Seismic Evaluation of High Rise Building with and without Base Isolation

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Abstract— Seismic isolation is a technique that has been used around the world to protect building structures from the damaging effects of earthquake ground shaking. Base isolation is the concept of separating the structure from the ground to avoid earthquake damage is quite simple to grasp. The term base isolation uses the word isolation in its meaning of the state of being separated and base as a part that supports from beneath or serves as a foundation for an object or structure. To study the dynamic behavior of the structure, dynamic analysis should be performed for any type of buildings such as regular and irregular with and without isolator. Dynamic analysis such as dynamic time history analysis or a linear response spectrum analysis can be performed. In the present study two 10-storey RCC buildings with and without base isolation are considered. Lead Rubber Bearing (LRB) Isolator is considered and designed as per UBC 97 code for the building. Response Spectrum Analysis is carried out for both the buildings. From this study it has been concluded that the design base shear for Base Isolated building is decreases compared to Fixed Base building, which means the structure becomes flexible leads to the energy absorption at the base level, which results in reduces the base shear. It is also found that time period in Base Isolated model is increased compared fixed base model, which means it reduces the possibility of resonance of the structure, and displacement at bottom is zero compared to Base Isolated building due to flexibility at base.

Key words: Base Isolation, Regular RCC Building, LRB, Response Spectrum Analysis

I. INTRODUCTION

Earth quake is a shaking of the ground caused by movement of the tectonic plates relative to each other, both in direction and magnitude. During earthquake attacks, the traditional building structures in which the base is fixed to the ground, respond with a gradual increase from ground level to the top of the building, like an amplifier. This may result in heavy damage or total collapse of structures. To avoid these results, while at the same time satisfying in-service functional requirements, flexibility is introduced at the base of the structure, usually by placing Lead Rubber Bearing isolators between the structure and its foundation. Seismic base isolation is the one of best method among the lateral load resisting systems. The term base isolation uses the word isolation in its meaning of the state of being separated and base as a part that supports from beneath or serves as a foundation for an object or structure. The system namely Lead Rubber Bearing (LRB) selected for this study includes sample of materials such as plate, rubber and central core. It has been selected to establish an innovative simplified design procedure for isolators incorporated in multi-storey building structures. Recent studies have shown that most isolated buildings is important to use multi-layer Laminated Rubber Bearings with steel reinforcing layers as the load carrying component of the system.

A. *Objectives of the Work*

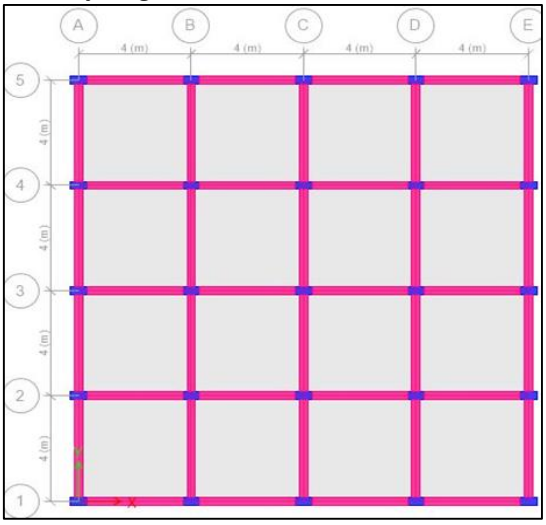
To compare the response of the building such as Time period, Base shear, Acceleration and Bottom displacement, for 10 storied RC regular building with and without base isolation by considering the Response Spectrum Analysis using Etabs-2013.

II. STRUCTURAL MODELLING & ANALYSIS

ETABS is a sophisticated, yet easy to use, special purpose analysis and design program developed specifically for building systems. ETABS Version 2013 features an intuitive and powerful. The ETABS building is idealized as an assemblage of area, line and point objects. Those objects are used to represent wall, floor, column, beam, and brace and link/spring physical members. The basic frame geometry is defined with reference to a simple three-dimensional grid system. Material properties such as concrete, rebar and section properties such as beam, column are defined as frame element and slab element defined as area element. Modal analysis and response Spectrum analysis are carried out.

