Vol-08 Issue 07, July -2024 ISSN: 2456-9348
Impact Factor: 7.936

iJETRM
International Journal of Engineering Technology Research & Management
Published By:
https://www.ijetrm.com/

SEISMIC PERFORMANCE OF BASE ISOLATED STEEL BRACED REINFORCED CONCRETE BUILDING FRAMES

Harish Kumar, M. Tech Student
Mr. Mirza Aamir Baig (Assistant Professor)
Structure Engineering (M. Tech), Department of Civil Engineering,
Al- Falah University Faridabad Haryana, 121004 (India)

ABSTRACT
Base Isolation altered the structure's reaction so that the ground underneath it can move without transferring motion to the structure above it. To put it another way, the basic isolation principle system is to govern reaction of structure such that ground can move under structure without the super-structure.
Earthquake proof structures, generally mean the structures which resist the earthquake and save and maintain their functions. The key points for their design includes select good ground for the site, make them light, make them strong, make them ductile, shift the natural period of the structures from the predominant period of earthquake motion and heighten the damping capacity.
This study investigates as well as compares the performances of Seismic Response for the following structural configurations:
1. Fixed base reinforced concrete frame Building
2. Fixed base reinforced concrete frame Building with steel cross bracing
3. Base Isolated reinforced concrete frame Building
4. Base Isolated reinforced concrete frame Building with steel cross bracing
To perform the analysis SAP 2000 is used to get the outcome using dynamic analysis (Time History). The performance of structures are evaluated based on the results of base shear, deflection and displacement.

1.1 INTRODUCTION

1.1.1 GENERAL

In this engineering world, there has been a growing interest among engineers and the general public in understanding how structures respond to extreme loads. The structures response to the extreme loads characterized by their high intensity but low probability of occurrence. The risks associated with accidents necessary facilities like hospitals or the construction of tall buildings and offshore structures in earthquake-prone areas serve as prime examples. Reliable data on the performance of various structural systems is essential for assessing the design of important structures. Such insights can only be obtained by thoroughly understanding the behaviour of each structural system and component.
Traditional approaches for seismic design of building structures, such as improving the stiffness, strength, and ductility of the buildings, is being used since long back. As a result, structural member size and material consumption is expected to a greater extent, resulting in a greater cost but also larger seismic reactions due to increasing structural stiffness leading to the standard method for seismic design of building structures is limited in its effectiveness. Lots of vibration-control approaches, known to be structural controls, were being developed to address the deficiency of the traditional method, and significant progress has been developed in this area in recent years. A passive control system rubber base isolation consists of one or more devices, attached or embedded to a structure, designed to modify the stiffness or the structural damping in an appropriate manner without requiring an external power source to operate, developing the control forces opposite to the motion of the structure.

1.2 STRUCTURAL CONTROL SYSTEM

To mitigating dynamic hazards, the traditional approach to reduce vibrations due to earthquake and any other dynamic loads is to design structures with sufficient strength and deformation capacity in a ductile manner. This approach, is subject to ensuring of strength-ductility combination, provides the strong wind or seismic action as ultimate loads, due to various number of structural or non-structural degradations.
The discipline of structural control comprises a broad range of topics. The four Structural control system may be defined as follows:

iJETRM
International Journal of Engineering Technology Research & Management
Published By:
https://www.ijetrm.com/

a. active control
b. Semi-active Control
c. Hybrid
d. Passive Control

From energetically point of view the passive control systems are divided into two classes:

i) BASE ISOLATION:

Isolation dampers such as elastomeric bearings or sliders (metal blocks), as well as isolation layers as fine sand or graphite material are introduced between the foundation and superstructure. Consequently, the reducing of the input energy of an earthquake in superstructure as well as the increasing of displacements across the isolation level are achieved due to the flexible decoupling between superstructure and foundation. The most common adopted technique is the laminated rubber bearing with alternating layers of rubber and steel. The stiff steel plates provide lateral constrain of each rubber layer when the bearing is subjected to vertical load, but does not constrain the horizontal shearing deformation of the rubber layers. This produces a bearing that is very stiff in the vertical direction and very flexible in the horizontal direction. A base isolation system is dependent of natural frequencies of a structure in its design. Base Isolation is a passive vibration control system. Passive vibration control system regarding base isolation works without an external source of electricity and uses the structural motion to develop control forces. This method is used for essentially elasticizing the building and thus ensuring safety during large earthquakes.

