

Comparative Analysis Of Multi-Storey Building In Zone II And Zone IV With And Without Rubber Base And Friction Pendulum Isolation

MD AWES SHADAB

Department of Civil Engineering

Poojya Doddappa Appa College of Engineering, Kalaburagi, Karnataka, India.

Prof. RAJASHREE CHINTA

Department of Civil Engineering

Poojya Doddappa Appa College of Engineering, Kalaburagi, Karnataka, India.

Abstract- The base isolation procedure has been utilized to shield the structures from the quake's harming impacts. The expansion of separators at the establishment improves the structure constructions' dependability. Seismic isolation and energy dissemination systems give an effective method of improving the seismic effectiveness of constructions through a typical seismic plan. Such strategies limit seismic loads by changing the inflexibility and damping of the constructions, though customary seismic design requires extra strength and flexibility to withstand seismic loads. Perhaps the main standards in the plan of tremor safe designs is the base detachment strategy.

In this present study a G+10 story building analyzed by using Rubber bearing isolation system and friction pendulum system in seismic Zone II and Zone IV with the help of IS 1893:2016 Code in ETABS Software package. The comparison is made between Rubber bearing system general building for seismic parameters like story drift, shear force, time period, storey-displacement.

Key words: Seismic isolation, Rubber bearing isolation system, story drift, shear force, building torsion.

I. INTRODUCTION

Introduction

Aim of earthquake protection in buildings is to offer comfort & structural safety by regulating displacement & internal forces within prescribed limits. The most frequent way for safeguarding structures from the damaging impacts of earthquakes is to dampen seismic energy by restricting seismic energy via structural features, hence creating earthquake resistance. Despite the fact that this approach provides some amount of protection, the building may be harmed for real at times. By separating the building from the ground or by installing seismic energy dissipation devices in earthquake locations the structure can be protected from the earthquake. By planning effectively against earthquakes, this strategy can give better protection and thereby reduce the amount of serious structural damage.

As we can see from the data, earthquakes continue to be a significant factor threatening the social and economic futures of countries. As a result, it is demanded that resolutions that limit seismic effects of structures must prove a significant level of performance in predicted earthquakes. For reducing effects of lateral loads on top storey the energy dissipating & seismic isolators devices are the best solution which are positioned in structure thus reducing seismic energy or place in among vertical structural systems & foundation for reducing the seismic energy. The use of earthquake protection systems in structures, both new and old, especially historical ones, enhances the value of these technologies.

Seismic isolation

It's a strategy for reducing damage that earthquakes do to structures and their components, as well as protecting them from damage. To restrict the lateral movement of structures (Drift), we use certain hardwires that I will cover later in this technique.

Seismic isolation, which is well-defined as separating or disconnecting structure from its foundation, is one of the most important notions in earthquake engineering. Seismic isolation, in other words, is a strategy used to prevent or limit structural failure in an earthquake. The idea of base isolation will be discussed in this essay using examples from other sport branches and engineering. Automobile suspension systems and boxing defence methods are two examples. In addition, certain experiments and analytic graphs will be shown to help students comprehend the notion of base isolation.

The Principle of seismic isolation:

Seismic isolation refers to all processes created to protect buildings from earthquakes, hence assuring security safety and under service loads, and that involve the placement of specified kinds of extra materials in the building. In buildings, different kinds of seismic isolation systems are used. Before discussing these methods, it is important to understand seismic isolator in the context of fundamental dynamics concepts. Within context of fundamental ideas of dynamics, seismic isolation in a building may be maintained by management, modification, and adjustment of building's mass, structure's restoring-force when touched by seismic forces, and damping of building. Equation of motion of a structure exposed to ground motion, as is well known, is influenced by the building's mass, stiffness, and energy damping properties, as well as external seismic forces affecting building. Stiffness of the structure may be changed to change the characteristics of the response forces. When the building's rigidity is diminished, displacements rise and reaction acceleration drops. On the other hand, by improving structure's ability to absorb sound, the acceleration and displacement response may be minimised. Dampers of various types and configurations may be installed in building. To modify structural system's dynamic qualities, one may play with system's overall mass and distribution of that mass. Separating building from the soil allows for control and organisation of seismic forces that affect the structure.

Need of the study

Base isolation as an approach for earthquake protection. It is a technique in which the structure is isolated from the foundation by installing base isolators beneath the structure. These isolators enable the structure to move independently of the moving ground underneath it, essentially separating it from ground motion. Base isolators might be of the friction pendulum or lead-core rubber type. Rubber base isolators stretch with the structure when it is pushed to one side by the earthquake, then pull the building back into position as the rubber finds its natural shape.