A. *Building Configuration*

In the present study, Two buildings with and without base isolation Are considered. Number of storey considered for each building is 10-storey located in V zone is taken for study. Plan layouts of each building include 4 base of size 4x4m and bay height 3.2m.



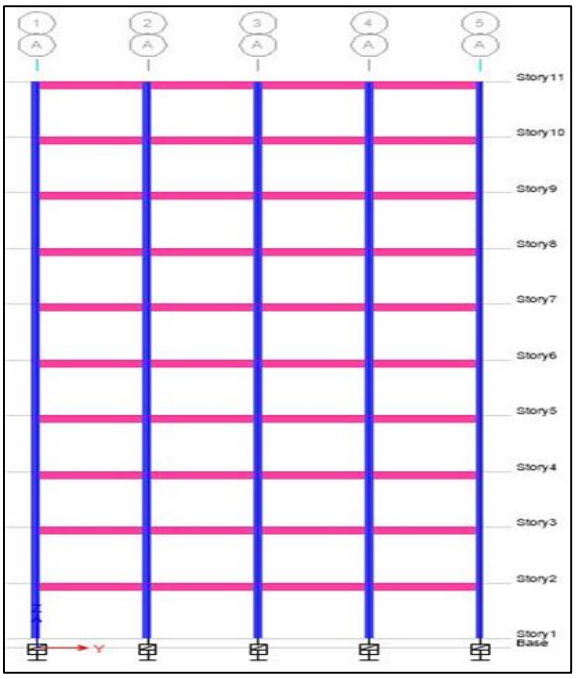
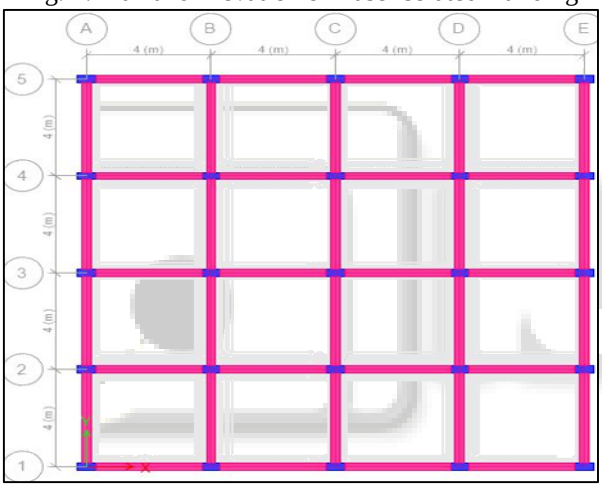


