Response Control of RC Frame Building Using LRB Isolator For Seismic Loading

Shah Richa U
Dept of Civil Engineering
Sardar Patel College of Engineering, Bakrol

Abstract- *Base isolation is a quite sensible structural control strategic design in reducing seismic responses. The response of structures can be controlled under earthquake actions by installing isolators. The aim of the response spectrum process is to minimize the maximum floor acceleration of the building. Under consideration, lead rubber bearing have been chosen for inserting isolator link element in structural base. Analyses will be performed using a ETAB software to study the influence of isolation damping on base and superstructure. A comparative analysis is presented for evaluating the behavior of the structure subject to seismic events. The important parameters of isolators are: ground motion characteristic by considering peak ground acceleration(PGA) to peak ground velocity(PGV) ratio; characteristic strength,Qd of the LRB isolator normalized by the weight acting on the isolator; flexibility of isolator by varying post yield time period,Td and yield stiffness(Ku) to post yield stiffness(Kd) ratio. For a specified ground motion, smaller MID and MIF are regarded as indicator of better seismic performance. The purpose of analysis is to investigate the most favorable parameters of the LRB for minimum earthquake response of the structure for different ground motions. Finally the recommendations will be made which are useful for the preliminary isolation design of the structure with LRB isolator.*

Keywords- Base isolation, LRB, ETABS, ground motion characteristic

I. INTRODUCTION

A natural calamity like an earthquake has taken the toll of millions of lives through the ages in the unrecorded, and recorded human history. A disruptive disturbance that causes shaking of the surface of the earth due to underground movement along a fault plane or from volcanic activity is called earthquake. The nature of forces induced is reckless, and lasts only for a short duration of time. Yet, bewildered are the humans with its uncertainty in terms of its time of occurrence, and its nature. However, with the advances made in various areas of sciences through the centuries, some degree of predictability in terms of probabilistic measures has been achieved. Further, with these advances, forecasting the occurrence and intensity of earthquake for a particular region, say, has become responsibly adequate, however, this solves only one part of the problem to protect a structure – to know what's coming! The second part is the seismic design of structures – to withstand what's coming at it! Over the last century, this part of the problem has taken various forms, and improvements both in its design philosophy and methods have continuously been researched, proposed and implemented.

1.1 Base I isolation

The term base isolation uses the word isolation in its meaning of the state of being separated and part that support from beneath or serves as a foundation for a structure.In practice, isolation is limited to a consideration of the horizontal forces to which buildings are most sensitive. Vertical isolation is less needed and much more difficult to implement.

The advantage of base isolation system is the ability to significantly reduce damage of structural and non-structural elements to improve the security of buildings, building components, and architectures to reduce seismic design acceleration. This potential advantage can be used for structures with high stiffness, such as low and medium-rise building, nuclear power plants, bridges, and etc.

1.2 Lead Rubber Bearing

This base isolation system provides the combined features of vertical support, horizontal flexibility, restoring force and damping in a single unit. A lead robber bearing is formed of a lead plug force fitted into a pre-formed hole in an elastomeric bearing. The lead core provides rigidity under service loads and energy dissipation under high lateral loads. When subjected to low lateral loads such as minor earthquake the lead-rubber bearing is stiff both laterally and vertically.

A major advantage of the lead rubber bearing is that it provides energy absorbing capacity through additional hysteretic damping in yielding of the lead core that reduces the lateral displacement of the isolator, especially under ambient vibrations. The LRB is generally represented by nonlinear characteristics following a hysteretic nature. The characteristics of lead material have been considered in the production of LRB isolator.

1.3 Response Spectrum Method

Response spectrum method is applicable for those structures where modes other than the fundamental one affect significantly the response of the structure. Generally the method is applicable to analysis of dynamic response of structures, which are asymmetrical or have area of discontinuity or irregularity.

This method is based on the fact that for certain forms of damping, which are reasonable models for many buildings, the response in each natural mode of vibration can be computed independently of the others and the modal response can be combined to determine thetotal response.

1.4 Time History Analysis

Time history analysis is a step by step analysis of the dynamic response of a analysis of a structure to a specified loading that may vary with time. Time history analysis is used to determine the seismic response of a structure under dynamic loading of representative earthquake.

This method calculates response of structure subjected to earthquake excitation at every instant of time. Various seismic data are necessary to carry out the seismic analysis namely acceleration, velocity, displacement data etc., which can be easily procured from seismograph deta analysis for any particular earthquake. It is an important technique for structural seismic analysis especially when the evaluated structural response is nonlinear. In time history analyses the structural response is computed at a number of subsequent time instants. In other words, time histories of the structural response to a given input are obtained as a result. THA of structures is carried out when the input is in the form of specified time history of ground motion.