II. LITERATURE REVIEW

Arathy S. and Manju P.M (2016) Friction pendulum are one type of base isolation technology that effectively detaches structures from the ground to enable stabilise the building from unstable ground motion, according to the research. It allow superstructures to be supported by 2 concave surfaces, in which a ball bearing acting as a buffer between them. During the time of an earthquake, the bearings change in the opposite direction of the earthquake, keeping the building stable. This technique may be used in a wide range of constructions, including buildings, bridges, and even oil rigs in the middle of the ocean. Implementing FPB can help maintain structures for decades, providing residents with a sense of security. Various structural factors of a structure isolated building with a friction pendulum, such as building deflection, drift, & overturning moment, is researched throughout this work. E-TABS 2015 was used to analyse structure nonlinearly over time. Using these metrics, a comparison study was carried out between a single, double, or triple concave friction pendulum system, and it was found that triple pendulum bearing isolator was most effective.

Tessy Thomas and Dr. Alice Mathai(2016) The paper states that Base isolation is a strategy used to minimise structure damage during the earthquake. Using flexible supports (isolators) underneath each point of support in a structure is principle behind this design, often between foundation and the main structure. Friction pendulum base isolation technology uses features of a pendulum to extend natural period of isolated structure, allowing it to withstand even most intense earthquake pressures. Nonlinear static analysis and development of a finite element

model of isolator are presented here. Model's analytical reaction is explored for structures with varying storeys, and the findings are interpreted. In ANSYS 14.5 software, a finite element model of the base isolator is produced. It is stated that as the number of storey load values grows, so does the stress intensity value. The stress intensity value which is obtained from 2 to 30 stories is within allowable limits, and the base isolator may be developed for a 22 to 30 story construction. Based on this study, it's easy to see how slider's motion generates a dynamic friction force capable of providing damping required to absorb earthquake's energy.

An Analysis of Research Concerning Friction Pendulum Base Isolation System in RC Buildings (2017) Mithranjali N. A.1, Mathew C. George2 It states that the buildings are very critical after natural disasters such as earthquakes. Using of base isolation methods to promote construction performance. One of the most effective base isolation techniques is friction pendulum. The primary goal of these works is to study at seismic study of multi-story structures with the friction pendulum isolation. Each paper includes FP with varying radius and friction coefficient. For time history analysis, different past recorded earthquakes are used, & SAP-2000 software is looked for modelling and analysis. According to a review of the research, friction pendulum isolation is the best retrofitting approach for reducing the strongest ground movements. Friction pendulum base isolation separates the building's foundation and superstructure. The purpose of using FPS is to extend the time period and lessen the building response to the greatest earthquake. In comparison to a fixed base system, a 30% earthquake demand reduces FPS while also reducing the need for strengthening meshes like bracings, frames, and shear walls. Link element is used to model FPS. Friction pendulum systems are appropriate for medium-rise buildings, and the usage of FPS increases the safety of the building and its users.

Nikolay Kravchuk, Ryan Colquhoun and Ali Porbaha (2008) It states that To improve the reliability during an earthquake the base isolation system have become an essential element of a structural system. Friction Pendulum Bearings are one sort of base isolation technology in which the superstructure is separated from foundation using specifically engineered concave surfaces & bearings to enable sway during seismic occurrences. This research shows the building of a base isolation system in the laboratory to physically illustrate the idea of Friction Pendulum for earthquake engineering education. To improve the reliability during an earthquake the

Donato Cancellara, et al (2016) Paper reports on a dynamic nonlinear investigation of several base isolation techniques for an irregularly shaped multi-story RC building. Seismic performance of a multi-story reinforced concrete structure was compared to that of two base isolation techniques. We provide a comparative technique for evaluating response of a base-isolated irregular structure to earthquakes. High Damping Rubber Bearing (HDRB) was also activated in conjunction with a Friction Slider (FS), as was Lead Rubber Bearing (LRB) with an FS. Three-dimensional, ground-up structure is subjected to a nonlinear dynamic analysis. Proposed base isolation approaches are evaluated in comparison to fixed base structure's performance.

