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Design of Multistorey Building using Lead Rubber Bearing (LRB) in sap 2000

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***Abstract*-Base isolation has become a traditional concept for structural design of buildings and bridges in high risk areas. By introducing flexible isolation system between the foundation and the structure the system will absorb the shock impact effects of earthquake with the help of its flexibility. This way the seismic energy transmitted to the structure will be reduced to greater extent and the structure will remain stable for a relative period. Elastomeric bearings are widely used by structural engineers, but their behaviour is not well understood. The paper provides a brief description of the state of knowledge throughout the world with respect to these bearings and process of base isolation. It summarizes the material behaviour of elastomers and the theoretical and experimental research on bearings. It notes the various modes of failure, and the major design methods are described and compared. There are wide variations in standard practice throughout the world, and the contradictions and reasons behind the variations are noted. The objective of the paper is to help the structural engineer get a better understanding of the design and selection of base isolators.This study is about 7 storied building and is analysed for two cases. First case is fixed base and second case is base isolated (lead rubber bearing). for this study Sap 2000 along with various standard codes is taken into consideration. For base isolator parameters F.Naeim and J.M. Kelly is used.**

***Keywords*-Response spectrum; Dynamic analysis; Lead rubber bearing; High damping rubber bearing; Response spectrum; Time history; Seismic base isolator; Base isolation, lead-rubber bearing, response spectrum analysis, storey acceleration, floor displacement, storey drift, base shear.**

I.INTRODUCTION

Base isolation has become a traditional concept for structural design of buildings and bridges in high risk areas. By introducing flexible isolation system between the foundation and the structure the system will absorb the shock impact effects of earthquake with the help of its flexibility. This way the seismic energy transmitted to the structure will be reduced to greater extent and the structure will remain stable for a relative period. Rubber bearing and lead rubber bearing are prime factors used to introduce flexibility in the structure. This increased the natural period of the structure and base displacement is more than prearranged limit. Though, base isolation not always liable to work against the strong earthquakes as it may result in larger displacement at the base of the structure. Fig below shows the performance of building with and without isolation.

Basic principle of base isolation is to differentiate the building from its foundation. During the seismic action, building is unaffected from the ground motion. In other words, even though ground moves aggressively, the building will tend to move ideally as a rigid body rather than collapsing. This reduces the floor hastening and storeygliding and so the building components are less harmed. Any stiff structure will have short period. During the ground movement, amount of acceleration entrusted in the structure is the same as that of ground acceleration that results in zero displacement between the structure and the ground. In other words, ground and structure will move with equal amount.

Base isolation increase the flexibility of the structure and hence increases the period of the structure which is due to the isolators. By introducing base isolation in a structure increases the displacement and eventually decreases the acceleration in the structure as the stiffness of the structure also decreases. Generally, the isolation is placed at the base of the structure, Base isolation protects the building components of the superstructure during earthquakes. So flexible structure will have longer life spa.

The principle in base isolation,

- To provide horizontally flexible as well as vertically stiff to the building.
- To lengthen the natural period of the building.
- Damping in the Isolation system reduces the displacement.
- It also reduces in the acceleration of the story.

Base isolation system should contain following:-

- An elastic mount to add enough vibration periods to the structure to lower down the forces in the structure over.
- An energy dissipater or damper to ease the deflection taking place between the structure and the ground.
- Introducing the stiffness against the seismic actions and wind loads.

Base isolation is required if any circumstances arise of the following:-

- Need to increase the safety of the structure.
- Low lateral seismic forces needed.
- Any existing building is not capable to withstand any earthquake.
- Withstand small earthquakes without any damage.
- Structure will not collapse in high level earthquake but some structural and non-structural damage will occur

II. ANALYSIS AND DESIGN

Various methods available for analysis are

- Equivalent Static Analysis
- Response Spectrum Analysis
- Linear Dynamic Analysis
- Non Linear Static Analysis
- Non Linear Dynamic Analysis

we use response spectrum method. In this method the peak responses of a structure during an earthquake is obtained directly from the earthquake responses. The maximum response is plotted against the undamped natural period and for various damping values, and can be expressed in terms of maximum relative velocity or maximum relative displacement. (DUGGAL). A Response Spectrum is a curve plotted in between response of a single degree freedom and oscillator of varying period to a specific earthquake motion. It plots a graph between acceleration, Velocity or displacement response. Damping is assumed, spectra may be generated in the structure. response based on soil type and Zone factor and various other parameters are derived from code