ii) PASSIVE CONTROL DEVICES:

The control passive devices generally dissipate or absorb energy inputted to a structure. The motion of the structure is utilized to produce a relative motion within the passive control devices, thereby the energy is dissipated. They may be also divided in two classes: energy dissipating devices, which are independent of the natural frequencies of a structure for their design, and tuned or resonant devices, which are dependent of the natural frequencies. An exception of frequency-independent devices is the viscoelastic dampers. Most of dissipating devices known as friction damper, hysteretic damper, viscoelastic damper or fluid viscous damper operate on principles such as frictional sliding, phase transformation in metals, deformation of viscoelastic solids. The plastic hinges are created in the structure when the elements of the structure are designed as energy dissipating devices.

The second class includes tuned mass damper (TMD), tuned liquid damper (TLD), tuned liquid columns damper (TLCD), suspended pendulum mass damper, mass pump, and so on. TMD and TLD systems have been extensively studied from point of theoretical, numerical and experimental view to control mostly wind input vibrations. Generally, inertial mass is attached near the top, through a spring and a viscous damping mechanism (*e.g.* fluid damper or viscoelastic damper)

1.3 MODEL CONFIGURATIONS

The following models has been of G+5 storey building has been done in Sap 2000 using Modal time history analysis for the following structural configurations:

1. Fixed base without bracing
2. Fixed base with steel bracing
3. Rubber base isolated without steel bracing
4. Rubber base isolated with steel bracing

1.3.1 DESCRIPTION OF BUILDING:

- No of Stories - G+5
- C/C distance in X-direction - 6.0m
- C/C distance in Y-direction- 6.0m
- Foundation Level to Ground Level – 3.0m
- Floor to Floor height – 3.0m
- Live Loads on All Floors – 3KN/m2
- Materials – M30 and reinforcement HYSD 450
- Size of Column – 400x400
- Size of Beam – 350x450
- Size of X -Bracing (Steel Pipe) – 200x200x8mm thick Pipe
- Material of Bracing Pipe – FE 345
- Depth of Slab – 150mm

iJETRM
International Journal of Engineering Technology Research & Management
Published By:
https://www.ijetrm.com/

- Bay Size in X and Y Direction -6m, 6m, 6m

1.3.2 RUBBER BASE ISOLATOR

1.3.2.1 Base-Isolation System

The collection of special elements, including all individual isolators and their connections to the adjoining structural elements, which transfer forces due to gravity and forces induced during earthquake shaking, between the structural elements of the building above and below the base-isolation system.

1.3.2.2 Base Isolator

The horizontally flexible and vertically stiff structural element of the base-isolation system provided in the building, which is designed to permit a specified value of lateral displacement at the base of the building during earthquake shaking, and to dissipate energy under cyclic loading.

The following properties considered in the modelling of the base isolator:

U1 Direction:

- Effective stiffness (Linear Properties) – 25000 KN/m

U2 & U3 Direction

- Stiffness (for Linear Analysis cases) – 1300 KN/m
- Stiffness (Nonlinear Properties) – 6800 KN/m
- Yield Strength (Nonlinear) – 75 KN
- Post Yield Stiffness ratio (Nonlinear) - 0.13

U3 Direction

- Stiffness (for Linear Analysis cases) – 1300 KN/m
- Stiffness (Nonlinear Properties) – 6800 KN/m
- Yield Strength (Nonlinear) – 75 KN
- Post Yield Stiffness ratio (Nonlinear) - 0.1

1.4 STRUCTURAL MODEL

Table 1-1: Structural Model Data

No. of Stories	G+5
Storey Height	3.0
Concrete Grade	M 30
Steel Grade	Fe 345
Width of Building – X Direction	18.0 m
Width of Building – Y Direction	18.0 m
Height of Building	18.0m