Lead rubber bearing technique for home foundation isolation - Dhiraj Narayan Sahoo (2018) Conventional seismic design practise allows for force reductions in designs slightly below elastic level on evidence that inelastic action by high energy dissipation potential in a well-constructed building should be effective & capable of surviving a strong earthquake without collapsing. Base isolation seismic design, on the other hand, provides protection, enabling the building to operate with minimum damage even after large earthquakes by just a minor increase in cost. Structure base isolation, in essence, reduces storey stress and acceleration while increasing time period, storey displacement, and storey drift, promoting flexibility in inflexible structures by transferring energy to foundation. The analogous static approach and E-TABS software are used for this base isolation investigation and seismic analysis. The structures were analysed in Zone-II using the Special moment resistant frame, and the reactions of the structures, such as storey displacement, stiffness, drift, overturning moment, and shear, were noted and graphed. G+10 & G+15 constructions with and without isolators were associated. IS 456-2000 and IS 1893-2002 are two of Indian standard codes. Rigidity and size of LRB core that will be put at bottom of buildings were evaluated through base isolator.

III. OBJECTIVES OF THE STUDY

Objectives

The study's objectives are as follows

- Using response spectrum method, model and analyse as base isolated & fixed base structures.
- To study the parameter such as time period, base shear, storey drift, storey displacement of multi storey building by fixed base and base isolated buildings
- To compare the results of fixed base, Rubber base, Friction base Isolator Building obtained by modelling in ETABS.
- To determine the effective way of isolation for buildings between Friction pendulum isolator and Rubber base isolator.

I . DESCRIPTION OF THE MODEL

Geometry Of The Models

- The considered structures are 10 storey frame structures.
- The storey height is 3 m.
- The structure entire height is 36m.
- Size of the building is 15mx15m.
- Bay number in X-Direction is 5 and in the Y-Direction bay number is 5.
- Spacing between the column in both X Y direction is 3m.
- Grade of concrete M30.
- Grade of steel HYSD Fe500.
- Dimension of Column 460mmX460mm.
- Dimension of Beam 450mmX230mm.
- Thickness of slab 150mm.

Models Considered In The Study

CASE 1:

Model 1: Multi storey building without base isolation in zone II .

CASE 2:

Model 2: Multi storey building with rubber base isolation in zone II .

CASE 3:

Model 3: Multi storey building with friction pendulum isolation in zone II .

CASE 4:

Model 4: Multi storey building without base isolation in zone IV .

CASE 5:

Model 4:Multi storey building with rubber base isolation in zone IV.

CASE 6:

Model 4:Multi storey building with friction pendulum isolation in zone IV.

V. RESULTS AND DISCUSSION

General

For the examination of each of structure models Response Spectrum strategies are applied. The examination of the all the distinctive structure models is finished by utilizing ETABS programming. The investigation results, for example, story displacements and story drifts of all structure models are introduced and looked at.

Displacement

The presentation of the models under the use of seismic burdens is concentrated to comprehend its impact. The displacements for each models which are probably going to happen because of different lateral loads are gotten and tabulated.

According to the Indian guidelines the most extreme permissible displacement in any multi- story building is $hs/500$,

Where hs - height of building.

For the models utilized in the examination the most extreme permissible displacement

$$=36/500=0.072m = 72mm$$

Storey Drifts

According to IS 1893-2016 the greatest permissible drift for any structure is $=0.004H$

H-height of one story

For our models greatest permissible drift $= 0.004*3=0.012m = 12mm$

Parameters Studied For All Models In Zone

Maximum time period comparison of all models due to seismic loads in Zone

Table1 Maximum time period comparison of all models due to seismic loads in Zone

Mode Number	Without base isolation	With rubber base isolation	With friction pendulum
1	0.971	1.133	1.118
2	0.971	1.133	1.118
3	0.857	1.006	0.997
4	0.316	0.363	0.358
5	0.316	0.363	0.358
6	0.281	0.321	0.318

7	0.18	0.199	0.196
8	0.18	0.199	0.196
9	0.163	0.181	0.179
10	0.123	0.134	0.131
11	0.123	0.134	0.131
12	0.113	0.122	0.12

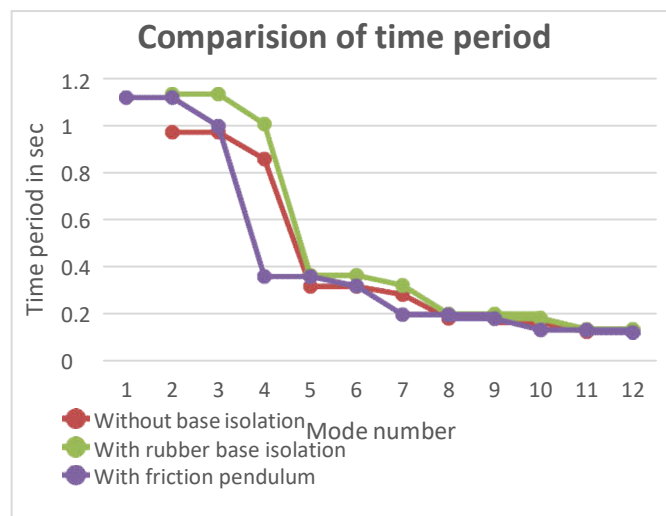


Chart 1: Maximum time period comparison of all models due to seismic loads in Zone .

