

COMPARATIVE ANALYSIS OF TALL STRUCTURE WITH AND WITHOUT BASE ISOLATION USING RESPONSE SPECTRUM METHOD

Chetan T G¹, C S Vijaya kumar², Dr M N Shivakumar³

¹Post Graduate in Structural Engineering, BIET College, Davanagere-577004, India

² Assistant Professor, Civil Engineering Department, BIET College, Davanagere

² Associate Professor, Civil Engineering Department, BIET College, Davanagere

Abstract— Reinforced concrete plays a very important in civil engineering field in development of infrastructures. And these reinforced concrete structure should be efficiently designed to take various type of load. Usually all the structures are designed efficient to take gravitational loads. But when it comes to seismic design of structures various parameters comes into picture. There are various techniques to make a structures resistant to earthquake forces. In our study we are using base isolation technique to make the structure resistant against seismic forces. These base isolators can reduce the story shear and acceleration and simultaneously increases the time period, storey displacement and storey drift increases the flexibility in the RCC structures to dissipate the energy to the foundation. In your study we are analyzing 29 storeyed conventional fixed base structures using response spectrum method of analysis and further comparing that with base isolated structure using E-TABS software. In the process of analyzing we have made the use of various Indian Standard code such as IS 456-2000, IS 1893-2002, IS 875-2015.

Keywords—Base isolation, Response spectrum analysis, Lead rubber bearing (LRB), High raised building, Response spectra

1. INTRODUCTION

Earthquake is natural calamities which is catastrophic causing major damage to infrastructure and living things. So the structure need to strong against the ground motion caused by earthquake. However the earthquake forces are of shorter duration but causes severe damage. Hence seismic design is important now a days. During earthquake the structure acts as an amplifier and acceleration will increase from bottom to top. Because of stresses in member increases and even drift will increase. The load and moment on column also increases .This increases the acceleration causing the damage to the structural elements. The acceleration can be limited by increasing the rigidity of the structural elements. But increasing the rigidity will make the structure uneconomical.

This made the engineers to think and come up with the new ideas and technique to protect the structures from the earthquake. So engineers and architect came up with new innovative idea of base isolation this will effectively moderate the response on the structure and this will make the structure safe against earthquake. In last two decades different methods of base isolation technique have been established. The technique of base isolation comprises of decoupling the structure from the earthquake induced ground motion. This makes the structure more flexible with adding suitable damping. By providing the base isolators we can reduce the diffusion of the earthquake forces and energy into the structures. The main character of seismic base isolators is to increase the flexibility, so natural period of structure. Once the natural period of the building is improved beyond that of earthquake seismic acceleration gets reduced.

2. BASE ISOLATION

In technique of base isolation, the superstructure is separated from the lateral movements caused due earthquake ground motion The base isolator bearing are designed in such a manner that they are vertically stiff and horizontally flexible to the difference in lateral movements while supporting the superstructure. The decoupling of the structure allows the building to perform more flexibly which amplifies its response to an earthquake. The added dampers will dissipate the earthquake forces and therefore decreases the energy transferred to the structure.

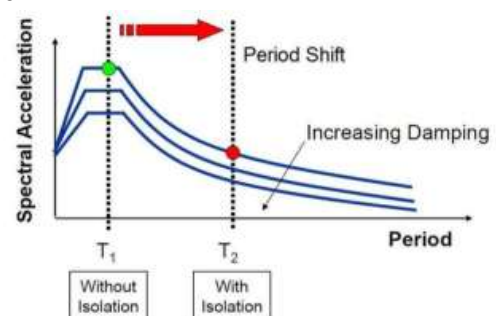


Fig 1.Effect of seismic isolation on Spectral acceleration

2.1. Lead rubber bearing

A lead-rubber bearing consists of alternate layers of rubber and steel plates with one or more lead plugs which are inserted into the holes. The lead core which is used will provide rigidity under service loads and energy dissipation under high lateral loads. Both top and bottom steel plates, thicker than the internal shims, are used to accommodate mounting hardware. The whole bearing is encased in cover rubber to provide environmental protection. When the structure is subjected to low lateral loads (such as minor earthquake, wind or traffic loads) the lead rubber bearing is stiff both laterally and vertically. The lateral stiffness of elastomeric results from the high elastic stiffness of the lead plug and the vertical rigidity (which remains at all load levels) results from the steel-rubber construction of the bearing.