1. Problem Statement

7 storied buildings is modelled using Sap 2000. This building is off were rectangular geometry as shown below. They are loaded with Dead, Live and Seismic Forces (according to IS:1893). This model is then analysed using response spectrum method in sap 2000 with following values.
Earthquake zone V
Importance Factor (I) =1
Damping Ratio is assumed to be 5%
The comparison is recorded via sap 2000

The following assumptions were made before the start of the modelling procedure:

- Only the main block of the building is considered. The staircases are not considered in the design procedure.
- The building is to be used for residential purposes, so we mainly focus on the response of the frame configuration.
- At ground floor, slabs are not provided and the floor is resting directly on the ground.
- For all structural elements, M30 & Fe 415 are used.
- The footings are not designed. Supports are assigned in the form of either fixed supports (for fixed base building) or link supports (for base isolated building).
- Seismic loads are considered in the horizontal direction only (X & Y) and the loads in vertical direction (Z) are assumed to be insignificant.

Initially, Total load of the structure, W = 1107 kN. The fixed base time period of the frame is, T = 0.86 s. Assuming a time period separation of 3, the fundamental time period of the frame is 2.25 s. Initially, Total load of the structure, W = 1107 KN. The fixed base time period of the frame is, T = 0.86 s. Assuming a time period separation of 3, the fundamental time period of the frame is 2.25 s.

Assuming a damping of 10% for the isolator, the response spectrum provides a value of Sa /g = 0.42 for T = 2.58 s
Base shear (W/g) Sa = 0.42×0.36×1107 kN = 167.38 kN
Sd (maximum base displacement) = (Sa×Tb2)/2g = 0.42×0.36×9.81X 2.58X2.58= 28.22 cm Isolator is designed for W = 1107 kN. Assuming the mass of the isolator to be negligible in comparison with the mass of the structure, effective stiffness of the isolator is

$$\text{Keq} = \frac{4\pi^2 W}{gT^2} = \frac{4x\pi^2 x1170}{9.81x2.58^2} = 670 \text{ kN /m}$$

Yield force,

$$Q_d = \frac{W_D}{4xS_d} = \frac{\pi}{2}\times K_{eff}\times \in_{eff} \times S_d$$

$$= \frac{\pi}{2}\times 670\times 0.1\times 0.28$$

$$= 29.46kN$$

The post yield horizontal stiffness,

$$K_d = K_{eff} - \frac{Q_D}{S_D}$$

$$= 669.267 - \frac{29.46}{0.28}$$

=564.05kN/m
Yield displacement,

$$D_y = \frac{Q_D}{9\times K_d} = \frac{29.46}{9\times 564.05}$$

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$F_y = Ku \times Dy = 10K_d \times D_y = 32.72$ kN

$F_m = Q_D + K_d \times S_d = 187.394$

$K_u = F_y / D_y = 5641.38$ kN/m

$K_{eff} = F_m / S_d = 669.25$ kN/m

III. MODELLING

1. Description of Models

Height of Building = 21.7m (G+6)
Height of each Storey = 3.1m
In X-direction = 5 bay of 4m length
In Y-direction = 4bay of 4m length

Grade of concrete = M30
Grade of steel = Fe415
Density of concrete = 25KN/m3
Beam size = 350mmx400mm
Outer Column = 550mmx500mm
Slab Thickness = 150mm
Wall Thickness = 230mm
Dead load = Column, Beam, Slab
Live load = 2KN/m2
Floor Finish = 1KN/m2
Soil Profile type = Medium
Seismic Zone Factor = Zone 5
Response Reduction Factor = 5.0
Importance Factor = 1.0
Damping = 5.0

Properties of isolator are calculated by using above formulas.