Maximum base shear comparison of all models due to seismic loads in Zone

Table 2 Maximum base shear comparison of all models due to seismic loads in Zone .

S.No	Load case	Without base isolation	With rubber base isolation	With friction pendulum
1	EQX	248.257	224.8922	231.9098

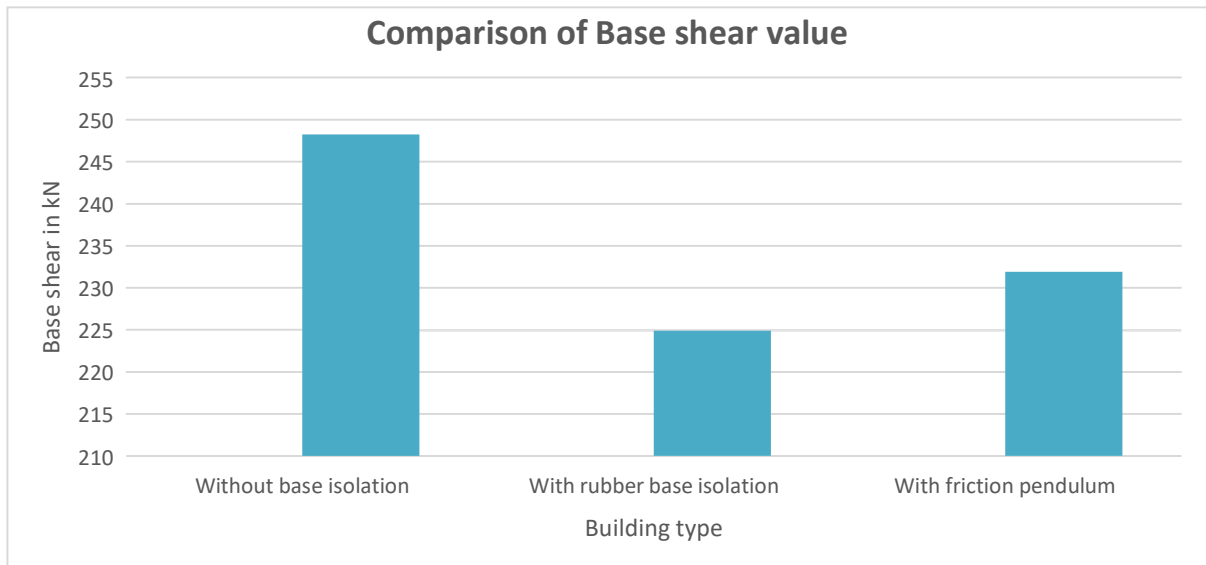


Chart 2: Maximum base shear comparison of all models due to seismic loads in Zone

Storey wise displacements in X direction for all model in Zone

Table 3 Storey wise displacement in zone

Story number	Load case	Without base isolation	With rubber base isolation	with friction pendulum
10	RSAX	4.303	4.12	4.12
9	RSAX	4.183	4.003	4
8	RSAX	4.003	3.763	3.8
7	RSAX	3.763	3.467	3.64
6	RSAX	3.467	3.122	3.45
5	RSAX	3.122	2.733	3.02
4	RSAX	2.733	2.305	2.43
3	RSAX	2.305	1.945	2.09
2	RSAX	1.845	1.259	1.43
1	RSAX	1.359	1.112	1.112
G	RSAX	0.854	0.567	0.63
P	RSAX	0.339	0.22	0.32