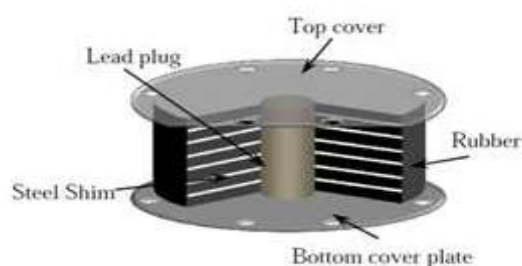


Fig 2. Lead rubber bearing

3. RESPONSE SPECTRUM METHOD OF ANALYSIS

To perform seismic analysis and design at particular location we need time history data. But Time history data is not available at every location. As structural response depend on the frequency of ground motion and its own dynamic properties, we cannot simply carry out the seismic analysis with the peak value of the ground acceleration. So response spectrum method is efficient way for the seismic analysis of the structures. In this method the displacement and member forces can predicted easily in structural systems. The maximum values of displacements and member forces in each mode of vibration using smooth design spectra that are the average of several earthquake motions are calculated

3.1. Response Spectra

Response spectra are curves obtained between maximum response of SDOF system subjected to specified earthquake ground motion and its time period (or frequency). Response spectrum can be interpreted as the locus of maximum response of a SDOF system for given damping ratio. Further, Response spectra used in obtaining the peak structural responses under linear

range, which can be used for compute lateral forces developed in structure due to earthquake thus facilitates in earthquake-resistant design of structures.

Usually response of a SDOF system is calculated by time domain or frequency domain analysis, and for a given time period of system, maximum response is picked. This process is continued for all range of possible time periods of SDOF system. Final plot with system time period on x-axis and response quantity on y-axis is the required response spectra pertaining to specified damping ratio and input ground motion. Same process is carried out with different damping ratios to obtain overall response spectra.

4. OBJECTIVES OF THE STUDY

- To accomplish the modelling and analysis of fixed base and base isolated building by using ETABS software and study the performance of both for seismic forces.
- To design the various parameters related to lead rubber bearing which is used as a base isolator in our study.
- To analyse the both fixed and base isolated structures using response spectrum method of analysis and comparing the results like story displacement, story drift, story stiffness and story acceleration.

5. METHODOLOGY

In our study we are modelling 29 story structure which is symmetrical in both direction and having dimensions 45mx35m. Initially fixed base structure is modelled and analysed using E-TABS software and then maximum column force is taken. Further, lead rubber bearing isolator is designed for maximum load manually. And then these properties are used for modelling and analysis of base isolated structure in E-TABS software. Both fixed and base isolated structure are analysed using Response Spectrum method of Analysis. The results obtained are discussed.

6. MODELLING AND ANALYSIS.

6.1. Different loads acting on structure

1. Gravitational loading on structure.
 - Live load on floors = 3 kN/m²
 - Dead load on roof = 1.5 kN/m²
2. Geometric Properties
 - Column size = 350mm x 350mm
 - Beam size = 350mm x 450 mm
 - Slab thickness = 150mm

3. Material properties

- Grade of concrete=M35
- Grade of steel=Fe500

4. Seismic parameters

- Seismic zone= zone II
- Response reduction factor, R=3
- Importance factor, I=1
- Type of building= Residential

5. Response spectrum

- Seismic zone factor, Z=0.1
- Soil type= II
- Damping ratio=0.05

6. Wind load parameters

- Wind speed=33 m/s
- Terrain category=3
- Importance factor=1
- Risk coefficient=1
- Topography=1

Table 1. Specification of lead rubber bearing

Sl. No.	Parameters	Values
1	Required stiffness	6710.133kN/m
2	Bearing horizontal stiffness	1774.48kN/m
3	Vertical stiffness	2309486.147kN/m
4	Yield strength	38.99kN
5	Stiffness ratio	0.1
6	Damping ratio	0.05

