International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 08 Issue: 06 | June 2021 www.irjet.net p-ISSN: 2395-0072

Comparative Study of Seismic Analysis of Fixed base and Base Isolated Structure Using ETABS Software

Prajakta Jawale[1], Shruti Bagmare[2], Aishwarya Shinde[3], Vedant Khedekar[4], Prof. G Arya[5]

[1,2,3,4]B.E. (Civil) Student, Dr. D. Y. Patil School of Engineering & Technology, Lohegaon, Pune, 412105 India.
[5]Professor, Dr. D.Y. Patil School of Engineering & Technology, Lohegaon, Pune, 412105 India.

Abstract - *Base-Isolation is an effective technique that is used to minimize the damage to building structures during an earthquake. Over the past few years, Base-Isolation has turned out to be one of the most trending designs. In the present analysis conducted for G+10 storied special RC moment-resisting frames with the fixed base along with the lead rubber isolation has been studied using ETABS software. The symmetrical structure is used as a test model and the equivalent static analysis has been carried out. The results are compared in order to check the adequacy of the base-isolated structure against the fixed base structure. The probable merits of base isolation over the fixed base structures are derived.*

Key Words: **Lead Rubber Bearing, Isolation, Drift, ETABS, Fixed base, etc.**

1. INTRODUCTION

Base isolation is one of the most effective seismic resistant techniques used in earthquake engineering which is nothing but separating or decoupling the structure from its foundation. The basic principle behind base isolation is to modify the response of the structure or a building such that the ground below is capable of moving without transmitting minimal or no motion to the structure above.

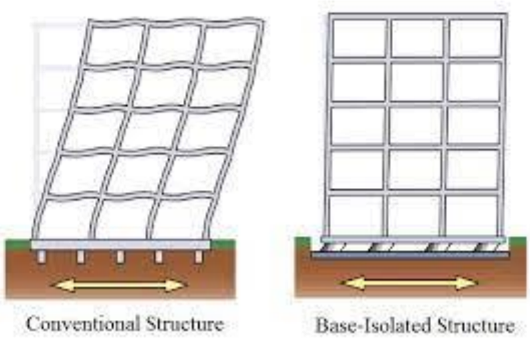

Fig -1 Concept of Base Isolation

Its main function is to prevent or reduce damage to the structures exposed to strong ground motions. This results in least floor acceleration and drifts ratios and safeguards the structures from hazardous seismic impacts. It is also used in bridges, nuclear power plants and liquid storage tanks, etc. Currently this technology is applied in several earthquake prone zones all over the world including some of the leading countries like New Zealand, Japan, United State, etc.

1.1 Types of Base Isolation Systems:

Two types of base isolation systems or their combination are in use, namely elastomeric bearings, sliding isolation bearings and Combined Isolation systems. These isolators are further classified as follows:

Elastomeric Bearings:

- Plain Elastomeric Bearing
- Laminated Rubber Bearing
- Lead Rubber Bearing
- High Damping Rubber Bearing

Sliding Isolation Bearings:

- Pure Friction System
- Friction Pendulum System
- Conical Friction Pendulum Isolator
- Variable Frequency Pendulum Isolator

Combined Isolation Systems:

- Resilient-Friction Base Isolator
- Electric de France System
- Sliding Resilient-Friction

Here we have used Lead Rubber Bearing (LRB) for the analysis.

Lead Rubber Bearing:

Lead Rubber Bearing also known as New Zealand (NZ) System was first invented in 1975 in New-Zealand. Lead rubber bearing is widely used in building and bridge constructions and is the cost-effective choice for seismic isolation. It is nothing but a modified laminated elastomeric bearing with top and bottom sealing & connecting plates along with a lead plug in the middle of the bearing as shown in the Fig 2.

The central lead plug can enhance the damping in elastomeric bearing. The lead plug has excellent damping characteristics and its behavior during earthquakes has special characteristics due to the properties of lead. The function of lead plug is primarily to dissipate energy, while the laminated rubber bearing provides the lateral flexibility. The energy absorbing capacity of the lead core reduces the lateral displacements of the isolator.