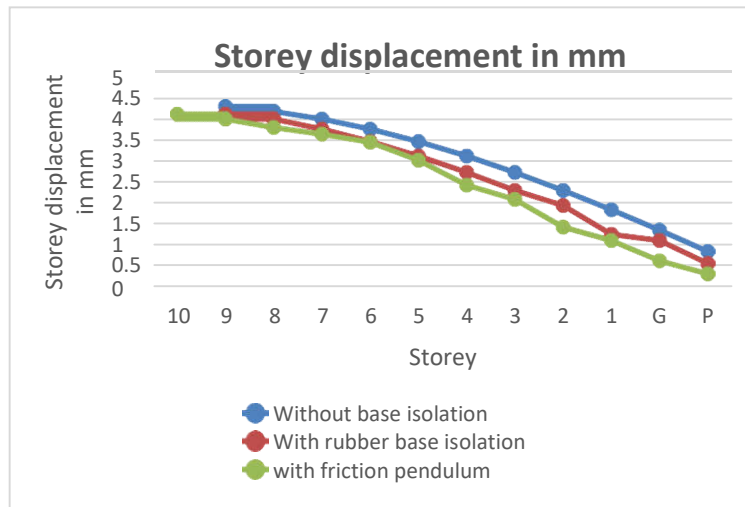


Chart 3: Storey wise displacement in zone

Storey wise storey drift ratio variation in X direction for all models in Zone

Table 4 Storey wise storey drift in zone

Story number	Load case	Without base isolation	With rubber base isolation
10	RSAX	0.000043	0.000038
9	RSAX	0.000065	0.000057
8	RSAX	0.000086	0.000076
7	RSAX	0.000105	0.000093
6	RSAX	0.000121	0.000107
5	RSAX	0.000134	0.00012
4	RSAX	0.000146	0.000131
3	RSAX	0.000155	0.000141
2	RSAX	0.000163	0.000149
1	RSAX	0.000169	0.00016
G	RSAX	0.000172	0.000203
P	RSAX	0.000113	0.000389

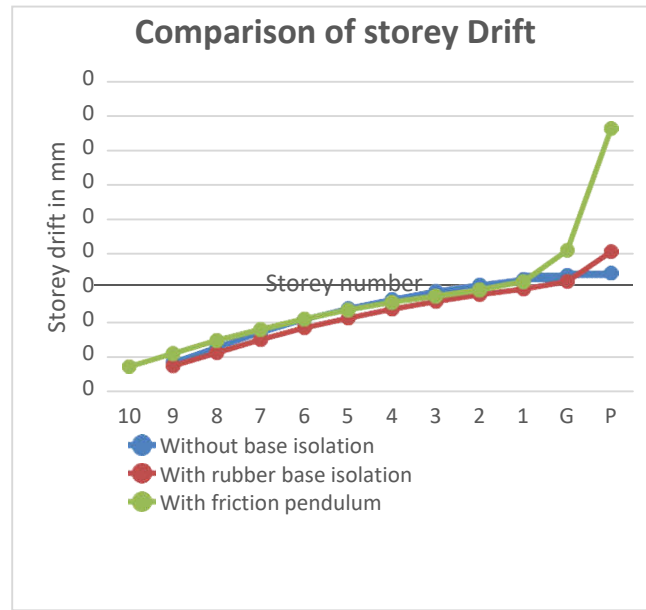


Chart 4: Storey wise storey drift in zone

Storey wise Acceleration in X direction for all models in Zone

Table 5 Storey wise storey drift in zone

Story number	Load case	Without base isolation	With rubber base isolation	With friction pendulum
10	RSAX	219.64	179.11	180.97
9	RSAX	199.1	166.95	168.81
8	RSAX	179.19	152.86	154.76
7	RSAX	166.86	141.31	143.25
6	RSAX	157.6	132.64	134.52
5	RSAX	152.26	127.18	128.88
4	RSAX	150.64	125.13	126.61
3	RSAX	145.66	123.6	124.81
2	RSAX	137.76	120.6	121.52
1	RSAX	126.9	115.81	116.47
G	RSAX	98.49	104.05	104.42
P	RSAX	43.83	73.52	73.48

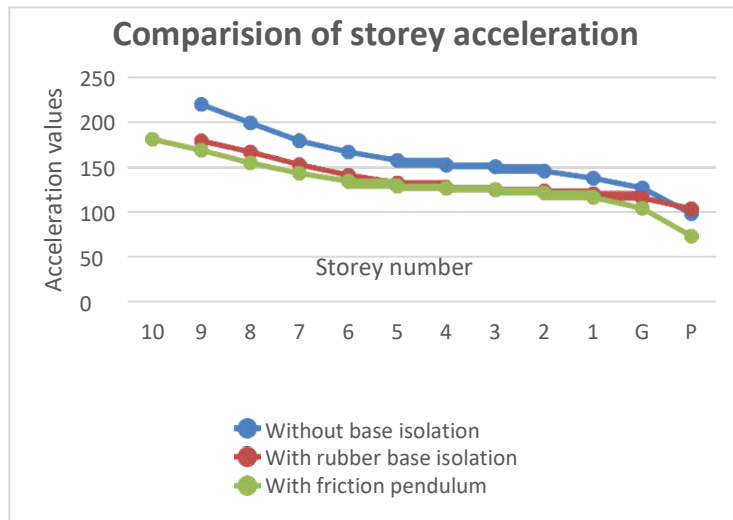


Chart 5: Storey wise acceleration drift in zone

Parameters Studied For All Models In Zone

Maximum time period comparison of all models due to seismic loads in Zone

Table 6 Maximum time period comparison of all models due to seismic loads in Zone

