Journal of Harbin Engineering University
ISSN: 1006-7043

Vol 44 No. 10
October 2023

Analysis of G+10 Storey Building with Rubber Bearing Isolation System and Friction Pendulum System in Seismic Zones

K. Reddy Likhitha[1], Dr. Vaishali G Ghorpade[2], Dr. H Sudarsana Rao[3]

[1]M. Tech (Computer Aided Structural Engineering), Civil Engineering Department, JNTUA College of Engineering, Ananthapuramu, India.

[2]Professor in Civil Engineering Department, JNTUA College of Engineering, Ananthapuramu, India. [3]Professor in Civil Engineering Department, JNTUA College of Engineering, Ananthapuramu, India.

ABSTRACT The process of base isolation has been applied to investigate the structures that were damaged by the earthquake. Base isolation is accomplished by putting in isolators and energy-absorbing equipment beneath the superstructure. Seismic isolation offers people and property inside the building safety and security in addition to structural safety. Historic building retrofitting also makes use of seismic isolation. By using a typical seismic plan, seismic isolation and energy distribution systems provide an efficient way to increase the seismic efficacy of projects. Although standard seismic design calls for more strength and flexibility to handle seismic stresses, these tactics limit improvements to the inflexibility and damping of the constructions.

With the use of ETABS, a G+10 storey building equipped with a friction pendulum system and rubber bearing isolation system is examined in all seismic zones in the current study. The analysis of seismic parameters such as joint displacement, shear force, bending moment, building torsion, time period frequency, etc. is done between Rubber bearing isolation system, friction pendulum system, and fixed base building. The analytical results showed that, in comparison to fixed base building models, the values of base shear increased with the use of base isolation systems. In all seismic zone conditions, the building that is damped using a friction pendulum model has the best control over these parameters.

Key words: ETABS, Three systems: friction pendulum, rubber bearing isolation, and seismic isolation.

1. Introduction

Using a technique called seismic isolation, one can lessen the effects of ground shaking during earthquakes on structures and their components while also shielding them from harm. This strategy reduces the lateral movement (Drift) of structures by using some hardwires, which I will explain later.

One of the key ideas in earthquake engineering is seismic isolation, which is the process of severing or disconnecting a structure from its foundation. Seismic isolation, then, is a method designed to avoid or reduce building damage during an earthquake. The idea of base isolation will be discussed in this essay with several instances from different technical and sports-related fields. These include certain boxing defense strategies and car suspension systems. Furthermore, a few demonstrations of analytical graphs and experiments will be given to help clarify the idea of base isolation.

1.1 Friction pendulum bearings

The most often utilized kinematic systems, particularly in base isolation, are friction pendulum systems. A steel globe positioned between two concave curved steel surfaces or a cylindrical member with global contact surfaces make up a pendulum system. Certain metals are employed in certain sections (see Fig.1).

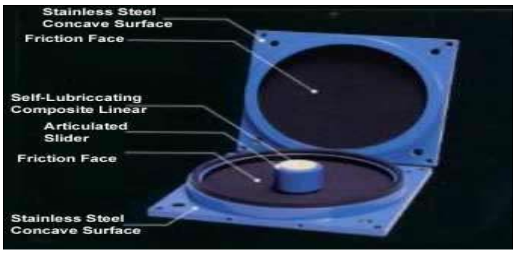

Fig 1: Friction pendulum bearing system

1.2 Rubber Bearings isolation

In addition to the rubber and neoprene types, these systems also feature steel laminated rubber types and steel laminated rubber types with lead nucleus. Later, the synthetic and natural rubber bearings used in bridge construction were developed and given the name elastomeric bearings. These are extensively used bearings that are employed as seismic isolators. Rubber plates are vulcanized to thin steel plates to create rubber laminated isolators. The more advanced of such are lead-nucleated laminated rubber varieties. Lead Laminated Rubber Bearing systems are advanced seismic isolators consisting of steel/rubber laminated layers with an embedded lead nucleus (refer to Fig. 2).

