

SCIENCE | ENGINEERING | TECHNOLOGY

e-ISSN: 2319-8753 | p-ISSN: 2347-6710

EDIA

INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 10, Issue 9, September 2021

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

Impact Factor: 7.569

9940 572 462

6381 907 438

 \bigcirc

| e-ISSN: 2319-8753, p-ISSN: 2347-6710| <u>www.ijirset.com</u> | Impact Factor: 7.569|

Volume 10, Issue 9, September 2021

| DOI:10.15680/LJIRSET.2021.1009110 |

Effect of Earthquake Resistant System on Vertically Irregular RC Tall Building

Anagh S. Ghule¹, Uttam R. Awari²

P.G. Student, Department of Civil Engineering, AISSMS College of Engineering, Pune, India¹

Associate Professor, Department of Civil Engineering, AISSMS College of Engineering, Pune, India²

ABSTRACT: Earthquake is a natural disaster which is experienced throughout the world. The effect of earthquake depends on the magnitude with which the earthquake occurs. There are many lives which are claimed due to earthquake and loss of property. The presence of vertical irregular frame subject to devastating earthquake is matter of concern. In this proposedwork, the effect of bracing and base isolation on the seismic analysis of vertically irregular high-rise buildings will be investigated. A 19-storey high rise vertically irregular building with plan dimension 48m x 30m located in zone III will be designed as per IS 1893:2016 (part1) and IS 16700:2017 provisions. The seismic analysis of the vertical irregularity called one sided irregularity will be done by CSI ETABS software by response spectrum method. From proposed workit is concluded that with the provision of base isolation system the seismic performance of building improves.

KEYWORDS: Vertical irregularity, Bracing, Base isolation, Response spectrum method

I. INTRODUCTION

Due to the increase in population, congestion in land has been seen. To overcome this tall buildings are been constructed. A structure cannot be made earthquake proof but with proper design consideration and lateral force resisting system the structure can be made earthquake resistant. Modern tall rise buildings are constructed with irregularities. An irregularity is introduced in a building for both aesthetic purpose and utility purpose. There are various types of irregularities namely horizontal and vertical irregularity. In this research work vertically irregularity is studied.

In this project vertical geometric irregularity is studied. As per IS 1893:2002 any building in which the horizontal dimension of the lateral force resisting system in any storey is more than 150 percent of that in its adjacent storey. Vertical setback on one side, vertical set back on both sides and multiple setbacks are the three types of vertical geometric irregularity allowed. In the Figure 1, three types of irregularities are shown. Multiple step back irregularity, both sided irregularity and irregularity on one side are the three types of irregularities shown.



Figure 1: Vertical geometric irregularities as per IS code

Bracing system is one of the most effective system in resisting the lateral forces like the seismic and wind forces. They are subjected to tension and compression. By providing a bracing system the stiffness and strength of the structure increases and the deformation decreases. Bracing system was widely used in the old period as well as it is used in the modern time period as well. In X bracing two diagonal supports are placed in X shaped manner. In X bracing the frame has bracing members in tension in both directions for loading and if they are sized to yield before column or beam fails ductility is developed.

International Journal of Innovative Research in Science, Engineering and Technology (IJIRSET)



| e-ISSN: 2319-8753, p-ISSN: 2347-6710| <u>www.ijirset.com</u> | Impact Factor: 7.569|

Volume 10, Issue 9, September 2021

| DOI:10.15680/IJIRSET.2021.1009110 |

In base isolation system the building is isolated from its base so that the vibrations which are produced during an earthquake do not get transferred to the building. Base isolation works on the principle of decoupling the building from the ground motions produced during an earthquake by rectifying the response of the structure so that the ground can move without transmitting the forces to the structure which if transmitted will lead to damage of the structure and risk to the life of the occupants. Amongst all the base isolation techniques lead rubber bearing isolator (LRB) is a widely used technique.