The G+5 story steel building was analysed for gravity, seismic (Time History) in SAP 2000. For the comparative study, beam and column dimensions are kept same in all buildings. Height of the story is 3.0 m. and beam length in longitudinal and transverse direction is shown in **Table 4.2.** The objective is study the seismic behaviors of different configurations of Structures for the following objectives:

1. Base shears Comparisons for different configurations
2. Deflection at the top of the isolator v/s story deflection
3. Moment comparisons

iJETRM
International Journal of Engineering Technology Research & Management
Published By:
https://www.ijetrm.com/

4. Techno-economic analysis

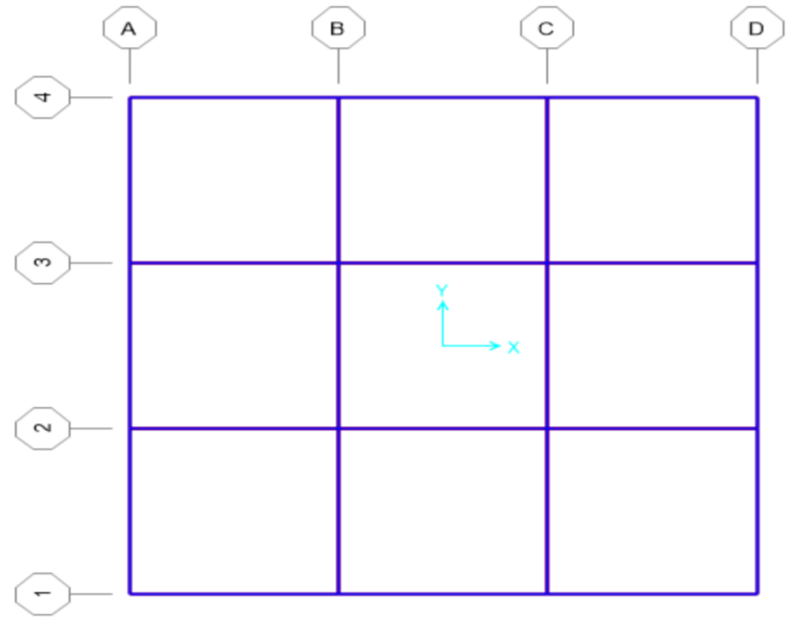
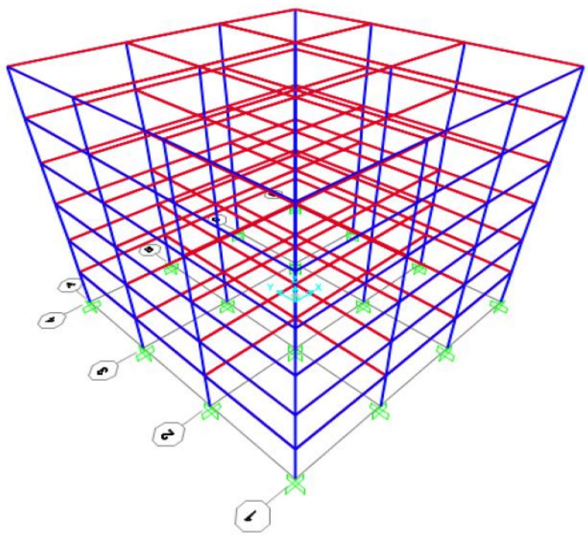


Fig. 1-2: Building Plan



iJETRM
International Journal of Engineering Technology Research & Management
Published By:
https://www.ijetrm.com/