Fig. 1: Plan and Elevation of Base Isolated Building



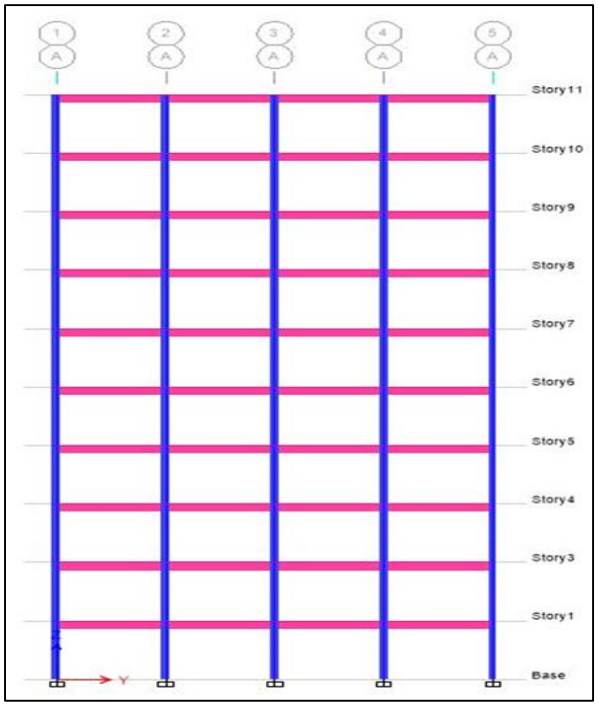


Fig. 2: Plan and Elevation of Fixed base Building

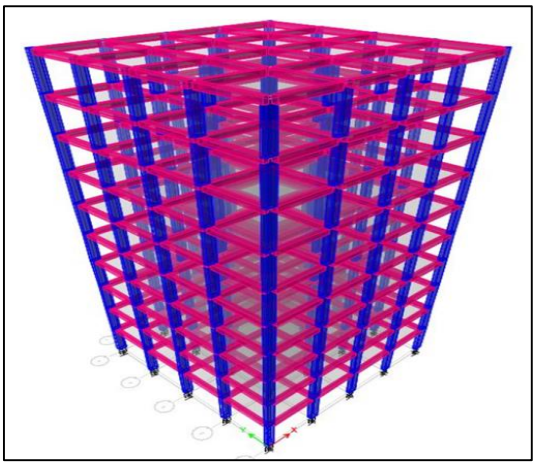


Fig. 3: 3D view of Building

B. Geometry Properties and Material Properties

Number of bays	4 No.
Spacing in x direction	4m
Spacing in y direction	4m
Beam sizes	300X450 mm
Column sizes	300X600 mm
Slab thickness	150 mm
Live load	3 kN/m^2
Floor finish	1 kN/m^2
Wall load	18.97 kN/m
Parapet	6.5 kN/m^2
Concrete grade	M30
Steel grade	Fe-500
Poisson's ratio	0.2
Density of concrete	25 kN/m^3
Density of Bricks	20 kN/m^3

Table 1: Building Details

C. Properties of LRB Used for Analysis

Lead Rubber Bearing Isolators are designed as per UBC 97 by considering maximum service load acting on column.

Properties of LRB design	**LRB Isolator properties**
Axial Load on column (P) kN	7920
Effective vertical stiffness (k_v) kN/m	1773103.88
Damping (ε)	0.10
Effective horizontal stiffness (k_h) kN/m	6050.07
Pre yield stiffness (k_u) kN/m	42498.49
PYSR (Kd/Ku)	0.10
Yield force of lead plug (Qd) kN	170.89

Table 2: Isolator Properties

III. RESULTS AND DISCUSSION

A. Base Shear Variation:

The base shear of both buildings obtained by Response spectrum analysis is presented in figure-4. The variation of which is studied with respect to building with fixed base and building with base isolated. Base shear is the total design Lateral force at the base of structure

Models	**Base Shear (kN)**
Fixed	1450.82
Base Isolated	1055

Table 3: Maximum base shear (kN) for different models

By the use of Base isolation at the base level of the structures, the structure becomes flexible which leads to energy absorption at the base level, which result in reduction the base shear for base isolated building. Hence from Figure-4 it is clear that, base shear in Base Isolated model is decreased by 27.28% compared to fixed model

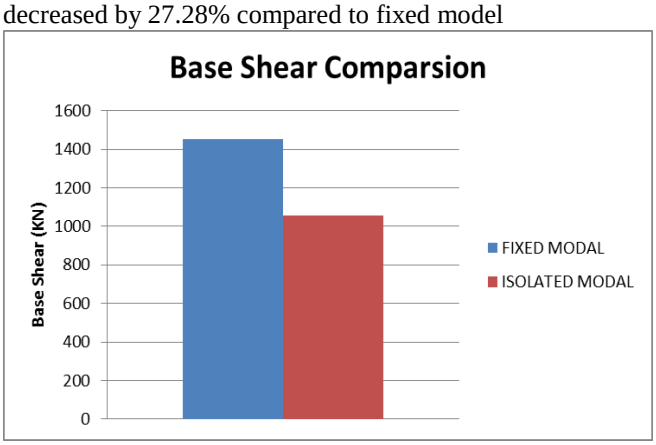


Fig. 4: Base Shear Variation

B. Time Period Variation:

The time period variations are studied with respect to with and without base isolation buildings, which are obtained from response spectrum analysis

Modes	Fixed	Base Isolated
Mode 1	2.287 sec	3.038 sec
Mode 2	1.746 sec	2.408 sec
Mode 3	1.745 sec	2.404 sec

Table 4: Time period for Base Isolated and Fixed models (Critical 1st 3 modes)