II. RELATED WORK

Seismic stability analysis of a RC building is beneficial by the method of response spectrum method. Equivalent static method for an irregular structure is not desirable for carrying out the seismic analysis. Dynamic analysis by response spectrum method gives an indication of the maximum displacement response, while the static method fails to give the displacement amplitudes for seismic events [1, 2]. When irregularities are introduced in the bottom two stories by in filled shear wall in frames it is observed that the largest amount of energy transfer is due to the overturning succeeded by shear deformation. The self-weight of irregular building contributes to resistance against the total overturning moment [3]. A model when provided with different types of bracing and subjected to seismic analysis it is concluded that the structure provided with X bracing performs seismically better as compared to the other types of bracing. X bracing performs seismically better because it transfers the horizontal load to the ground [4]. Seismic analysis when performed on regular and irregular building it is observed that the irregular building is stiffer as compared to that of regular building. As the irregularity goes on increasing the base shear of the structure decreased due to reduction in mass of structure. The base shear of the regular building frame is maximum and able to resist the seismic forces more efficiently as compared to irregular building [5]. Regular RC frame when subjected to seismic analysis with base isolation technique proves to be better than fixed base. Due to the application of base isolation reduction in moment and shear force is seen due to which less reinforcement is needed when compared to fixed base. Modal time period of the frame increases and the displacement is also higher which shows that the structure is flexible [6, 7].

III. METHODOLGY

Dynamic analysis is performed with the help of CSI ETABS software on the three models namely fixed base, bracing and base isolation. Dynamic analysis is performed with the help of response spectrum method.

IV. SOFTWARE ANALYSIS

A G + 18 building have been modelled in ETABS software and is considered for the following study [8, 9]. Figure 3.1 shows the building with fixed base, Figure 3.2 shows the building with provision of bracing and Figure 3.3 shows the building with base isolation. The properties of the building have been mentioned in the Table 3.1.

Sr. No.	Parameter	Value
1	Height of building	59 m
2	Type of structure	Multi storey RC frame
3	Soil type	Type-I
4	Number of stories	G + 18
5	Plan dimension	48 m x 30 m
6	Size of column	600 mm x 600 mm
7	Size of beam	350 mm x 450 mm
8	Thickness of slab	125 mm
9	Location	Pune
10	Seismic Zone	III

Table 1: Properties of the model considered for analysis

| e-ISSN: 2319-8753, p-ISSN: 2347-6710| <u>www.ijirset.com</u> | Impact Factor: 7.569|



|| Volume 10, Issue 9, September 2021 ||

DOI:10.15680/IJIRSET.2021.1009110



Figure 3.1: Model with fixed base Figure 3.2: Model with bracingFigure 3.3: Model with base isolation

3.2 Modelling of lead rubber bearing

Sr. No.	Property	Value
1	Rotational Inertia	0.00231 kN/m
2	For U1 effective stiffness	389220 kN/m
3	For U2 and U3 effective stiffness	389.20 kN/m
4	For U2 and U3 effective damping	0.05
5	For U2 and U3 distance from end j	0.00316 m
6	For U2 and U3 stiffness	3586.8 kN/m
7	For U2 and U3 yield strength	11.36 kN

Table 2:	Propert	ties of 1	LRB	isolator
----------	---------	-----------	-----	----------

The lead rubber isolator is modelled with the help of design steps mentioned in UBC 97 [10]. The maximum vertical reaction is obtained from the analysis on ETABS. The properties mentioned in the table below are further entered in ETABS while defining lead rubber isolator as spring elements as shown in Table 3.2.

IV. RESULT

Dynamic analysis by response spectrum method is done on a building with fixed base, bracing and base isolation. Dynamic properties after performing analysis on ETABS like the base shear, storey displacement, storey drift and modal time period are studied. The results of response spectrum performed are mentioned below.

4.1 Base Shear

From the Table 4.1 and Figure 4.1 it is evident that the shear force is the most for bracing system because the weight of the structure increases. While when the building is applied with base isolation the base shear reduces which helps the building to perform better due to distribution of mass and stiffness by which the modal time period improves. A reduction in base shear of 21.63 % is seen when applied with base isolation system. As for base isolation by lead rubber technique the base shear is less the reinforcement required for the building will be less as compared to other buildings with fixed base and bracing. The base shear for fixed base is 1019.277 KN, for bracing system it is 1603.469 KN and for base isolation it is 798.73 KN.

