SEISMIC ANALYSIS OF REGULAR AND IRREGULAR BUILDINGS HAVING FIXED BASE AND BASE ISOLATOR USING TIME HISTORY ANALYSIS

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Abstract - *Earthquakes in past have caused extensive damage, collapse to reinforced concrete structures due to vibration of the ground which creates torque and subsequently results in the collapse of the building. This paper describes comparative study of regular and irregular reinforced concrete structures with fixed base and base isolator by using linear dynamic time history analysis. Seismic time history response is studied to understand the seismic behavior of the building. When seismic load is applied on a fixed base building the structure tries to move in the direction of the earthquake which separates the superstructure from the substructure and thus the building collapses. Whereas, in a base isolated building the decoupling effect is created by separating the superstructure from the substructure by using rubber base isolation units which makes the building more resistant to seismic activity. This analysis includes the modelling of G+9 RCC multi-storey regular and irregular (L-shape &T-shape) building considering ground motion data for Kozani, 1995 and Jiashi, 1997 earthquakes. The results of the analysis show variations in displacements, moment and axial force for due to seismic loading by time history analysis method using SAP2000 V14.*

Key Words: Seismic response, Time history analysis, Base isolation, SAP2000 V14.

1. INTRODUCTION

Earthquake is caused by the shaking and vibration of the Earth's crust due to movement of tectonic plates at the surface of Earth. The shaking of ground may result in landslides, avalanche, all of which can cause damage to buildings. In previous decades, Earthquake has caused enormous losses in human life and substantial economic losses because of collapse of tall structures. Due to extensive rise in the population, need of tall buildings are increasing which are vulnerable to the collapse of the buildings in Earthquake prone zones. Base isolation is one of the most prominent vibration control techniques used. It is introduced between the superstructure and the substructure to protect the building against seismic forces. Time history analysis is to be performed to study the behaviour of the building with respect to ground motion data obtained from previous Earthquakes. In time history method, the structure is constrained to a specified loading varied with respect to time. Kozani, 1995 and Jiashi, 1997 ground motion acceleration data's have been used to analyse the seismic response of the structure.

J. P. Annie Sweetlin. [1] analysed symmetrical (G+10) and irregular (G+13) reinforced concrete structure has been considered, which lies in Zone II. The analysis is performed using STAAD.Pro. From the results it is clear that the storey drift in irregular building is lesser than the regular building.

Dona Meriya Chacko and Akhil Eliyas. [5] studied the response of Base isolated building and fixed base building using response spectrum analysis and the results were obtained for Storey Displacement, Base shear, Time period and Storey drift using ETABS software. For Base isolated building, the results show that there is an increase in Storey displacement and Time period and decrease in Base shear and Storey drift compared with Fixed Base building.

Atul N.Kolekar. [3] analysed the (G+12) RC multi-storied framed building considering for Koyna and Bhuj earthquake is carried out by response spectrum analysis and time history analysis. Time histories data of Koyna and Bhuj have been used to develop different acceptable criteria (base shear, storey displacement, storey drift). From the results it is recommended that time history analysis should be performed as it predicts the structural response more accurately than the response spectrum analysis.

Time History Method is a process to analyse the dynamic response of the structure at each time increment when its base is subjected to ground motion time history record. To perform such an analysis a representative earthquake time history data is essential for a structure being evaluated. It is used to determine the seismic response, storey displacement, axial force and moment of a structure under dynamic loading of considered earthquake. [2, 3, 8, 11].

2. OBJECTIVES

a) Using time history analysis, the behavior of RC multi-storey Regular and Irregular building are compared for seismic forces.

b) To evaluate various responses such as displacements, axial force, and moment for Kozani and Jiashi earthquakes.

c) Comparison of fixed base buildings and base isolated buildings are carried out.

3. STRUCTURAL MODELLING AND ANALYSIS

The following models are considered for G+9 Storey RCC building. Three types of geometry are adopted for this analysis Regular building, L-shape building, T-shape building. The area of all three buildings are kept constant i.e. 648 m2. Storey height of all floors is 3.6m and height of plinth is 1.2m. The buildings consist of columns with dimension 500mm x 500mm and beam with dimension 500mm x 300mm. Thickness of slab is taken as 150mm and Grade of concrete is considered as M25 and Grade of steel as Fe415. Time history analysis is carried out using SAP2000.

