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Earth quake analysis of structure by isolation technique in E-Tabs

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Abstract
The base isolation is technique that has been used to protect the structures from the damaging effects of earthquake. The installation of isolators at the base increases the flexibility of the building structures. The aim of this research is to study the seismic behavior of different structures under fixed condition and base isolated condition. In present study Modeling and analysis of G+5 storey RC building is done in ETBS software for two cases. The first one is fixed base and the second one is base isolated. The Lead rubber bearing (LRB) is designed as per UBC 97 code and the same was used for analysis of base isolation system. Lead rubber isolator are provided to both the structures and then analysis are carried out for both fixed base and base isolated buildings under zone II and soil type II i.e. medium soil (according to IS 1893(part 1):2002). The results obtained from analysis were Storey displacement. Storey shear, storey acceleration, and Inter storey drift. Due to the presence of isolators the inter storey drift, storey accelerations and storey shear is greatly reduced and storey displacement is increased in both X and Y directions compared to fixed base structures.

Keywords: Bare Frame, Lead Rubber Bearing Isolator, ETABS

1. Introduction

A natural calamity like an earthquake cause significant loss of life and destruction to property every year. A disturbance that causes shaking of earth surface due to movement at underground along fault plane or from volcanic activity is called earthquake. The seismic forces produced are harmful and lasts only for a small duration of time. Yet, humans are confused with uncertainty in terms of its time of occurrence and its nature. However with advances made in varies areas of sciences it has been learned how to pinpoint the locations of earthquake and how to accurately measure their sizes, however, this solves only one part of the problem to protect a structure. The other part is seismic design of the structures. Since from the last century, this part of problem has taken various forms, and improvements in design philosophy and methods have been done. There are two types of methods for the seismic design of structures,

1. Conventional method: This is the traditional method to resist lateral force is by increasing the design capacity and stiffness. Ex- Shear wall, Braced frames or Moment resisting frames.
2. Non-conventional method: Based on reduction of seismic demands instead of increasing capacity. Ex- Base isolation, Dampers.

Earthquake is unpredictable to the engineers and after effects of such earthquake is severe. India has experienced most devastating earthquakes in the world and during this earthquake lot of people lost their lives and most structures have collapsed. Therefore it is essential to protect structures from future earthquakes.

The existing building found inadequate for resisting future probable earthquake. The buildings with regular geometry and uniformly distributed stiffness and mass both plan and in elevation undergo much less damage as compared to the building with irregular configurations. To reduce the earthquake effects on building, certain seismic control techniques were adopted.

Conventional seismic design of building attempt to make buildings that not to undergo compete collapse during strong earthquake shaking, but may sustain damage to non-structural elements and structural members in the building. Special techniques are required to design buildings such that structure remaining undamaged even in a severe earthquake.

Two seismic control techniques are used to protect buildings from damaging earthquake effects are Base Isolation Devices and Seismic Dampers. The provision of isolators in the structure isolates the building from the ground, such that earthquake motions are not transmitted through the building. Seismic dampers are the special devices provided in the building to absorb the energy produced by the strong ground motion during earthquake. The main concept of the base isolation and provision of dampers in building is to introduce flexibility in structures. The seismic improvement is helpful to withstand structure against collapse during severe earthquakes.

1.1 Isolation devices

For superior seismic isolation of a structure we have to choose the appropriate system and the essential features for such system should be as follows:

- Capable in supporting the structure
- Provide horizontal flexibility
- Capable to dissipate energy

Isolation system should be rigid for low lateral loads to avoid vibration at frequent minor earthquakes or wind loads. Basic Requirements to develop a new base isolation device by overcoming the possible disadvantages of other devices are:

- Possibly its manufacturing should be a combination of several types of seismic isolators.
- Accommodation of tension forces should not occur suddenly but progressively in order to prevent impact loads on the isolated super structure.
- Permanent tension capacity to receive tension forces should occur in isolator.

