Earthquake Analysis of Structure by Base Isolation Techniques using Etabs Software

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Abstract: Base Isolation design is one of the latest technology used in a structure to resist the seismic waves caused by earthquake. The present work attempts to differentiate between base isolated structure and conventional method. Base isolator is a device which decouples a super structure from its substructure resting on a shaking ground thus protecting structural and non-structural components. This project deals with design modeling and analysis of G+6 RCC frame structure. Building displacement and acceleration are compare for both methods. For analysis ETABS software is used and for designing of base isolator 1893:2002 (part 1) and design of seismic isolated structure (F.Naeim and J.M.Kelly) is used.

Keywords: Base isolation, Lead rubber bearing, seismic effect, response spectrum analysis, floor displacement, storey drift, base shear.

1. INTRODUCTION

Earthquakes causes drastic disaster of thousands of human lives and national wealth due to the destruction of structures. To reduce the destruction of structure many methods have been invented. Here we are going to deal with advance techniques of earthquake resistance by reducing earthquake generated forces acting upon the structure. Severity of ground shaking at a given location during an earthquake can be minor, moderate and strong which relatively speaking occurs frequently, occasionally or rarely. Design and construction of a building to resist the rare earthquake shaking that may come only once in 500 years or even once in 2000 years at a chosen project site even though life of the building itself may be only 50 to 100 years is too expensive. Hence, the main intention is to make building earthquake-resistant such that it resists the effect of ground shaking by getting damaged severely but not collapsing during strong earthquakes. Thus the safety of people and contents is assured in earthquake-resistant buildings. This is a major objective of seismic design codes throughout the world.

1.1Earthquake

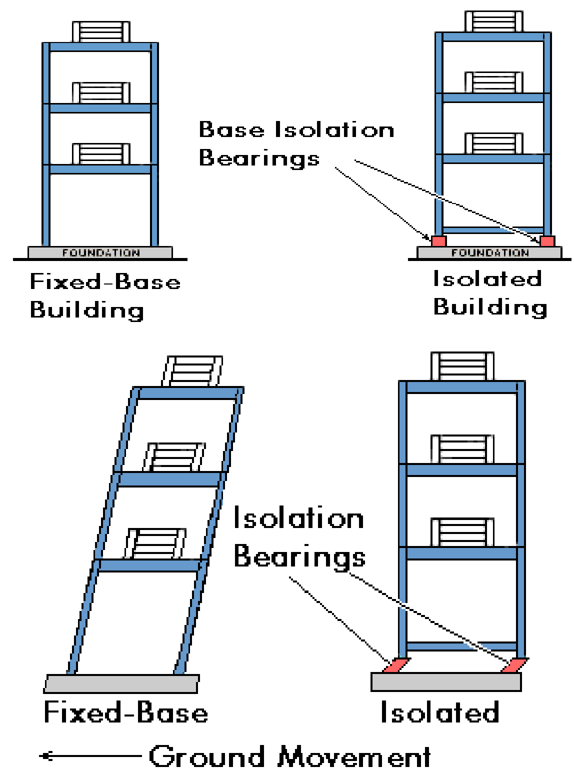
Pune, formerly known as Poona is the eighth largest metropolis and the second largest in the state of Maharashtra after Mumbai. The city is an academic, administrative and industrial center situated 560 meters above sea level on the Deccan plateau at the confluence of the Mula and Mutha rivers. As per the 2010 census of India, the population of the Pune urban area is around 5,518,688. Pune is emerging as an Information Technology hub, presence of automobile and manufacturing companies resulted to rank as the eight largest metropolitan economy and the sixth highest per capita income in the country. Pune has a mixed type of building stock from modern steel structures to old historic buildings. The city core areas are densely populated with a mix of various building types. Pune lies very close to the seismically active zone around Koyna Dam, about 100 km (62 mi) south of the city, and has been rated in Zone 4. Pune has experienced some moderate-intensity and many low-intensity earthquakes in its history. Earthquakes felt in Pune with a magnitude of more than 3.0.

