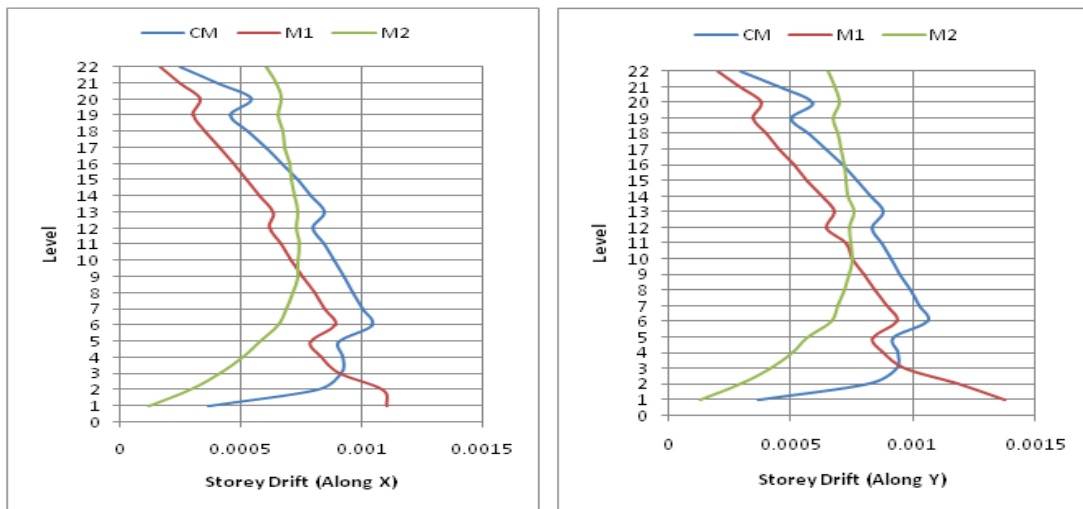
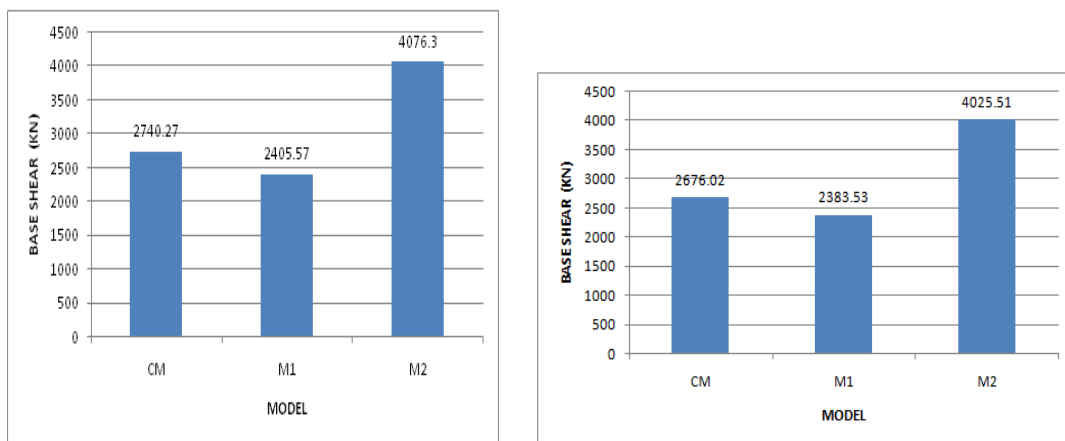


Figure 5: Storey Drift Profile

The storey drift for model with base isolation was found to be more as compared to control model at lower levels, however after level 3 the drift is considerably reduced



