SEISMIC ANALYSIS OF MULTISTOREYED RC BUILDING DUE TO MASS IRREGULARITY BY TIME HISTORY ANALYSIS

Sampath Nagod[1] , Prof. A.J.Zende[2]

[1]Student of Master of Technology in Structural Engineering
BLDEA's V.P. Dr. P.G Halakatti College of Engineering and Technology, Vijayapur - Karnataka, India.
[2]Professor at Civil Engineering Department
BLDEA's V.P. Dr. P.G Halakatti College of Engineering and Technology, Vijayapur - Karnataka, India.

---***---

Abstract - *From earthquakes history, it can be observed that if the structures are not appropriately analyzed and constructed with necessary quality, then it may lead great damage and loss to human lives. We can see many of structures are fully or partially damaged due to earthquake. So, there is need to establish seismic responses of buildings. Seismic analysis of the structure is done to determine seismic responses by time history analysis which is one of the important techniques for structural seismic analysis especially when the evaluated structural response is non- linear in nature. To perform such an analysis, a representative earthquake time history is required for the structure being evaluated. In this present work non-linear dynamic analysis of 12 storeyed RC building having mass irregularity considering Bhuj earthquake time history is carried out using ETABS software. Then, Lead Rubber Bearing is manually designed and isolator properties are assigned to the building. Various parameters like Base shear, Time period and Storey displacement are determined for regular and mass irregular buildings with fixed base and base isolated condition and compared with each other.*

Key Words: Base isolation, Mass irregularity, Time history analysis, Bhuj earthquake.

1. INTRODUCTION

1.1 General

All over the world, there is much need of construction of high-rise multi-storey buildings due to the urbanization and increase in population. These multi-storey structures are unsafe when they are subjected to the earthquakes. While earthquake engineering is noticeably progressed, structures failures are found wherever strong disturbances caused due to the motion of the earth. Earthquake forces are unpredictable. Environmental loads like an earthquake are harmful and last only for the small duration but cause severe damage to the structures and harm lives of people. Yearly near 1.5 crore, people lose their lives due to the earthquake that strikes the earth. The multi-storey structure generally subject to failure due to seismic forces at the location where there is a weakness. The weakness of structures is due to the presence of irregularities in stiffness, strength and mass. Earthquake code IS 1893 is used to design multi-storey buildings. But Ahmedabad during Bhuj earthquake, because of mass irregularity the buildings got severely damaged. Excess mass leads in reduction of ductility of vertical load resisting elements and increase inertia forces and thus increase the tendency towards collapse. Excess mass on upper floors has a more unfavorable effect than those at lower floors. Thus there is the necessity of designing these structures for earthquake loading so that they sustain moderate to strong earthquake forces. Multi-storey buildings and their structural members can be protected against earthquake forces by installing structural isolation devices. The technique used to avoid earthquake damage by separating the structure from the ground known as base isolation.

1.2 Base Isolation

Base isolation is a technique in which during an earthquake, separating the superstructure or reducing the lateral movements of building superstructure from the movement of ground or foundation is done. The bearings of base isolation are designed in such a way that they are stiff vertically and flexible horizontally to allow for the difference in lateral movement while still supporting the superstructure. The structures with base isolation are different than that of fixed base structure, in which the connection between the superstructure and the foundation are rigid and the superstructure translation in all direction is constrained. Behavior of the building with base isolators is shown in below fig

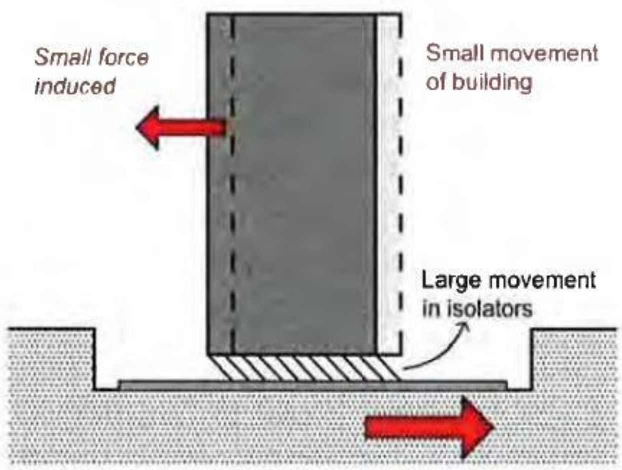

Figure 1.1: Behaviour of the building with Base Isolators

The main aspire of base isolation is to decrease the earthquake force produced on building's superstructure. To some amount by reducing the superstructure's spectral acceleration, the lessening in seismic force at superstructure is achieved. By mounting the base isolated structure fundamental period and through damping caused by dissipation energy within bearing the accelerations are reduced. The effect of base isolated and fixed base building on spectral acceleration is shown in fig below.