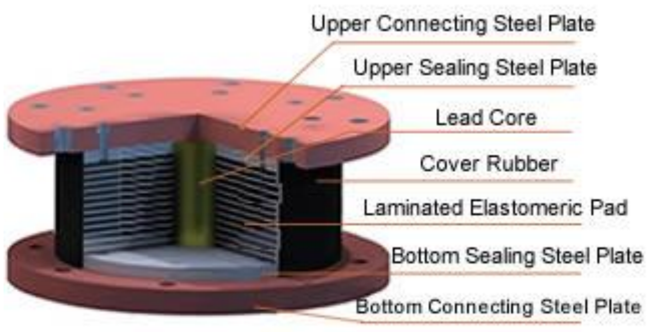

Fig -2 Lead Rubber Bearing

The system found wide application in New Zealand as well as in Japan, Iceland, Italy and United States.

2. OBJECTIVE OF THE PROJECT

The main objective of project was to compare fixed base and base isolated structure by seismic analysis. The results were compared for Story drifts, Base shear, Story shear and Story displacements to know adequacy of base isolated structure over fixed base structure.

3. METHODOLOGY

- ETABS v 17.0.1 is used for the analysis of structure.
- The seismic analysis is carried out.
- For load definition IS 875 code is used.
- For structural analysis IS 1893 (PART I) 2002 code is used.
- Firstly, the building is modeled then the loads are applied.
- After the analysis of a fixed base structure the maximum axial load is noted from support reaction results.
- Depending on the maximum axial load, the suitable lead rubber isolator is selected from the available literature. Then properties of Lead rubber bearing (LRB) are noted.
- These properties are used as link properties for base isolated structure.
- Then the Base Isolated Structure is analyzed and results are discussed.

4. MODELING AND ANALYSIS

There are two commonly used procedures for seismic design lateral forces:
1. Equivalent static force analysis
2. Dynamic analysis

Equivalent Static Analysis method is used in the work.

EQUIVALENT STATIC ANALYSIS:

The equivalent static method is a simplified technique which substitutes the effect of dynamic loading of an expected earthquake by a static force laterally distributed on a structure for design purposes. The total seismic force *V* is generally evaluated in both horizontal directions parallel to the main axes of the building.

4.1 DESCRIPTION AND MODELING OF BUILDING:

- Software used for analysis is ETABS v 9.7.1
- Units used are 'KN-m'
- Code provisions as per IS 1893 (PART 1)
- Analysis performed is Equivalent Static analysis

4.2 BUILDING DETAILS:

- Structure: RCC (SMRF)
- Structure Type: Plan Irregular structure
- Plan Dimension: 25.82m×21.30m
- Height of Building: 36.00 m
- Height of Each Storey: 3
- Building Type: Residential