Mode Number	Without base isolation	With rubber base isolation	With friction pendulum
1	0.971	1.118	2.068
2	0.971	1.118	2.068
3	0.857	0.996	1.89
4	0.316	0.358	0.448
5	0.316	0.358	0.448
6	0.281	0.318	0.393
7	0.18	0.196	0.218
8	0.18	0.196	0.218
9	0.163	0.179	0.2
10	0.123	0.131	0.143
11	0.123	0.131	0.143
12	0.113	0.12	0.132

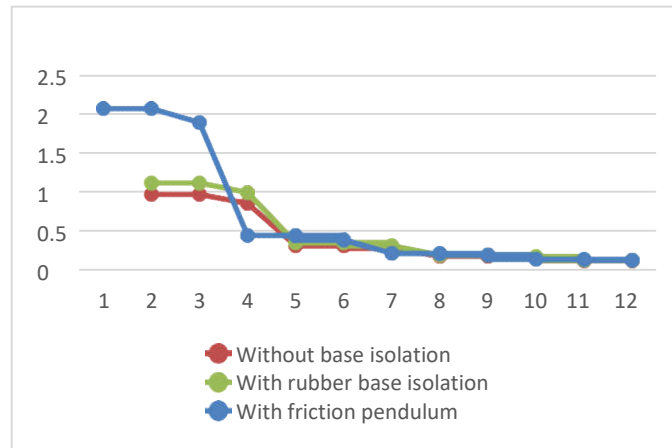


Chart 6: Maximum time period comparison of all models due to seismic loads in Zone .

Maximum base shear comparison of all models due to seismic loads in Zone

Table 7 Maximum base shear comparison of all models due to seismic loads in Zone .

S.No	Load case	Without base isolation	With rubber base isolation	With friction pendulum
1	EQX	595.8169	556.6058	328.7417

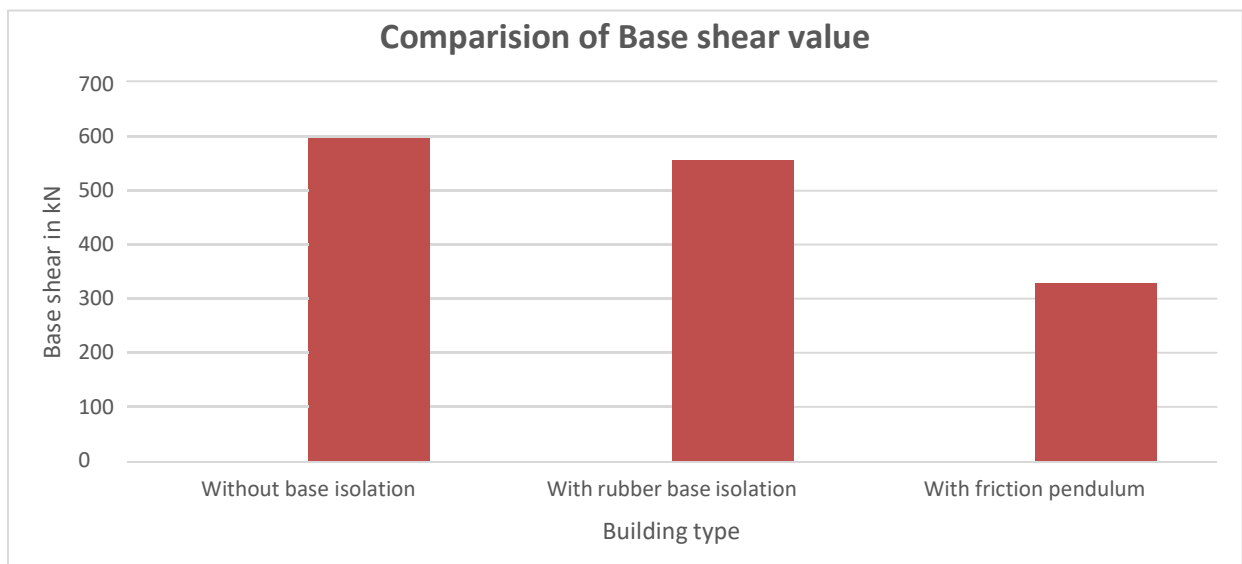


Chart 7: Maximum base shear comparison of all models due to seismic loads in Zone