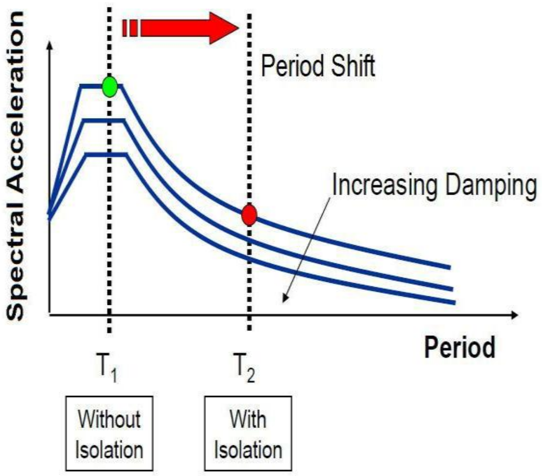

Figure1.2: Effect of Seismic Isolation on Spectral Acceleration

Due to the reduced lateral stiffness of isolated structures, the effective period of the superstructure is increased. The stiff structures with the small period the base isolation are most effective. Below equation shows the relation between effective period and the stiffness.

$$T = 2\pi\sqrt{(M/K)}$$

As, $\downarrow K \Rightarrow \uparrow T$

Where, T = Period (sec.)

K = Stiffness (kN/mm)

M = Mass (N –Sec.^{2}/mm)

1.3 Objectives of the Study

In the present study, the work includes the analysis of a 12 storey reinforced concrete mass irregular building in accordance with IS1893-2002 provisions; one with fixed base and other with base isolated.

The objectives of the study are as follows;

1. To carry out modeling and analysis of multi-storeyed RC building with and without mass irregularity by using ETABS software and study the effect of seismic forces on different models.
2. To design and study the effectiveness of lead rubber bearing used as a base isolation system
3. To carry out comparison between fixed base and base isolated building by Time history analysis considering Bhuj earthquake record and obtaining different parameters such as Base shear, Time period and Storey displacement.

2. METHODLOGY

In this study, 12 storied reinforced concrete building with and without base isolation are considered. In addition to that, mass irregularity is also taken into consideration by providing heavy mass at 11th floor. The RC frame with infill panels is modeled for Indian seismic zone V IS: 1893-2002 having medium stiff soil. Time history analysis is performed on buildings using ETABS software.

2.1 Models considered for analysis

- Model 1: Building with fixed base
- Model 2: Building with base isolation
- Model 3: Mass Irregular Building with fixed base
- Model 4: Mass Irregular Building with base isolation

2.3 Structural specifications

2.3.1Member properties

Table 2.1: Member properties

No of storey	12
Size of Building	20 x 12m
Spacing of frames in X direction	5m
Spacing of frames in Y direction	4m
Size of Beam	300 x 450mm
Size of Column	300 x 500mm
Storey height	3m
Thickness of slab	150mm
Thickness of wall	230mm
Height of parapet wall	1m

2.3.2Load intensities

Table 2.2: Load intensities

Live load on Roof	1.5 kN/m^2
Live load on Floor	3.0 kN/m^2
Floor finish	1.0 kN/m^2
Swimming pool	18 kN/m^2

2.3.3Material properties

Table 2.3: Material properties

Grade of Concrete	M25
Grade of Steel	Fe415

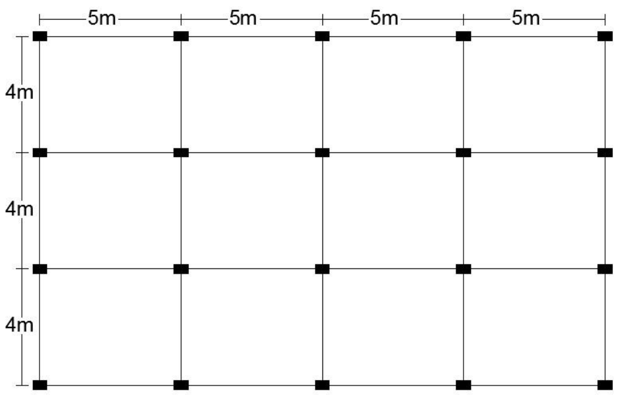

Figure 2.1: Plan of Building

Figure 2.2: 3D view of Building

Lead Rubber Bearing is used as a base isolator. After analysis of fixed base RC building with and without mass irregularity using E-TABS software, the maximum vertical reaction is obtained for respective models. By using this vertical reaction lead rubber bearing is designed manually and the properties obtained by design are used as base isolator properties for model 2 and model 4.