i) Longitudinal Direction

ii) Transverse Direction

Figure 6: Base shear

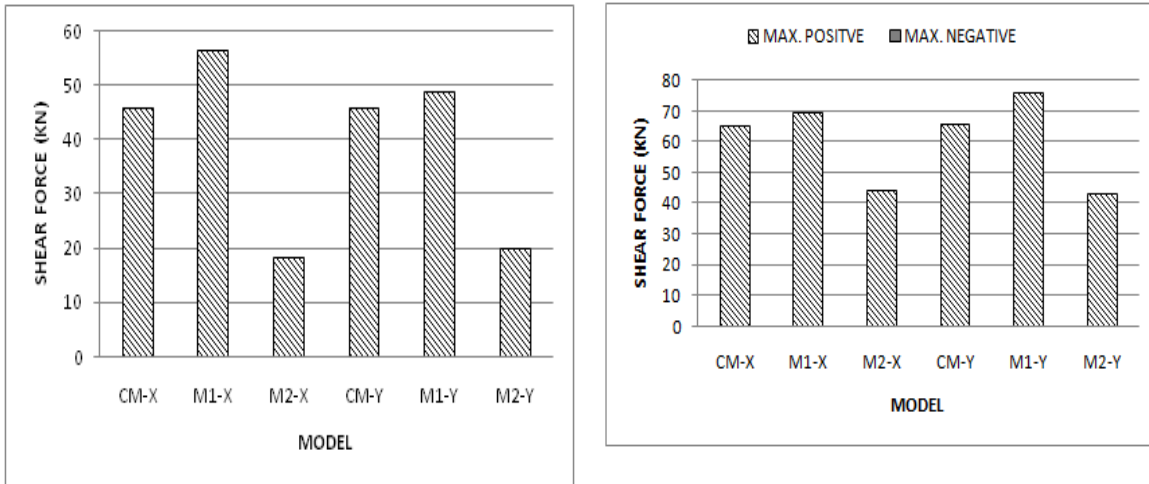
As observed from above graph base shear for model with base isolator was found to be minimum and the model with shear wall gives maximum base shear. There is around 14% reduction in base shear was observed in model with lead rubber isolator as compared to control model.

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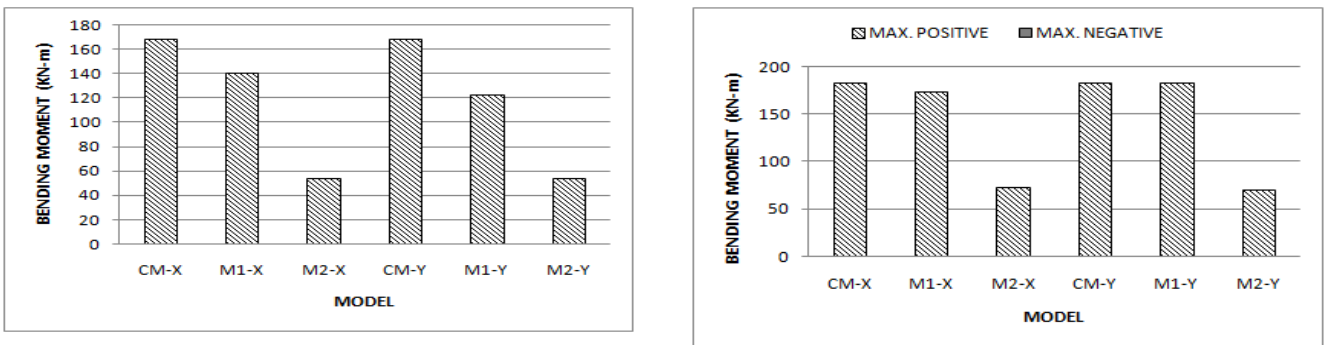
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i) Exterior Column (C1)    ii) Interior column (C19)

Figure 7: Maximum Shear Force

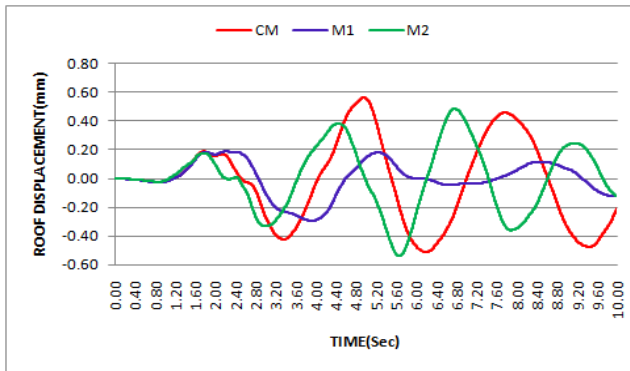


i) Exterior Column (C1)

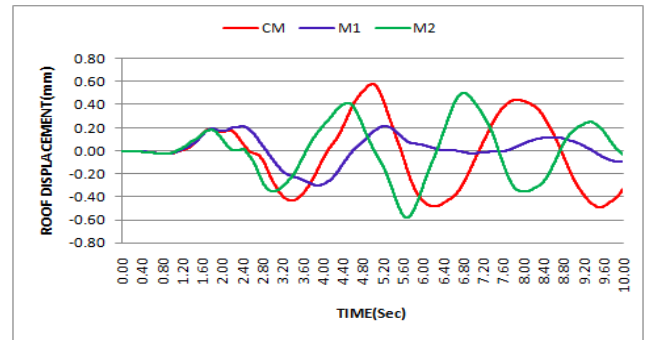
ii) Interior column (C19)