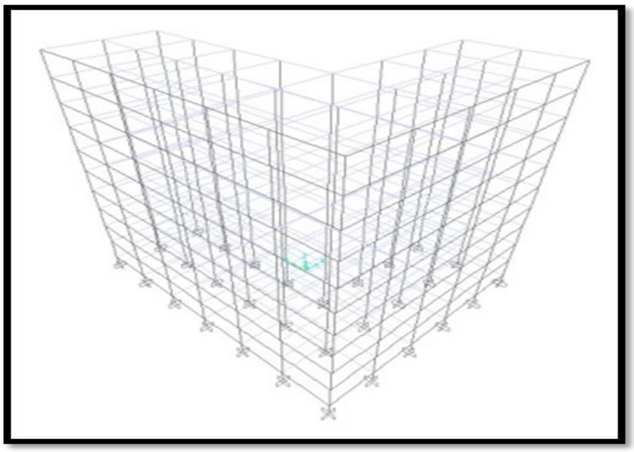


Fig. 1: L-shaped building with fixed base

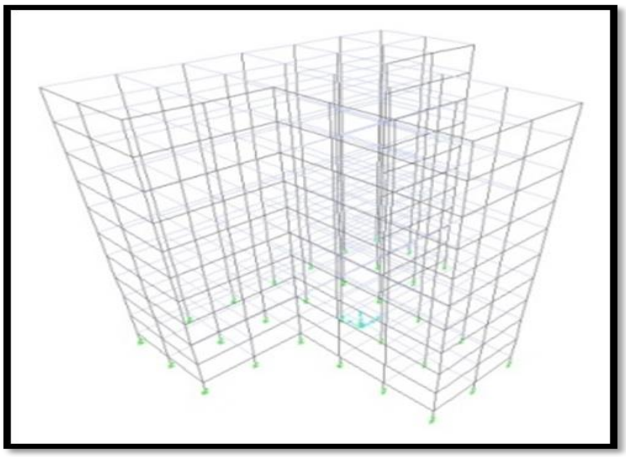


Fig. 2: T-shaped building with base isolator

Load Details: -

Wall load - 18KN/m

Parapet wall load - 5KN/m

Live load - 4KN/m^2

Live load (Terrace) - 2KN/m^2

Floor finish - 1KN/m^2

Roof treatment – 2KN/m^2

4. RESULT AND DISCUSSION

The comparative study of Storey displacement, Axial force, Shear force and Moment of a fixed base building and base isolated building by time history method for Kozani and Jiashi ground motion data are performed. The results obtained from the analysis are given below and comparative study is carried out.

4.1 Storey Displacement

Table -1: Comparison of Storey displacement for Regular building.

Storey height (m)	Storey displacement (m)							
	Kozani				Jiashi			
	Fixed base		Base isolated		Fixed base		Base isolated	
	X	Y	X	Y	X	Y	X	Y
0	0	0	0.03	0.005	0	0	0.02	0.028
19.2	0.027	0.006	0.04	0.004	0.01	0.04	0.04	0.048
37.2	0.04	0.011	0.04	0.004	0.03	0.06	0.04	0.048

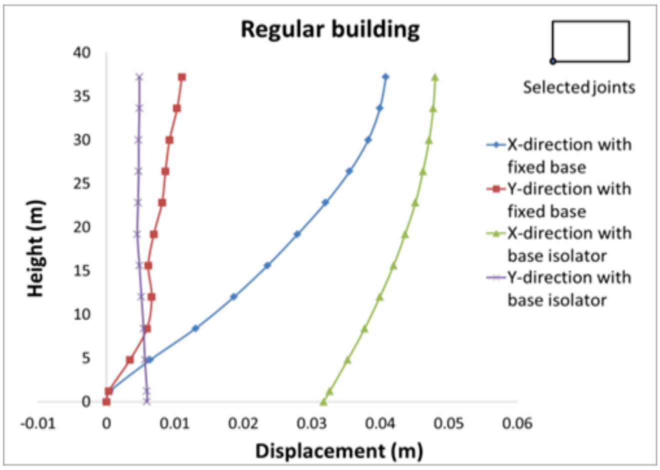
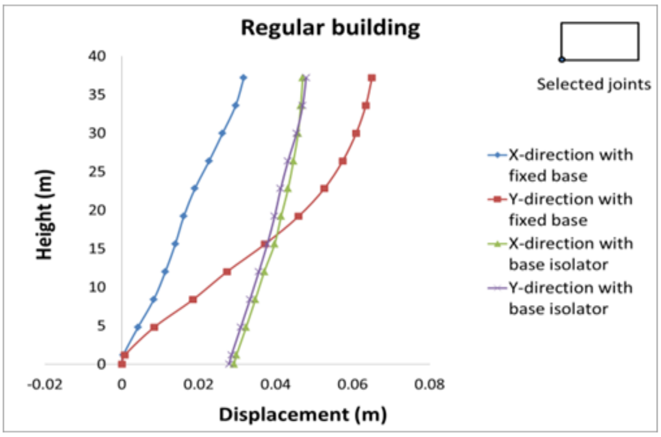


Fig. 3: Displacement for Kozani Earthquake



Fig, 4: Displacement for Jiashi Earthquake

From the result, it is observed that the storey displacement for the regular building with fixed base increases linearly. Fig. 3 and Fig. 4 shows storey displacement of 31.7mm and 29.2mm respectively at the ground level of the base isolated building.

Table 2: Comparison of Storey displacement for L-shape building.