2.4 Lead Rubber Bearing Properties

Table 2.4: Summary of Lead Rubber Bearing Properties

Properties	Building without mass irregularity	Building with mass irregularity
Axial load on column	4981kN	5330kN
Required stiffness (k_{eff})	5011.26 kN/m	5362.38 kN/m
Bearing horizontal stiffness (Kb)	1005.93 kN/m	1078.93 kN/m
Vertical stiffness (Kv)	889963.50 kN/m	992048.12 kN/m
Yield force (F)	75.13 kN	80.40 kN
Stiffness ratio	0.1	0.1
Damping	0.05	0.05

3. RESULTS AND DISCUSSION

3.1 Base Shear

From the obtained results, it is observed that for a 12 storey RC Base Isolated building without mass irregularity analyzed by Time history analysis (Bhuj earthquake), Base Shear is decreased by 38.68% in the X direction and by 49.47% in Y direction compared to a fixed base building without mass irregularity. Similarly, Fixed base building with mass irregularity analyzed by Time history analysis (Bhuj earthquake), Base Shear is increased by 31.08% in X direction whereas decreased by 14% in Y direction compared to a fixed base building without mass irregularity.

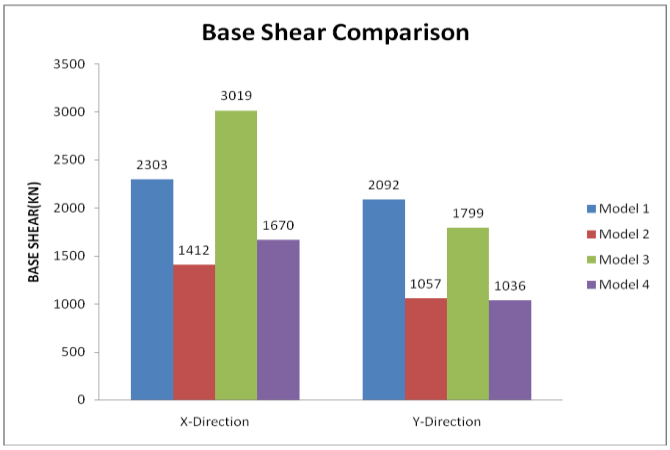

Figure 3.1: Base Shear Comparison

3.2 Time Period

From the obtained results, it is observed that for a 12 storey RC Base Isolated building without mass irregularity analyzed by Time history analysis (Bhuj earthquake), Time Period is increased by 26.77% in the X direction and by 28.46% in Y direction compared to a fixed base building without mass irregularity. Similarly, Fixed base building with mass irregularity analyzed by Time history analysis (Bhuj earthquake), Time Period is increased by 8% in X and Y direction compared to a fixed base building without mass irregularity.

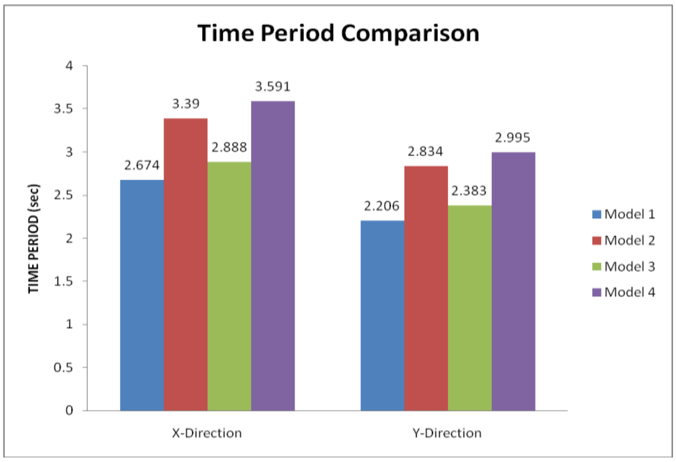

Figure 3.2: Time Period Comparison

3.3 Storey Displacement

From the obtained results, it is observed that for a 12 storey RC Base Isolated building without mass irregularity analyzed by Time history analysis (Bhuj earthquake), storey displacement is increased by 25.147% in the X direction whereas decreased by 31.964% in Y direction compared to a fixed base building without mass irregularity. Similarly, Fixed base building with mass irregularity analyzed by Time history analysis (Bhuj earthquake), storey displacement is decreased by 7.199% in X direction and by 4.472% in Y direction compared to a fixed base building without mass irregularity