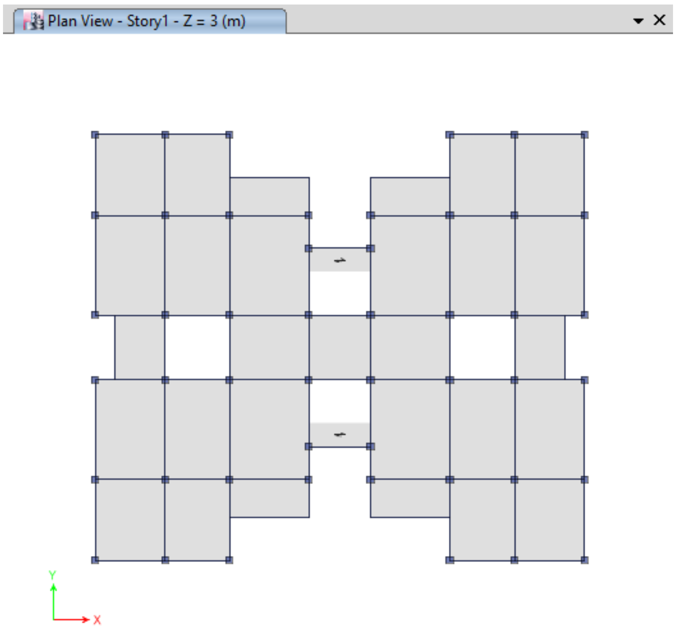

Fig -3 Plan of Building

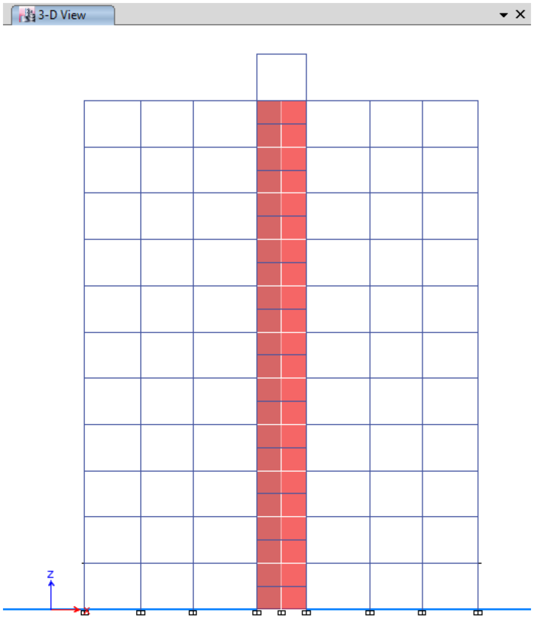

Fig -4 Elevation of Building

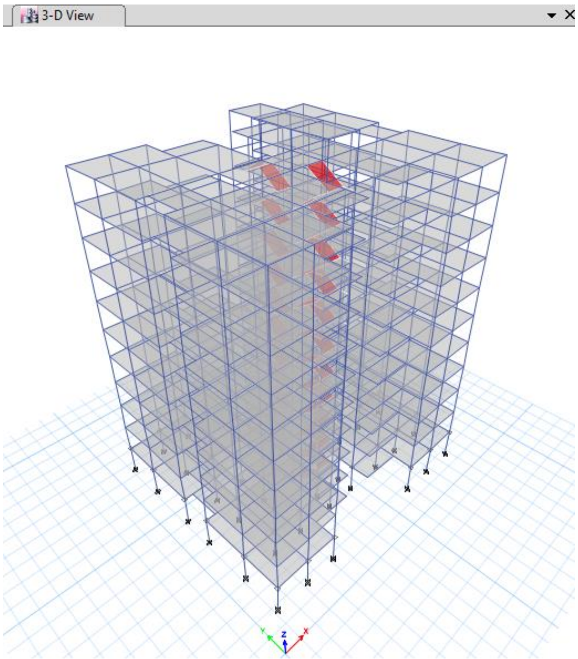

Fig -5 3D View of Building

4.3 MATERIAL PROPERTIES

- Grade of Concrete: M30
- Grade of Steel: Fe500

4.4 SECTION PROPERTIES

- Beam Size: 300mm×450mm
- Column Size: 350mm×350mm
- Slab 1 Thickness: 150mm
- Slab 2 Thickness: 200mm

5. LOAD CONSIDERATION

5.1 GRAVITY LOAD

Dead Load:

- Column: 3.0625 kN/m
- Beam: 3.375 kN/m
- Slab 1:3.75 kN/m^2
- Slab 2: 5 kN/m^2

Live Load:

- Live Load: 2.5 kN/m^2

5.2 LATERAL LOAD FACTORS FROM IS 1893 (PART 1)

- Seismic Zone Factor (Z): 0.36 (for Zone 5)
- Soil Profile Type: Medium
- Importance Factor (I): 1
- Response Reduction Factor (R): 5 (For SMRF)
- Damping (βeff): 5%

6. BASE ISOLATOR PROPERTIES

The properties of isolator are taken from the research paper "Dynamic Analysis of 11 Storey Rc Structure by Providing Lead Rubber Bearing As Base Isolation System" by Venkatesh, Mr.Arunkumar.H.R.

DIMENSIONS OF LEAD RUBBER BEARING (LRB):

- Let thickness of shim plates be 2.8mm
- Number of shim plates: 9
- End plate thickness is in between 19.05 to 38.1
  Adopt thickness of end plate as 25mm
- Total height of LRB (h): 425.2 mm
- Diameter of Rubber Bearing: 350 mm

Rotational Inertia	0.0745 m^4
Effective Stiffness for U1	2296145.25 kN/m
Effective Stiffness for U2 and U3	2296.15 kN/m
Effective Damping for U2 and U3	0.05
Distance from end J for U2 and U3	0.0032 m
Stiffness for U2 and U3	21140.6 kN/m
Yield Strength	61.09 kN

Table -1 Quantities to used in ETABS

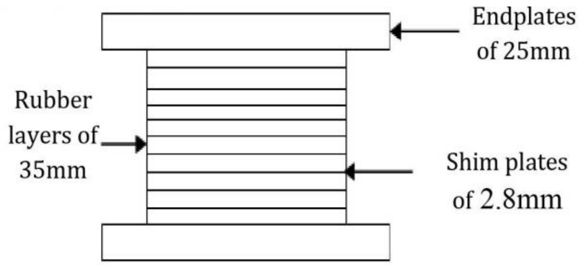

Fig -6 Lead Rubber Bearing

7. RESULTS

Following are the results obtained from the analysis:

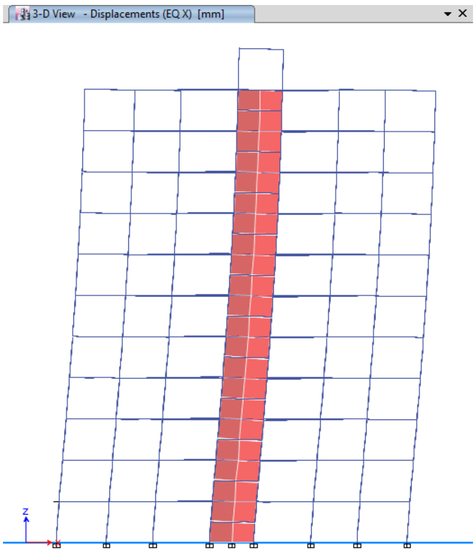

Fig -7 Deformed Shape of Fixed Base Structure

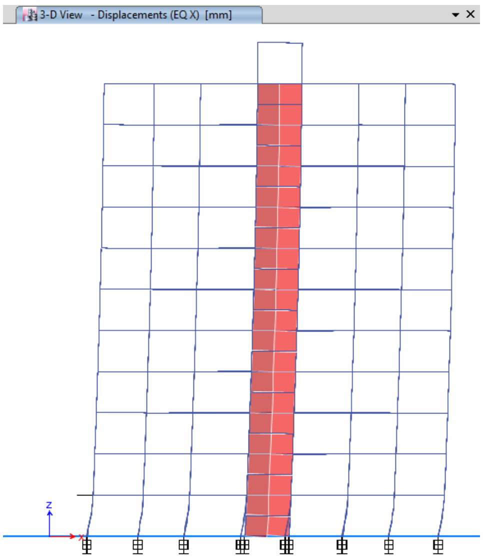

Fig -8 Deformed Shape of Base Isolated Structure

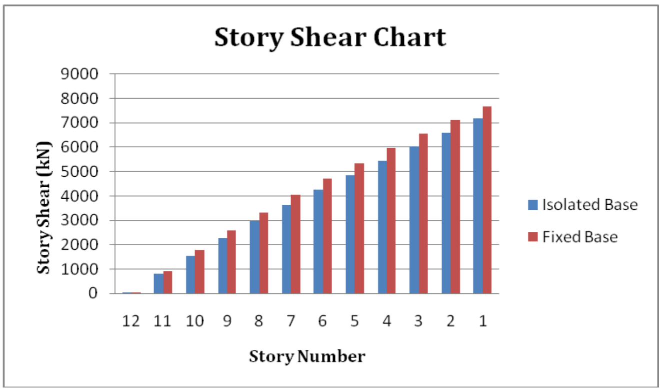

Fig -9 Graph showing Shory shear in X direction vs story number for Fixed base and Base Isolated Strucutre

In Figure 9, the graph of story shear to both the stuctures is plotted. The story shear for storey 6 and below for base isolated structure is found to be 400-500 kN less than that of Fixed Base structure.

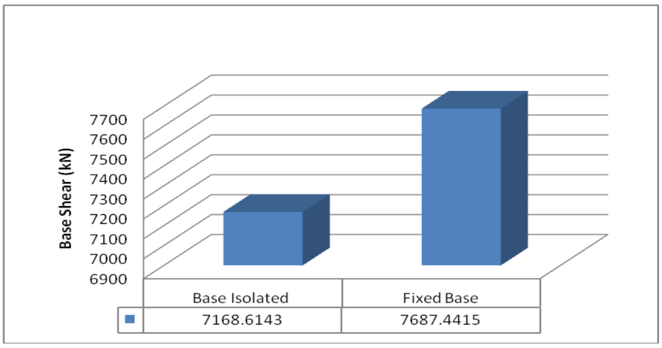

Fig -10 Chart showing variation in base shear in X direction for Base isolated and fixed base structures

In Figure 10, the graph of Base Shear of Base Isolated and Fixed Base structure is plotted. The Base Shear is the possible maximum lateral force due to earthquake. The same for the Base isolated structure is found to be about 500kN less as compared to Fixed Base structure.

