

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 8, Issue 4, April 2019

Seismic Analysis of Multistorey Building using Base Isolation

Suyash Kangane¹, Pratik Mahajan¹, Shriya Vanage¹, Akash Parthe¹, N.G. Gore²

UG Student, Department of Civil Engineering, Mahatma Gandhi Mission's College of Engineering and Technology,
Kamothe, Navi Mumbai, India ¹

Professor, Department of Civil Engineering, Mahatma Gandhi Mission's College of Engineering and Technology,
Kamothe, Navi Mumbai, India ²

ABSTRACT: The world is fast developing and infrastructure has been one of the important contributors to this development. These structures when fail or collapse, many problems occur in the form of loss of life or property. The failure may be caused due to faulty construction or may be due to human intervention (such as terrorist attacks etc.) and some maybe due to the natural disasters. An earthquake is one such natural disaster. It is very severe as it ranges from barely felt to violent enough to toss people. This paper aims to draw one's attention towards the construction of structures by using earthquake resistant technique namely base isolation. Several design philosophies in earthquake engineering, make use of experimental results, observations from past earthquakes to sustain the seismic attack that may occur in future. It varies from sizing the structure to be strong and ductile enough to survive the shaking with an acceptable damage, to equipping it with base isolation to minimize the forces and deformations.

KEYWORDS: Base Isolation, spring isolators, lead rubber bearing, earthquake resistant

I. INTRODUCTION

The main principle of base isolation is to modify the stimulus of building to the earthquake so that the ground below the building can move without transmitting these motions into the superstructure. In the real world, there needs to be some contact between the structure and the ground. But for the rigid structures, the superstructure will be affected due to the movement of ground induced by seismic waves and there will be zero relative displacement between the structure and the ground that is structure will move along with the ground and so it will be devastated. Base isolation aims to make the structure flexible due to which the structure will have infinite period. When the ground beneath the structure moves, acceleration will not be induced in the superstructure and the relative displacement between the structure and the ground will be equal to the ground displacement.

The patent for base isolation was first claimed in 1800s, but its practical application was introduced to the world in 1970 at Tokyo Imperial Hotel. Later on, it was moved to the mainstream of structural engineering. Bridges were the most frequent ones to get acquainted with base isolation techniques as it uses bearings to separate superstructure from substructure. Further in 1980s a compound named "High Damping Rubber" was introduced which had low stiffness at high strains and vice versa. Some of the projects made use of lead rubber bearing and high damping rubber along with the sliding bearing which served the purpose of supporting the light component such as stairs.

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 8, Issue 4, April 2019

II. RELATED WORKS

ELASTOMERIC BEARING: - It consists of thin horizontal layers of synthetic or natural rubber bonded between steel plates. The steel plates prevent the rubber layers from bulging and so the bearing is able to support higher vertical loads with only small deformations. Plain elastomeric bearings provide no significant damping but just the flexibility due to which it moves under service loads. To overcome these deficits lead cores are inserted in the bearings and also formulated elastomers are used.

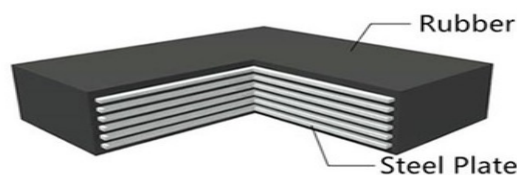


Fig 1: Elastomeric bearing

LEAD RUBBER BEARING: -As the name suggests it makes use of lead and rubber. Rubber is provided on both the sides of the lead which is placed at centre, also called as core. Rubber has high deforming and restoring capacity whereas the lead absorbs the kinetic energy generated by seismic waves and converts it into heat which reduces the energy entering into the building.