Fig. 1-3: 3D View of Fixed Support Unbraced Building

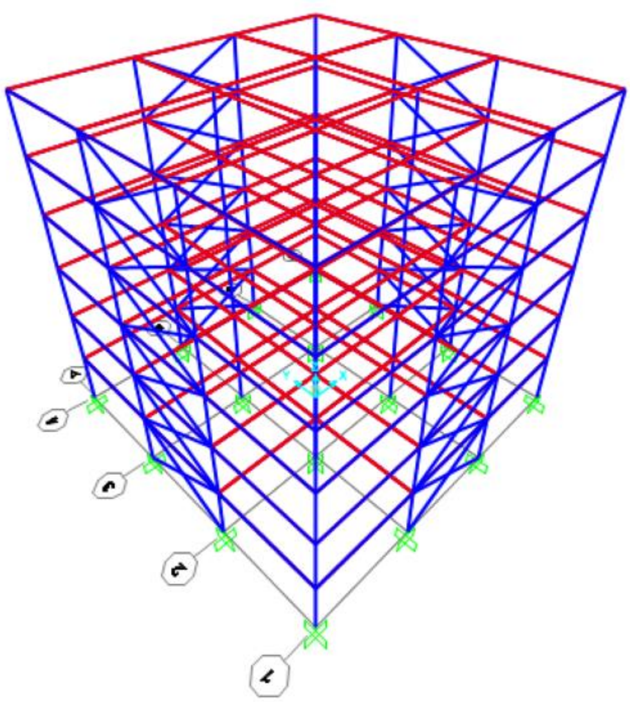


Fig. 1-4: 3D View of Fixed Support braced Building

The study of the dynamic characteristics of the base-isolated and fixed base multi story building. To examine the influence of isolator characteristics and compare the seismic response of base-isolated multi story building for zone V.

The work includes design of G+7 and G+14 story reinforced concrete symmetric building in accordance with IS1893:2002 provisions, one with fixed base and other is base isolated. By analyzing the fixed base building, we get maximum reactions under each column. For these maximum values lead rubber bearings (LRBs) are analyzed in order to isolate the superstructure from substructure. 3 bay G+7 and G+14 story structure was analyzed for dynamic earthquake using Response Spectrum Analysis. Modeling and analysis is done using ETAB software. The design is based on IS1893-2002 and IS875-1987.

The specific objectives of the study are:

1. To carry out modeling and analysis of fixed base and isolated base buildings by using E-TABS software and compared their results, to identify the effectiveness of isolation system.
2. To evaluate story displacement in case of multi-story building structures.
3. Characterizing base-isolation structures and the study for the parameters influencing its behavior during earthquake.

The study of the dynamic characteristics of the base-isolated and fixed base multi story building. To examine the influence of isolator characteristics and compare the seismic response of base-isolated multi story building for zone V.

The work includes design of G+7 and G+14 story reinforced concrete symmetric building in accordance with IS1893:2002 provisions, one with fixed base and other is base isolated. By analyzing the fixed base building, we

iJETRM
International Journal of Engineering Technology Research & Management
Published By:
https://www.ijetrm.com/

get maximum reactions under each column. For these maximum values lead rubber bearings (LRBs) are analyzed in order to isolate the superstructure from substructure. 3 bay G+7 and G+14 story structure was analyzed for dynamic earthquake using Response Spectrum Analysis. Modeling and analysis is done using ETAB software. The design is based on IS1893-2002 and IS875-1987.

The specific objectives of the study are:

1. To carry out modeling and analysis of fixed base and isolated base buildings by using E-TABS software and compared their results, to identify the effectiveness of isolation system.
2. To evaluate story displacement in case of multi-story building structures.
3. Characterizing base-isolation structures and the study for the parameters influencing its behavior during earthquake.

The study of the dynamic characteristics of the base-isolated and fixed base multi story building. To examine the influence of isolator characteristics and compare the seismic response of base-isolated multi story building for zone V.

The work includes design of G+7 and G+14 story reinforced concrete symmetric building in accordance with IS1893:2002 provisions, one with fixed base and other is base isolated. By analyzing the fixed base building, we get maximum reactions under each column. For these maximum values lead rubber bearings (LRBs) are analyzed in order to isolate the superstructure from substructure. 3 bay G+7 and G+14 story structure was analyzed for dynamic earthquake using Response Spectrum Analysis. Modeling and analysis is done using ETAB software. The design is based on IS1893-2002 and IS875-1987.

The specific objectives of the study are:

1. To carry out modeling and analysis of fixed base and isolated base buildings by using E-TABS software and compared their results, to identify the effectiveness of isolation system.
2. To evaluate story displacement in case of multi-story building structures.
3. Characterizing base-isolation structures and the study for the parameters influencing its behavior during earthquake.