Storey height (m)	Storey displacement (m)							
	Kozani				Jiashi			
	Fixed base		Base isolated		Fixed base		Base isolated	
	X	Y	X	Y	X	Y	X	Y
0	0	0	0.031	0.005	0	0	0.029	0.029
19.2	0.027	0.010	0.044	0.005	0.01	0.047	0.040	0.038
37.2	0.04	0.013	0.048	0.005	0.03	0.066	0.045	0.047

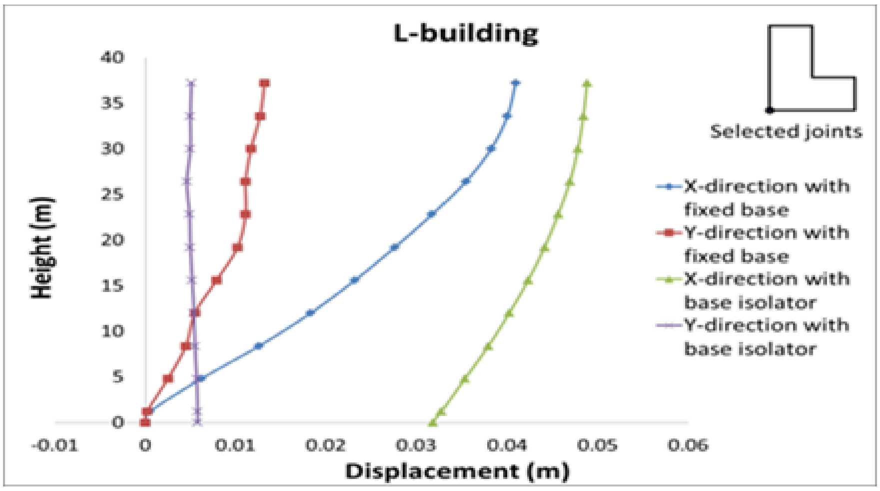


Fig. 5: Displacement for Kozani Earthquake

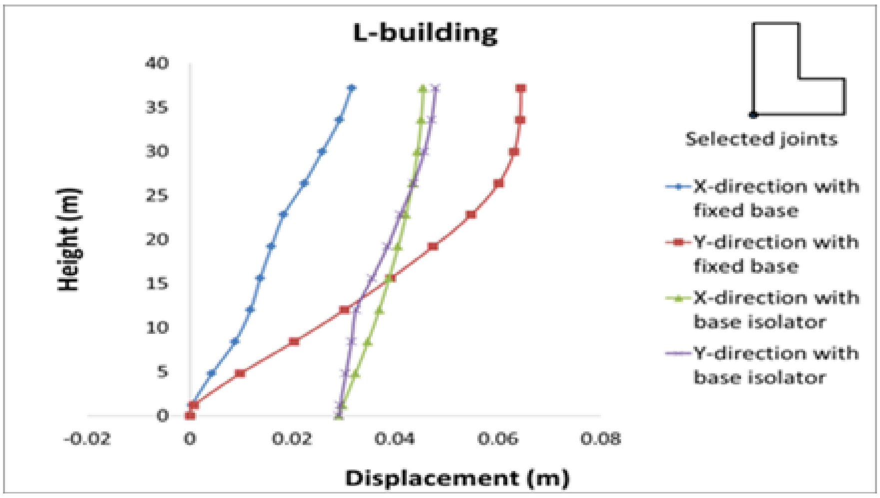


Fig. 6: Displacement for Jiashi Earthquake

From Fig. 5 and Fig. 6 it is found that the storey displacement is 0mm at ground level for fixed base building and 31.8mm for base isolated building.

Table -3: Comparison of Storey displacement for T-shape building.

Storey height (m)	Storey displacement (m)							
	Kozani				Jiashi			
	Fixed base		Base isolated		Fixed base		Base isolated	
	X	Y	X	Y	X	Y	X	Y
0	0	0	0.03	0.005	0	0	0.030	0.028
19.2	0.02	0.008	0.04	0.004	0.2	0.046	0.041	0.038
37.2	0.04	0.050	0.01	0.003	0.03	0.063	0.047	0.048