Table 3.1: Storey Displacement along X direction

Storey	Model 1	Model 2	Model 3	Model 4
12	101.4	126.9	93.8	106.6
11	98	123.6	91.9	103.7
10	93.2	118.2	88.4	98
9	87.5	110.7	83.5	90.7
8	79.6	101.9	78	82.1
7	69.4	92.1	73.8	72.9
6	58.5	81.6	69.2	66.8
5	49	71	62.4	61.5
4	38.7	61.6	52.8	56.2
3	28.4	52.7	40.3	50.7
2	18.3	43.7	25.4	43.6
1	7.3	33.2	10	33.8
Base	0	13.7	0	15

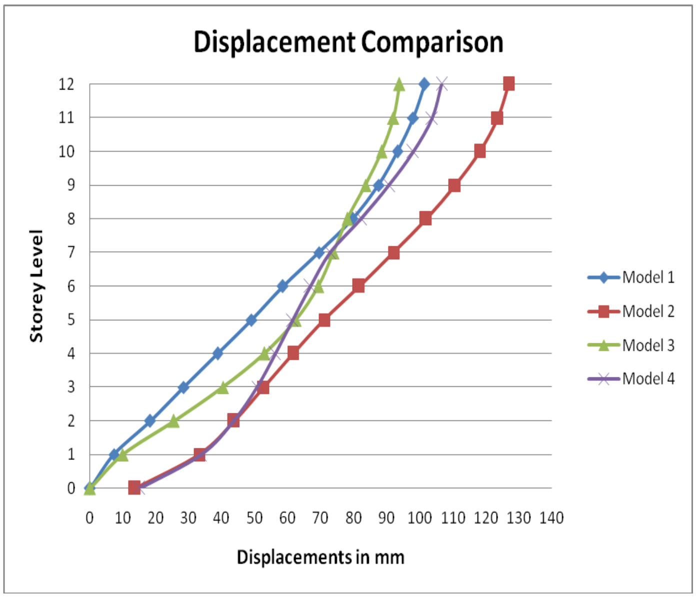

Figure 3.3: Storey Displacement in X direction

Table 3.2: Storey Displacement along Y direction

Storey	Model 1	Model 2	Model 3	Model 4
12	136.4	92.8	130.3	98.9
11	131.2	91.1	125.1	96.9
10	121.9	88.5	113.8	93.2
9	109.1	84.9	99.5	88.6
8	94.3	80.4	84	83.6
7	80.6	75.1	69.1	78.2
6	71.9	69.2	57.5	72.4
5	65.6	62.8	50.3	66.1
4	56.3	56.1	42	59.6
3	43.8	49.9	32.2	52.7
2	28.9	43.3	21.5	45
1	12.6	34.4	9.6	35.4
Base	0	10	0	10.5

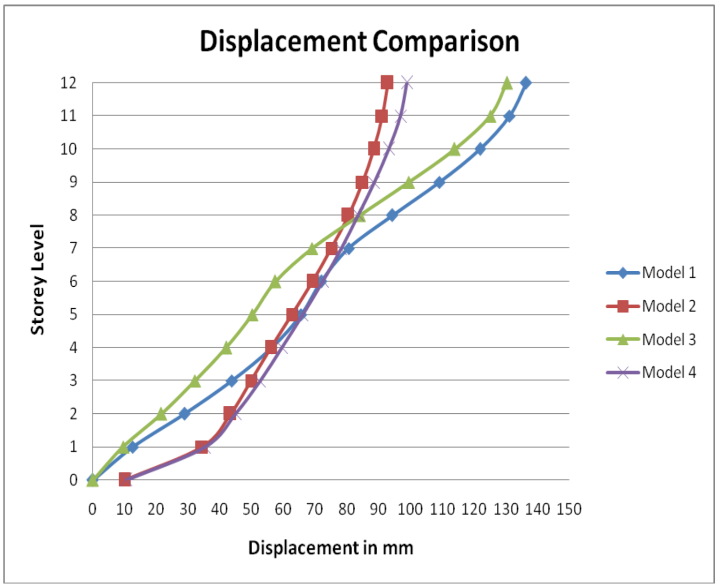

Figure 3.4: Storey Displacement in Y direction

4. CONCLUSION

From the analysis and results, it is observed that the base isolator and mass irregularity in a building influence on the seismic response of a building. By comparing the response of the structure, following conclusions are made.