4.2 Modal time period

From the Table 4.1 and Figure 4.2 below it is observed that the modal time period for base isolation by lead rubber technique increases as compared to that of fixed base and bracing system. For fixed base the time period is 2.674 s, for bracing it is 2.035 s and for base isolation it is 6.329 s. An increase of 3.655 s is seen as compared to that of fixed base. For the model with base isolator the time period is more due to the flexibility of the building with base isolator.

| e-ISSN: 2319-8753, p-ISSN: 2347-6710| <u>www.ijirset.com</u> | Impact Factor: 7.569|

L SET

|| Volume 10, Issue 9, September 2021 ||

| DOI:10.15680/IJIRSET.2021.1009110 |



Figure 4.1: Modal time period of the model

Table 4.2:	Table	showing	modal	time	period
-------------------	-------	---------	-------	------	--------

Sr. No.	Mode	Model 1 (s)	Model 2 (s)	Model 3 (s)
1	1	2.674	2.035	6.329
2	2	2.645	1.81	6.295
3	3	2.107	1.101	5.379
4	4	1.137	0.933	1.618
5	5	1.11	0.701	1.613
6	6	1.077	0.555	1.424
7	7	0.583	0.429	0.796
8	8	0.575	0.32	0.778
9	9	0.513	0.314	0.72
10	10	0.422	0.222	0.504
11	11	0.418	0.221	0.498
12	12	0.397	0.217	0.456

4.3 Storey displacement

 Table 4.3: Table showing storey displacement

Sr. No.	Storey number	Fixed base (mm)	Bracing (mm)	Base solation (mm)
1	Base	0	0	35.249
2	1	1.042	0.601	37.1
3	2	2.187	1.125	38.116
4	3	3.37	1.71	39.056
5	4	4.507	2.344	39.928

よう 総 IJIRSET | e-ISSN: 2319-8753, p-ISSN: 2347-6710| <u>www.ijirset.com</u> | Impact Factor: 7.569|

|| Volume 10, Issue 9, September 2021 ||

DOI:10.15680/IJIRSET.2021.1009110

6	5	5.576	3.003	40.732
7	6	6.573	3.673	41.468
8	7	7.499	4.338	42.137
9	8	8.354	4.99	42.742
10	9	9.16	5.599	43.301
11	10	10.228	6.071	43.991
12	11	11.457	6.811	44.735
13	12	12.697	7.64	45.442
14	13	13.878	8.495	46.082
15	14	14.963	9.354	46.643
16	15	15.932	10.193	47.12
17	16	16.766	10.99	47.511
18	17	17.448	11.722	47.817
19	18	17.961	12.335	48.041
20	19	18.315	12.661	48.199

From the Table 4.3 and Figures 4.3 it is seen that the storey displacement for bracing system is the least as compared to that of fixed base and base isolation. When response spectrum is conducted in x direction it is observed that the storey displacement is maximum at the base for base isolation. At the base in base isolated model the displacement is 36.651mm. This higher displacement at the base of the structure shows that the structure is flexible. A flexible structure will perform better in a seismic activity.



Figure 4.2: Figure showing storey displacement

4.4Storey drift

Table 4.4: Table showing storey drift

Sr. No.	Storey number	Fixed base (m)	Bracing (m)	Base isolation (m)
1	Base	0	0	0
2	1	0.000286	0.00017	0.000376
3	2	0.000382	0.000176	0.000339

よう は IJIRSET | e-ISSN: 2319-8753, p-ISSN: 2347-6710| www.ijirset.com | Impact Factor: 7.569