1.5 RESULT AND DISCUSSION

1.5.1 BASE REACTION

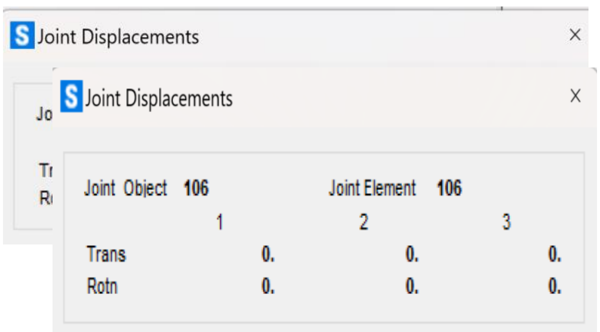
Base reaction is the force of building response force acted at the point to check the foundation / soil bearing capacity at that point

1.5.2 ABSULUTE DISPLACEMENT OF JOINTS

The absolute displacements are the total displacements of joints / floors with respect to the base points.

1.5.3 RELATIVE DISPLACEMENT OF JOINTS FOR FIXED BASE

The relative displacements are the relative displacements of joints / storey drift with respect to the base points.



Vol-08 Issue 07, July -2024 ISSN: 2456-9348
Impact Factor: 7.936

iJETRM
International Journal of Engineering Technology Research & Management
Published By:
https://www.ijetrm.com/

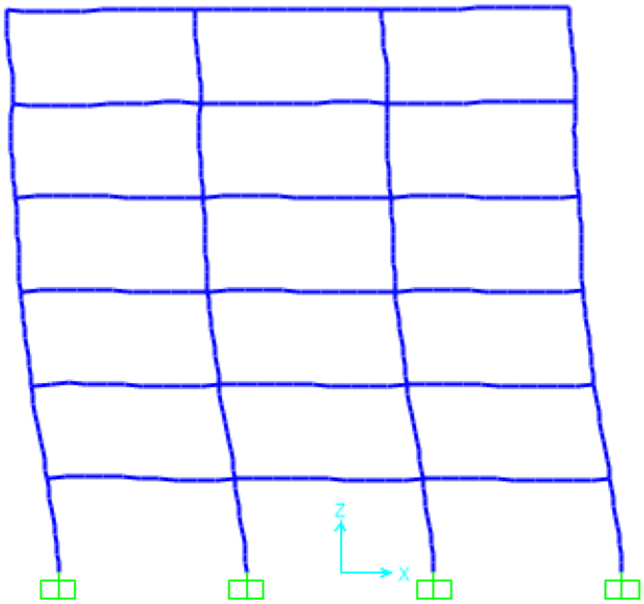
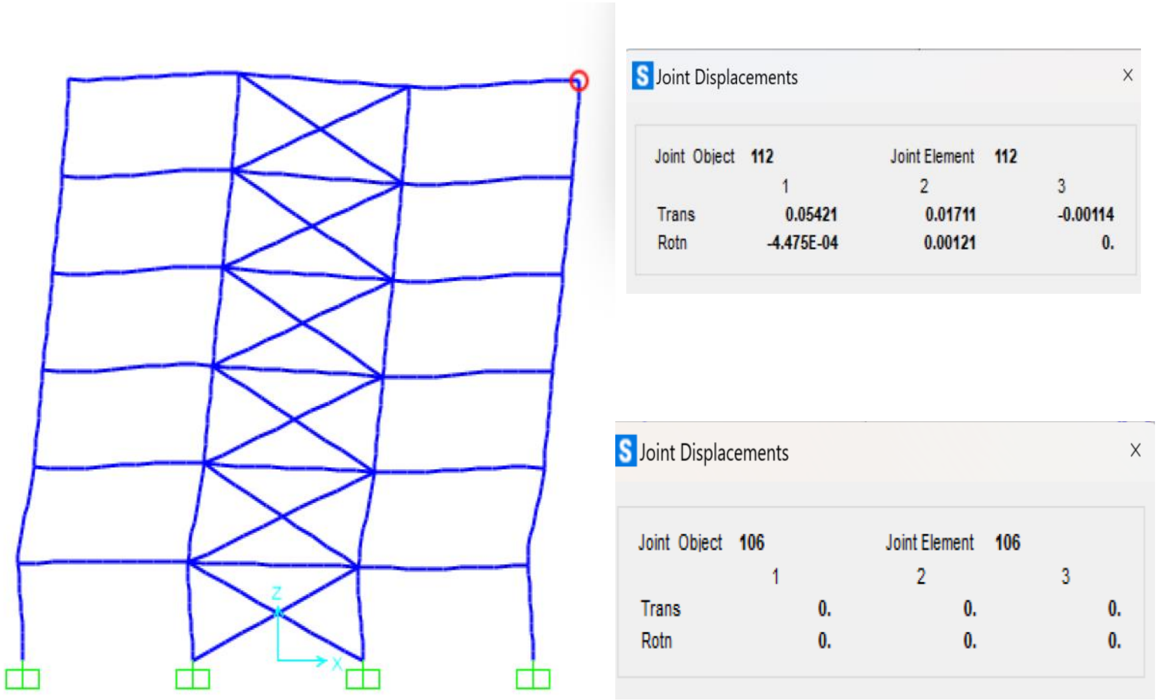