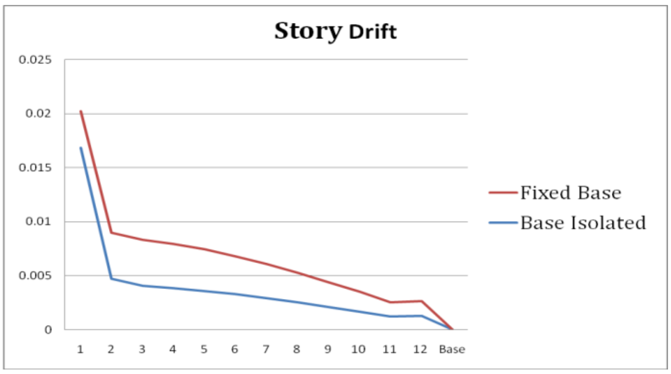

Fig -11 Combined Line diagram for Story Drifts of both the structures

Story Drift is the lateral displacement of the story relative to the story above or below. Larger the story drift, less stiff is the structure. Figure 9 shows the line graph of the Story Drifts of both the models. It can be clearly observed that the Drifts for the Story 2 and above are higher for the fixed base structure as compared to the base isolated structure.

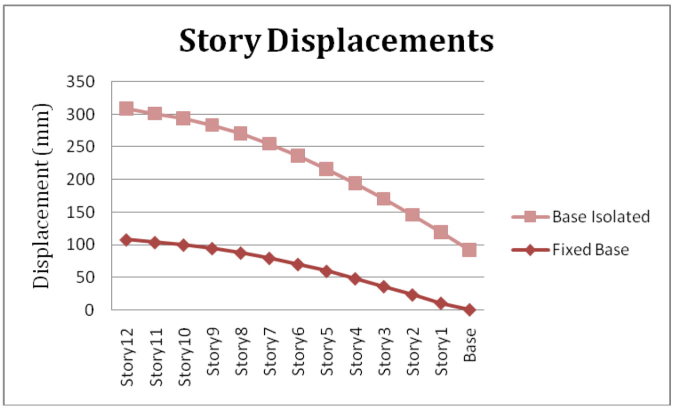

Fig -12 Combined Line diagram for Story Displacements of both the structures

From Figure 12 it is observed that the Displacements of the stories for base isolated structure are on higher side than the fixed base structure.

9. CONCLUSIONS

The Residential Building was analyzed for both fixed base and isolated base. It is observed that the base isolated structure is more effective than the fixed base structure. After comparing the results for both the models following conclusions are made:

- When LRB was provided, the Story shear was found to be reduced as compared to the Base Isolated Structure.
- Base Shear of the structure was also reduced due to which structure remains stable during earthquake.
- For the higher storey, Story Drift is also reduced which safeguards the structure against earthquake.
- As there are large displacements at the base level of isolated structure, the Story Displacements of Base Isolated structure are higher than that of fixed base structure. Though the displacements are on higher side the upper stories act as a rigid mass as compared to the base.

Finally, it is concluded that the use of LRB not only protects the structure against earthquakes, but also reduces the cost of strengthening the structure.

REFERENCES

[1] Study of Base Isolated Building by Tejas Jitendra Chordiya, Vaishnavi Yogesh Totla (IRJET)

[2] Effect Of Base-Isolation For Building Structures by Prof.R.B.Ghodke, Dr.S.V.Admane (IJSETR)

[3] Dynamic Analysis of 11 Storey Rc Structure by Providing Lead Rubber Bearing As Base Isolation System by Venkatesh, Mr.Arunkumar.H.R. (IRJET)

[4] Sustainability of Structure Using Base Isolation Techniques for Seismic Protection by Pallavi Wamanrao Taywade 1 , Madhuri Narayan Savale (International Journal of Innovative Research in Science, Engineering and Technology)

[5] Effective Semi-active Base Isolation System under Multiple Earthquakes by Mohtasham Mohebbi and Hamed Dadkhah (Hindawi)

[6] Experimental Study Of An Adaptive Base Isolation System For Buildings by Michael D Symans , Glenn J Madden and Nat Wongprasert

[7] A Critical Review On Base Isolation Techniques For Its Application As Earth Quake Resistant Buildings With Particular Need/Adherence In Eastern Uttar Pradesh by Ajai Kumar Rai , Brajesh Mishra (IJESRT)

[8] A Literature Study to Seismic Isolation in Building and Water Tank by Dhaval V. Shankhpal and Ankit Pal (International Journal of Current Engineering and Technology)

[9] Analysis, Design, and Construction of a Base-Isolated Multiple Building Structure by Stefano Sorace1 and Gloria Terenzi (Hindawi)

[10] Application Of Base Isolation For Flexible Buildings By Sarvesh K. Jain1 And Shashi K. Thakkar (13th World Conference on Earthquake Engineering Vancouver, B.C., Canada)