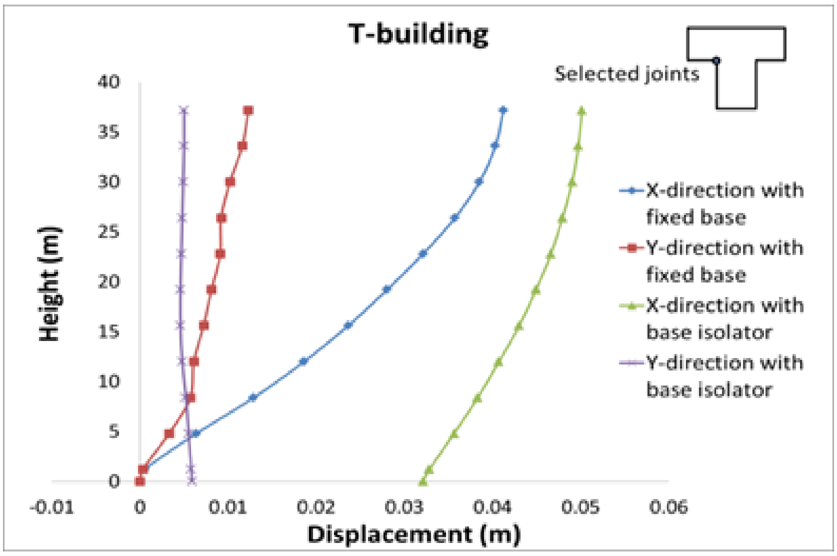


Fig7: Displacement for Kozani Earthquake

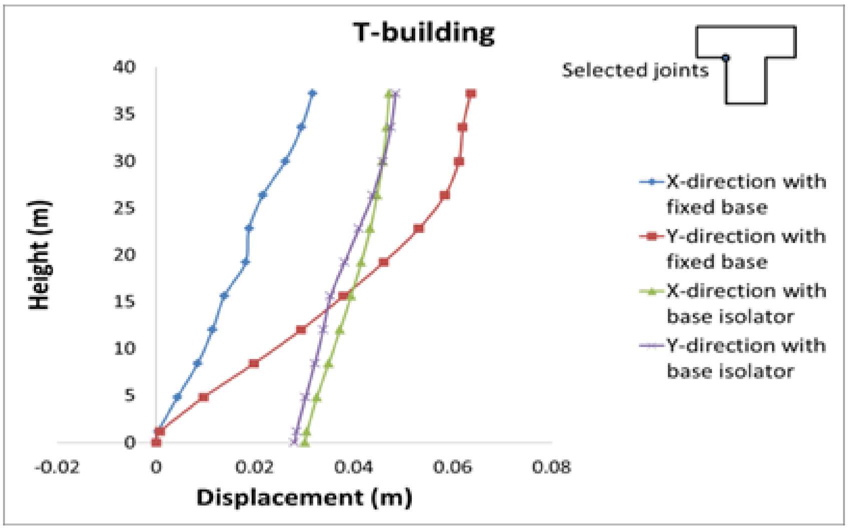


Fig. 8: Displacement for Jiashi Earthquake

Storey displacement for the top floor is 31. 6mm as shown in Fig. 7 for fixed base building and 47.1mm as shown in Fig. 8 for base isolated building for Jiashi earthquake.

Moment

Table 4: Comparison of Moment for Regular building.

Column no.	L-shape			
	Kozani		Jiashi	
	Fixed base	Base isolator	Fixed base	Base isolator
Column 1	108.85	0.0162	77	0.0123
Column 2	18.68	1.42	25.16	1.5
Column 3	45.66	20	42.09	13.11

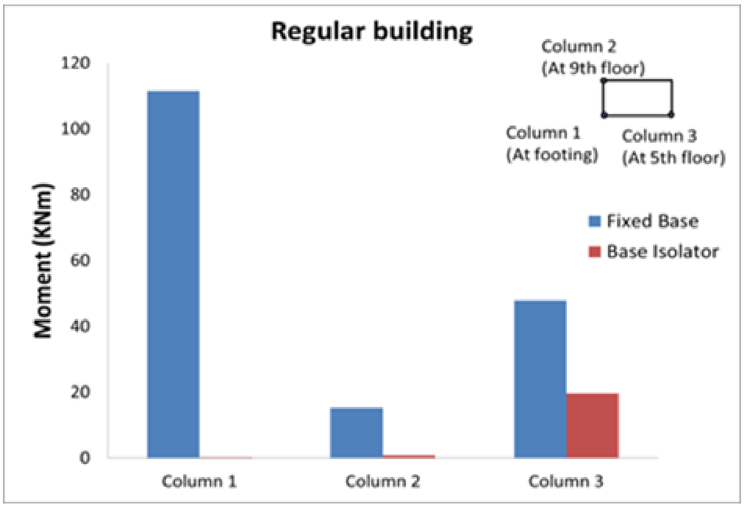


Fig. 9: Moment for Kozani Earthquake

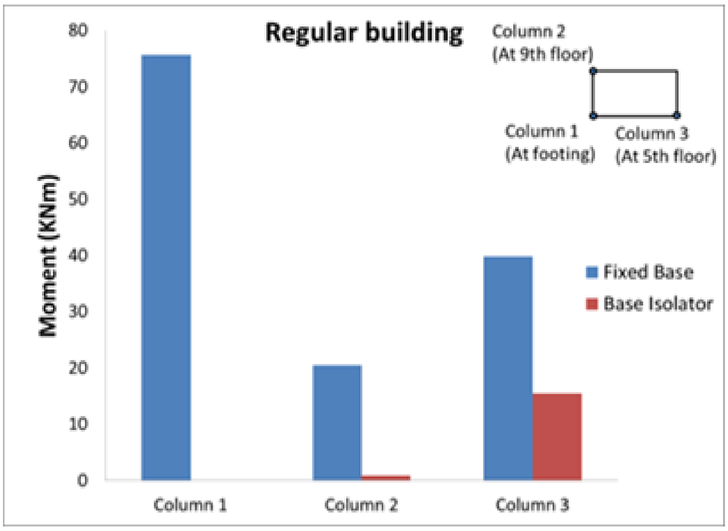


Fig. 10: Moment for Jiashi Earthquake

In the fixed base building the Moment for Column 1 is found to be 111.54KNm for Kozani earthquake and 75.65KNm for Jiashi earthquake. For the base isolated building the results are found to be 0.0207KNm and 0.0257KNm respectively for for Kozani and Jiashi earthquake for Column 1.