Figure 7: Maximum Bending Moment

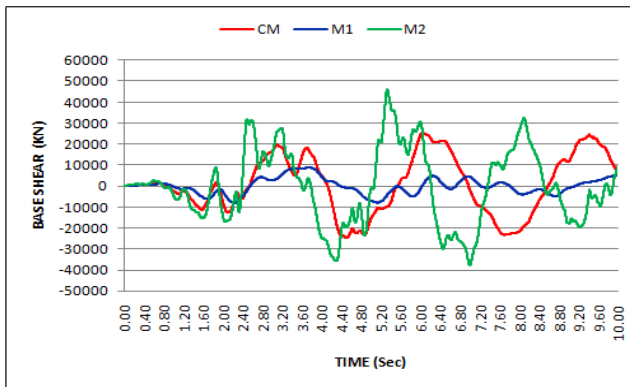
As observed from the above graph the shear forces in rubber isolator model is found to be increased however these large forces are developed for lower 2 stories only and for all other stories the shear forces are found to be less than the shear forces in control model. The bending moment in exterior and interior column are found to be minimum in model M2 (Model with shear wall). The bending moment in model M1 in both principal directions is found to be less than control model CM. The bending moment is reduced by about 20% in model with base isolation.



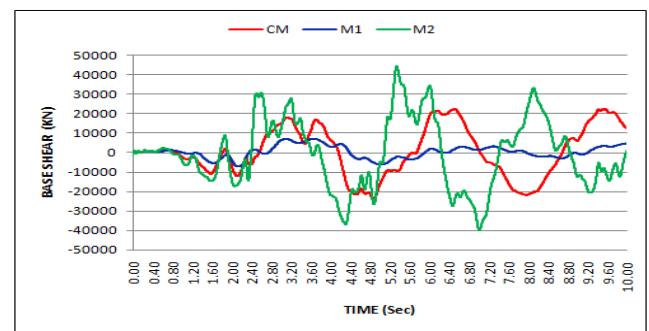
i) Longitudinal Direction



ii) Transverse Direction



i) Longitudinal Direction



ii) Transverse Direction

Figure 7: Base shear time history

As observed from the history analysis the response of the structure with base isolator (Model M1) is much better than other two models. There is considerable control over lateral displacement was observed, this is in contrast with the results obtained from response spectra analysis. This may be because the response spectra analysis there are displacement at base of structure however the displacements obtained from the time history analysis are the absolute values.

## V. CONCLUSION

- 1) Comparison of two basic framing system namely bare frame system and shear wall frame interaction system with plug lead rubber type base isolator shows that the shear wall frame is considered to be the stiffest system where as the isolator building is consider as flexible one.
- 2) The modal time period for the fundamental mode is 28% more than control model where as fundamental period for shear wall frame interaction system is found to be around 30% less than control model. These result shows that the stiffer building have smaller natural period. There is not much change in fundamental period for higher modes.
- 3) The roof displacement for model with base isolator was found to be more than control model. However even if the displacement is found to be more, it should be noted that there is an initial displacement at the base of the structure in case of building with base isolation. The relative roof displacement considering this initial displacement at base is found to be less than the control model.
- 4) For the bottom one or two stories, storey drift was found to be more in building with base isolator however for



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all other storey the drift is considerably reduced this results in less lateral forces

5) The base shear for the building with base isolation is found to be less in both the principal direction. This is considered as most important parameter as far as lateral forces are concern. There is around 14% reduction in base shear was observed in model with lead rubber isolator as compared to control model.

6) The roof displacement profile for Elcentro time history shows that the response is smoothen in case of building with base isolation. Also, almost for all time intervals the displacement in model M1 is found to be less than model CM (control model). There is reduction in displacement for model M2 was observed.

7) The Elcentro time history result shows that there is reduction of about 65% in base shear in model M1 over model CM

8) There is slight increase in shear forces was observed in model with base isolation, this increase in shear forces was mainly concentrated at lower level near base. The bending moment is found to be reduced by around 16%. The forces are found to be minimum in the building with shear wall.

9) The column forces are found to be minimum in shear wall frame interaction system and base shear is found to be minimum in base isolated building. This may be because the major portions of lateral forces are carried by shear wall and thus the portion of lateral forces left for the columns will be minimum.

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