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IMPLEMENTATION OF SEISMIC ISOLATION SYSTEM IN R.C BUILDINGS

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ABSTRACT

The study of this paper is on seismic isolation. It is the most powerful technique to protect the building from structural and non-structural damages of earthquake. Seismic isolation are commonly known as Base isolation system, that is utilized is composed of elastomeric bearings such as Lead rubber bearing (LRB) with different sizes are designed. The purpose of this study deals with the structural behavior of R.C building with LRB isolators are designed for economical point of view to the required building. For this study, a 12 story RC frame building is considered and non-linear pushover analysis method is carried out up to failure of the building with using ETABS2015 software. Also compared fixed base structure and base isolated structure and various parameters like Base shear, Displacement, Story drifts of building with isolator. This comparative result shows the high effective and suitable size of isolator that can be implemented much more economical for the structures.

Keywords: *Seismic Isolation, Elastomeric Bearings, Lead Rubber Bearing, E-TABS2015.*

I. INTRODUCTION

Earthquake is the highly unpredictable and devastating of all natural disasters, causes heavy loss to both life and property if it occurs in populated regions. Building that can cause by earthquake of two main reason, they are floor acceleration for stiff building and inter-story drift for flexible buildings, so these two main important factors that can cause the building safety. Many methods for earthquake resistant structures of buildings was published to reduce the seismic effects of building and was greatly improved. New methods are mainly based on structural control. In recent times many new systems have been developed either to reduce the earthquake forces acting on the structure or to absorb a part of seismic energy. One of the most widely implemented and accepted seismic protection system is seismic isolation or base isolation. The term isolation refers to reduce the interaction between structure and the ground. The earthquake resistant structures can be categorized into rigid structures and flexible structures. In rigid structures, the control methods that are applied to withstand extreme loads are basically reducing the interstory displacement with the help of diagonal bracing, the installation of shear walls and the use of composite materials. In flexible structures, such as Base-isolated buildings, the key control approach is to reduce the excitation input with the use of dampers and isolators. The incorporation of base isolators in the structures i.e. mounting buildings on an isolators will prevent most of the horizontal moment generated by the ground at the time of earthquake from being transmitted to the structural components. This results in significant reduction in floor accelerations and inter story drifts. Installing an isolator increases the time period and damping ratio in structures to increase the energy dissipation in the system. Thus this principle of seismic isolation is based on decoupling of structures by introducing the bearings between the structure and foundation is known as base isolation or seismic isolation.

II. REVIEW OF LITERATURE

Ali Yeganehfar[1] and *Behnam Mehrparvar[2]In this paper they performedthe different nonlinear static and dynamic analysis methods and their accuracy in predicting the seismic response of structures isolated by sliding base isolators has been compared. Between these two, he concluded that the nonlinear static analysis method is quite simple and effective. The amount of computation required is very less as compared to time history analysis. In this study they compared non-linear analysis methods including pushover analysis with triangular, uniform, modal pushover analysis for 5 & 10 story model. They concluded that modal pushover analysis is the most accurate method in predicting floor acceleration and story drifts.

Numair A. Shaikh[1], Dr. Ashok S. Kasnale[2] performed non-linear time history analysis on a 3D frame model of different stories height of buildings subjected to earthquake forces. He shows the comparisons fixed base building and base isolated building with respect to different stories height. Lead rubber bearing is implemented for the structures to reducing floor acceleration and story drifts. The authors concluded that providing of base isolators in building can reduces the base shear, story drifts and story acceleration.

III. MODAL PUSHOVER ANALYSIS

Modal Push over analysis of a structure is static non-linear analysis under permanent vertical loads and gradually increasing lateral loads. This method used to consider the effects of higher modes contributions in predicting final seismic response to determine the force displacement relationship, or the capacity curve, for a structure or structural element that indicate any premature failure or weakness. The analysis is carried out up to failure, thus it enables determination of collapse load and ductility capacity. On a building frame, load/displacement is applied incrementally,and formation of hinges, and stiffness degradation is monitored. The lateral inelastic force versus displacement response for the complete structure is analytically computed. This type of analysis enables weakness in the structure to be identified.