1. The Base shear is decreased by about 40% in the base isolated building when compared to the fixed base building. It is also observed that the Base shear is increased by about 30% in mass irregular building compared to the regular building.
2. As compared to all four models studied, Base shear is found to be minimum in a regular building with base isolators.

3. Time period of a building increased by about 27% by the use of base isolators which leads to less transfer of lateral forces at the time of an earthquake. It is also observed that mass irregular building have about 8% increased time period compared to the regular building.
4. At the base, fixed base buildings have zero displacements whereas base isolated buildings have a considerable amount of bottom displacement.
5. Storey displacement is increased by 25% in the buildings with base isolators compared to the buildings with a fixed base. Displacement is reduced by 7% in mass irregular buildings compared to regular buildings.

Finally, it can be recommended that Time History analysis shall be carried out for the multi-storeyed buildings before their construction for earthquake function with a high magnitude such as Bhuj earthquake time history as considered in present study along with consideration of mass irregularity in buildings.

5. REFERENCES

1. IITK-BMTPC EQTips – National Information Centre of Earthquake Engineering (www.nicee.org) EQ Tip6

2. C.P. Providakis "Effect of LRB isolators and supplemental viscous dampers on seismic isolated buildings under near-fault excitations" Engineering Structures ELSEVIER 2007

3. Naveen K, Dr. H.R Prabhakara and Dr. H Eramma "Base Isolation of Mass Irregular RC Multi-Storey Building" International Journal of Research in Engineering and Technology.

4. Ms. Minal Ashok Somwanshi and Mrs. Rina N. Pantawane "Seismic Analysis of Fixed Base and Base Isolated Building Structures." International Journal of Multidisciplinary and Current Searches. July/August 2015.

5. Mr. Pathan Irfan Khan, Dr. Mrs. N.R.Dhamge "Review Paper on Seismic Analysis of Multistoried RCC Building Due To Mass Irregularity" International Journal of Science & Engineering Development Research June 2016

6. Vinodkumar Parma, G.S.Hiremath " Effect of Base Isolation in Multistoried RC Irregular Building using Time history analysis." International Journal of Research in Engineering and Technology.

7. Ashish R. Akhare, Tejas R. Wankhade "Seismic Performance of RC Structures using different Base Isolators." International Journal of Engineering Science and research Technology. May 2014.

8. Syed Ahmed Kabeer K I, Sanjeev kumar K.S "Comparision of Two Similar Buildings with and without Base Isolation." International Journal of Advanced Researches, Ideas and Innovations in Technology. October 2014.

9. Jyothi. C. Hawaldar, Dr. D. K. Kulkarni "Earthquake Analysis Of A G+12 Storey Building With And Without Infill For Bhuj And Koyna Earthquake Functions" International Journal of Research in Engineering and Technology. August 2015

10. Moussa Leblouba "Combined System for Seismic Protection of Buildings." International Symposium on Strong Vrancea Earthquakes and Risk Mitigations. October 2007.

11. L. Di Sarno, E. Chioccarelli and E. Cosenza "Seismic Assessment of an Irregular Base Isolated Hospital." The 14th Word Conference on Earthquake Engineering. October12-17, 2008, Beijing, China.

12. H.P. Santosh, K. S. Manjunath, K. Satish Kumar "Seismic Analysis of Low to Medium Rise Buildings for Base Isolations." International Journal of Research in Engineering and Technology.

13. Sonali Anilduke, Amay Khedikar "Comaprision of Building for Seismic Response by using Base Isolation." International Journal of Research in Engineering and Technology.

14. Abdolrahim Jalali and Peyman Narjabadifam "Optimum Modal Characteristics for Multistory Buildings Isolated with LRB's." 4th International Conference on Earthquake Engineering. Taipei, Taiwan. October 12-13, 2006.

15. Indian Standard Criteria for Earthquake Resistant Design of Structures IS 1893(Part 1): 2002.

16. Ductility Detailing of RC Structures Subjected to Seismic Forces IS 13920 : 1993