Storey wise displacements in X direction for all model in Zone

Table 8 Storey wise displacement in zone

Story number	Load case	Without base isolation	With rubber base isolation
10	RSAX	10.327	9.507
9	RSAX	10.039	9.321
8	RSAX	9.607	9.031
7	RSAX	9.031	8.642
6	RSAX	8.322	8.122
5	RSAX	7.493	7.293
4	RSAX	6.559	6.221
3	RSAX	5.533	5.332
2	RSAX	4.428	4.217
1	RSAX	3.261	3.121
G	RSAX	2.049	1.532
P	RSAX	0.814	0.661

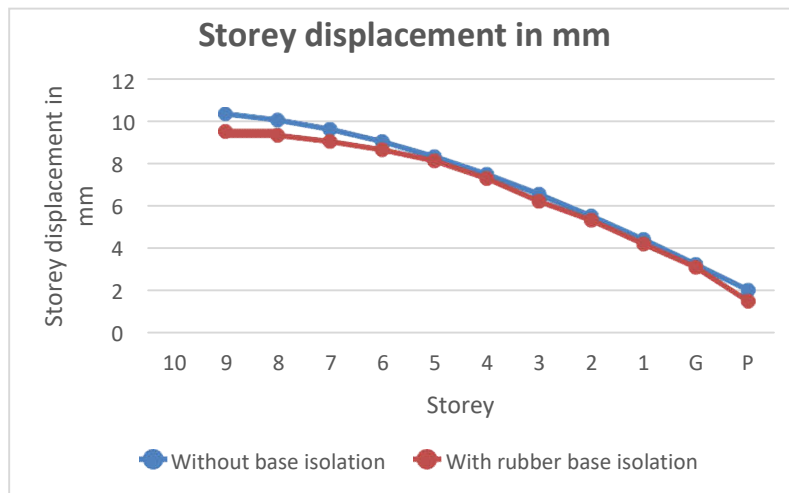


Chart 8: Storey wise displacement in zone

Storey wise storey drift ratio variation in X direction for all models in Zone

Table 9 Storey wise storey drift in zone

Story number	Load case	Without base isolation	With rubber base isolation	With friction pendulum
10	RSAX	0.000103	0.000089	0.000043
9	RSAX	0.000156	0.000134	0.000063
8	RSAX	0.000207	0.000179	0.000084
7	RSAX	0.000251	0.000219	0.000105
6	RSAX	0.000289	0.000254	0.000125
5	RSAX	0.000322	0.000285	0.000143
4	RSAX	0.00035	0.000311	0.000161
3	RSAX	0.000373	0.000334	0.000177
2	RSAX	0.000391	0.000356	0.000193
1	RSAX	0.000405	0.000384	0.000215
G	RSAX	0.000412	0.000486	0.000286
P	RSAX	0.000271	0.000911	0.000604

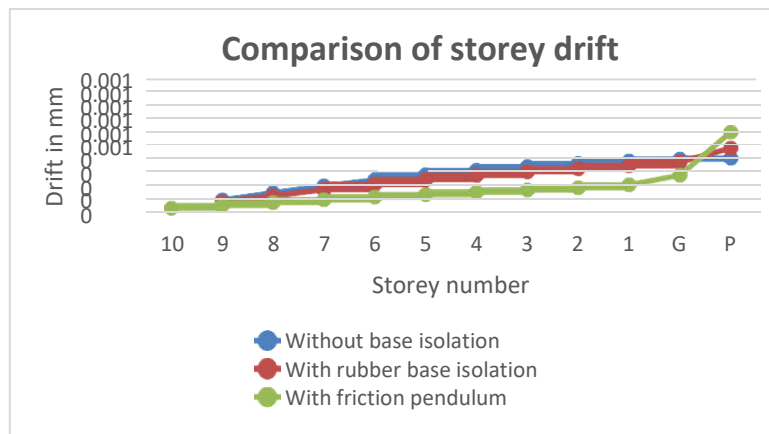


Chart 9: Storey wise storey drift in zone

Storey wise Acceleration in X direction for all models in Zone

Table 10 Storey wise acceleration in zone

Story	Load case	Without	With rubber	With friction
-------	-----------	---------	-------------	---------------

number		base isolation	base isolation	pendulum
10	RSAX	527.13	434.28	185.04
9	RSAX	477.83	405.12	180.67
8	RSAX	430.07	371.43	175.13
7	RSAX	400.46	343.8	169.61
6	RSAX	378.24	322.84	164.61
5	RSAX	365.42	309.29	160.47
4	RSAX	361.54	303.84	157.65
3	RSAX	349.59	299.53	155.94
2	RSAX	330.63	291.62	154.65
1	RSAX	304.57	279.49	153.33
G	RSAX	236.37	250.47	151.18
P	RSAX	105.19	175.63	145.72