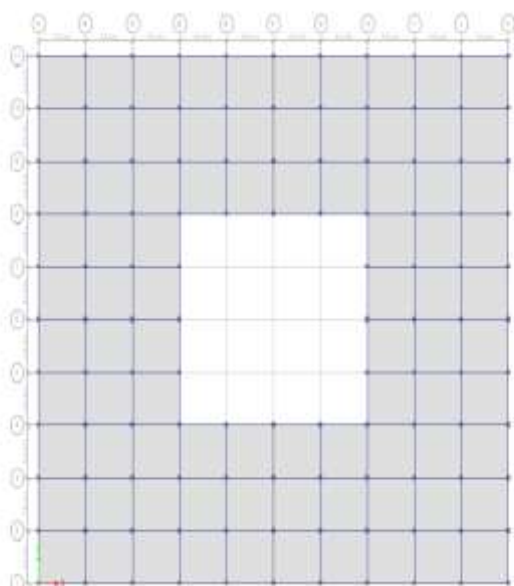


Fig 3. Plan of building in E-TABS

7. RESULTS AND DISCUSSION

7.1. Story displacement

Story displacement of both fixed and Base isolated structures can be observed in graph shown in fig 4 and fig 5. Story displacement of base isolated structure will increase due to increase in flexibility of the building.

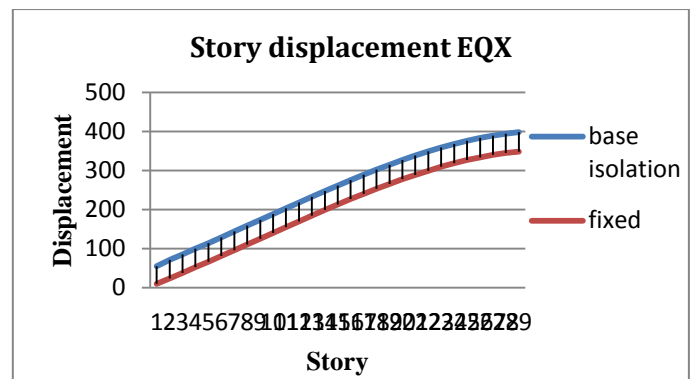


Chart 1. Comparison of story displacement in fixed base and base isolated structure for load case EQX

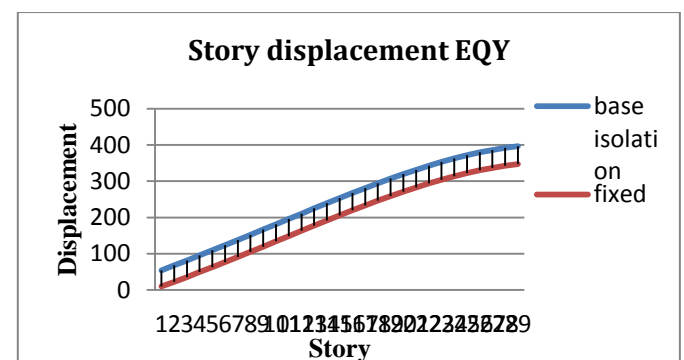


Chart 2. Comparison of story displacement in fixed base and base isolated structure for load case EQY

7.2. Story drift

Story drift of both fixed and Base isolated structures can be observed in graph shown in fig 6 and fig 7 from graph it is observed that the story drift of base isolated structure will significantly reduce from bottom to top of structure in comparison with fixed base.

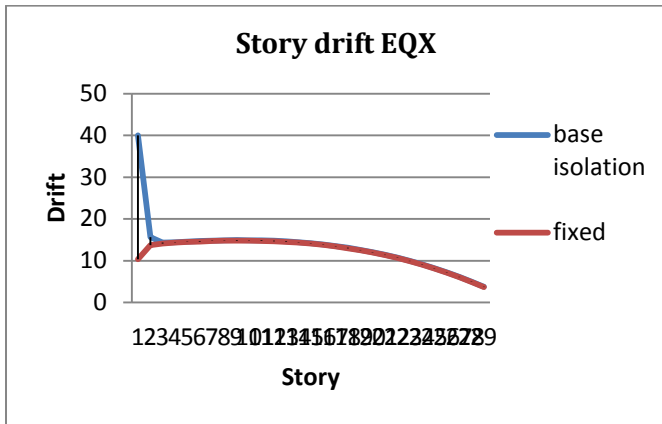


Chart 3. Comparison of story drift in fixed base and base isolated structure for load case EQX