1.2Base Isolation:

The concept of base isolation technique had been suggested in last few decades and the available technologies and the knowledge of base isolation system are getting mature and well established. Seismic isolation systems are more effective when applied to high stiffness, low-rise buildings, owing to their abilities to alter the characteristic of the building from rigid to flexible. An increasing number of structures to be isolated reflect the fact that base isolation system is gradually becoming accepted as a proven technology in earthquake hazard mitigation. Lead-plug bearings are made up of low-damping elastomers and lead cores with diameters between 15% to 33% of the bonded diameter of the bearing. Laminated-rubber bearings supplies the required displacements for seismic isolation by combining laminated-rubber bearings with a lead-plug insert, which provides hysteretic energy dissipation, the damping required for a successful seismic isolation system can be incorporated in a single compact component. The maximum shear strain range for lead-

Plug bearings varies as a function of manufacturer but is generally between 125% and 200%. LRB isolators have cylindrical rubber bearings, which are reinforced with steel shims. Shims and rubber is placed as alternate layers. Steel plates are also provided at the two ends of the isolator. The steel shims boost the load carrying capacity, thus the structure is stiff under vertical loads and flexible under horizontal loads.

The fundamental principal of base isolation system is to rectify the response of the structure so that the ground can move below the structure without transferring these motions into the superstructure. In an ideal system for the supple this separation would be total. But In the existing world there is a need to have some contact between the superstructure and sub structure.



Types of base isolators

-Lead Rubber Bearings: Lead rubber bearing (LRB) are the laminated rubber bearing containing one or more lead plugs to deform in shear. The lead in the bearing deforms physically at a flow stress of 10 MPa, providing the bearing with bilinear response. For that reason the lead must fit tightly in the elastomeric bearing, and this is achieved by making the lead plug slightly larger than the hole and applying force at the time of inserting it in the hole.

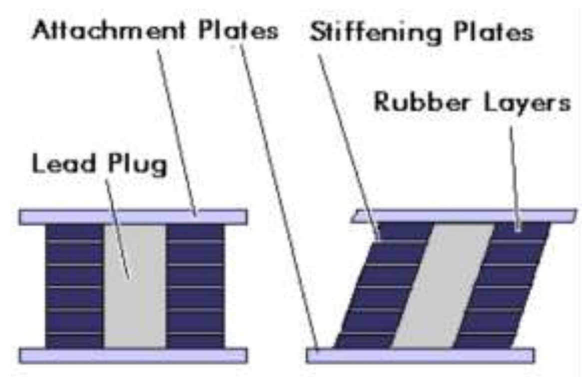
-High Density Rubber Bearings: High density rubber bearing (HDRB) is another type of elastomeric bearing which consist of thin layers of high damping rubber and steel plates in alternate layers. Like LRB this type of bearing does not contain lead at the center of bearing. The rubber used is either natural rubber or synthetic rubber which provide a sufficient amount of damping.

-Friction Pendulum System: The friction pendulum system (FPS) is a sliding type isolation system and consists of a spherical stainless steel surface and an articulated slider, covered by Teflon based composite material. It works on the principal of simple pendulum. Friction Pendulum bearings are seismic isolators that are installed between a structure and its foundation to protect the supported structure from earthquake ground shaking.

-Lead rubber isolation bearing

The earthquake is a disruptive disturbance that cause shaking of surface of the earth due to undergoes moment along a fault plane or from volcanic activity is called Earthquake. Earthquake resistant structure is structure designed to withstand earthquakes. While no structure can be entirely immune to damage from earthquakes. Base isolation is a most effective method for earthquake resisting structure.

"Earthquake doesn't kill folks, folded building do." The Indian landmass contains a history of devastating earthquakes. The most recent version of unstable seismic zoning map of India given within the earthquake resistant design code of India [IS 1893 (Part1) two002] divides India into four unstable zones (Zone 2, 3, 4 and 5), with Zone five expects the best level of seismicity whereas Zone two is related to very cheap level. Every zone indicates the results of Associate in Nursing earthquake at a selected place supported the observations of the affected areas and may even be delineated employing a descriptive scale like changed Mercalli intensity scale or the Medvedev-Sponheuer-Karnik (MSK) scale. The MSK intensity generally related to the varied unstable zones is VI (or less), VII, VIII and IX (and above) for Zones two, 3, 4 and 5, severally, like most thought-about Earthquake (MCE). Zone 5, that is mentioned because the terribly High injury Risk Zone within the IS code, assigns zone issue of zero.36 toit, that is indicative of effective (zero period) peak horizontal ground accelerations of zero.36 g (36% of gravity) which will be generated throughout MCE level earthquake during this zone. The state of Kashmir, the western and central Himalayas, the North-East Indian region and also the Ran of tannic acid fall during this zone.