Volume 10, Issue 9, September 2021

| DOI:10.15680/IJIRSET.2021.1009110 |

4	3	0.000396	0.000197	0.000314
5	4	0.000386	0.000216	0.000291
6	5	0.000371	0.000227	0.000269
7	6	0.000355	0.000232	0.000247
8	7	0.000336	0.000233	0.000224
9	8	0.000317	0.000232	0.000204
10	9	0.000306	0.000221	0.000189
11	10	0.000427	0.000191	0.000234
12	11	0.000496	0.000299	0.000253
13	12	0.000499	0.000332	0.000242
14	13	0.000474	0.000341	0.00022
15	14	0.00044	0.000341	0.000193
16	15	0.000403	0.000332	0.000165
17	16	0.000359	0.000313	0.000136
18	17	0.000302	0.000285	0.000106
19	18	0.00023	0.000238	7.80E-05
20	19	0.000156	0.000122	5.50E-05

From the Table 4.4 and Figures 4.4 it is seen that at the bottom in x direction the storey drift is maximum at the base for base isolation system as compared to the other two systems i.e., fixed base and bracing system. The increased drift at the bottom storey due to base isolation shows that the structure is flexible. At the top storey drift of only 0.000050 mm is seen and for fixed base it is 0.000156 mm and for bracing system it is 0.000122 mm. The storey drifts first increases and then reduces due to the reduction in the stiffness of the building. For base isolation the drift is more because by the addition of a base isolator the structure becomes flexible which results in greater drift at the base.



Figure 4.3: Figure showing storey drift

International Journal of Innovative Research in Science, Engineering and Technology (IJIRSET)

e-ISSN: 2319-8753, p-ISSN: 2347-6710 www.ijirset.com | Impact Factor: 7.569



|| Volume 10, Issue 9, September 2021 ||

| DOI:10.15680/IJIRSET.2021.1009110 |

V. CONCLUSION

In this research the effect of earthquake resistant system on a vertically irregular building is analysed. The modal time period of a building increases due to the application of base isolation in a RC building. The increased modal time helps the building to perform seismically better it shifts the fundamental period of a building from a more force shorter periods to a less force longer period which makes the system susceptible to less damage during a seismic activity. The storey displacement at the base of the structure is greater for base isolated structure which makes the building more flexible. The top storey drift is least for the building with base isolation which helps it perform better. The base shear is least for base isolation which helps in distribution of mass.

REFERENCES

[1]. Jack P. Moehle "Seismic response of vertically irregular structures" Journal of Structural Engineering, Vol. 110, pp. 2002-2014, 1984.

[2]. George Georgoussisa, Achilleas Tsompanos and Triantafyllos Makariosb, "Approximate seismic analysis of multistorey buildings with mass and stiffness irregularities", The 5th International Conference of Euro Asia Civil Engineering Forum, Surabaya, East Java, Indonesia, pp.959-966, 2015.

[3]. Han-Seon Lee and Dong-Woo Ko, "Seismic response characteristics of high-rise RC wall buildings having different irregularities in lower stories", Journal of Engineering Structures, Vol. 29, pp.3149-3167, 2007.

[4]. Z. A. Siddiqi, Rashid Hameed and Usman Akmal," Comparison of different bracing systems for tall buildings" Pakistani Journal of Engineering & Applied Science, Vol. 14, pp.17-26, 2014.

[5]. Sanyogita and B. Saini, "Seismic analysis of vertical irregularities in buildings", International Conference on Sustainable Waste Management through Design, Switzerland, Europe, pp.537-546, 2019.

[6]. A. Hasan and S. Pal, "Performance analysis of base isolation and fixed base building", International Conference in Emerging Technology in Structural Engineering, Nagpur, India, pp.1-5, 2017.

[7]. O. V. Mkrtychev, G. A. Dzhinchvelashvili and A. A. Bunov, "Study of lead rubber bearings operation with varying height buildings at earthquake", Journal of Theoretical Foundation of Civil Engineering, pp.48-53, 2014.

[8]. IS 1893 (Part 1): 2016, Criteria for earthquake resistant design of structures, Bureau of Indian Standards New Delhi.

[9]. IS 16700: 2017, Criteria for structural safety of tall concrete building, Bureau of Indian Standards New Delhi.

[10]. Uniform Building Code, International Conference of Building Officials, California 1997.





Impact Factor: 7.569





INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY





www.ijirset.com