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Comparison between Conventional Seismic analysis and Lead Rubber Bearing Base Isolation system using ETABS software

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Abstract —The main objective of project is to compare conventional Seismic analysis and lead rubber bearing system. While no structure can be entirely immune to damage from earthquakes, the goal of earthquake resistant construction is to erect structures that fare better during Seismic activity than their conventional counterparts. The installation of isolators at the base increases the flexibility of the building structures. In present study Modeling and analysis of P+10 storey RC building is done in ETBS 19.1 version software for two cases. The first one is fixed base and the second one is base isolated, one vertical irregular model is considered and analysis is done by equivalent static and response spectrum method. The Lead rubber bearing (LRB) is designed as per IS and UBC 97 code and the same was used for analysis of base isolation system. The results obtained from analysis were Storey displacement. Damper systems are designed and manufactured to protect integrities and structural damages and to prevent injuries. There are many techniques to make seismic resistant structure. The base isolation technique is used in this project to resist against earthquake. Lead Rubber Bearing is a new type earthquake resistance rubber bearing, formed by inserting lead core into ordinary laminated rubber bearing, vertical supporting, and horizontal displacement and hysteric damping are combined in single unit together.

Index Terms— Base isolation, Lead rubber bearing, Equivalent static method, Response spectrum method, storey displacement, shear store, base shear

1 INTRODUCTION

Earthquakes are constant threats to human civilization. In the last few decades, with the deployment of seismometers in many parts of the world, we are now able to detect tremors around the globe, including those in remote areas and seafloors. Traditional seismic design of buildings is founded on structural ductility and redundancy. Forces induced by severe earthquakes are reduced as a function of the energy dissipation capacity at the structural components and their connections.

Base isolation systems partially uncouple a structure from the seismic ground motion by means of specially designed, replaceable, devices inserted between the structure and its foundation. It illustrates a conventional P+10 storey building and a protected base isolated one. The conventional building reduces dynamic forces by plasticity of the structural and non-structural components. In order to understand the performance of the building under seismic effect and the effect of lateral loads on a structure, it is necessary to evaluate the time period of a structure. It is necessary to determine the significance of the time period before evaluating the time period of a structure. Time period plays an important role in estimating the lateral loads and hence contributes to the seismic assessment of a structure.

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. The value obtained for time period as per the code and as per the software is compared.

1.1 Base Isolation system

In base isolation technology during earthquake, separating the superstructure or reducing the lateral movements of building superstructure from the movement of ground or foundation. The bearings of base isolation are designed in such a way that they are stiff vertically and flexible horizontally to allow for the difference in lateral movement while still supporting the superstructure. The base isolated structures are different than that of fixed base structure, in which the connection between the superstructure and the foundation are rigid and the superstructure translation in all direction is constrained. A building is decoupled from the earthquake ground motion or seismic waves. When a building is decoupled from ground motion it significantly reduces response in the structure which would have affected building if it is fixed base. Base isolation decouples the building from ground motion by decreasing the fundamental frequency when compared to fix based building. To some extent by reducing the superstructure's spectral acceleration, the reduction in seismic force at superstructure is achieved. By increasing the base isolated structure fundamental period and through damping caused by dissipation energy within bearing the accelerations are reduced.

1.2 Lead Rubber Bearing System:-

Lead rubber bearing (LRB) was firstly invented by Williamson in 1975. It was found in Newzeland. A variety of isolation devices including elastomeric bearings with lead core, frictional sliding bearings and roller bearings have been developed and used practically for a seismic design of buildings during the last 25 years. Among the various base isolation system, the lead rubber bearing had been used extensively. It consists of alternate layers of rubber and steel plates with one or more lead plugs that are inserted into the holes. Due to lateral forces the lead core deforms, yields at low level of shear stresses approximately 7 to10 Mpa at normal (200c) temperature, so the lead bearing lateral stiffness is significantly reduced.

Functions of Lead Rubber Bearing System

LRB has 4 main Components which are listed below

A) Load supporting function: Laminated Rubber reinforced with steel plates provides stable support for structures. Multilayer construction rather than single layer rubber pads provides better vertical rigidity for supporting a building.

B) Horizontal elasticity function: With the help of LRB, earthquake motion is converted to low speed motion. As horizontal stiffness of multilayer rubber bearing is low, strong earthquake vibration is lightened and the oscillation period of the building is increased.

C) Restoration function: Horizontal elasticity of LRB returns the building to its original position. In LRB, elasticity mainly comes from restoring force of the rubber layers. After an earthquake this restoring force returns the building to the original position.

D) Damping Function: Provides required amount of damping that is necessary.

