Response Control of RC Frame Using LRB base Isolator For Seismic Load

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Abstract- *In case of dynamic analysis of RC frame buildings, the various important dynamic characteristics of building namely, the natural frequency or simply time period (T, seconds),lateral displacement, story shear and of RC frame buildings using ETABS software. In this, an approximate procedure is generated to perform the seismic analysis of RC frame building system with base isolation (lead-rubber bearings) system and the outcome compared with the results obtained without base isolation (lead-rubber bearing) of RC frame buildings. Base isolation system is basically a passive control device which decouples the super structure from substructure resting ground motion by insinuating structural elements with low horizontal stiffness between the structure and foundation. This analysis of G+2 and G+4 RC frame building with four earthquake data, First is Chamoli earthquake, second is Northridge earthquake, third is Loma Earthquake and fourth is imperial valley earthquake with simple RC frame with fixed base and with base isolation (LRB). The effectiveness of base isolation in every cases is compared with simple RC frame building with fixed base. This analysis is done by using ETABS software and for design purpose of base isolated system and for seismic design of isolated structures1893:2002 (part 1) is used.*

Keywords- Base isolation, ETABS, Time history analysis, LRB.

I. INTRODUCTION

An earthquake is the shaking of the surface of the Earth due to underground movement along a fault plane or from volcanic activity.

The severity of the shaking can range from barely felt to violent enough to loss people around

An Earthquake is the result of Sudden release of energy in the Earth's crust creates seismic waves, which causes vibration of the ground and structures resting on it

Depending on the characteristics of these vibrations, the ground may develop cracks, fissures and settlements.

Shaking and ground rupture are the main effects, principally resulting in more or less severe damage to buildings and other rigid structures.

1.1 Base isolation

It is a system that may be defined as a flexible or sliding interface positioned between a structure and foundation, for the purpose of decoupling the horizontal motions of the ground from the horizontal ground motions of the structure, thereby reducing earthquake damage to the structure and its content.

Base isolation system absorbs and deflects the energy released from earthquake before it is transferred to the structure.

1.2Lead Rubber Bearing

Lead Rubber Bearings (LRB) is a type of base isolation employing a heavy damping. The basic components of LRB are steel and rubber plates, built through vulcanization process in alternate layers. The dominant feature of LRB is parallel action of linear spring and damping. The LRB is characterized with high damping capacity, horizontal flexibility and high vertical stiffness. The relatively low shear stiffness in the horizontal plane is provided by the rubber, and the high vertical stiffness is provided by steel shims to control the bouncing effect on the structure due to vertical vibration caused by the earthquake. The steel shims also help to confine the rubber from bulging out. The damping constant of the system varies considerably with the strain level of the bearing. The system operates by decoupling the structure from the horizontal components of the earthquake ground motion by interposing a layer of low horizontal stiffness between the structure, and its foundation. The isolation effects in this type of system are produced not by absorbing the earthquake energy, however by deflecting through the dynamics of the system. Usually, there is a large difference in the damping of the structure, and the isolation device, which makes the system non-classically damped.

1.3 Principle of base isolation

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. Although each earthquake is unique, it can be stated in general that earthquake ground motions result in a greater acceleration response in a structure at shorter periods than at longer period. A seismic isolation system exploits this phenomenon by shifting the fundamental period of the building from the more force-vulnerable shorter periods to the less force vulnerable longer periods. The principle of seismic isolation is to introduce flexibility in the basic structure in the horizontal plane, while at the same time adding damping elements to restrict the resulting motion. In an ideal system, the isolation would be total. In the real world, there needs to be some contact between the structure and the ground. A building that is perfectly rigid will have a zero period. When the ground moves, the acceleration induced in the structure will be equal to the ground acceleration and there will be zero relative displacement between the structure and the ground. Thus, the structure and ground moves by same amount.

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, story drifts, displacements.
- 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+3 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) using computational software ETABS 17.0.1.
- For time history analysis four earthquake data are taken:
    - Imperial valley Earthquake (1940)
    - Chamoli (Gopeshwar) Earthquake (1999)
    - Loma Prieta Earthquake (1989)
    - Northridge Earthquake (1994)
- 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 G+ 2 stories, G+3 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

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 6.1: Acceleration data

EQ	Acceleration			
	G+4 story		G+2 story	
	Fixed base	LRB	Fixed base	LRB
Chamoli	423.3	250.74	329.31	299.03
Imperial valley	470.66	264.02	443.24	390.53
loma	399.28	270.72	448.09	387.45
Northridge	506.4	274.61	439.45	430.53

- For different earthquake data acceleration values are shown in table.
- For Loma Prieta Earthquake acceleration value 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.

Table 6.2: Displacement data

EQ	Displacement			
	G+4 story		G+2 story	
	Fixed base	LRB	Fixed base	LRB
Chamoli	69.99	119.01	12.681	38.285
Imperial valley	22.81	16.82	10.82	22.31
Loma	30.28	18.33	13.75	24.95
Northridge	29.6	20.0	13.2	27.3

- Same as in G+4 RC frame structure displacement in LRB isolator increase by 41% in X & Y direction.

3.2.3 Story shear

Table 6.3: story shear data

EQ	Story shear			
	G+4 story		G+2 story	
	Fixed base	LRB	Fixed base	LRB
Chamoli	230.32	177.45	105.25	60.42
Imperial valley	121.9811	73.969	53.062	61.4388
Loma	143.57	8.12	81.87	58.91
Northridge	144.3471	24.391	81.037	66.3084

- 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

3.2.4 Time period and Frequency

Table 6.3: Time period and Frequency

System	Fundamental time period (sec)	
	G + 2 story	G + 4 story
Fixed base system	0.93	2.113
Isolated Base system	1.72	3.004
System	Frequency (cyc/sec)	
	G + 2 story	G + 4 story
Fixed base system	1.076	0.473
Isolated Base system	0.582	0.333

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 3 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 54 to 51% than the fixed base system

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