Table 5: Comparison of Moment for L-shape building.

Column no.	Regular			
	Kozani		Jiashi	
	Fixed base	Base isolator	Fixed base	Base isolator
Column 1	111.54	0.0207	75.65	0.0257
Column 2	15.18	0.77	20.52	0.93
Column 3	47.83	19.58	39.21	15.48

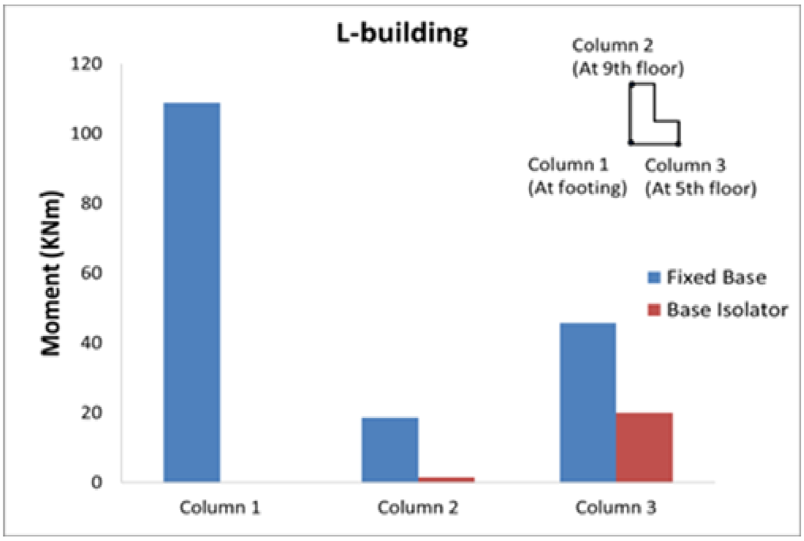


Fig. 11: Moment for Kozani Earthquake

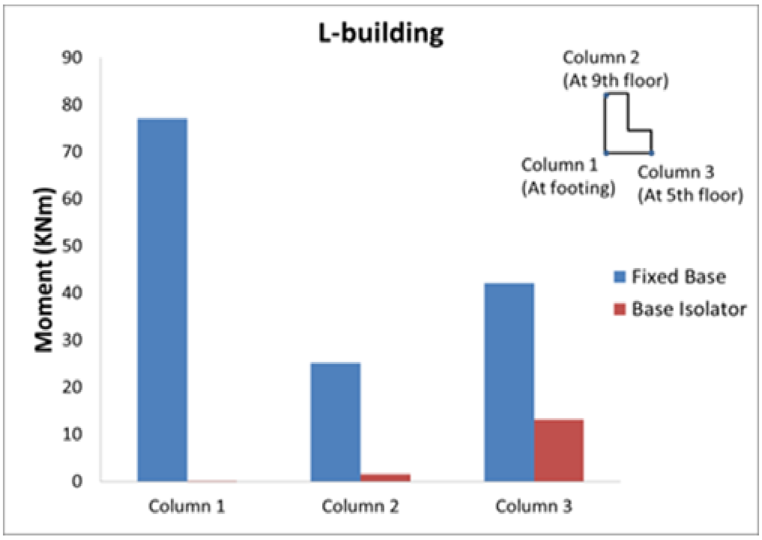


Fig. 12: Moment for Jiashi Earthquake

From the above Fig. 11 and Fig. 12 Moment for Column 2 is found to be 18.68KNm for Kozani earthquake and 25.16KNm for Jiashi earthquake. And for the base isolated building the results are found to be 1.42KNm and 1.5KNm respectively for Kozani and Jiashi earthquake for Column 2.

Table 6: Comparison of Moment for T-shape building.