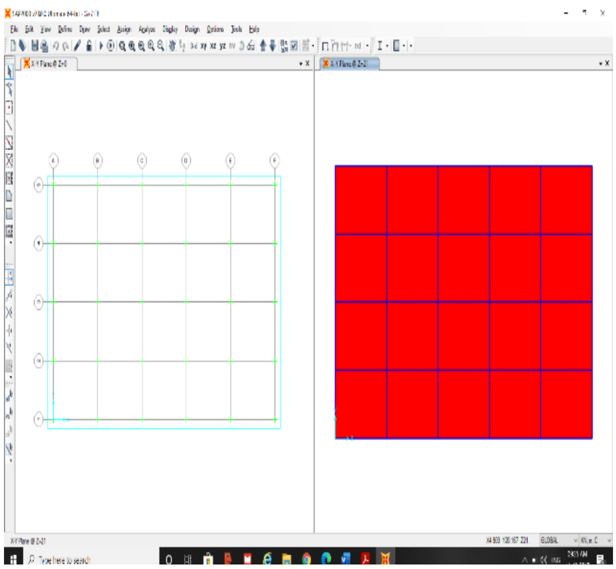


Fig no. 1. Top view of model.

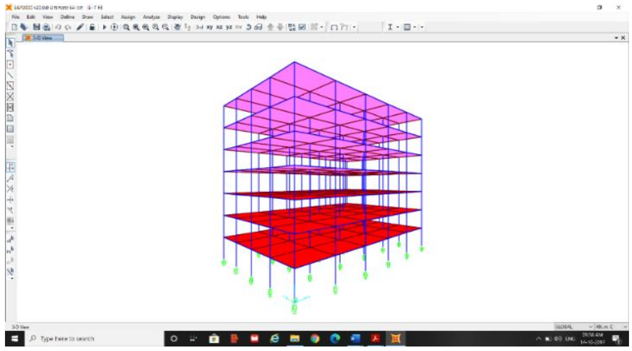


Fig no 2. 3D view of model.

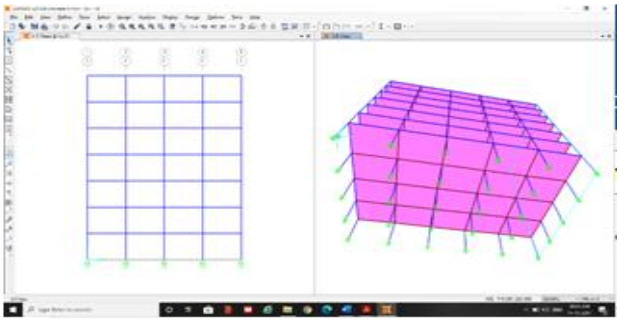
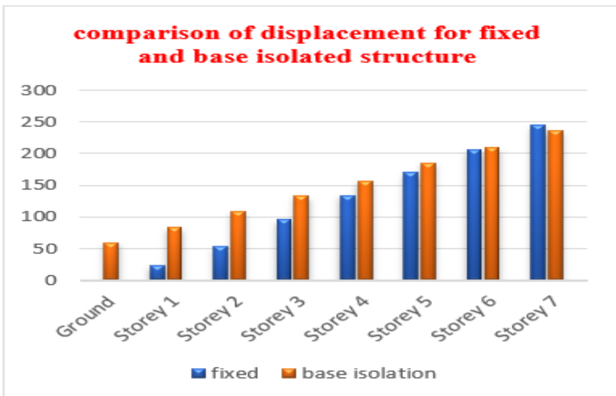


Fig no. 3. Model showing lead rubber bearing (LRB).

IV. RESULT

Table 1. Storey displacement with fix base and base isolator.