Figure-4 it is absorbed that, time period in Base Isolated model is increased by 24.72% (M1), 27.49% (M2) and 27.41% (M3) compared to fixed base model. This shows that the installation of isolator in building considerable increases the time period of the structure, which means it reduces the possibility of resonance of the structure

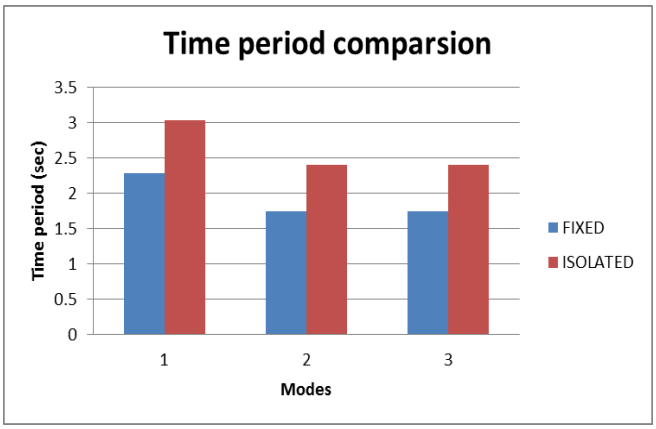


Fig. 5: Time period variation3.3 Bottom Displacement

Form the analysis the maximum story displacement variation are studied For both fixed and isolated building, the top and bottom displacement are tabulated below

Storey level	Fixed	Base Isolated
Bottom Displacement (mm)	0	8

Table 5: shows the Top and Bottom Storey Displacements

For fixed base building due to fixity there is no displacement at the base hence zero displacement & for base isolated building due to flexibility at the base there is a considerable displacement at the base i.e. 8 mm.

C. Acceleration Variation

The acceleration variation for both buildings are obtained by response spectrum analysis are studied, the maximum storey acceleration for both with and without base isolation buildings are tabulated below.

Models	Acceleration (mm/sec^2)
Fixed	756.71
Base Isolated	358.13

Table 6: Shows the Maximum Acceleration

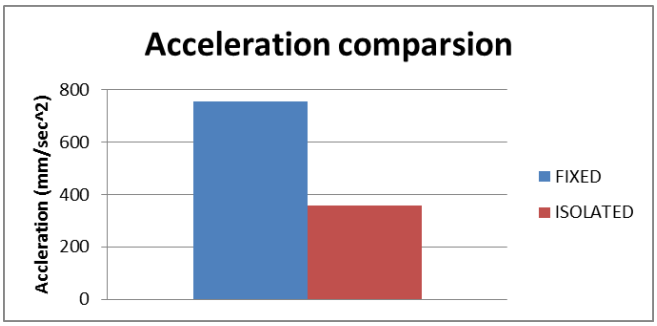


Fig. 6: Acceleration variation

The fig 6 shows the variation of maximum roof acceleration for both building the Response spectrum analysis of Base Isolated building shows a considerable is 52.67% decrease in the acceleration responses as shown in figure-6.5 as compared to the Fixed base building.

IV. Conclusion

Seismic response and characteristics of an isolated and non-isolated building is studied using the finite element method by ETABS-2013.

1) By the Response Spectrum Analysis it is observed that base isolation increases the flexibility at the base level of the building.
2) The base isolation has high efficiency in decreasing the base shear compared to fixed base building. As result of the increased flexibility of the system, time period of the structure is also increases.
3) By the use of Base Isolation at the Base level of structures, the structure becomes flexible which leads to the energy absorption at the base level, which results in reduces the base shear. Hence from Response Spectrum Analysis it can concluded that design base shear for Base Isolated building is decreases by 27.28% compared to Fixed Base building.
4) From Analysis it is absorbed that, time period in Base Isolated model is increased by 24.72% (M1), 27.49% (M2) and 27.41% (M3) compared Fixed base model. Which means it reduces the possibility of resonance of the structure.
5) By the use of LRB as the time period increases, acceleration decreases. Hence the acceleration becomes in lower due to the higher time period occur, So from analysis acceleration is decrease by 52.67% as compared to the Fixed base building.
6) Bottom displacement of isolated building is zero compared to Base Isolated building

7) From above all studies, Finally, we can say that incorporation of base isolation is necessary for design load reduction and structural safety.

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