Column no.	**T-shape**			
	Kozani		**Jiashi**	
	Fixed base	**Base isolator**	**Fixed base**	**Base isolator**
Column 1	120.53	0.014	81.2	0.0083
Column 2	13.65	0.734	18.76	0.9
Column 3	56.63	21.76	42.74	15.77

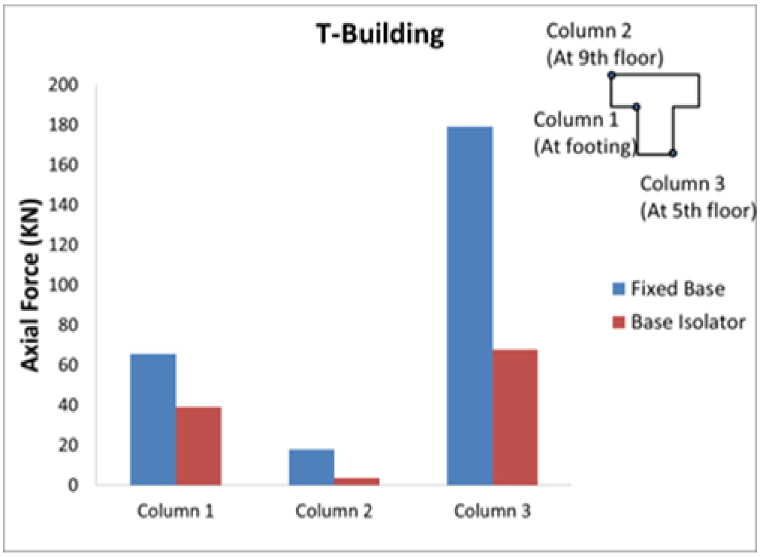


Fig. 13: Moment for Kozani Earthquake

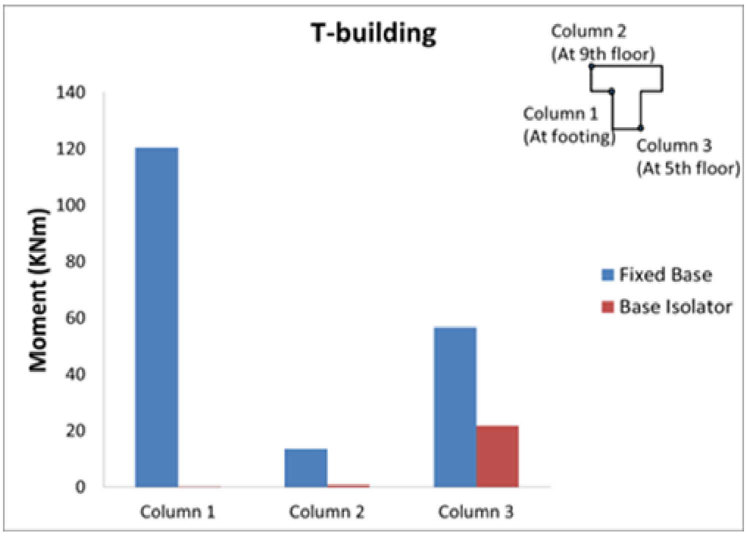


Fig. 14: Moment for Jiashi Earthquake

The above Fig. 13 and Fig. 14 shows Moment for Column 3 as 56.63KNm for Kozani earthquake and 42.74KNm for Jiashi earthquake. On the other hand, the base isolated building shows 21.76KNm and 15.77KNm respectively for Kozani and Jiashi earthquake for Column 3.

AXIAL FORCE

Table 7: Comparison of Axial Force for Regular building.

Column no.	Regular			
	Kozani		Jiashi	
	Fixed base	Base isolator	Fixed base	Base isolator
Column 1	232.26	137.76	426.821	259.12
Column 2	13.38	1.89	15.86	3.317
Column 3	108.21	41.57	180.14	69.62