1.3 Important terminologies

a. **Storey Displacement**: Total displacement of any storey with respect to ground and there is maximum permissible limit prescribed in IS codes for buildings.

b. **Storey Shear:** It is the sum of design lateral forces at all levels above the storey under consideration.

c. **Storey Drift:** It is defined as ratio of displacement of two consecutive floors to height of that floor. It is very important term used for research purpose in earthquake engineering

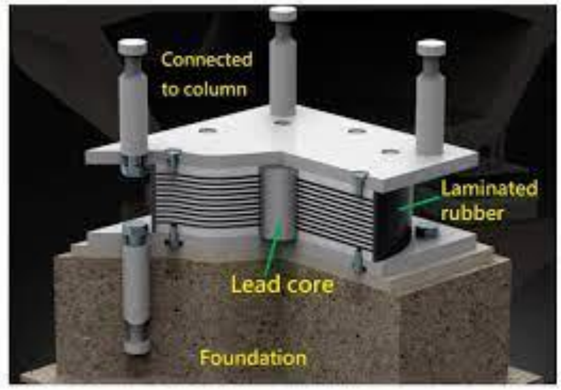

Fig1. Lead bearing rubber system connection to foundation and column

2. Objective Study

In the present study, the work includes the analysis of a P+10 storey reinforced concrete plan geometric irregular and vertical geometric irregular buildings in accordance with IS1893-2002,UBC provisions; one with fixed base and other with base isolated.

The objectives of the study are as follows;

- To carry out modeling and analysis of fixed base and base isolated building by using ETABS 19.1 version software and study the effect of seismic forces on these models.
- To carry out comparison between fixed base and base isolated building by equivalent static method and dynamic method on the bases of response properties like storey displacement, inter storey drift, storey shear and storey acceleration.
- To study the behavior of plan irregular RC building at higher seismic zone area.

3 LITERATURE SURVEY

Ioannis Kalpakidis had worked on Lead-Rubber Bearings with Emphasis on Their Implementation to Structural Design. He had published his research paper in Earthquake Engineering Society U.S.A. in 2021. The seismic design of conventionally framed bridges and buildings relies on the dissipation of earthquake-induced energy through inelastic (nonlinear) response in selected components of the structural frame. Such response is associated with structural damage that produces direct (capital) loss repair cost, indirect loss (possible closure, rerouting, business interruption), and perhaps casualties (injuries, loss of life) There are various mechanisms/devices that have been invented in the past for the protection of structures from the damaging effects of earthquakes. A lot of these devices are based on the idea of uncoupling the structures from the ground. Rollers, layers of sand, or similar materials are among the ideas proposed in the past to allow a building to slide. Such mechanisms are early versions of the now widely accepted and applied concept of base/seismic isolation. Lead-rubber bearings are one of various existing types of seismic isolation devices and have been used for years for the protection of structures from the damaging effect of earthquakes. This entry presents summarized information regarding the use, benefits, properties, and applications of lead-rubber bearings along with literature sources for further reading on the subject.

Earthquake early warning-enabled smart base isolation system" was studied by Yan-Shing L. their study paper was published in automation in construction.in 2021. Recent deployments of Earthquake Early Warning (EEW) system in Japan and some other earthquake-prone regions provide the vital warning signals prior to the arrival of destructive ground motions. The EEW system uses the different traveling speed of seismic P- and S-waves to achieve the goal of earthquake warning. This technology is primarily used to produce warning signals to alert the public to avoid potential risks, such as to evacuate from buildings. It is also used to mitigate other risks such as reducing train speed of Shinkansen trains. The present study suggests a new seismic-risk mitigation technique by connecting a base isolation system with the EEW. Base isolation is a mature technology which decouples structure from its base and lengthens its natural period of vibration. However, existing base isolation devices must possess certain lateral resistance to withstand service lateral forces such as wind, and such stiffness hinders the effectiveness of vibration isolation. In addition, supplementary damping devices are sometimes added to control excessive displacements in isolation level. This paper proposes a smart system which changes the property of a base isolation system upon EEW signal. In normal times when earthquake risk is not present, the base isolation system is locked by shear keys.

"SEISMIC ANALYSIS OF RC STRUCTURES USING BASE ISOLATION TECHNIQUE" was studied by Shameena Khannavar et.al. Their study and research paper is published in International Research Journal of Engineering and Technology (IRJET) in Volume: 03 Issue: 07 in July-2016. 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. In present study Modeling and analysis of 10 storey RC building is done in ETBS 15.1 version software for two cases. The first one is fixed base and the second one is base isolated. Two vertical irregular and Two plan irregular models are considered and analysis is done by equivalent static and response spectrum method. The Lead rubber bearing (LRB) is designed as per UBC 97 code and the same was used for analysis of base isolation system. The results obtained from analysis were Storey displacement. Storey shear, storey the inter storey drift, 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.