Dhananjay A. Chikhalekar and M. M. Murudi, In this paper, ten storey structures with fixed base and structure with high damping rubber bearing and viscous damper are considered and analysis is carried out using response spectrum method and non linear static analysis. Storey displacement, storey drift, natural time period and performance point of the structure were compared using the software SAP. Study shows that performance of base isolated structure against seismic effect is high when compared to the structure with viscous damper.

Muralidhara. G.B and Santoshkumar. N.B; In this paper comparison between the fixed base building and various isolation systems such as friction pendulum isolator, high damping rubber isolator and lead rubber isolator subjected to strong earthquakes were analysed. The study shows the high damping rubber isolated frame is performing better as compared to the other isolator stiffness. Julie S and Sajeeb R studied the seismic performance of the base isolators and mass dampers in the vibration control of the building. Displacement, story drift and base shear of the structure is compared. The study shows that base isolators are superior in controlling the acceleration response.

Izumi Masanory studied on the remained literature, the first base isolated structure was proposed by Kawai in 1981 after the Nobi Earthquake (M=8.0) on journal of Architecture and building Science. His structure has rollers at its foundation mat of logs put on several steps by lengthwise and crosswise manually. After the San Francisco Earthquake (M=7.8) an English doctor J.A. Calantarients patented a construction by putting a talc between the foundations in 1909. The first base isolated systems actually constructed in the world are the Fudo Bank Buildings in Himeji and Simonoseki, Japan designed by R. Oka. After the world War-II, the U.S took a leading part of Earthquake Engineering.

2. Design seismic base shear

The total design lateral force or design seismic base shear (Vb) along any principal direction shall be determined by the following expression:

Vb = Ah W

Where,

Ah = horizontal acceleration spectrum

W = seismic weight of all the floor

Fundamental Natural Period

The approximate fundamental natural period of vibration (T,), in seconds, of a moment-resisting frame building without brick in the panels may be estimated by the empirical expression:

Ta=0.075 h0.75 for RC frame building

Ta=0.085h0.75 for steel frame building Where,

H = Height of building, in m. This excludes the basement storeys, where basement walls are connected with the ground floor deck or fitted between the building columns. But it includes the basement storeys, when they are not so connected. The approximate fundamental natural period of vibration (T,), in seconds, of all other buildings, including moment-resisting frame buildings with brick lintel panels, may be estimated by the empirical Expression:

T=.09H/√D

Where,

H= Height of building

D= Base dimension of the building at the plinth level, in m, along the considered direction of the lateral force.

2.1 Distribution of Design Force

Vertical Distribution of Base Shear to Different Floor Level

The design base shear (V) shall be distributed along the height of the building as per the following expression:

Qi=Design lateral force at floor i,

Wi= Seismic weight of floor i,

Hi=Height of floor i measured from base, and

n=Number of stores in the building is the number of levels at which the masses are located. Distribution of Horizontal Design Lateral Force to Different Lateral Force Resisting Elements in case of buildings whose floors are capable of providing rigid horizontal diaphragm action, the total shear in any horizontal plane shall be distributed to the various vertical elements of lateral force resisting system, assuming the floors to be infinitely rigid in the horizontal plane. In case of building whose floor diaphragms cannot be treated as infinitely rigid in their own plane, the lateral shear at each floor shall be distributed to the vertical elements resisting the lateral forces, considering the in-plane flexibility of the diagram.

Fig 1: Seismic zone map of India

In India seismic zones are divided into four zones, i.e Zone – II, Zone – III, Zone – IV and Zone - V. Zone – II is low earthquake prone area, Zone – III is moderate zone, Zone – IV is high earthquake prone area and Zone – V is the highest earthquake intensity zone.

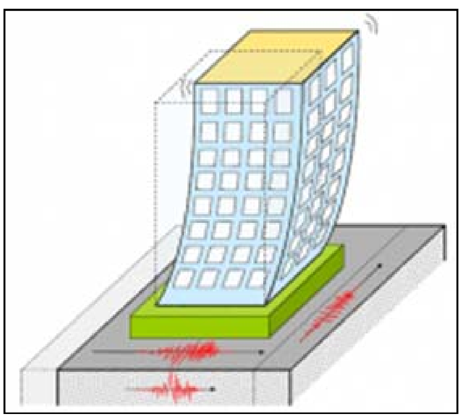

Fig 2: Behavior of building under earth quake

3. Results and discussion

3.1 base shear

The maximum base shears for fixed support and base isolation support is show in table. 1 and table. 2. Graph shows base shear along X and Y Direction with fixed and base isolation support.