IV. CONCEPT OF SESMIC ISOLATION

The concept of isolating structures from the damaging effects of earthquakes is not new. The first patent for a seismic isolation scheme was taken out in 1909 by Johannes Avetican Calantarients. He suggested separating the structure from the foundation. The new concept for resist the buildings is the seismic isolation or base isolation. Base isolation is a proven technology for the seismic design of structures.Base isolation is one of the most power full tools of earthquake engineering pertaining to the passive structural vibration control technologies. The goal of base isolation is to reduce the energy that is transferred from the ground motion to the structure. The ability to eliminate or very significantly reduce structural and non-structural damage. The system reduces the likelihood of structural and non-structural damage to a building subjected to seismic forces. As a result of the use of seismic isolation lives and properties has been saved. The isolation system decouples the structure from the horizontal components of the ground motion by imposing structural elements with low horizontal stiffness between the structure and foundation. The superstructure essentially acts like a rigid body with reduced inter story drifts, thus mitigating the subsequent seismic damage. Base isolation is a technique developed to prevent or minimize damage to buildings during an earthquake. This results in a significant reduction in floor accelerations and inter-story drifts, the principle of seismic isolation is to introduce flexibility at the base of a structure in the horizontal plane. In seismic isolation, the isolator bearings are placed exactly below the structure so that the building can have substantial lateral deformations. When the earthquake is happen, a major translation occurs at the ground level and the structure moves like a rigid body with small deformations within the super-structure. Thus it will increases the time period and damping ratio in structures to increase the energy dissipation in the system, so instead of increasing the seismic resistance of structures, seismic demand is reduced.

V. LEADER RUBBER BEARING (LRB)

Base isolated system that has been applied most in recent years with composed of elastomeric bearing such as lead rubber bearing. A typical laminated rubber bearing consist of alternative layers of rubbers and steel plates with one or more lead plug(core) that are inserted into the holes. Here the layers of steel plates provide vertical stiffness and layers of rubbers supply the device with high lateral flexibility. The lead core is the device that will supply extra stiffness to the isolator and appropriate damping to the system. The lead core deforms in shear providing the bilinear response also provide the initial rigidity against minor earthquake and strong winds. The design and manufacture of high-quality elastomeric (rubber) pads, frequently called bearings, that are used to support the weight of the structure but at the same time protect it from earthquake-induced forces. The rubber in the isolator acts as a spring. It is very soft laterally but very stiff vertically. The high vertical stiffness is achieved by having thin layers of rubber reinforced by steel shims. These two characteristics allow the isolator to move laterally with relatively low stiffness yet carry significant axial load due to their high vertical stiffness. The energy dissipation provided by the lead core, through yielding, allows to achieve an equivalent viscous damping coefficient up to about 30%, i.e. two times that of high damping elastomeric isolators.

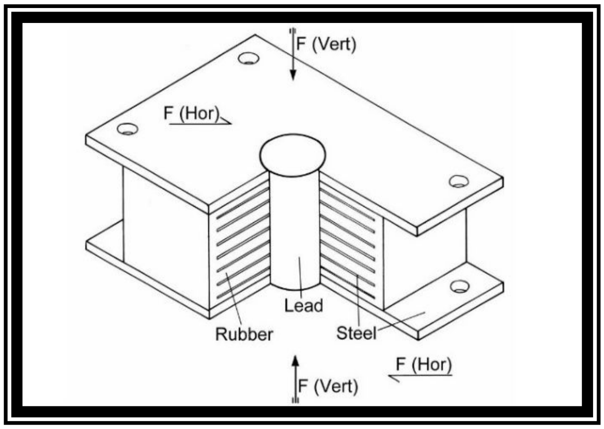

Fig 1: Lead rubber bearing isolator

PROPERTIES OF LRB

Determinant factors for the design of LRB isolator are:

- The effective stiffness (K_{eff}) of lead rubber bearing is
  $(K_{eff}) = (2\pi / T_{eff})^{2} * w/g$

Where,
(T_{eff}) = Effective fundamental period of the superstructure corresponding to horizontal translation.
W=the weight on the isolator i.e. maximum vertical reaction
Keff= Effective stiffness of the isolator

- Bearing horizontal stiffness (Kh)
  $Kh = (G \times A_{r}) / (H)$

Where,
G = shear modulus (varying from 0.4 to 1.1 MPa)
A_r = rubber layer area
H = height of LRB

- Total bearing vertical stiffness

$Kv = (G \times Si^2 \times A_r \times k \times 6) / (6 \times GSi^2 + k) H$

Where,
Si = Shape factor = 10,
k = rubber compression modulus = 2000 MPa

By considering each vertical reaction coming on the column at the base of structure, the Lead Rubber Bearing of different sizes has been designed. Here shows one of the property of this isolator.

Table 1: Properties of LRB isolator

1	Axial load on column(P)	2646 kN
2	Required Stiffness (Keff)	2660 kN/m

3	Bearing hor. Stiffness(Kh)	612.77 kN/m
4	Vertical stiffness (Kv)	397.03 mN/m
5	Yield force (F)	66.48 kN
6	Stiffness ratio	0.1
7	Damping	5%

VI. OBJECTIVES OF THE STUDY

1. The main objective of this study is to modelling and analysis of both fixed base and base isolated buildings using the method of non-linear pushover analysis with the use of E-TABS software.
2. The purpose of the work is the comparison of fixed base and isolated base structure on the basis of their properties like base shear, story drifts and lateral displacements.
3. By taking each vertical reaction from each column the Lead Rubber Isolator is to be design for economic structure.

Table no 2: Assumed Preliminary data required for the Analysis of the frame

S.NO	VERIABLES	DATA
1	Type of structure	SMRF
2	No.of stories	12
3	Plan dimensions	4m x 4m for each bay
4	No.of bays	4 on both sides
5	Floor to floor height	3.2 m
6	Bottom height	3.0 m
7	Size of column	520 x300 mm
8	Size of beam	450 x300 mm
9	Depth of slab	125 mm
10	Materials	M30, Fe500
11	Loads on beams	12 kN/m
12	Dead load	1 kN/m
13	Live load	4 kN/m
14	Specific wt of RCC	25 kN/m^3
15	Zone	V