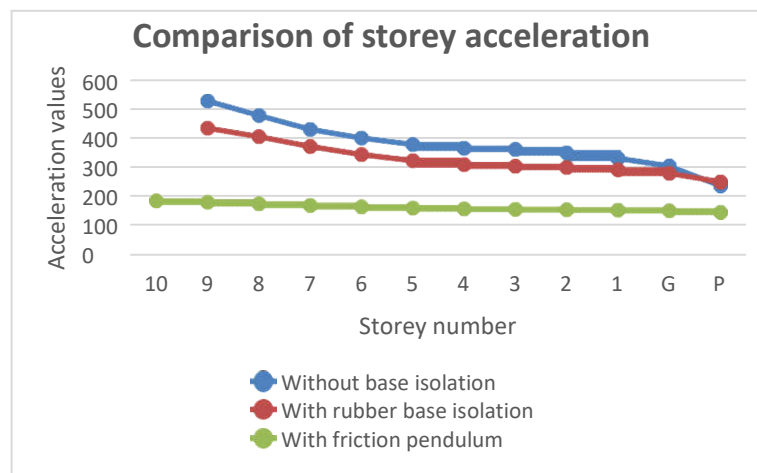


Chart 10: Storey wise acceleration drift in zone

VI. CONCLUSION

FOR ZONE

- Time period for rubber base & friction pendulum isolation is 14% more than without base isolation in zone II.

- Base shear for rubber base isolation is 9% less than without base isolation in zone II.
- Base shear for friction pendulum is 7% less than without base isolation in zone II.
- Storey displacement uniformly decreasing when base isolation is provided for all the floors
- The value of the storey drift for all the stories is found to be within permissible limit i.e, not more than 0.004 times of storey height according to the IS 1893:2016 (part 1) in zone II

FOR ZONE IV

- Time period for rubber base isolation is 13% more than without base isolation in zone IV
- Time period for friction pendulum is 53% more than without base isolation in zone IV. & time period for friction pendulum is 45% more than rubber base isolation.
- Base shear for rubber base isolation is 6% less than without base isolation in zone IV
- Base shear for friction pendulum is 44% less than without base isolation in zone IV.& base shear for friction pendulum is 40% less than rubber base in zone IV.
- Storey displacement uniformly decreasing when base isolation is provided for all the floors.
- The value of storey drift for all the stories is found to be within permissible limit i.e, not more than 0.004 times to storey height according to IS 1893:2016 (part 1) in zone IV

FOR BOTH ZONE II and ZONE IV

- Because of the longer time period and lower acceleration acting on the structures while building using base isolation, the values of drift, displacement & base shear are significantly decreased
- Optimum control of the parameters considered was observed when the building is damped with Friction Pendulum System followed by Lead Rubber isolation.
- When we compared the analysis results in zone II almost the similar results are obtained for drift, shear, time period ,displacement. But in case of zone IV seismic condition the less values are obtained for the friction pendulum model than rubber base isolation.
- So from the work carried out it can be stated that Friction Pendulum System is the best supplemental damping system

REFERENCES

1. IS 456-2000 Plain and Reinforced Concrete - Code of Practice is an Indian Standard code of practice for **general structural use of plain and reinforced concrete**
2. IS 1893-2016 Analysis of seismic zone and soil factor.
3. Tessa Thomas I, "Dr. Alice Mathai, Study of base isolation using friction pendulum bearing system".
4. Arathy S.I, Manju P.M, "Analysis of friction pendulum bearing isolated structure".
5. Ms. Minal Ashok Somwanshi† and Mrs. Rina N. Pantawane," Seismic Analysis of Fixed Based and Base Isolated Building Structures".
6. Athanasios A. Markou (2016) "Response simulation of hybrid base isolation systems under earthquake excitation Soil Dynamics and Earthquake Engineering 84(2016) 120– 133".
7. Fabio De Angelis (2016) "Nonlinear dynamic analysis for multi-storey RC structures with hybrid base isolation systems in presence of bi-directional ground motions Composite Structures 154 (2016) 464–492".
8. N Murali Krishna et al (2016), "nonlinear time History Analysis of Building with Seismic Control Systems, International Journal of Science Technology and Engineering".
9. Radmila B. Salic et al (2008)," Response of lead rubber bearing isolated structure,14th world conference on earthquake engineering October 12-17,2008,China".