4 METHODOLOGY

4.1. Modeling

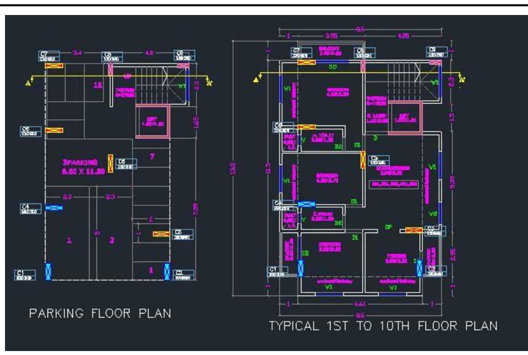

Fig. 2. Working Plan in Autocad.

4.2. Description and Modelling of building:-

1. Software used for analysis is ETABS v 9.7.1
2. Measurements are in Kn-m
3. Code Provisions as per
   - IS 456-2000
   - IS 875-1987(PART 1,2,3,)
   - IS 1893- PART 1
   - UBC 1997
4. Types of analysis performed are response spectrum analysis and time history analysis

4.3. Building details:-

- Location of site:- Ahmednagar
- Plan dimensions :- 8.5m X 13.5m
- Total number of Storeys :- 11 (Parking+10)
- Type of building :- Residential
- Structure type :- plan regular type
- Height of each storey:- 3.15m
- Total height of structure:- (3.15X11+2.55)=37.2m
- Material Properties
- Grade of concrete: - M25
- Grade of steel: - FE500
- All wall thickness:- 150 mm
- Interior beam sizes:- 230mm X 530mm
- Exterior beam sizes:- 230mm X 530mm
- Slab thickness:- 150mm

4.4. Gravity loads:-

Dead load (slab) = 25X0.15X13.5X8.5
= 430KN (3.75KN/M2)
Live load = 2 KN/M2
Floor finish load = 1.5 KN/M2
Beam load = 150 KN/M
Wall load = 20X0.15X2.7=7.9 KN/M
Parapet load = 20X0.15X1.2= 3.6 KN/M

Calculation of various design parameters

- Zone factor:-
  For Ahmednagar zone III (As per IS 1893:2002) (Clause -6.4.2)
  Z = 0.16
- Importance factor
  Building is residential building type so as per (As per IS 1893:2002) (Clause -6.4.2)
  I = 1
- Response reduction factor
  Building s special RC moment resisting frame
  R=5 (As per IS 1893:2002) (Table-7)

- Calculation of time period
  $T_{ax} = 0.09h/d^{0.5}$
  $= 0.09X37.2/(8.5)^{0.5}$
  = 1.15 sec
  $T_{ay} = 0.09h/d^{0.5}$
  $= 0.09X37.2/(13.5)^{0.5}$
  = 0.92 sec
- Average acceleration coefficient
  For Hard Soil
  Sa/g = 1/T ……….(0.4<T<4)
  = 1/1.15
  = 0.87

Damping percentage = 5%

Factor =1.00
Sa/g=0.87

- Calculation of horizontal seismic coefficient
  A_h = Z X I X Sa / (2 X R X g)
  = 0.16X1X0.87/(2X5)
  = 0.014
  Total load on structure = 32565 KN
  Base shear = V_b = 32565 X 0.014
  = 455.9 KN

The work started with modeling and analysis of RC building for two cases. The first one is fixed base and the second is base isolated. In the present study Lead Rubber Bearing is used as a base isolator. After analysis of fixed base regular or rectangular model using E-TABS 19.1 version software,