16	Importance factor	1
17	Response reduction factor	5
18	Type of soil	Medium (ii)

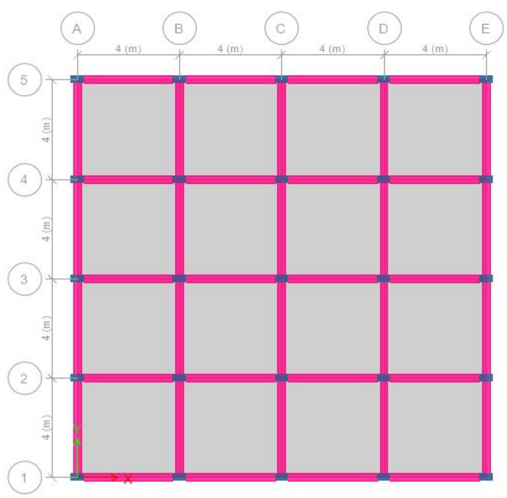

Fig 2: top view plan of fixed base structure

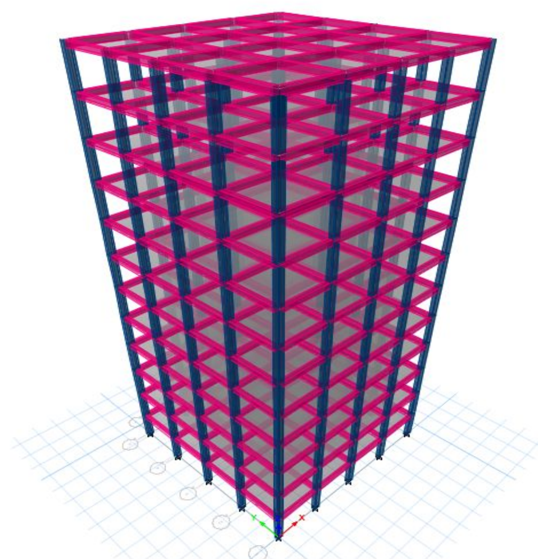

Fig 3: 3d view of fixed base structure

VII. RESULTS AND DISCUSSIONS

From this analytical results the comparative study of both fixed base and base isolated building is done. It is observed that the technique of base isolation system is very essential in order to reduce base shear, story drift and floor acceleration. Also it has been observed that when the story height increases, significantly increases in lateral displacement in fixed base building as compared to isolated building. Due to this reduction damages of structural and non-structural elements are minimized.

BASE SHEAR

In this figure the max.base shear in fixed base and base isolated buildings of both x and y directions are presented. It has been observed that the base shear of isolated building is reduced by 51% in x-direction while 58% in y-direction.

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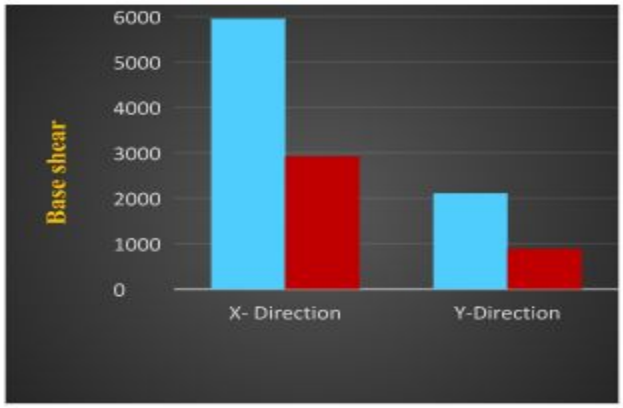

Fig 4: Comparing of base shear in x and y direction

STORY DISPLACEMENT

The figure illustrated between story height and story displacement of both fixed and base isolated building. It is observed that the lateral displacement is more in isolated building as compare to fixed base.