Fig. 1-5: Relative Displacement at roof level and base level for Fixed base (Joint Element No. 106 and 112) SAP - XY View



iJETRM
International Journal of Engineering Technology Research & Management
Published By:
https://www.ijetrm.com/

Fig. 1-6: Relative Displacement at roof and base level for Fixed base Braced (Joint Element No. 106 and 112) SAP - XY View

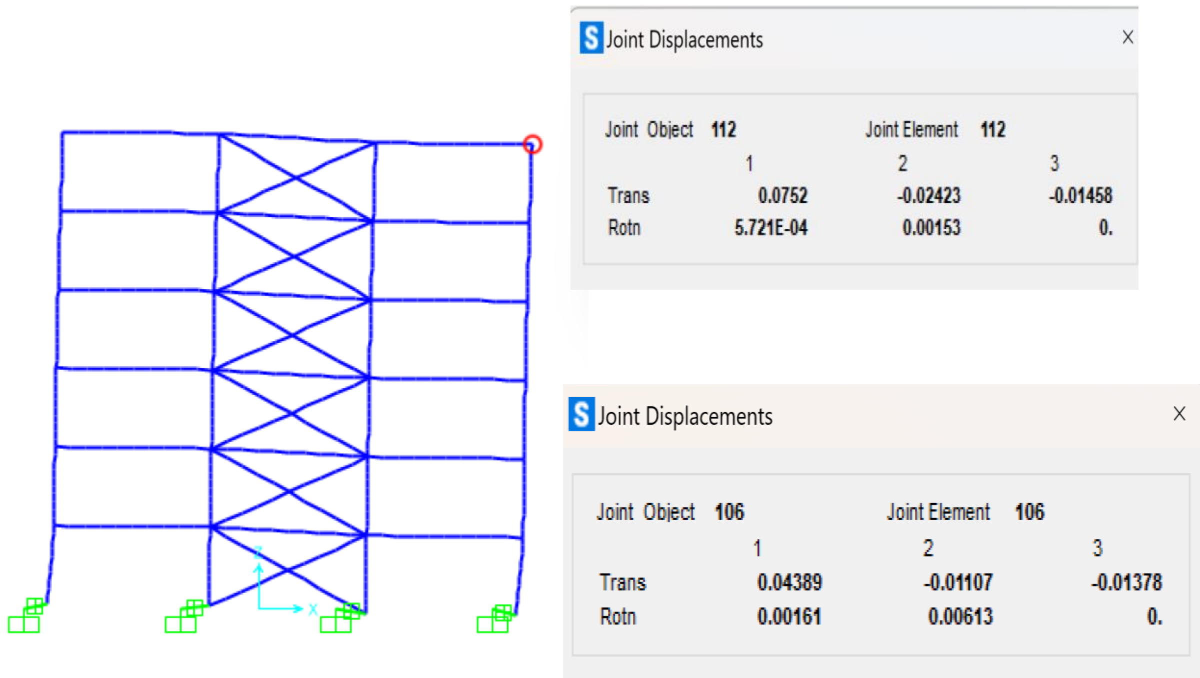


Fig. 1-7: Relative Displacement at roof and base level for Rubber base Isolator Steel Braced (Joint Element No. 106 and 112) SAP 2000- XY View

1.5.4 RESULTS COMPARISON

The results comparison for Joint displacements and displacements absolute for row 1-D and base reactions are tabulated below from table 1.2 to 1.8 followed by conclusion.