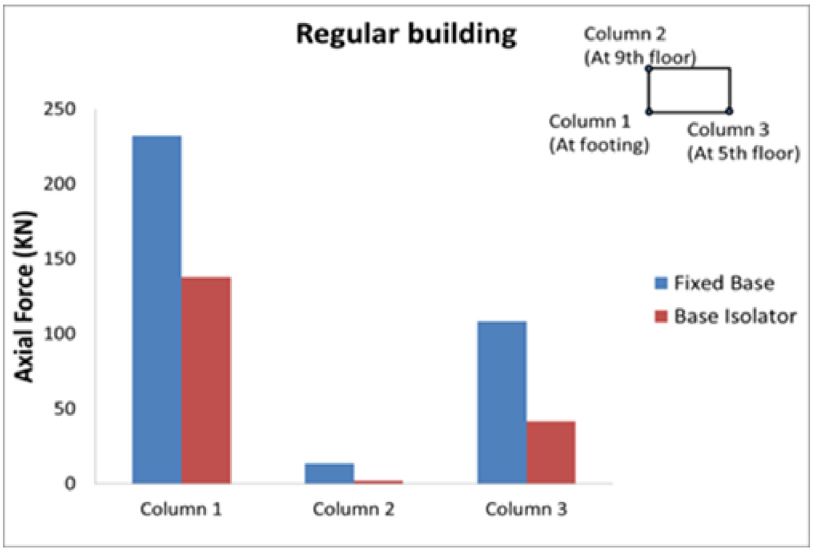


Fig. 15: Axial Force for Kozani Earthquake

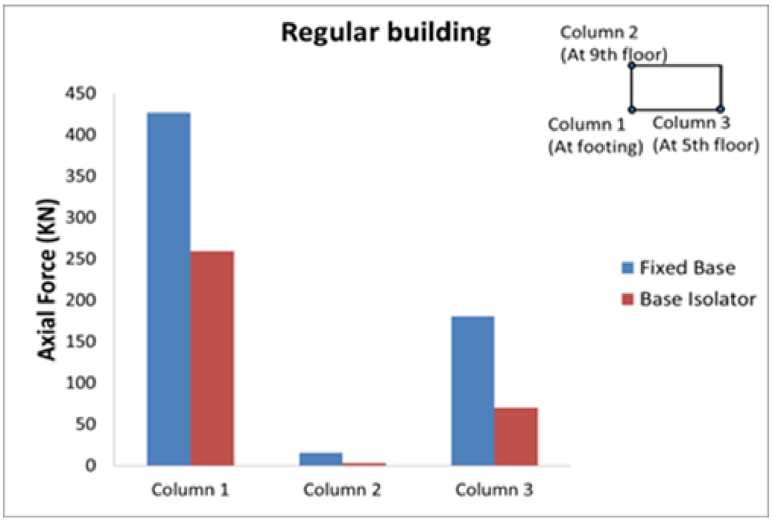


Fig. 16: Axial Force for Jiashi Earthquake

For Column 1 Axial Force is 232.26KN and 426.821KN for Kozani and Jiashi respectively. And for base isolated building the results are found to be 137.76KN and 259.12KN respectively for Kozani and Jiashi earthquake for Column 1.

Table 8: Comparison of Axial Force for L-shape building.

Column no.	L-shape			
	Kozani		Jiashi	
	Fixed base	Base isolator	Fixed base	Base isolator
Column 1	229.35	142.93	428.89	257.34
Column 2	14.92	2.801	17.2	3.47
Column 3	126.54	46.197	177.89	64.91

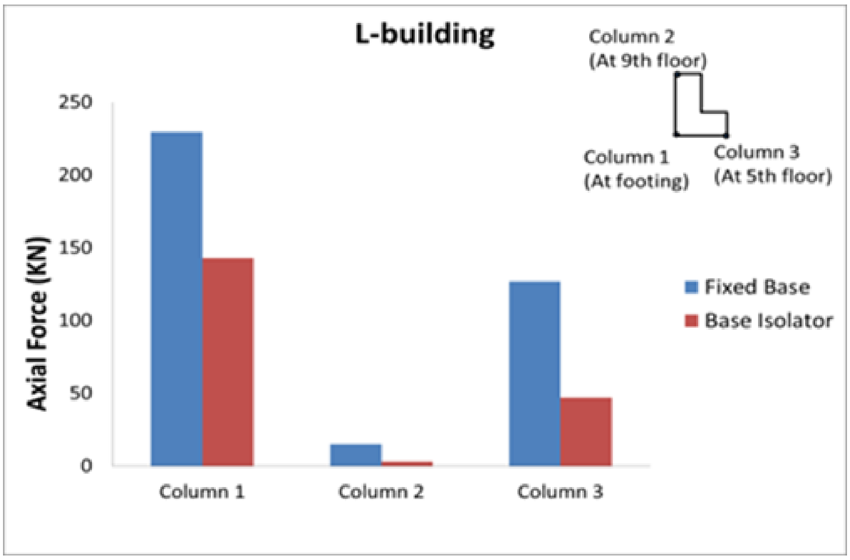


Fig. 17: Axial Force for Kozani Earthquake

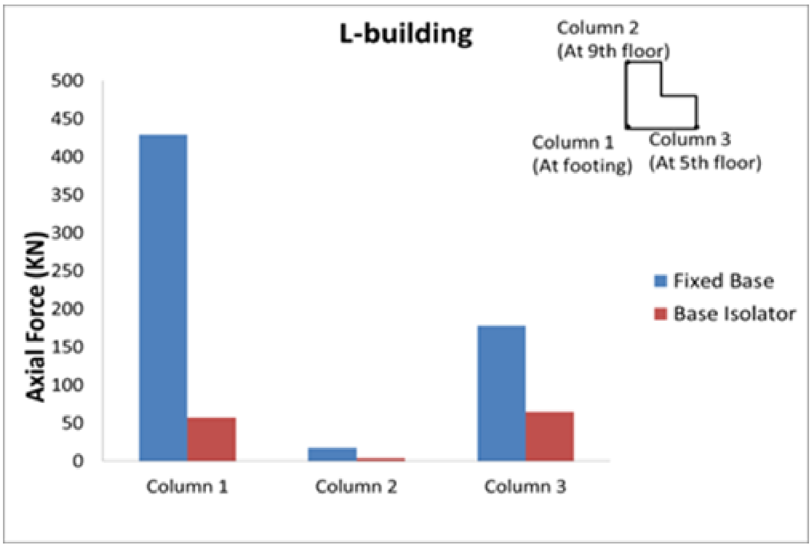


Fig. 18: Axial Force for Jiashi Earthquake

From the above bar graph Axial Force for Column 2 is found to be 14.29KN for Kozani earthquake and 17.2KN for Jiashi earthquake, the base isolated building shows 2.801KN and 3.47KN respectively for Kozani and Jiashi earthquake for Column 2.