Table 1: Story Shear for Fixed Support

Story Shear For Fixed Support (kN)		
STORY ID	Vx	Vy
STORY7	299.79	260.00
STORY6	524.21	454.64
STORY5	667.84	579.21
STORY4	748.63	649.27
STORY3	784.54	680.42
STORY2	793.51	688.20
STORY1	793.51	688.20

Table 2: Story Shear for Base Isolation Support

Story Shear For Base Isolation Support (kN)		
STORY ID	Vx	Vy
STORY7	223.40	242.61
STORY6	390.64	424.23
STORY5	497.68	540.46
STORY4	557.88	605.84
STORY3	584.64	634.90
STORY2	591.33	642.16
STORY1	582.21	597.88

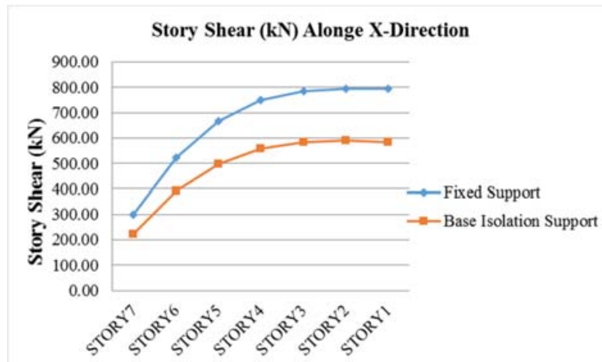

Fig 3: Story Shear for Fixed and Base Isolation Support along X-Direction.

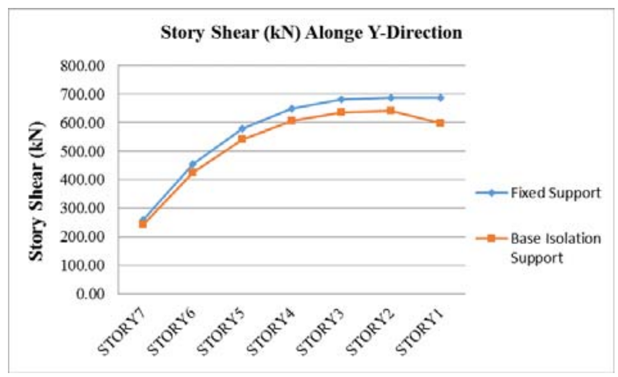

Fig 4: Story Shear for Fixed and Base Isolation Support along Y-Direction.

3.2 story drift

The maximum story drift for fixed support and base isolation support is show in table. 3 and table. 4. Graph shows maximum story drift along X and Y Direction with fixed and base isolation support.

Table 3: Story Drift for Fixed Support

Story Drift For Fixed Support (m)		
STORY ID	Drift-X	Drift-Y
STORY7	0.0008	0.0007
STORY6	0.0012	0.0011
STORY5	0.0016	0.0014
STORY4	0.0018	0.0015
STORY3	0.0019	0.0016
STORY2	0.0023	0.0020
STORY1	0.0012	0.0010

Table 4: Story Drift for Base Isolation Support

Story Drift For Base Isolation Support (m)		
STORY ID	Drift-X	Drift-Y
STORY7	0.0006	0.0007
STORY6	0.0009	0.0010
STORY5	0.0012	0.0013
STORY4	0.0013	0.0014
STORY3	0.0014	0.0015
STORY2	0.0017	0.0014
STORY1	0.0009	0.0002