Table 1-2: Comparison Table of Joint Displacement max. (U1)

Joint Text for 1 D rows base to 6th Storey floor	Fixed Base (U1)	Fixed Braced Base (U1)	Rubber Isolated (U1)	Rubber Isolated Braced (U1)
85	0	0	0.0389	.0438
86	0.0183	0.005	0.05299	.0577
87	0.0379	0.0127	0.0579	0.0602
88	0.047	0.0231	0.0614	0.0627
89	0,051	0.0347	0.0647	0.0660
90	0.0578	0.0457	0.0677	0.0703

iJETRM
International Journal of Engineering Technology Research & Management
Published By:
https://www.ijetrm.com/

91	0.069	0.0542	0.0704	0.0751

Table 1-3: Comparison Table of Joint Displacement max. (U2)

Joint Text for 1 D rows base to 6th Storey floor	Fixed Base (U2)	Fixed Braced Base (U2) m	Rubber Isolated (U2) m	Rubber Isolated Braced (U2) m
85	0	0	0.008	0.0057
86	0.004	0.0029	0.009	.0.0068
87	0.009	0.0066	0.0109	0.0077
88	0.014	0.0100	0.0127	0.0100
89	0.017	0.0130	0.0138	0.0129
90	0.019	0.0154	0.0160	0.0157
91	0.020	0.0171	0.0179	0.0183

Table 1-4: Comparison Table of Joint Displacement max. (U3)

Joint Text for 1 D rows base to 6th Storey floor	Fixed Base (U3)	Fixed Braced Base (U3) m	Rubber Isolated (U3) m	Rubber Isolated Braced (U3) m
85	0	0.	0.0062	0.0072
86	0.0003	0.0001	0.0063	0.0073
87	0.0006	0.0002	0.006	0.0074
88	0.0008	0.0003	0.0064	0.0075
89	0.0010	0.0004	0.0065	0.0075
90	0.0011	0.0004	0.0066	0.0076
91	0.0011	0.0004	0.0066	0.0076

iJETRM
International Journal of Engineering Technology Research & Management
Published By:
https://www.ijetrm.com/

Table 1-5: Comparison Table of Joint Displacement - Absolute max. (U1)

Joint Text for 1 D rows (base to 6th Storey floor)	Fixed Base (U1) m	Fixed Base Braced (U1) m	Rubber Isolated (U1) m	Rubber Isolated Braced (U1) m
85	0.928	0.928	0.093	0.9292
86	0.928	0.928	0.930	0.9294
87	0.928	0.928	0.930	0.9294
88	0.928	0.928	0.930	0.9293
89	0.928	0.928	0.930	0.9293
90	0.928	0.928	0.930	0.9292
91	0.928	0.928	0.930	0.9292

Table 1-6: Comparison Table of Joint Displacement - Absolute max. (U2)

Joint Text for 1 D rows base to 6th Storey floor	Fixed Base (U2)m	Fixed Braced Base (U2) m	Rubber Isolated (U2) m	Rubber Isolated Braced (U2) m
85	0.005	0.005	0.0076	0.0080
86	0.006	0.006	0.0093	0.0082
87	0.010	0.008	0.0111	0.0082
88	0.015	0.010	0.0127	0.0097
89	0.018	0.011	0.0138	0.0112
90	0.021	0.013	0.0146	0.0127
91	0.022	0.014	0.0167	0.0149

Table 1-7: Comparison Table of Joint Displacement - Absolute max. (U3)

Joint Text for 1 D rows base to 6th Storey floor	Fixed Base (U3) m	Fixed Base - Braced (U3) m	Rubber Base Isolated (U3) m	Rubber Base Isolated - Braced (U3)

iJETRM
International Journal of Engineering Technology Research & Management
Published By:
https://www.ijetrm.com/

