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Behavior of Symmetric Frame Structure with Base Isolator and Fixed Base Building

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Abstract

In this study, Non-linear time history analysis of 2 building modals have been carried out with using of lead rubber bearing and fixed based modal of G+6 and G+14 story symmetrical RC frame building. Passive vibration control keeps the buildings remain elastic during large earthquake and higher wind. SAP 2000 v18.2.0 software is used for analysis the structural model. The result of Acceleration, Displacement and Velocity is compared with the fixed based structural model and result of modal period and natural frequency. A better performance of the isolated structure with respect to the fixed base structure is also observed in roof floor displacements, floor acceleration relative to the ground. Introduction of horizontal flexibility at the base helps in proper energy dissipation at the base level thus reducing the seismic demand of the super structure to be considered during design. It is found that there is major difference between the results of base isolated and framed structure. The results of base isolated structure have performed better compare to the fixed base structural modal.

1. Introduction

For seismic design of building structures, the general method used is, strengthening the stiffness, strength, and ductility of the structures, has been in common use for a long time. Therefore, the dimensions of structural members and the consumption of material are expected to be increased, which leads to higher cost of the buildings as well as larger seismic responses due to larger stiffness of the structures. Structural Control is the one of the areas of current research aims to reduce structural vibrations during loading such as earthquakes and strong winds. The passive control is more studied and applied to the existing buildings than the others. Base isolation is a passive vibration control system that does not require any external power source for its operation and utilizes the motion of the structure to develop the control forces. It was of interest to check the difference between the responses of a fixed-base building frame and the isolated-base building frame under seismic loading. This is the primary motivation of the present study. In terms of different vibration absorption methods, structural control can be classified into active control, passive control and so on. Base isolation technology is a viable alternative to conventional earthquake-resistant design of medium-rise buildings. Since a base-isolated structure has fundamental frequency lower than both its fixed base frequency and the dominant frequencies of ground motion. In the isolated system the base is remains elastic and super structure remains rigid. In this way, the isolation becomes an attractive approach. The cost and performance requirements for both buildings and equipment have motivated advances in the field of Structural Control, which deals with methodologies for the protection of high performance structural systems. The vibration isolator is a device that is designed to effectively isolate such structures from harmful vibrations.

2. Modeling and Analysis

In this study, G+6 and G+14 story symmetric RC building of 5 bays in X direction and 4 bays in Y direction have been considered for modal analysis. Here, two models with base isolator and another two with fixed based taken for analysis for the same data. For that Imperial Valley earthquake data is taken from PEER ground motion.

Following are the building details for the G+6 storey:
1. Number of story = G+6
2. Story height = 3 m
3. Grade of concrete = M30, M25
4. RC Column sizes = 300mm x 400mm
5. RC Beam sizes = 230mm x 450mm
6. Slab thickness = 150mm
7. Live load = 2.5 KN/m^2
8. Floor Finish = 1 KN/m^2

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Building details for the G+14 storey:
1. Number of story = G+14
2. Story height = 3 m
3. Grade of concrete = M30, M25
4. RC Column sizes = 400mm x 500mm
5. RC Beam sizes = 300mm x 400mm
6. Slab thickness = 150mm
7. Live load = 2.5 KN/m^2
8. Floor Finish = 1 KN/m^2

Total 4 symmetrical models are analyzed in this study. Two models, G+6 and G+14 with base isolator and another two for G+6 and G+14 with fixed based. Here time history records of Imperial Valley Earthquake, El Centro, 1940 data recorded at LACC NORTH available from PEER Strong Motion Database is used for the time history analysis.

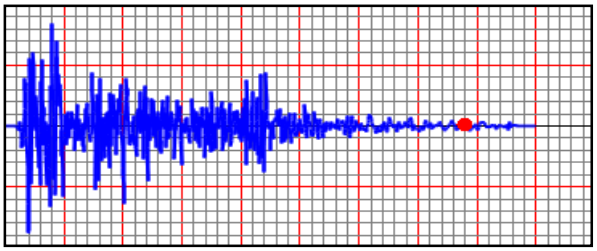

Figure 1. Imperial Valley Time History function record

2.1 Model for 7 story Symmetric RC building

Figure 2 and 3 shows the 7 story symmetrical building plan and 3d view of the model with base isolator.