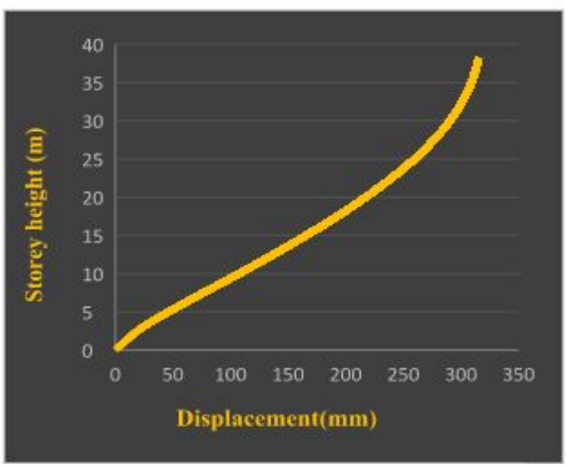

Fig 5: Fixed base lateral displacement

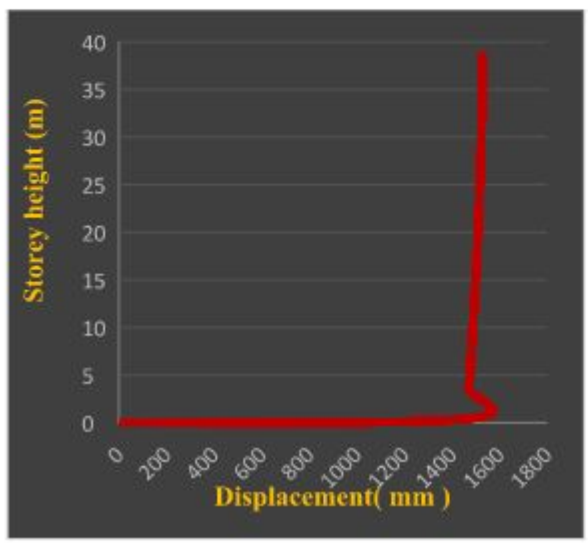

Fig 6: Base isolated lateral displacement

STORY DRIFT

The story drift of fixed base and base isolated buildings are shown in figures 7 & 8. It illustrated that the story drift in isolated base building is more compare to fixed one. When the story height is increases the story drift of isolated building is drastically decreases as compared to fixed base building.

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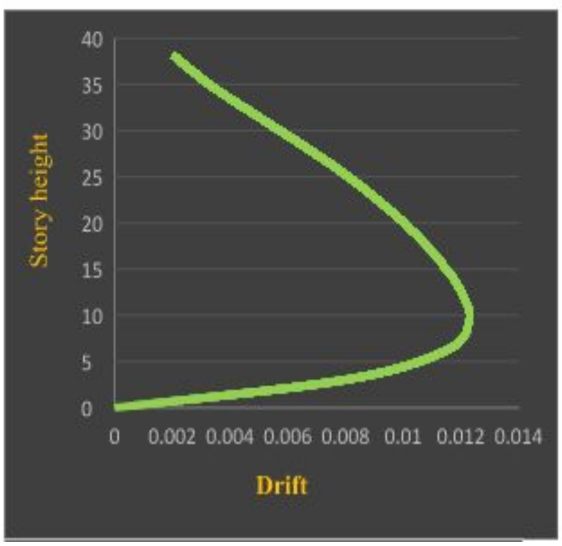

Fig 7: Fixed based Story drift

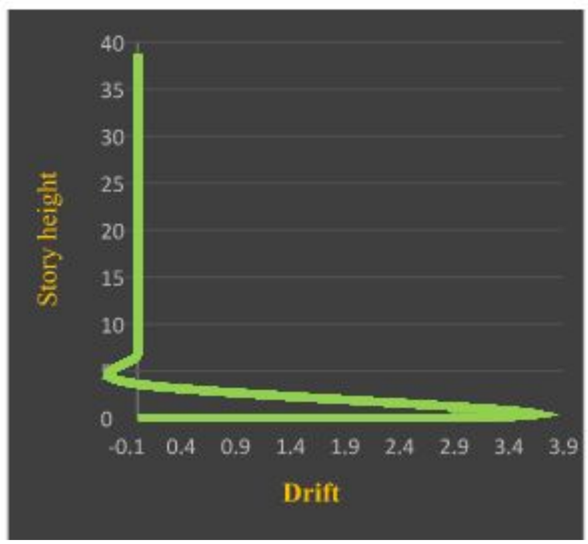

Fig 8: Base isolated Story drift

VIII. CONCLUSION

1) From analytical results, it is observed that base isolation technique is very significant in order to reduce the seismic response of 12-story RC building as compared to the fixed base building and control the damages in building during strong ground moment.

2) It has been observed that maximum base shear, story drifts decreases; whereas increase in lateral displacements were observed for bottom story then gradually decreases for top story of base isolated building as compared with fixed base building.

3) It has been observed that the base shear of isolated building is reduced by 51% in x-direction while 58% in y-direction.

4) The story drift of the isolated building is more at the base level as compared to the fixed base building. Also when the story height increases the story drifts in isolated building drastically decreases as compared to the fixed base building.

5) Finally it is concluded that base isolation system is significantly effective to protect the structural and non-structural elements too against moderate as well as strong earthquake ground motion.

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