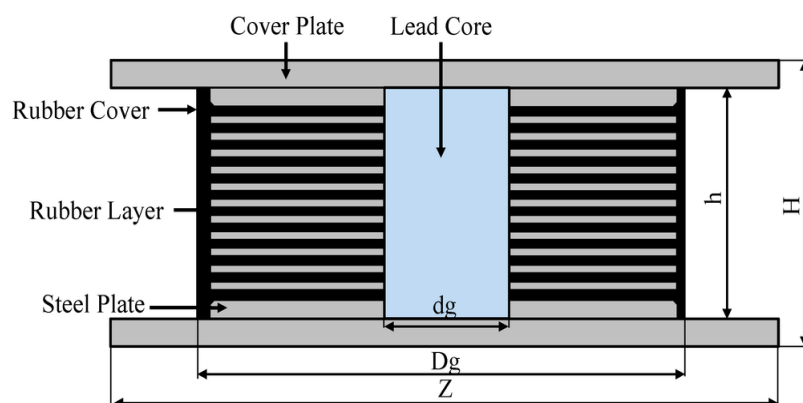


Fig 2: Lead Rubber Bearing

FRICTION PENDULUM SYSTEM (FPS):-Friction Pendulum Bearings works on the principle of simple pendulum. During an earthquake it gets activated and the slider moves along the concave surface causing the structure to move in small harmonic motions. These bearings increase the structures natural period by causing the building to slide along the concave inner surface of the bearing.

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 8, Issue 4, April 2019

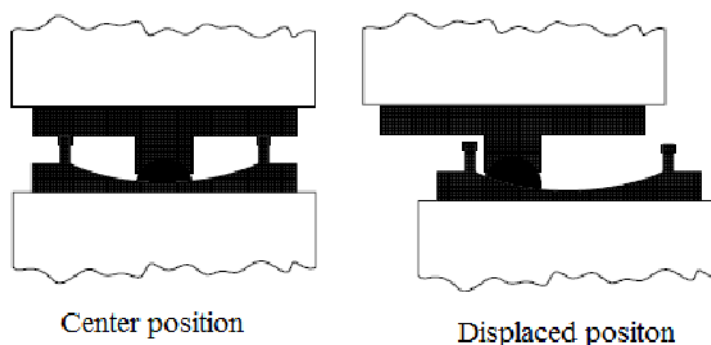


Fig 3: Friction Pendulum System

SPRING BEARINGS: - It has the ability of reducing both horizontal and vertical deformations which is experienced by the structure. It consists of helical springs compressed in the box along with the elastomers pad between them.



Fig 4: Spring Bearings

III. EXPERIMENTAL ANALYSIS

For experimental analysis we have decided to make a model of the framed G+5 structure and testing it on the shake table to find out the resisting nature of the structure against induced earthquake forces. To reduce this force acting on the framed structure we have used the base isolators.

MODEL DEVELOPMENT.

The main challenge faced by us in making of the model is that the framed structure has to be light in weight but also has to withstand the forces during the testing on shake table. So to increase the weight of the frame we have used steel instead of fibre or aluminium.

Specifications of the model made:

Material used - Steel

Dimension ratio - 1:20

Dimensions of the plate – 35 cm X 15 cm

Thickness of the plate – 1.2 cm

Width of the end panel – 2.4 cm

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 8, Issue 4, April 2019

Plate to plate height – 15 cm
Total height of the model – 98.4 cm
Sizes of bolts used - 13 mm, 15 mm



Fig 5: Framed Structure Model

MAKING OF BASE ISOLATORS ACCORDING TO REQUIREMENT OF THE MODEL

SPRING ISOLATOR: In actual practice the spring isolators used shall be of very large size but according to our model we have used relative smaller size springs which can withstand the forced induced by the Shake Table on the structure. The springs used are obtained from the engine head of two-wheeler vehicle. The diameter of the spring is 2.8 cm and the height is 4 cm. To connect the spring to the structure and also the shake table, we have welded the spring with washer with attached nut bolt



Fig 6: Spring Isolator

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 8, Issue 4, April 2019

RUBBER ISOLATOR: Actual rubber isolator is of larger size and their bearing capacity is high. As our model is of relatively smaller size and only for experimental purpose, we need not use the actual sized rubber isolator and we have made our own. For our experimental purpose we have opted rubber used in tyre tubes, folded them and inserted steel plate in between. And joined this to two more plates of larger size with holes in it so as to connect them to our structure as well as shake table.