2. ANALYTICAL MODELING

Among all methods available for analysis we use response spectrum method. This method is the linear dynamic analysis 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 un damped natural period and for various damping values, and can be expressed in terms of maximum relative velocity or maximum relative displacement. (Duggal S K, 2010). 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.

2.1 Problem Statement

- Analysis of Design of RCC structure by response spectrum method and time history method .
- G+6 RCC residential structure
- Area= 4448.876 sq.ft
- Fe 500
- M25
- Slab thickness = 125mm
- Column size =300×600mm
- Beam size = 230×450mm
- Live load= 2KN/m2
- Floor finish= 1.5 KN/m2
- Wall thickness external =230mm
- Wall thickness internal =115mm

3. Modeling

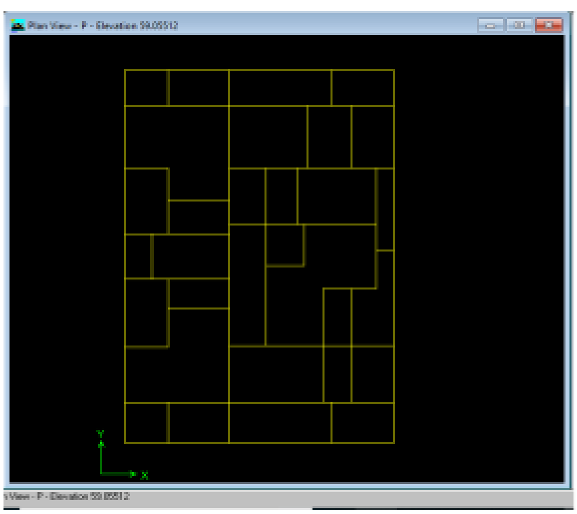


Image no 3.1 Plan for modeling

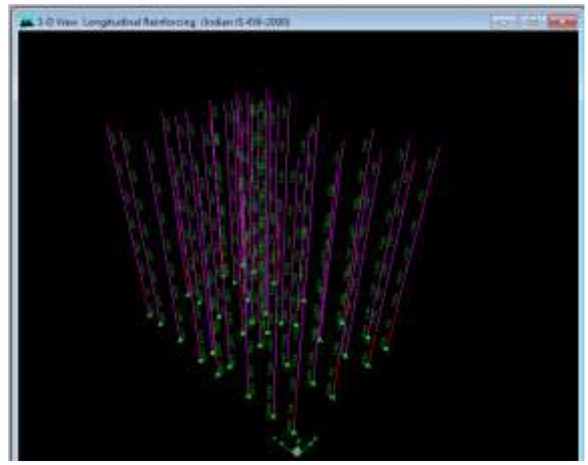


Image no 3.2 Column with isolators

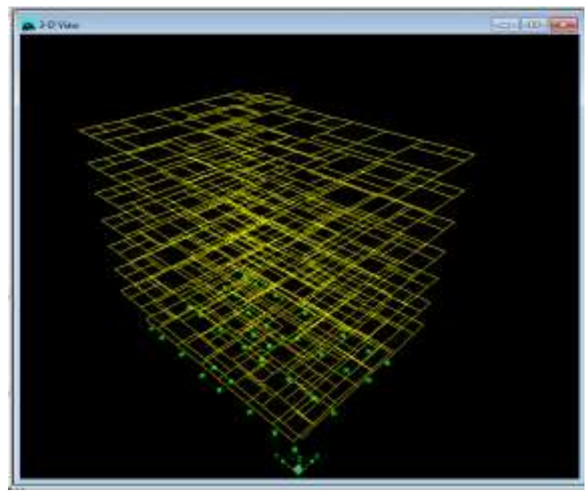


Image no 3.3 Beam with isolators

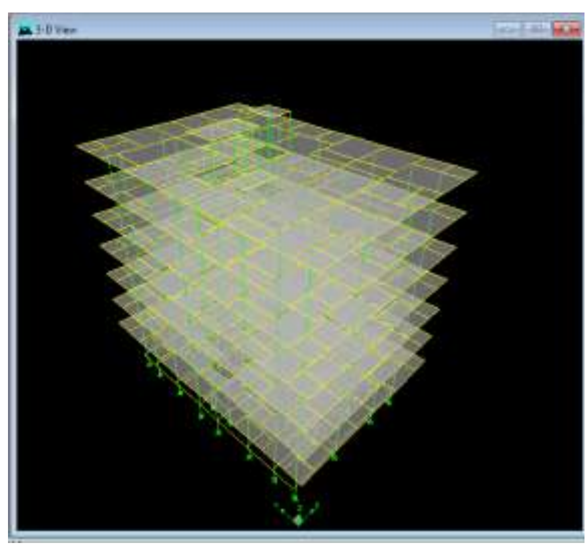


Image no 3.4 3D model with isolators

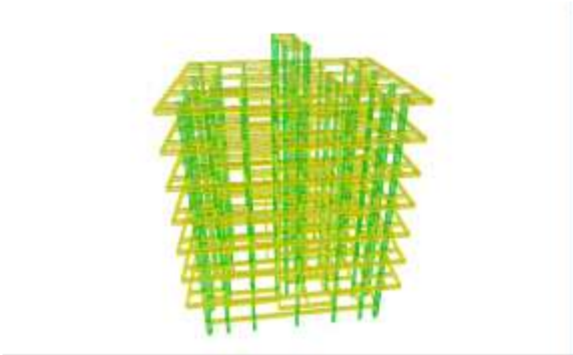


Image no 3.5 Extrusion

4. ANALSYISIS AND RESULTS

Following are the load combinations considered in this analysis

