REDVET - Revista electrónica de Veterinaria - ISSN 1695-7504
Vol 25, No. 1 (2024)
http://www.veterinaria.org
Article Received: Revised: Accepted:

Comparison Of Multi-Storey Building In Zone Ii And Zone Iv With And Without Rubber Base With Friction Pendulum System

Mr. Vishwanath M. Kumbhar[1*], Dr. Manik G. Deshmukh[2], Mr. Ravikiran P. Jadhav[3], Mr. Pruthviraj H. Gund[4]

[1*]M.Tech Student, Civil Engineering Department, SVERI's College of Engineering, Pandharpur. Maharashtra
[2]Associate Professor, Civil Engineering Department, SVERI's College of Engineering, Pandharpur. Maharashtra
[3,4]Assistant Professor, Civil Engineering Department, SVERI's College of Engineering, Pandharpur. Maharashtra

ABSTRACT-The structures have been protected from the damaging effects of the earthquake by the base isolation process. The establishment's growth of separators enhances the reliability of the structure builds. By using a typical seismic plan, seismic isolation and energy distribution systems provide an efficient way to increase the seismic efficacy of projects. Although conventional seismic design calls for additional strength and flexibility to sustain seismic loads, such solutions reduce seismic loads by altering the inflexibility and damping of the buildings. The base detachment strategy is one of the requirements in the plan of tremor safe designs that may be most important.
The current study used the IS 1893:2016 Code in the ETABS Software package to analyse a G+10 storey building in seismic Zones II and IV employing a friction pendulum system and rubber bearing isolation system. Rubber bearing systems for general buildings are compared in terms of seismic factors such as story drift, shear force, time period, and storey displacement.

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

1. INTRODUCTION

The purpose of earthquake protection in buildings is to provide structural safety and comfort by controlling internal stresses and displacement within predetermined bounds. The most common method of preventing structures from being severely damaged by earthquakes is to create earthquake resistance by reducing seismic energy through structural elements. Although this method offers some protection, there is always a chance that the building will suffer actual damage. The structure can be earthquake-proofed by raising it off the ground or by placing seismic energy dissipation devices in high-risk areas. By planning effectively against earthquakes, this strategy can give better protection and thereby reduce the amount of serious structural damage.

In seismic-prone regions, the design and construction of multi-storey buildings demand meticulous attention to structural resilience and safety. Earthquakes pose significant threats to structures, making it imperative to explore innovative engineering solutions to mitigate potential damages. One such solution is the integration of rubber base isolation with friction pendulum systems, which offers enhanced seismic performance. This study delves into the comparison of multi-storey buildings situated in seismic Zone II and Zone IV, both with and without the incorporation of rubber base with friction pendulum systems. The focus is on assessing the structural response and seismic behavior under varying levels of seismic activity. Zone II and Zone IV represent regions with differing seismic hazards, with Zone IV being characterized by higher seismic activity compared to Zone II. The comparison between these zones allows for a comprehensive understanding of how different seismic intensities influence the effectiveness of structural solutions. Rubber base isolation, coupled with friction pendulum systems, serves as a promising technique to mitigate seismic forces by enhancing the building's ability to dissipate energy and reduce seismic vibrations. By isolating the superstructure from the ground motion, this system aims to minimize structural damage and ensure occupant safety during earthquakes. The objective of this study is to analyze and compare the structural responses of multi-storey buildings with and without rubber base isolation and friction pendulum systems across different seismic zones. Through numerical simulations and analytical evaluations, the effectiveness of these systems in mitigating seismic impacts will be thoroughly examined. The findings of this research are anticipated to provide valuable Insights for engineers and stakeholders involved in the design and construction of multi-storey buildings in seismic-prone areas. By identifying the optimal structural solutions based on seismic zone classifications, it is possible to enhance the resilience and safety of buildings against seismic hazards, ultimately contributing to sustainable and disaster-resilient urban development.
The statistics clearly shows that earthquakes remain a major threat to a nation's social and economic destiny. Resolutions that restrict the seismic effects of structures must therefore demonstrate a high degree of performance in earthquakes that are anticipated. The best method for minimizing the effects of lateral loads on upper stories is to insert energy-dissipating and seismic isolator devices between vertical structural systems and the foundation, or elsewhere in the structure to reduce seismic energy. The value of these technologies is increased when earthquake protection measures are used in both new and ancient construction, particularly historical buildings.