The adhesive agent used to stick the plate and the rubber is the same one used in the patching of tubes during puncture conditions of a tyre.



Fig 7: Rubber Isolator

TESTING OF MODEL

The model has been tested on the shake table present in our laboratory three times.

- i) Only structure without base isolator
- ii) Structure with spring isolator
- iii) Structure with rubber isolator

‘Kampana’ Software was used to record the acceleration, velocity and displacement of the modal for different frequency.

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 8, Issue 4, April 2019

IV. RESULTS

WITHOUT BASE ISOLATORS: The modal is fixed on the shake table without any isolators and the readings were taken for different frequencies. The frequency is gradually increased from 2Hz to 6Hz.

Frequency on control panel	Frequency in software	Acceleration			Velocity			Displacement		
Hz	Hz	m/s ²			m/s			mm		
		CH 1	CH 2	CH 3	CH 1	CH 2	CH 3	CH 1	CH 2	CH 3
2	1.72	0.21	0.15	0.12	193.27	137.74	108.9	35.7	25.4	20.12
3	2.61	0.28	0.21	0.17	168.53	126.22	100.1	20.56	15.4	12.82
4	3.54	0.42	0.33	0.26	185.8	146.8	114.1	16.69	13.19	10.26
5	4.53	0.71	0.56	0.39	244.9	191.7	132.8	17.22	13.48	9.34
6	5.46	0.85	0.74	0.48	243	211.1	137.3	14.16	12.3	8

Table No: 1

WITH SPRING ISOLATORS: Spring Isolators are installed between the model and the shake table and following readings were taken.

Frequency on control panel	Frequency in software	Acceleration			Velocity			Displacement		
Hz	Hz	m/s ²			m/s			mm		
		CH 1	CH 2	CH 3	CH 1	CH 2	CH 3	CH 1	CH 2	CH 3
4	3.59	0.2	0.11	0.34	87.54	100.3	146.42	7.76	9.53	12.97
5	4.53	0.51	0.29	0.97	174.67	101.5	333.1	12.28	7.14	23.42
6	5.46	0.29	0.16	0.49	82.15	44.44	140.73	4.79	2.59	8.2

Table no: 2

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 8, Issue 4, April 2019

WITH RUBBER ISOLATOR: After spring isolator, Rubber isolator are installed between the model and shake table and following readings were taken.

Frequency on control panel	Frequency in software	Acceleration			Velocity			Displacement		
Hz	Hz	m/s ²			m/s			mm		
		CH 1	CH 2	CH 3	CH 1	CH 2	CH 3	CH 1	CH 2	CH 3
3	2.66	0.35	0.23	0.12	232.54	155.72	72.67	27.85	18.65	8.7
4	3.59	0.35	0.23	0.12	394.71	280.03	97.78	34.97	24.81	8.66

Table no:3

V. CONCLUSION

Lastly, we conclude with the understanding of the behaviour of a structure under earthquake force with base isolator & without base isolator (fixed base).

- 1) After whole study, we can clarify that the point displacements of fixed base building are comparatively less than isolated building. But in case of base isolated building the point displacements at each story are almost same.
- 2) In isolated base building the moments due to earthquake forces are comparatively less than fixed base buildings.
- 3) From the experimental analysis of the framed structure using different base isolation devices we can conclude that the deflection of the structure is the least when rubber isolators are used.
- 4) In seismic zone IV & V base isolated structure is economical and advisable.

Finally, we can say that, though primary cost of isolated building is high as compared to fixed base building, it proves profitable on a future date.