1)1.5(DL+LL)

2)1.2(DL+LL+EQX)

3)1.2(DL+LL-EQX)

4)1.2(DL+LL+EQY)

5)1.2(DL+LL-EQY)

6) DL+1.5EQX

7) DL-1.5EQX

8) DL+1.5EQY

9) DL-1.5EQY

10)1.2(DL+LL+WINDX)

11)1.2(DL+LL-WINDX)

12)1.2(DL+LL+WINDY)

13)1.2(DL+LL-WINDY)

14) DL+1.5WINDX

15) DL-1.5WINDX

16) DL+1.5WINDY

17) DL-1.5WINDY

Table no 1. storey drift of different stories in X direction

Storey	Fixed Base Building (KN)	Lead Rubber Bearing (KN)	Percentage variations
S 9	0.0010005	0.0009304	7.534394
S 8	0.00131	0.0012049	8.722716
S7	0.0017851	0.0016015	11.46425
S 6	0.0021953	0.001998	9.874875
S 5	0.0025041	0.0023031	8.727367
S 4	0.0026416	0.0024632	7.242611
S 3	0.0026416	0.0026233	0.697595
S 2	0.0022673	0.0028064	-19.2097
S 1	0.000655	0.0025547	-74.361
Base	0.0000288	0.0000381	-24.4094

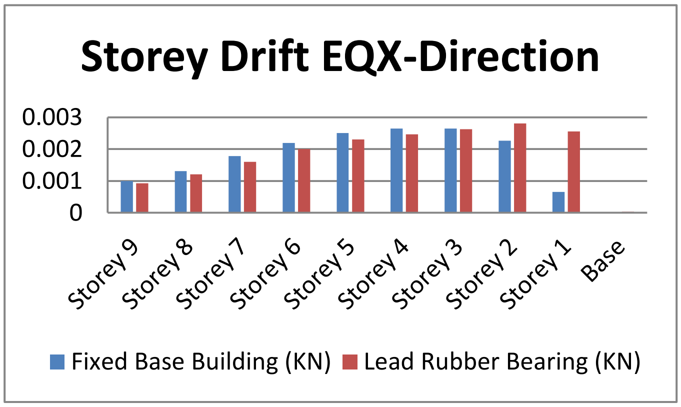


Table no.2 storey drift of different stories in Y direction

Storey	Fixed Base Building (KN)	Lead Rubber Bearing (KN)	Percentage variations
S 9	0.0009404	0.0008873	5.984447
S 8	0.0012864	0.0011959	7.567522
S 7	0.0017754	0.0016511	7.528314
S 6	0.0022042	0.00206	7
S 5	0.0025503	0.0023764	7.317792
S 4	0.0027158	0.0025692	5.706056
S 3	0.0027685	0.0027544	0.511908
S 2	0.0023698	0.0028393	-16.5358
S 1	0.0006996	0.0024677	-71.6494
Base	0.000015	0.0000386	-61.1399