Table 9: Comparison of Axial Force for T-shape building.

Column no.	T-shape			
	Kozani		Jiashi	
	Fixed base	Base isolator	Fixed base	Base isolator
Column 1	36.61	21.25	65.56	38.97
Column 2	14.3	2.184	17.81	3.48
Column 3	119.1	30.02	179.2	67.64

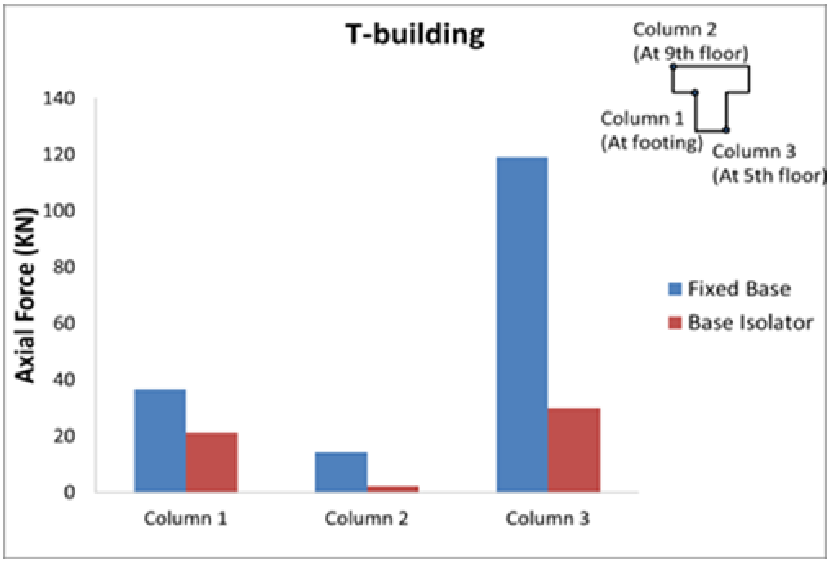


Fig. 19: Axial Force for Kozani Earthquake

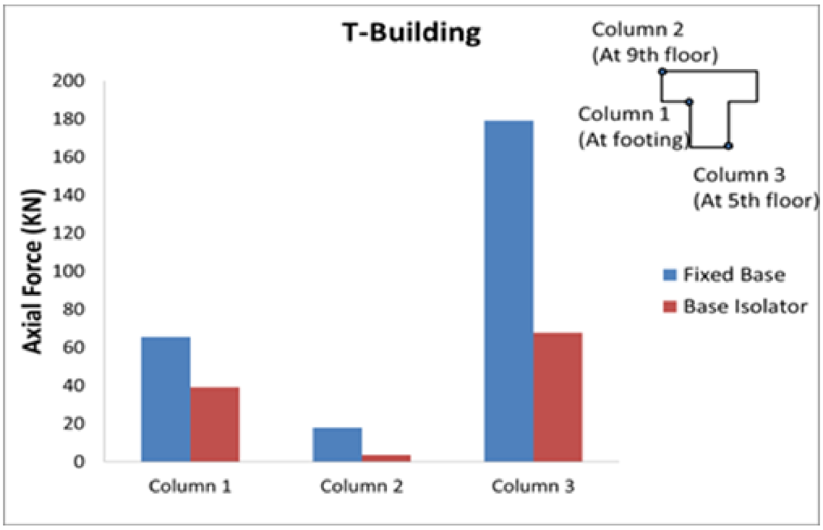


Fig. 20: Axial Force for Jiashi Earthquake

In the fixed base building the Axial Force for Column 3 is found to be 119.1KN for Kozani earthquake and 179.2KN for Jiashi earthquake. For the base isolated building the results are found to be 67.64KN and 30.02KN respectively for Kozani and Jiashi earthquake for Column 3.

CONCLUSIONS

1. The Storey displacement for the T-shape building with base isolator along Y-direction is similar for the all stories.
2. All the fixed base buildings show zero displacements at the base whereas, the base isolated buildings show increase in amount of Storey displacements at base for all the three buildings.
3. The base isolated building has more Storey displacement as compared to the fixed base building for all the three buildings.
4. Moment at the topmost storey of the Regular building with fixed base is found to be 1870% of the base isolated building for Kozani earthquake.
5. For Jiashi earthquake, the moment at the base for L-shape building with base isolator is found to be negligible as compared to the fixed base building.
6. Axial force for T-shape fixed base building at Column 3 is 300% more than the base isolated building for Kozani earthquake.
7. For the L-shape building with fixed base it is found that the Axial Force is more than the base isolated building for both Kozani and Jiashi earthquakes.
8. From the above results it is concluded that the base isolated buildings have less Axial force and Moment than the fixed base building.

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