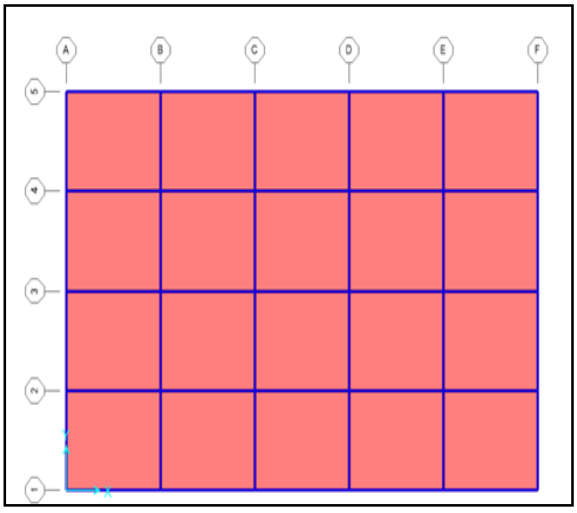

Figure 2. Plan of symmetric 7 storey RC building

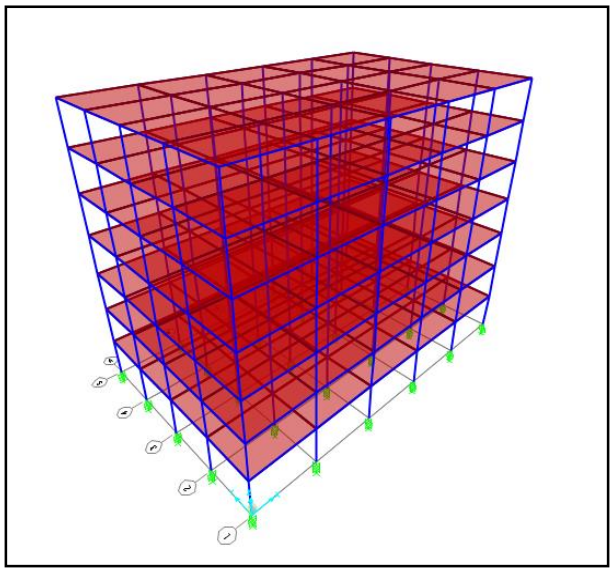

Figure 3. 3-d View with base isolator

2.2 Model for 15 story RC building

Figure 4 and 5 shows the 15 story symmetrical building Elevation and 3d view of the model with base isolator.

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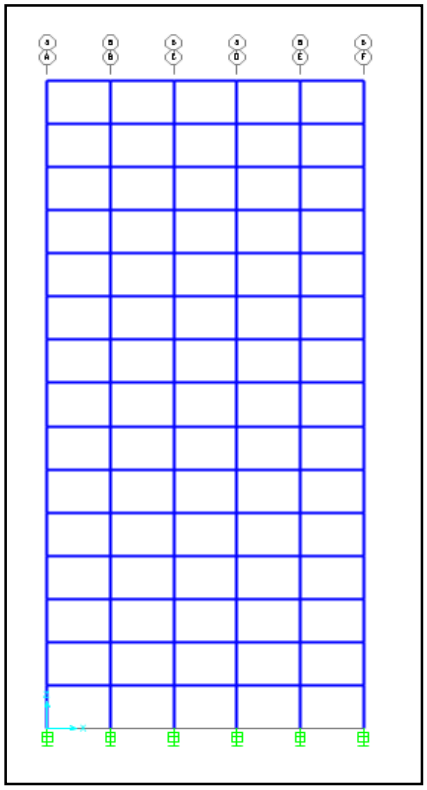