REDVET - Revista electrónica de Veterinaria - ISSN 1695-7504
Vol 25, No. 1 (2024)
http://www.veterinaria.org
Article Received: Revised: Accepted:

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.

2. Literature Review

Arathy S. et al. [1] Friction pendulum are one type of base isolation technology that effectively detaches structures from the ground to enable stabilize the building from unstable ground motion, according to the research. It allows 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 triplependulum bearing isolator was most effective.

Thomas et al. [2] the paper states that Base isolation is a strategy used to minimize 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 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.

Mithranjali N. et al. [3] It states that the buildings are very critical after natural disasters such as an earthquake. 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

REDVET - Revista electrónica de Veterinaria - ISSN 1695-7504
Vol 25, No. 1 (2024)
http://www.veterinaria.org
Article Received: Revised: Accepted:

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.

Kravchuk et al. [4] 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.

Cancellara et al. [5] 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.

Sahoo et al. [6]

Conventional seismic design practice 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.

3. OBJECTIVES OF THE STUDY

The objective includes the following:

1] Using response spectrum method, model and analyse as base isolated & fixed base structures.

2] To study the parameter such as time period, base shear, storey drift, storey displacementof multi storey building by fixed base and base isolated buildings.

3] To compare the results of fixed base, Rubber base, Friction base Isolator Buildingobtained by modeling in ETABS.

4] To determine the effective way of isolation for buildings between Friction pendulum isolator and Rubber base isolator.

4. DESCRIPTION OF THE MODEL

4.1 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**.**

4.2 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.

REDVET - Revista electrónica de Veterinaria - ISSN 1695-7504
Vol 25, No. 1 (2024)
http://www.veterinaria.org
Article Received: Revised: Accepted:

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.

5 RESULTS AND DISCUSSION
5.1 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.

5.1.1 DISPLACEMENT
The presentation of the models under the use of seismic burdens is concentrated to comprehend itsimpact. The displacements for each model 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- storybuilding 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

5.1.2 Storey Drifts
According to IS 1893-2016 the greatest permissible drift for any structure is =0.004HH-height of one story
For our models greatest permissible drift = 0.004*3=0.012m = 12mm

5.2 PARAMETERS STUDIED FOR ALL MODELS IN ZONE II
5.1.1 Maximum time period comparison of all models due to seismic loads in Zone II

TABLE 6.1 Maximum time period comparison of all models due to seismic loads in Zone II

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

REDVET - Revista electrónica de Veterinaria - ISSN 1695-7504
Vol 25, No. 1 (2024)
http://www.veterinaria.org
Article Received: Revised: Accepted:

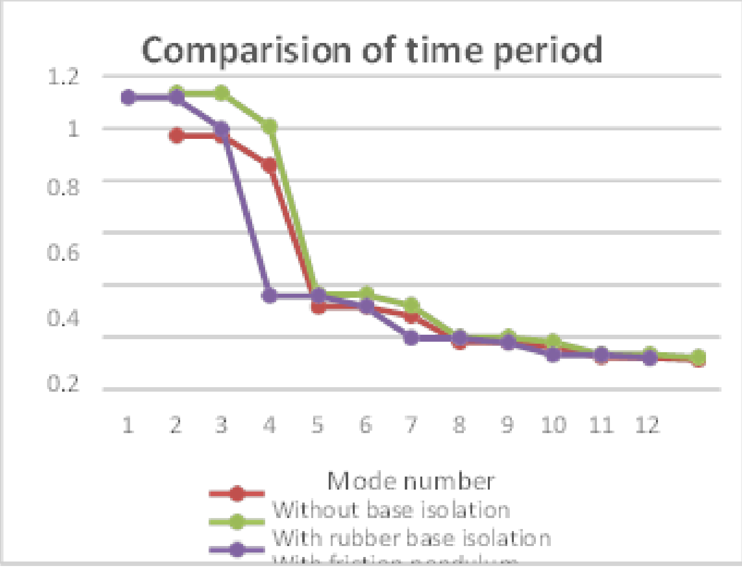

CHART 5.1: Maximum time period comparison of all models due to seismic loads in Zone II

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

TABLE 5.2 Maximum base shear comparison of all models due to seismic loads in Zone II.

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

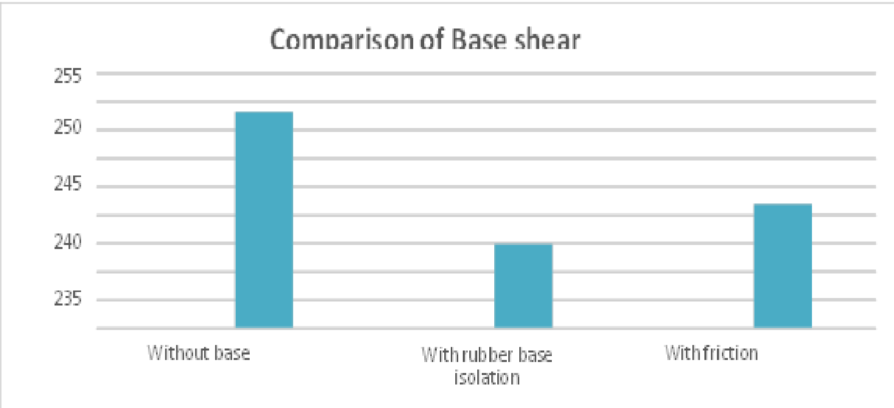

CHART 5.2: Maximum base shear comparison of all models due to seismic loads in Zone II

5.1.3 Storey wise displacements in X direction for all model in Zone II

TABLE 5.3 Storey wise displacement in zone II

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

REDVET - Revista electrónica de Veterinaria - ISSN 1695-7504
Vol 25, No. 1 (2024)
http://www.veterinaria.org
Article Received: Revised: Accepted:

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

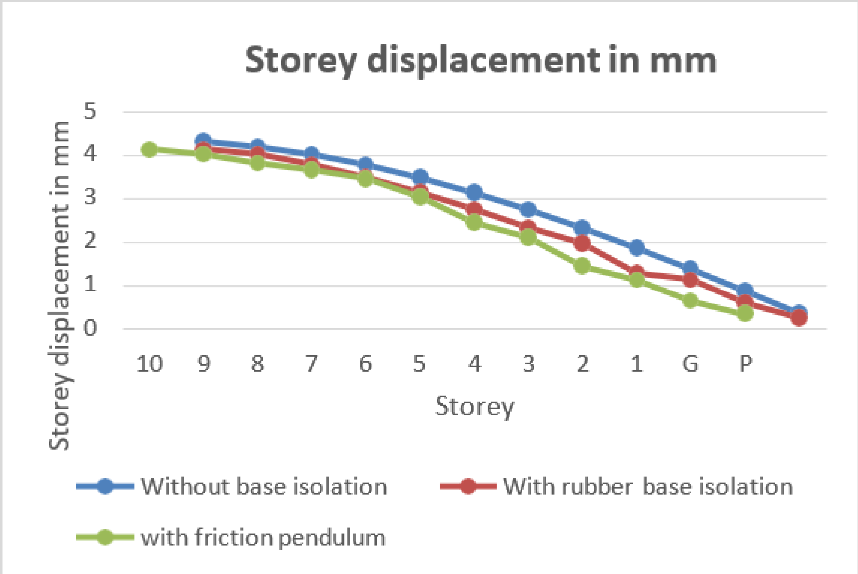

CHART 5.3: Storey wise displacement in zone II

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

TABLE 5.4 Storey wise storey drift in zone II

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

REDVET - Revista electrónica de Veterinaria - ISSN 1695-7504
Vol 25, No. 1 (2024)
http://www.veterinaria.org
Article Received: Revised: Accepted:

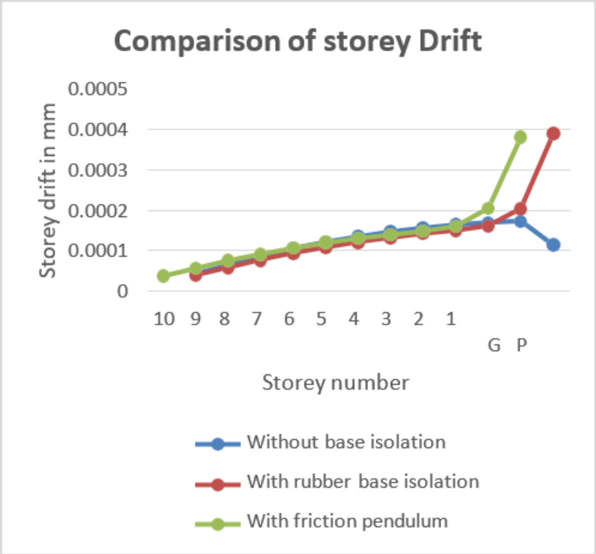

CHART 5.4: Storey wise storey drift in zone II

5.2 PARAMETERS STUDIED FOR ALL MODELS IN ZONE IV

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

TABLE 5.5 Maximum time period comparison of all models due to seismic loads in Zone IV

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

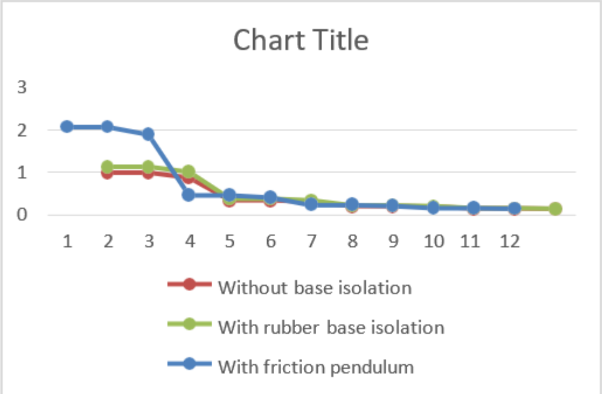

CHART 5.6: Maximum time period comparison of all models due to seismic loads in Zone IV

REDVET - Revista electrónica de Veterinaria - ISSN 1695-7504
Vol 25, No. 1 (2024)
http://www.veterinaria.org
Article Received: Revised: Accepted:

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

TABLE 5.6 Maximum base shear comparison of all models due to seismic loads in Zone IV.