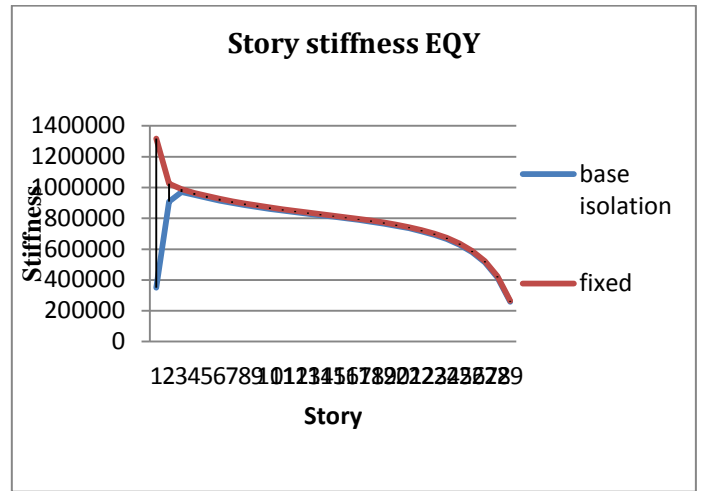


Chart 6. Comparison of story stiffness in fixed base and base isolated structure for load case EQY

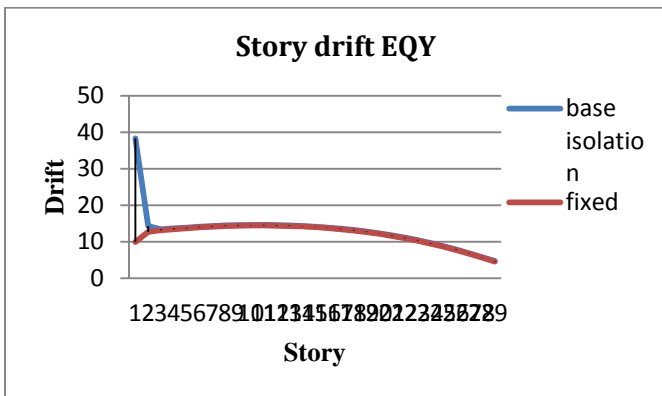


Chart 4. Comparison of story drift in fixed base and base isolated structure for load case EQY

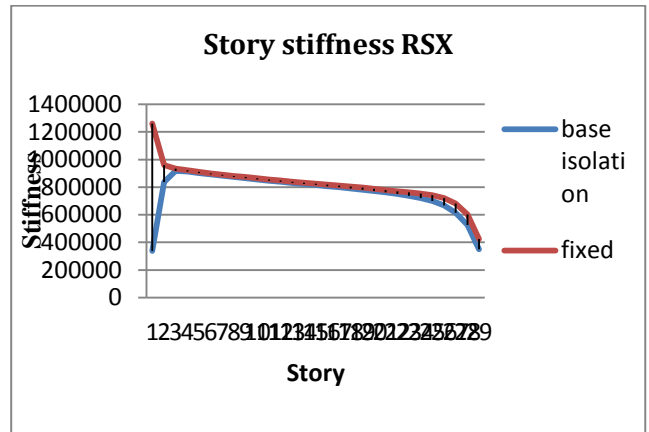


Chart 7. Comparison of story stiffness in fixed base and base isolated structure for load case RSX

7.3. Story stiffness

Story stiffness of both fixed and Base isolated structures can be observed for load case EQX, EQY, RSX and RSY variation can be observed in graph shown in fig 8, fig 9, fig 10 and fig 11. From graph it is observed that the story stiffness of base isolated structure initially increases and gradually decreases as we move along the height of structure in comparison with fixed base.

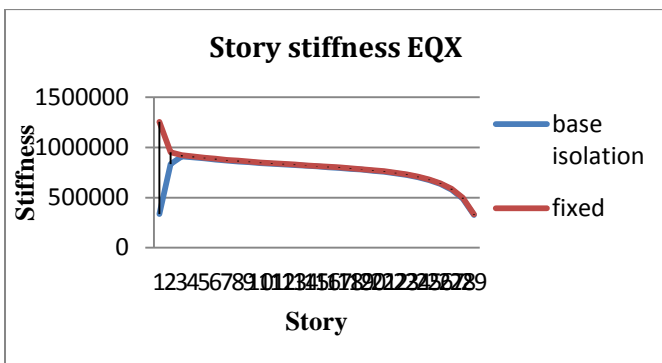


Chart 5. Comparison of story stiffness in fixed base and base isolated structure for load case EQX