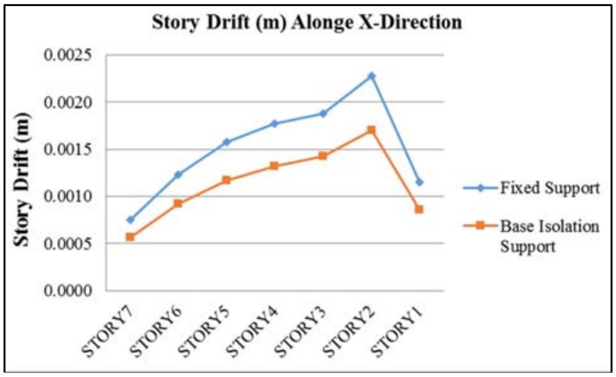

Fig 5: Story Drift for Fixed and Base Isolation Support along X-Direction.

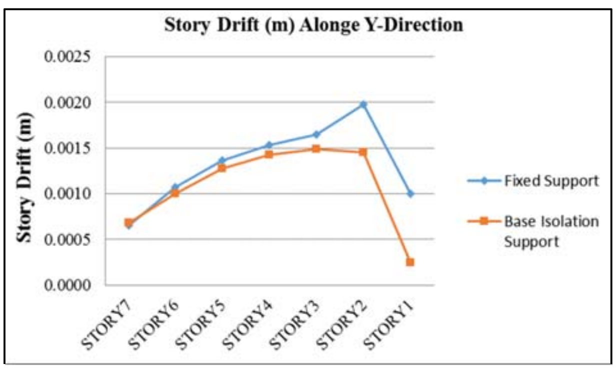

Fig 6: Story Drift for Fixed and Base Isolation Support along Y-Direction.

3.3 story displacement

The maximum story displacement for fixed support and base isolation support is show in table. 5. Graph shows maximum story drift with fixed and base isolation support.

Table 5: Story Displacement for Fixed & Base Isolation Support.

Displacement (m)		
STORY ID	With Fixed Support	With Base Isolation
BASE	0	0
STORY1	0.0017	0.0029
STORY2	0.0047	0.006
STORY3	0.0073	0.0086
STORY4	0.0094	0.0106
STORY5	0.0109	0.0121
STORY6	0.0119	0.0131
STORY7	0.0124	0.0136

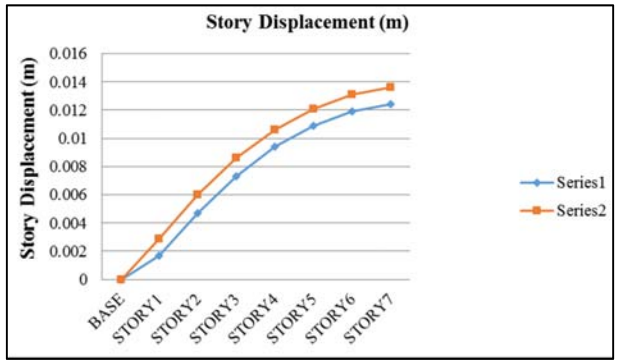

Fig 7: Story Displacement for Fixed and Base Isolation Supports.

4. Conclusion

- When compared with fixed base structure, the base shear is reduced in base isolated structures, thus the response of building is good in base isolated structures than fixed base structures.
- For base isolated building Response have been increased from 0.26sec to 0.36 sec. Since the super structure will be subjected to lesser earthquake forces, the cost of isolated structure will be cheaper.
- This specific provision of stiffness attracts lesser seismic forces and thus resulting double benefits compared to conventional structure i.e. reduction of axial forces from 3756.03 to 3441.8kN.
- Storey drift will also be reduced by using isolators i.e. from 73 mm to 52 mm.
- The emerging architectural designs are mostly irregular in geometry which leads to torsional and differential moments in X and Z directions. This may cause overstress to the frames. This can be overcome by provision of Base Isolator in the form of lead.
- A base-isolation system reduces Ductility demands on a building, and minimizes its deformations.
- Base isolation increases the flexibility at the base of the structure which helps in Energy Dissipation due to the horizontal component of the earthquake.
- Hence the better fitted isolator based on the requirement is constructed economically to ensure Safe structure withstanding damages due to natural calamities.

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