REFERENCES

- [1] S.J.Patil,G.R.Reddy. State Of Art Review -Base Isolation Systems For Structures International Journal of Emerging Technology and Advanced Engineering.(ISSN 2250-2459, Volume 2, Issue 7, July 2012)Heavy Water Board, Mumbai, India . Bhabha Atomic Research Centre, Mumbai, India.
- [2] Sandip Kumar Saha*, Vasant A. Matsagar, Arvind K. Jain.Comparison of base-isolated liquid storage tankmodels under bi-directional earthquakes.Vol.5, No.8A1, 27-37 (2013) doi:10.4236/ns.2013.58A1004.Department of Civil Engineering, Indian Institute of Technology (IIT) Delhi, New Delhi, India; Corresponding Author: sandipksh@civil.iitd.ac.in Received 13 June 2013; revised 13 July 2013; accepted 20 July 2013
- [3] Satish Kumar S.R.– Research On Earthquake Resistant Structural Design At IIT, Madras. (International Workshop on Earthquake Hazards & Mitigations on December 7-8, 2007 at IIT Guwahati, India, Paper No. 12)
- [4] Parulekar Y.M., Reddy G.R., Vaze K. K., Ghosh A.K.- Seismic response control of complex piping system using elasto-plastic dampers – Experiments and analysis. (International Workshop on Earthquake Hazards & Mitigations on December 7-8, 2007 at IIT Guwahati, India.
- [5] Mahmoud Sayed Ahmed.Building With Base Isolation (Techniques Presented to Ryerson University)Toronto, Ontario, Canada, 2012. m.sayedahmed@engineer.com
- [6] Gordon P. Warn 1,* and Keri L. Ryan.A Review of Seismic Isolation for Buildings: Historical Development and Research Needs. Department of Civil and Environmental Engineering, Pennsylvania State University, 226B SackettBuilding, University Park, PA 16802, USADepartment of Civil and Environmental Engineering, University of Nevada, Reno/MS 0258, Reno,NV 89557, USA; E-Mail: keri.ryan@unr.edu Received: 24 April 2012; in revised form: 12 July 2012 / Accepted: 18 July 2012 / Published: 3 August 2012
- [7] Mehdi EzatiKooshki , Abbas AbbaszadehShahri. Seismic response controlling of structures with a new semi base isolation devices Department of Civil Engineering, Science and Research Branch, Islamic Azad University, Tehran, Iran ISSN 1026-3861 WALIA journal 31(S1): 30-38, 2015.
- [8] San Bartolomé1, D. Quiun.EXPERIMENTAL RESEARCH AND SEISMIC DESIGN PROPOSAL FORCONFINED ADOBE MASONRY. Vancouver, British Columbia, June 2-5,2013Professor, Department of Engineering, Catholic University of Peru, Av Universitaria 1801, Lima



ISSN (Online): 2319-8753
ISSN (Print) : 2347-6710

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 8, Issue 4, April 2019

- 32, Peru, asanbar@pucp.edu.pe Professor, Department of Engineering, Catholic University of Peru, Av Universitaria 1801, Lima 32, Peru, dquiun@pucp.edu.pe
- [9] AHMER ALI NADIN ABU HAYAH, DOOKIE KIM and SUNG GOOK CHO. PROBABILISTIC SEISMIC ASSESSMENT OF BASE-ISOLATED NPPS SUBJECTED TO STRONG GROUND MOTIONS OF TOHOKU EARTHQUAKE. *Department of Civil and Environmental Engineering, Kunsan National University, Jeonbuk, Korea R & D Center, JACE KOREA Company, Gyeonggi-do, Korea*, Received March 19, 2014 Accepted for Publication June 13, 2014
- [10] J. C. Ramallo, E. A. Johnson, A.M.ASCE, and B. F. Spencer Jr, M.ASCE "Smart" Base Isolation Systems