II. OBJECTIVE AND SCOPE OF STUDY

2.1 Objective:

The general objective of this study is to modify the response of the building by using base isolation, so that the ground can move below the building without transmitting these motions into the building

The following specific objectives were addressed by this study:

- Reducing damaging deformations in structural and non
- structural component. Reducing acceleration response to minimize the damage.
- To compare Dynamic characteristics such as Natural time period (Ta), story drifts, displacements.
- Protection of Building Frame
- Provide for an Operational facility after the Earthquake
- Protection of Life **-** Safety of occupants
- Improvement for Safety of Building

2.2 scope of study

- To carry out analysis of Single story, G+2 story and G+4 story RC frame with LRB isolator and with fixed base by equivalent static method, response spectrum method and time history analysis as per the provision of IS 1893 (part 1) : 2002 using computational software ETABS 17.0.1.
- For time history analysis four earthquake data are taken:
  1) Imperial valley Earthquake (1940)
  2) Chamoli (Gopeshwar) Earthquake (1999)
  3) Loma Prieta Earthquake (1989)
  4) Northridge Earthquake (1994)
- To compare Lateral forces**-** story shears, base shear, computed as per the provisions of code IS 1893 in LRB base and fixed base.
- To compare Dynamic characteristics such as Natural time period (Ta), story drifts, displacements, acceleration.
- To study the structure response with LRB base and with Fixed base with different earthquake data.

III. PROBLEM FORMULATION

For comparing RC frame with fixed base, RC frame with base isolation a single story, G+ 2 stories, G+4 stories building is modeled in the ETABS software.

3.1 Building data

Floor height : 3 m
Column size : 0.23 × 0.45 m
Beam size : 0.23 × 0.41 m
Slab thickness : 0.125 m
Grade of steel : Fe 415
Concrete grade : M-25

- Dead load
  - ✓ Self weight of : 1 kN/m^2
  - ✓ Floor finish : 1 kN/m^2
  - ✓ DL on roof : 1.5 kN/m^2

- Live load
  - ✓ Typical floor : 3 kN/m^2
  - ✓ LL on roof : 1.5 kN/m^2

Table 3.1: parameter for designing lead robber bearing

	Single story	G+2 story	G+4 story
Effective damping	0.05	0.05	0.05
Assumed time period T (sec)	0.573	2.571	5.052
Design displacement : D_D (m)	202	908	1.785
Effective stiffness : K_e (kN/m)	2320	1670	1436
Energy dissipated per cycle : W_D (kN)	110	1297	4310
Post yield stiffness : K_2 (kN/m)	1720	1270	604.2

3.2 Structure is subjected to earthquake motion for

Imperial valley Earthquake (1940)
Chamoli (Gopeshwar) Earthquake (1999)
Loma Prieta Earthquake (1989)
Northridge Earthquake (1994)

3.2.1Acceleration

Table 3.2: Acceleration data

EQ	Acceleration					
	G+4 story		G+2 story		Single story	
	Fixed base	LRB	Fixed base	LRB	Fixed base	LRB
Chamoli	423.3	250.74	329.31	299.03	528.98	141.23
ELCX	470.66	264.02	443.24	390.53	559.57	177.94
CAPX	399.28	270.72	448.09	387.45	529.9	178.46
CNPX	506.4	274.61	439.45	430.53	530.52	191.61

- For different earthquake data acceleration values are shown in table.
- For Loma Prieta Earthquake accelerationvalue reduce by around 41% in LRB base than fixed base system.
- The behavior of other three time history is same as Loma Prieta Earthquake time history.

3.2.2 Displacement

- For Loma earthquake data displacement in isolated base is increase than fixed base.
- For G+2 RC frame structure displacement in LRB isolator increase by 74% in X & Y direction than fixed base system.
- Same as in G+4 RC frame structure displacement in LRB isolator increase by 41% in X & Y direction.