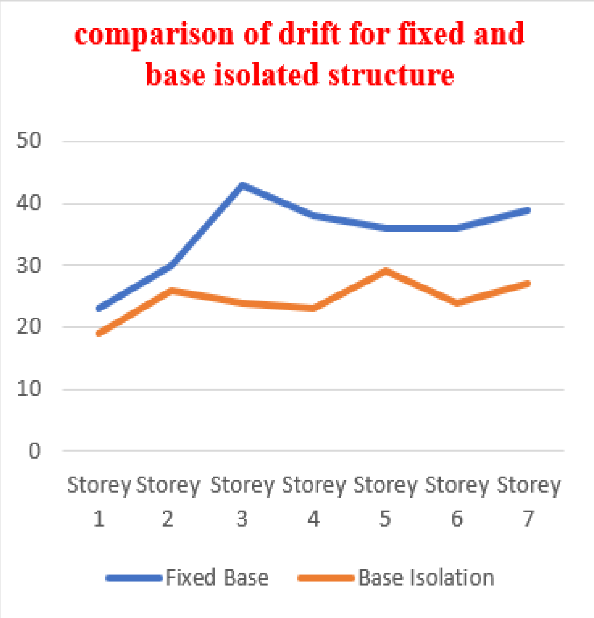
Storey	Fixed base building (m)	Base isolated building (m)
Storey 7	0.245	0.236
Storey 6	0.206	0.209
Storey 5	0.170	0.185
Storey 4	0.134	0.156
Storey 3	0.096	0.133
Storey 2	0.053	0.109
Storey 1	0.023	0.083
Ground	0.000	0.064



By using base isolation (LRB) technique top story displacement reduce to approximately 10 % as compare to fixed support structures.

Table 2. Storey drift with fix base and base isolator.

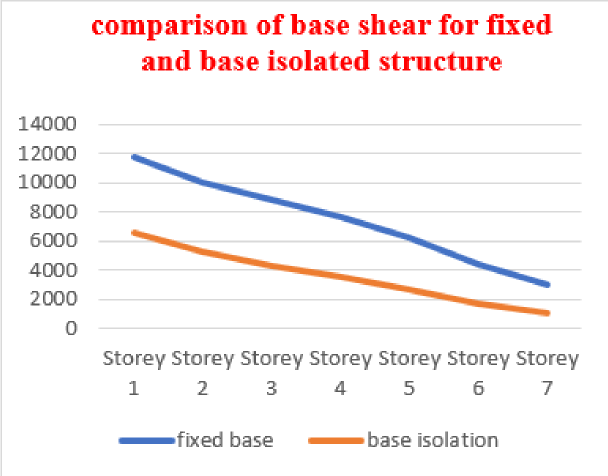
Storey	Fixed base building (mm)	Base isolated building (mm)	Percentage reduction
Storey 7	39	27	30.76
Storey 6	36	24	33.33
Storey 5	36	29	19.44
Storey 4	38	23	39.47
Storey 3	43	24	44.18
Storey 2	30	26	13.33
Storey 1	23	19	17.39



By using LRB system as base isolator inter story drift reduce 30 to 40% as compare to fix support structures

Table 3. Base shear with fix base and base isolator.

Storey	Fixed Base (KN)	Base isolated (KN)	%age reduction
Storey 7	3066.13	1096.14	35.75
Storey 6	4387.72	1705.94	38.88
Storey 5	6210.55	2658.73	42.81
Storey 4	7635.86	3566.71	46.71
Storey 3	8902.94	4341.96	48.77
Storey 2	10063.88	5266.42	52.33
Storey 1	11734.32	6526.62	55.62



By using LRB system as base isolator base shear reduce to approximately 65% as compare to fix support structures

V. CONCLUSION

In this dissertation work an attempt has been made to check the performance of RC frame building with and without isolator. Push over and nonlinear time history analysis is carried out to compare the results. Response study of ten story building considering three different models namely fixed base, and base isolated both LRB and FPS systems.
Following major conclusions are drawn on the basis of analysis of results-

- Top story displacement is decreased for the isolated base model compare to fixed base model.
- Story drift is reduced for the isolated base models compare to fixed base models.
- Base shear is reduced for the isolated base models compare to fixed base models.
- Structural response of the building is reduced in isolated base models compare to fix base model.
- Mode period increases in isolator when compared with fixed base building, Because, flexibility is more in isolator than the fixed base.
- The main factor governing the building is its story drift. The study shows that the drift is significantly reduced in base isolated buildings.
- From the above conclusion it is clearly shown that the performance of the base isolated structures are significantly better than the fixed base structures.

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