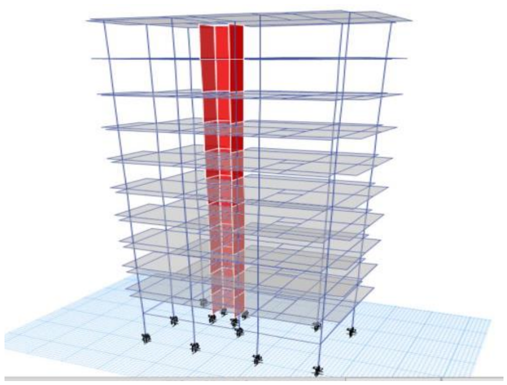

Fig. 3. Mode with fixed base made in ETABS

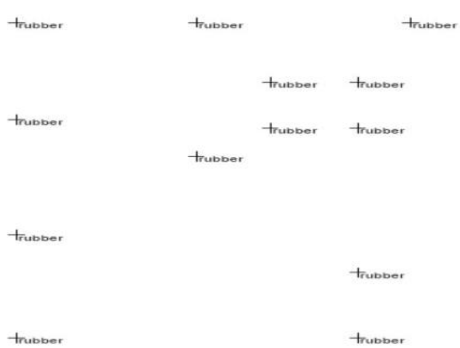

Fig. 4. Assigning isolated rubber base to model-2 in software

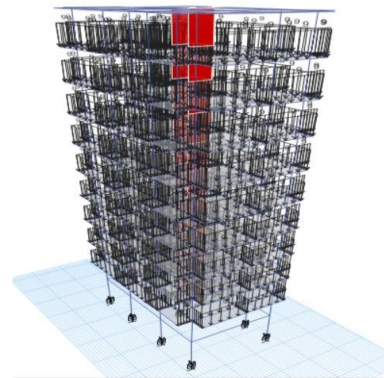

Fig. 5 Assigning wall loads and assigning slab panels in ETABS software

The above figures indicate loading applied to the stories of the building. The major loads considered are wall load and slab load. The major displacement and moment are caused due to this load. The analysis did by the software have generated some images as shown below.

5 Software Outcome

As loading is applied there will some shear force generated at the base. This shearer forces are result of loading from all the floors above and there individual floor load. The shear load generated by the software as shown below. There are loads pre calculated by the software according to pre-defined IS parameters.

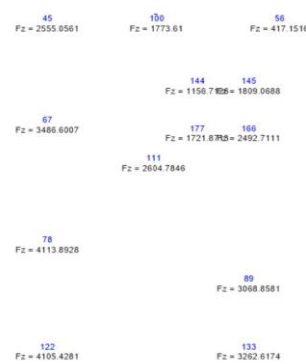

Fig. 6. Outcome of Maximum compressive loads

Table 1:- Isolator properties model-2

Required Stiffness K_{eff}	4275.83KN/M
Yield Force	351.80KN
Stiffness ratio	0.1
Damping	0.05

5 RESULTS

Analysis was done in ETBS 19.1.0 software. On the basis of analysis of data we designed for maximum compressive loaded column. And we get sizes of lead rubber bearing components are as follows

1. **Story Displacement**- In model -1 with fixed base it is observed that it has more displacement in upper floor than model-2 which is isolated base. The following graph shows model-1 and model-2 displacement on each floor. These graph are calculated from Etabs software

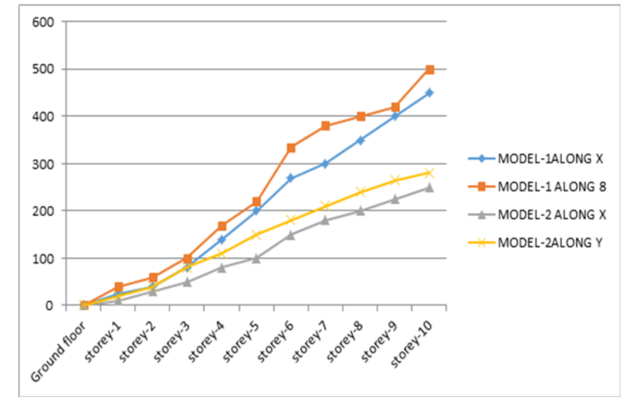

Fig.7. Storey displacement along X and Z direction in both models

After analyzing the above graph it shows the value of storey displacement along X and Z direction. All displacement values are in mm. after applying base isolator to model -2 it reduces the displacement values. Along X direction displacement is reduced by 44 %. And along Z direction displacement it is reduced by 40%

2. **Base Shear**

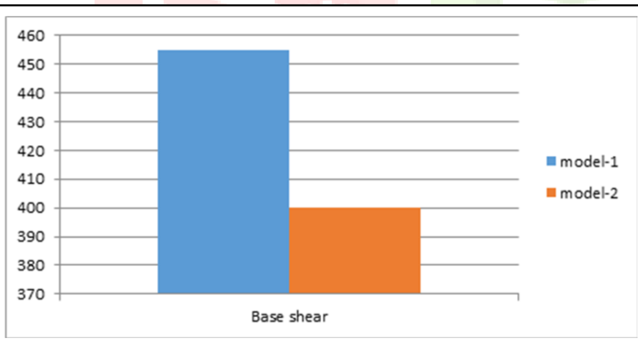

Fig.8. Graph of base shear in both models

After applying rubber to base along x-x and y-y direction there is decrement in base shear value model-2 than model-1. The value of base shear in regular structure is 455.9 KN but after applying lead rubber bearing base shear is nearly 400KN. That means it was reduced up to 88.8%