Table 3.3: Displacement data

EQ	Displacement					
	G+4 story		G+2 story		Single story	
	Fixed base	LRB	Fixed base	LRB	Fixed base	LRB
Chamoli	69.99	119.0	8.97	34.9	1.696	47.58
ELCX	22.81	16.82	10.82	22.31	0.87	77.31
CAPX	30.28	18.33	13.75	24.95	1.491	88.07
CNPX	29.6	20.0	13.2	27.3	1.267	116.07

3.2.3 Story shear

- Story shear for loma earthquake data reduced in isolated base than fixed base. For G+2 RC frame structure story shear in LRB isolator reduced by 50% in X & Y direction than fixed base system.
- Same as in G+4 RC frame structure story shear in LRB isolator reduced by 24% in X & Y direction

Table 3.4: Story Shear data

EQ	Story shear					
	G+4 story		G+2 story		Single story	
	Fixed base	LRB	Fixed base	LRB	Fixed base	LRB
Chamoli	229.3	175.4	100.2	57.42	70.481	22.11
ELCX	109.16	18.19	67.93	58.24	36.31	12.78
CAPX	143.57	8.12	81.87	58.91	61.94	13.20
CNPX	144.3471	24.3914	81.037	66.3084	52.6524	14.4716

IV. CONCLUSION

It is observed that the LRB isolated system is quite effective in reducing the displacement and acceleration of building as compared to fixed base system.

The time period for isolated base system is 2 to 4 times more than the fixed based system at this range the response of the structure is minimum.

The isolated base system is found to be effective in reducing the story shear of building as compared to fixed base system.

Story shear in isolated base system can be reduced by 70 to 75% than the fixed base system

V. ACKNOWLEDGEMENT

It is great pleasure and privilege to have an opportunity to take this project work entitled “**RESPONSE CONTROL OF RC FRAME BUILDING USING LRB ISOLATOR FOR SEISMIC LOADING”.** I would like to express my heart full thanks and deepness of gratitude to my research work guide **Mr. Chetan Machi,** professor of SPCE, Bakrol and co guide **Mr. Vishal Patel**, professor of BVM, V.V.Nagar for their inspiring guidance and valuable suggestions that have given throughout this work.

I would express our heart felt appreciation to **Mr. Mohitsagar** (HOD of civil Engineering Department, SPCE, Bakrol) for their tehnical guidance & support.

Last but not the least, I am grateful to our family & friends to provide support & guidance mentally as well as financially to finish & submit our work successfully.

REFERENCES

[1] SwapnilAmbasta, Dushyantsahu, G.P. Khare “ANALYSIS OF THE BASE ISOLATED BUILDING (LEAD PLUG BEARING)in ETABS” (2018) (IRJET)volume:05 issue: 01

[2] Amar Hassen, Shilpa Pal “Performance Analysis of Base Isolation & Fixed Base Building” (2017) (IFERP)

[3] BhavnaBalahandran, Susan Abraham “Effete of Base Isolation in Multi-storied RC Building “ (2018) (IOSRJEN) Volume:08, issue 6, (VII), Pg No. 84-93

[4] OmkarSonawane, Swapnil B. Walzade “Effect of Base Isolation in Multistoried RC Regular & Irregular Building using Time History Analysis” (2018) (IJOER) volume: 4, issue-5

[5] Chandak N.R. “Effect of base isolation on the response of Reinforced concrete Building”(2013) (journal of civil engineering and research)

[6] AamirRiyaz Dar, Simranjit Singh “Dynamic analysis of the base isolated tall building system (lead rubber Bearing) in etabs” (2019) (IJCIET) Volume 10 Issue:03

[7] N.H. Hamid, I.F. Azmi and S. Shin “Trends of Using Based Isolation System in High Seismic Regions” (2018) International Journal of Applied Engineering Research ISSN 0973-4562 Volume 13

[8] ShameenaKhannavar, M.H.Kolhar “Seismic analysis of rc structures using base isolation technique” (2016) (IRJET) Volume: 03 Issue:07

[9] YogeshSonawane, ChetanChitte, SnehalShisode, PrachiKagane “Analysis and Design of Base Isolation for Multi Storied Building Using Lead Rubber Bearing” (2018) (IJREAM)

[10] m.sharbatdar, s. hoseini, g. ghodratiamiri, h. naderpour “Seismic Response of Base-Isolated Structures with LRB and FPS under near Fault Ground Motions” (2011)

[11] Tiwari, A.K., Kumar, A. and Khan, M.A. (2017), “A review of Improving Seismic Performance of Structures by Isolation System, International Research Journal of Engineering and technology, 4(4), 2376-2380.

[12] Buckle, I.G., (2000), “Passive Control of Structures For Seismic Loads” 12th World Conference of Earthquake Engineering, Paper No. 2825.

[13] IS 1893 part 1:2002

[14] Book of design of seismic isolated structures, wiley publication, author farzadnaiem&james M. kelly