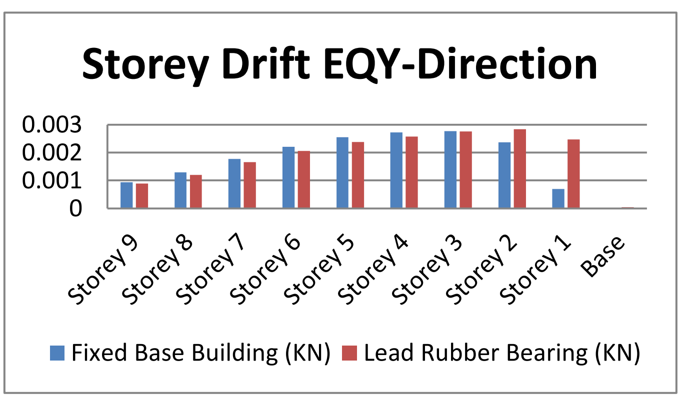


Table no.3 storey shear of different stories

Storey	Fixed Base Building (KN)	Lead Rubber Bearing (KN)	Percentage variations
S 9	2.22	1.96	13.26531
S 8	44.51	37.52	18.63006
S 7	311.56	283.45	9.917093
S 6	620.9	573.86	8.197121
S 5	849.69	781.23	8.763104
S 4	1007.58	923.45	9.110401
S 3	1110.69	1021.23	8.760025
S 2	1162.25	1068.64	8.759732
S 1	1181.59	1086.41	8.760965
Base	1181.59	1086.4 1	8.760965

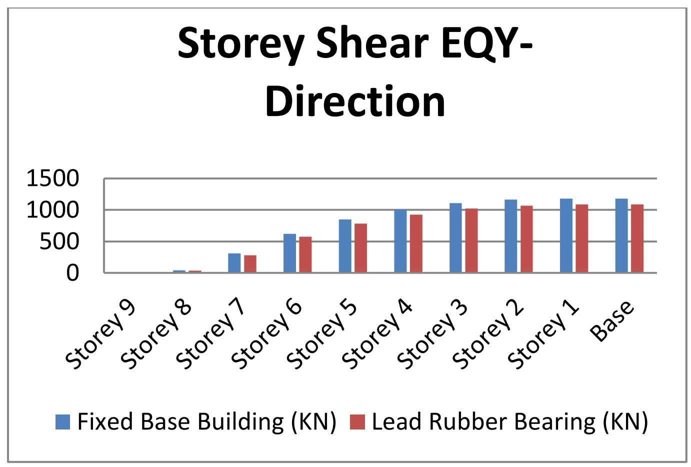
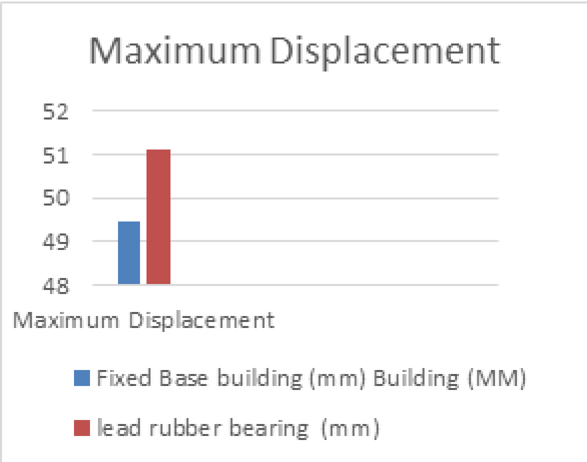


Table no.4 maximum displacement for different stories

Displacement	Fixed Base building (mm) Building (MM)	lead rubber bearing (mm)	Percentage variations
Maximum Displacement	49.44	51.11	3.377832



5. CONCLUSION

As comparing both the models by linear response spectrum analysis following conclusions are being made.

- Due to providing base isolation (LRB) decrease in shear is observed as compared to fixed base.
- Base shear is also reduced after providing LRB which makes structure stable during earthquake.
- Story drift are reduced in higher stories which makes structure safe against earthquake.
- Displacements are increased in every story after providing LRB which is important to make a structure flexible during earthquake.
- Natural periods are increased which reduces earthquake forces on the shaking.

So we can conclude that base isolation structures are the best solution for earthquake resistance.

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