85	0	0	0.006	0.0072
86	0.0003	0.0001	0.006	0.0073
87	0.0006	0.0002	0.006	0.0074
88	0.0008	0.0003	0.006	0.0075
89	0.0010	0.0004	0.006	0.0075
90	0.0011	0.0004	0.006	0.0076
91	0.0012	0.0004	0.006	0.0076

Table 1-8: Base Reactions

Fixed Base Model Response			Fixed Braced base Model Response			Rubber Base Isolated Model Response			Rubber Base Isolated Braced Model Response		
Global FX - KN	Global FY - KN	Global FZ - KN	Global FX - KN	Global FY - KN	Global FZ - KN	Global FX - KN	Global FY - KN	Global FZ - KN	Global FX - KN	Global FY - KN	Global FZ - KN
4466.58	851.91	0.004	4593.20	1969.80	0.004	1264.3	954.0	0.0006	1303.1	883.6	0.004

1.5.5 CONCLUSION

- Base isolators controls structural response in which the building or structure is decoupled from the horizontal component of the earthquake ground motion.
- The Base isolation substantially increases the absolute displacement of the building and hence correspondingly reduces base shear, story drift and story acceleration.
- Story drift in Base isolated building is reduced compared to fixed base building.
- From the results, it is observed that how effective seismic isolation works but considering various aspects such as: base shear, absolute joint displacement, joint displacement etc. for all the four structural models the lateral displacements reduces in fixed base with bracing than fixed base with bracing.
- In Rubber base with bracing and without bracing the absolute displacements, relative displacements and base reaction having very marginal difference hence it is concluded that the bracings in base isolation system having almost no impact due to reduction in relative displacement (story drift)
- The bracings are much effective in fixed base model which provide lateral stiffness due to increase in relative story displacement and reduces the relative as well as absolute displacements vis a vis base shear / base reaction

REFERENCES

1. Budescu M., Ciondradi I.P., Ţăranu N., Gavrilaş I., Ciupală Mihaela Anca, Lungu Irina, Rehabilitation of Constructions, Editura Vesper, Iaşi, 2001.
2. Ciupală Mihaela Anca, Optimal Procedures for Increasing the Safety of Constructions subjected to Seismic Motions considering Torsion Effect, PhD thesis, Technical University ”Gh. Asachi” of Jassy, 1998.
3. Hrovat, D., Barak P., Rabins M., Semi-active versus passive or active tuned mass dampers for structural control, ASCE Journal Eng. Mech., pp. 691–705 (1983).
4. Housner G.W., Bergam L.A., Cauchy T.K., Chassiakos A.G., Claus R.O., Skelton S.M. and R.E., Soong T.T., Spencer B.F., Yao J.P.T., Structural control: Past, Present and Future Control, Journal of Engineering Mechanics, pp. 897-971, (1997).

iJETRM
International Journal of Engineering Technology Research & Management
Published By:
https://www.ijetrm.com/

5. Karnopp D.C., Crosby M.J., Harwood R.A., Vibration Control Using Semi-Active Force Generators. ASME Journal of Enginering for Industry 2, 619-626 (1974).
6. Kabori T., Mission and Perspective towards Future Structural Control Research. Proceedings of the Second World Conference on Structural Control, Vol. I, Kyoto, Japan, 1999, ISBN 0471 98310 11999.
7. Jerome P.L., Active Structural Control Research at Kajima Corporation. The National Science Foundation's Summer Institute in Japan Program, 1998.
8. Magonette G., Marazzi F., Tognoli P., Buchet P., Renda V., Experimental Analysis of Active Control of Vibration of a Large-Scale Cable-Stayed Bridge Mock-Up. Proceedings of the 7th International Seminar on Seismic Isolation, Passive Energy Dissipation and Active Control of Vibrations of Structures, Assisi, Italy, 2001.
9. Marazzi F., Magonette G., Active and Semi-Active Control of Structures: A Comparison. European Meeting on Intelligent Structures, Ischia, Italia, 2001.
10. IS:1983: 2016 (Part 1)
11. IS:1983: 2016 (Part 6) ; Criteria for earthquake resistance Design of Structures Base Isolation Building