3. **Story Shear:-**

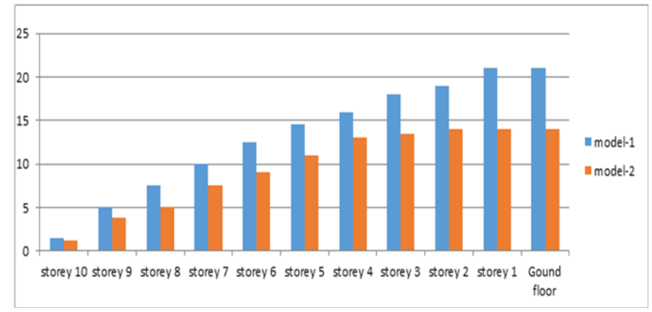

Fig.9. Graph of storey shear in both models

After applying lead rubber bearing to structure changes in story shear is reduced by 35%.

4. **Storey drift:-**

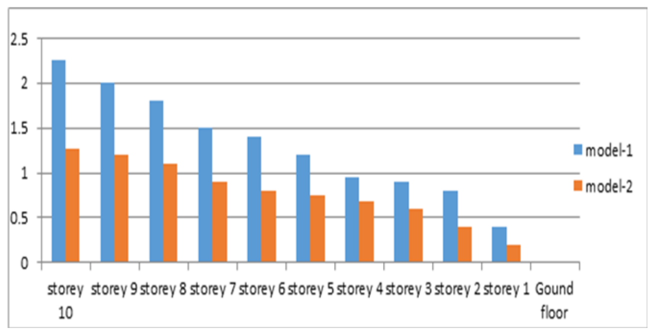

Fig.10. Graph of storey drift in both models

It is observed that story drifts in x-x direction are increased in story 1 and 2 of model-2 when compared to model-1 and in story 3 to story 11 the story drifts in x-x direction are reduced in model-2 compared to model-1 which is the effect of lead rubber bearing at base. It is important to reduce story drifts of top stories which damage structure during earthquake. In model-2 (base isolated) story drift in x-x direction at story 6 reduced by 20% when compared to model-1 (fixed base) and in model-2 storey drift in x-x direction of storey 11 reduced by 25% when compared to model-1.

6 CONCLUSION

1. After applying LRB Story shear reduced by 35%. After the lead rubber bearing (LRB) is provided as base isolation system which reduces the seismic effect on building
2. Base shear is also reduced after providing LRB which makes structure stable during earthquake
3. Story drift are reduced in higher stories which makes structure safe against earthquake
4. Point displacements are increased in every stories after providing LRB which is important to make a structure flexible during earthquake
5. Finally it is concluded that after LRB is provided as base isolation system it increases the structures stability against earthquake and reduces reinforcement hence make structure economical.

7 REFERENCES

[1] Mahdi Ghasemi, Sayed Behzad Talaeitaba, On the effect of seismic base isolation on seismic design requirements of RC structures, Structures 28 (2020) 2244–2259,2020

[2] Laril Lawline Cutinha, Pradeep Karanth, STUDY ON TIME PERIOD AS PER IS CODE USING ETABS SOFTWARE,IRJET,2019

[3] A. Martelli, M. Forni, P. Clemente, 'Recent Worldwide Application of Seismic Isolation and Energy Dissipation and Conditions for Their Correct Use' , sciencedirect,2021

[4] A.H. Barbat, L.M. Bozzo, 'Seismic Analysis of Base Isolated Buildings' , Archives of Computational Methods in Engineering, Vol. 4, 2, 153{192 (1997).

[5] Ricky W.K. Chan, Yan-Shing Lin, Hiroshi Tagawa, 'A smart mechatronic base isolation system using earthquake early warning' , Elsevier 119 (2019) 299–307

[6] Shameena Khannavar, M.H.Kolhar, 'SEISMIC ANALYSIS OF RC STRUCTURES USING BASE ISOLATION TECHNIQUE', International Research Journal of Engineering and Technology (IRJET), Volume : 03 Issue: 07 , July-2016

[7] Shoaei P, Mahsuli M. Reliability-based design of steel moment frame structures isolated by lead-rubber bearing systems. Struct J 2019.

[8] Dao D, Nguyen-Van H, Nguyen T, Chung A. A new statistical equation for predicting nonlinear time history displacement of seismic isolation systems. StructJ 2020.

[9] Skinner RI, Robinson WH, McVerry GH. An introduction to seismic isolation. London: John Wiley and Sons; 2019.