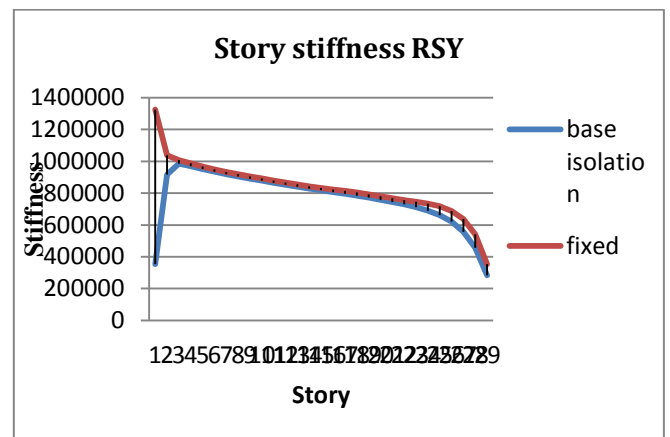


Chart 8. Comparison of story stiffness in fixed base and base isolated structure for load case RSY

7.4. Story Acceleration

Story acceleration of both fixed and Base isolated structures can be observed in graph shown in fig 12. From graph it is observed that the story acceleration of base isolated structure is more for lower storeys and gradually

decreases. But for fixed base structure initially it be less but increases gradually as we move along the height of structure

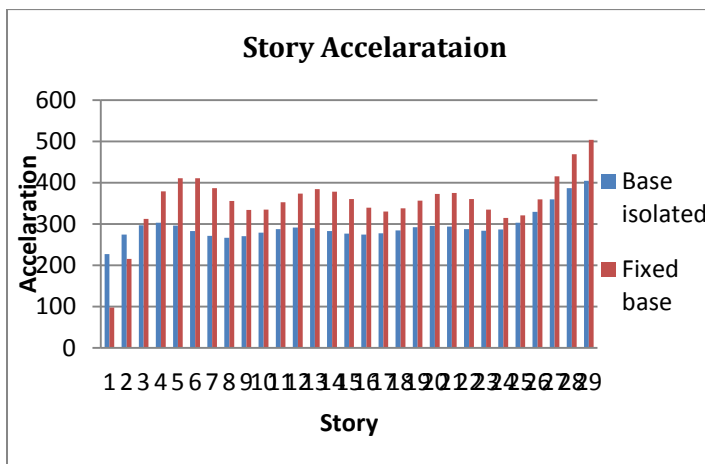


Chart 9. Comparison of story Acceleration in fixed base and base isolated

8. CONCLUSION

1. Story displacement of base isolated structure will increase due to increase in flexibility of the building.
2. The story drift of base isolated structure will significantly reduce from bottom to top of structure in comparison with fixed base. That shows the reduction of force.
3. The story stiffness of base isolated structure initially increases and gradually decreases as we move along the height of structure in comparison with fixed base. Reduce in stiffness increases the flexibility of the structure that induces the dissipation of seismic energy
4. The story acceleration of base isolated structure is more for lower stories and gradually decreases. But for fixed base structure initially it be less but increases gradually as we move along the height of structure.
5. From the above observation we conclude that the LRB bearing is having good resistance to the seismic force than the structure with the fixed base.

9. REFERENCES

1. Islam, ABMS., Ahmad, S. I., Jameel, M., Jumaat, M. Z., 2010a, Seismic base isolation for buildings in regions of low to moderate seismicity: A practical alternative design, Practice Periodical on Structural Design and Construction, ASCE.[DOI: 10.1061/(ASCE)SC.1943-5576.0000093].
2. G.Mounica, Dr.B.L.Agarwal, "Seismic Analysis of Fixed Base and Base Isolated Structures", IJATES, Vol. No.4, Issue No. 08, August 2016.

3. Swapnil Ambasta, Dushyant sahu, G P Khare, "Analysis of the Base Isolated Building (Lead Rubber Bearing) in E-TABS", IRJET, Volume:05 Issue: 01 Jan- 2018.
4. IS 456 (2000) "Indian Standard Code of Practice for Plain and Reinforced Concrete", Bureau of Indian Standards, New Delhi, India.
5. IS 1893 (Part 1)-2002 "Criteria for Earthquake Design of Structure", Bureau of Indian Standards, New Delhi, India.
6. IS 875-Part 1 (1987), "Indian Standard Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures. Part 1 Dead load-Unit Weights of Building Material and Stored Structures", Bureau of Indian Standards, New Delhi, India.
7. IS 875-Part 2 (1987), "Indian Standard Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures. Part 2 Imposed Loads", Bureau of Indian Standards, New Delhi, India.
8. IS 875-Part 3 (1987), "Indian Standard Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures. Part 3 Wind Loads", Bureau of Indian Standards, New Delhi, India.