Figure 4. Elevation of symmetric 15 storey RC building

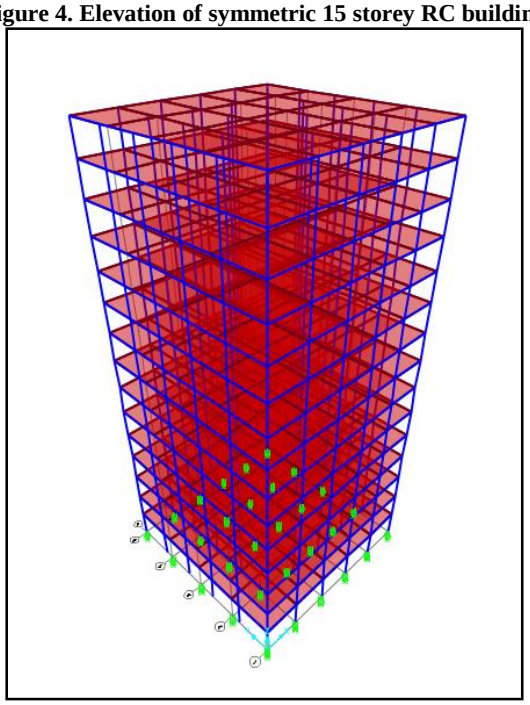

Figure 5. 3-d view of symmetric 15 storey RC building

3. RESULTS AND DISCUSSIONS

Results of analysis are given below in the form of various graphs and their discussion.

Table 1. Modal Period for Base Isolated Structure

	7 Story	15 Story
Step Type	**Period**	**Period**
Text	Sec	Sec
Mode 1	2.025136	3.42221
Mode 2	1.90841	3.404232
Mode 3	0.455284	3.072781
Mode 4	0.228256	0.952561
Mode 5	0.183853	0.939772
Mode 6	0.142344	0.831347
Mode 7	0.075166	0.487185
Mode 8	-	0.316991
Mode 9	-	0.227015
Mode 10	-	0.172036
Mode 11	-	0.135342
Mode 12	-	0.117882
Mode 13	-	0.10238
Mode 14	-	0.076441
Mode 15	-	0.051212

Results in Table 1 shows the modal Period of base isolated structure with 7 story and 15 story building data. While, Table 2 shows the modal period of fixed based structure with 7 story and 15 story building data.

Table 2. Modal Period for Fixed Structure

	7 Story	15 Story
Step Type	**Period**	**Period**
Text	Sec	Sec
Mode 1	0.98999	2.097437
Mode 2	0.590312	2.080327
Mode 3	0.320952	1.841048
Mode 4	0.183463	0.686898
Mode 5	0.12468	0.677949
Mode 6	0.092698	0.585128

Mode 7	0.072207	0.388449
Mode 8	-	0.263931
Mode 9	-	0.193625
Mode 10	-	0.148993
Mode 11	-	0.119161
Mode 12	-	0.108414
Mode 13	-	0.091049
Mode 14	-	0.069053
Mode 15	-	0.050668

Compare to the fixed base in 7 stories building the value is about 2 times in the fix based structure for the first mode and in the 15 stories building the value is about 50% more in the fixed based structure.

Table 3. Results for 7 story Building

7 Story Base Isolated		
	Max	Min
Acceleration	23.21	-25.74
Displacement	2.53	-3.18
Velocity	5.65	-7.99
7 Story Fixed		
Acceleration	171.99	-134.97
Displacement	3.87	-4.19
Velocity	19.11	-28.37

Table 4. Results for 15 story Building

15 Story Base Isolated		
	Max	Min
Acceleration	24.51	-29.97
Displacement	2.79	-3.23
Velocity	6.20	-5.20
15 Story Fixed		
Acceleration	178.16	-190.34
Displacement	10.54	-11.69
Velocity	40.53	-34.12

Table 3 and 4 shows the results of acceleration, displacement and velocity for isolated and fixed based for G + 6 and G + 14 story building. The results are for the roof top of the building which shows minimum and maximum value of modals.

From table 3 Acceleration in the 7 story building is 7 times more in fixed base compare to the base isolated. In displacement the value is 50% more in fixed based structure. In velocity, the value is 3.5times more in the fix based structure.

From table 4 Acceleration in the 15 story building is 7 times more in fixed base compare to the base isolated. In displacement the value is 3.7 times more in fixed based structure. In velocity, the value is 6.5 times more in the fix based structure.

4. CONCLUSIONS

Following are the conclusions of the study –

(1) Base isolator provides better strength and stiffness to the RC building.

(2) Comparing to fixed base structure the value of acceleration in the base isolator is 5 to 7 times more.

(3) In the displacement the result affects more in the higher story building.

(4) Velocity is about two times more in the higher story building.

(5) Comparing to lower story building the results of higher story building is way better in acceleration displacements and velocity.

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