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

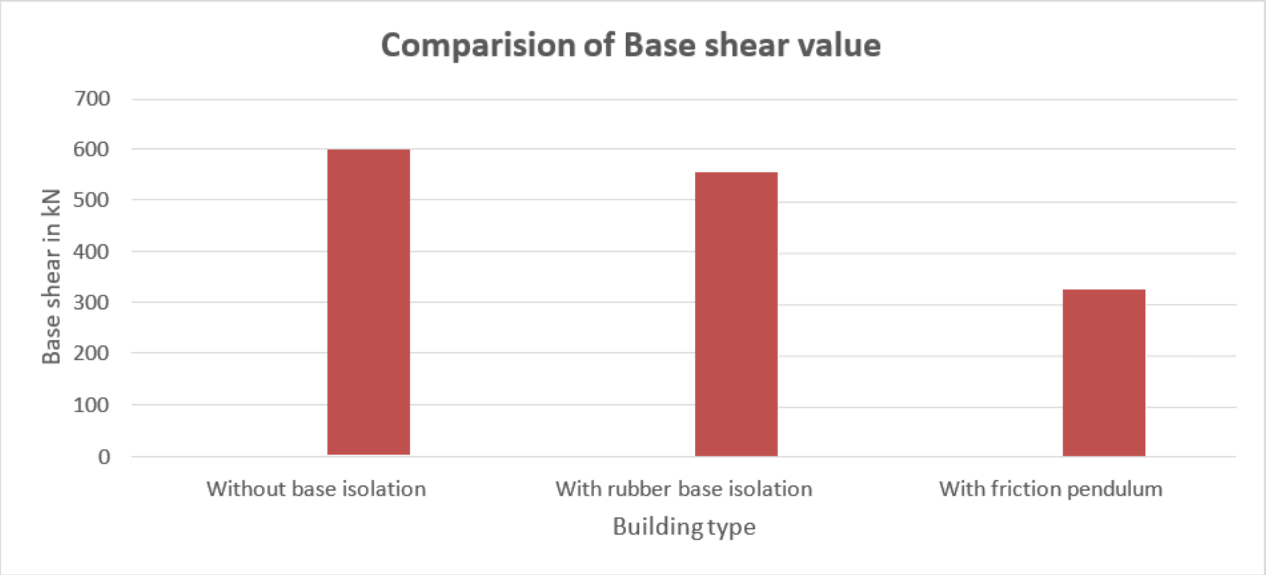

CHART 5.7: Maximum base shear comparison of all models due to seismic loads in Zone I

5.2.3 Storey wise displacements in X direction for all model in Zone IV

TABLE 5.7 Storey wise displacement in zone IV

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

REDVET - Revista electrónica de Veterinaria - ISSN 1695-7504
Vol 25, No. 1 (2024)
http://www.veterinaria.org
Article Received: Revised: Accepted:

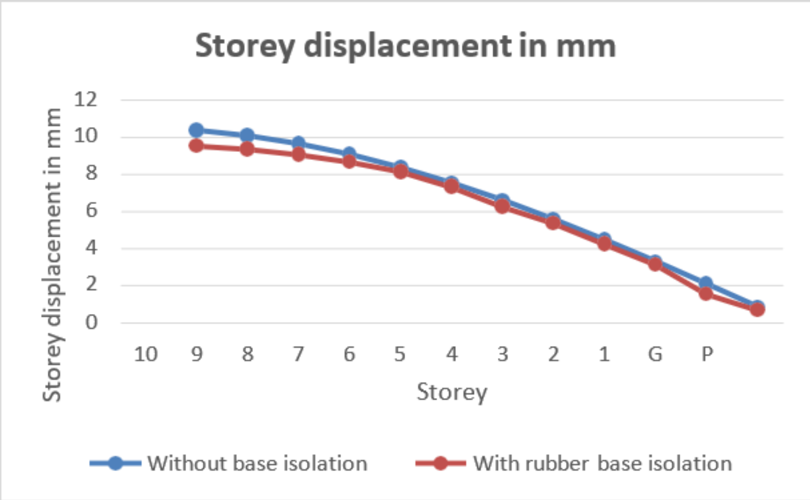

CHART 5.8: Storey wise displacement in zone IV

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

TABLE 5.8 Storey wise storey drift in zone IV

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

REDVET - Revista electrónica de Veterinaria - ISSN 1695-7504
Vol 25, No. 1 (2024)
http://www.veterinaria.org
Article Received: Revised: Accepted:

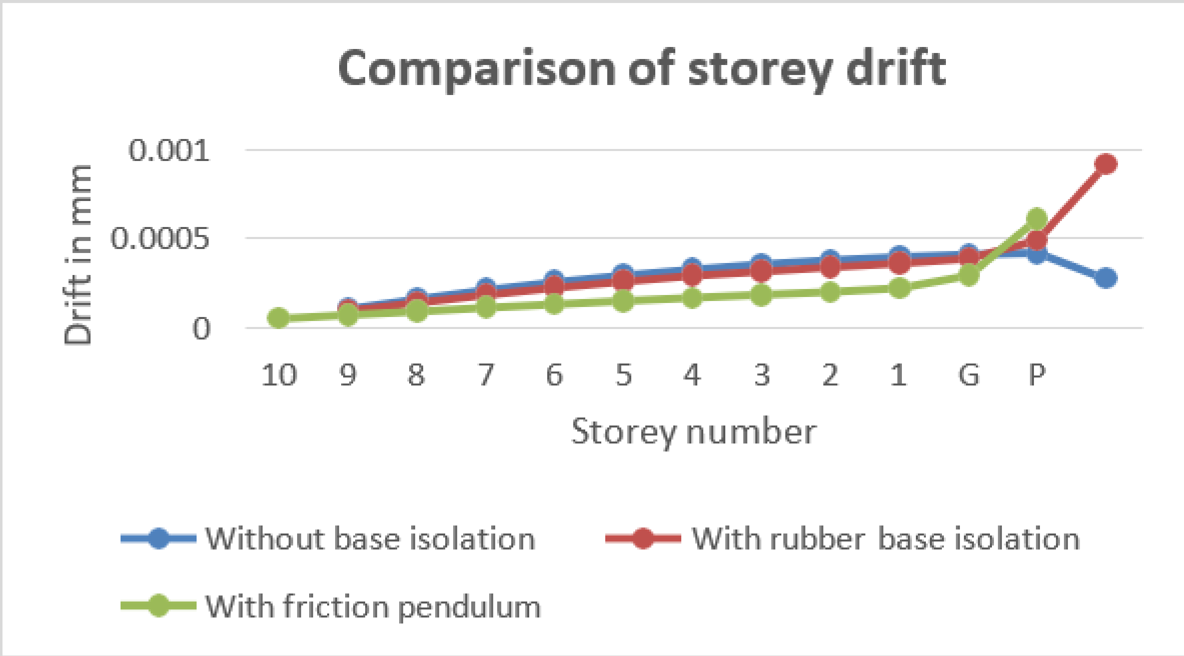

CHART 5.9: Storey wise storey drift in zone IV

6. CONCLUSION

FOR ZONE II

- Time period for rubber base & friction pendulum isolation is 14% more than without baseisolation 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 zoneII

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 Arathy S.1, Manju P.M, “Analysis of friction pendulum bearing isolated structure”.
2 Tessy Thomas1, “Dr. Alice Mathai, Study of base isolation using friction pendulum bearing system”.

REDVET - Revista electrónica de Veterinaria - ISSN 1695-7504
Vol 25, No. 1 (2024)
http://www.veterinaria.org
Article Received: Revised: Accepted:

3 Mithranjali, N. A., and Mathew C. George. "Study on RC Building with Friction Pendulum Base Isolation System– A Review." International Journal for Research in Applied Science & Engineering Technology 5 (2017).
4 Kravchuk, Nikolay, Ryan Colquhoun, and Ali Porbaha. "Development of a friction pendulum bearing base isolation system for earthquake engineering education." In Proceedings of the 2008 American Society for Engineering Education Pacific Southwest Annual Conference, pp. 22-25. 2008.
5 Cancellara, Donato, and Fabio De Angelis. "Assessment and dynamic nonlinear analysis of different base isolation systems for a multi-storey RC building irregular in plan." Computers & Structures 180 (2017): 74-88.
6 Sahoo, Dhiraj Narayan, and Pravat Kumar Parhi. "Base isolation of residential building using lead rubber bearing technique." Int J Eng Res Technol (IJERT) 7.05 (2018).
7 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.
8 IS 1893-2016 Analysis of seismic zone and soil factor