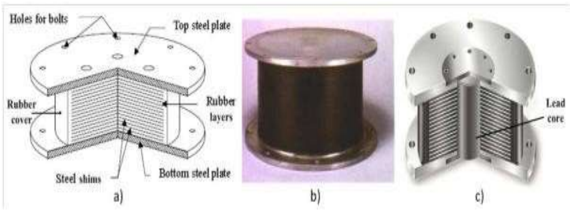

Fig 2: Lead rubber bearing isolation

1.3 Objectives of the study

The following lists the primary goals of the current study.

• To investigate the G+10 building's seismic behavior using the IS 1893:2002 code and the response spectrum approach in ETABS.

• To investigate the G+10 building in each of the four seismic zones—Zone II, Zone III, Zone IV, and Zone V—with two distinct base isolation systems: friction pendulum bearing isolation and rubber bearing isolation.

• To compare the seismic analysis results of fixed base buildings in various seismic zones with those of buildings with various base isolation systems in order to determine the most effective and earthquake-resistant system using the analysis results of joint displacements, shear, bending, torsion, base shear, and time period.

2. MethodologyUsed

The linear dynamic statistical analysis approach is another name for response spectrum analysis. Usually, IS code for seismic analysis is used to aid in this study. For this investigation, IS 1893:2016 (Part 1) was the IS code. The IS 1893:2016 (Part 1) code's tables include the values for the soil type and seismic zone factor.

For this analysis, the damping ratio is typically assumed to be 5%. Figure 3 displays the response spectrum graph under medium soil conditions. The Spectral Acceleration Coefficient (Sa/g) and Time Period are presented on the

graph.

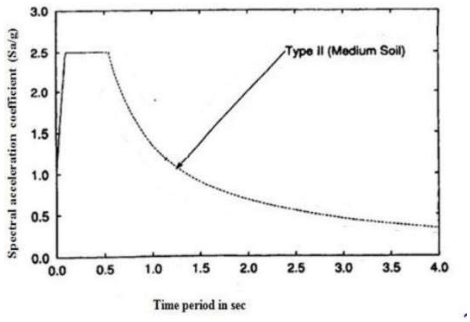

Fig 3: Response spectrum for medium soil type for 5% damping

In order to see the effects on the structure, we must first determine the size of powers completed, such as X, Y, and Z. Blending methods blend the going with:

1. Without a doubt, crest esteems are

2. The amount of the squares' square foundation (SRSS)

3. The complete quadratic blend (CQC) approach is a modification of the SRSS for sharply divided modes.

Response spectrum analysis yields an output that is entirely different from linear dynamic analysis based on ground motions. If a structure or building is irregularly shaped or a high-rise building, for example, this response analysis is not as accurate as other analyses; instead, nonlinear static or dynamic analysis is required.

I was regarded as a regular structure and a medium-rise building for the response analysis case's seismic loading condition in the current study.

3. Design considerations and modeling of building

The study's building layout is depicted in Figure 4.

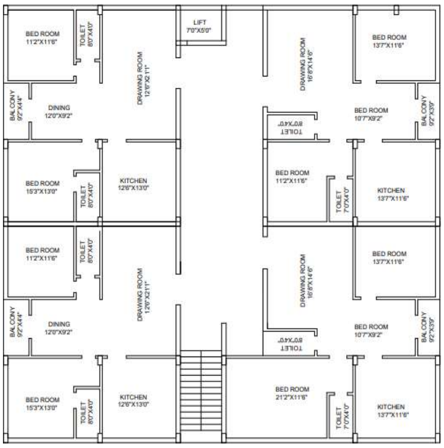

Fig 4: Building plan

3.1 Problem statement

In the present study, analysis of G+10 multi-storey building is carried Basic parameters considered for the analysis are:

1. Utility of building : Residential building
2. Number of stories : G+10
3. Shape of building : Rectangular
4. Type of walls : Brick wall
5. Geometric details
a. Ground floor : 3.3m
b. floor to floor height : 3m
6. Material details
a. Concrete Grade : M30 (COLUMNS AND BEAMS)
b. All Steel Grades : HYSD reinforcement of Grade Fe500
c. Bearing Capacity of Soil : 200 KN/m^2
7. Type Of Construction : R.C.C FRAMED structure
8. Column : 0.6m X 0.23m
9. Beams : 0.45m X 0.23m
10. Slab : 0.150m
11. Live load :3kN/m2
12. Dead load :2Kn/m2
13. Seismic zone V
14. Soil type :medium
15. RCC code :IS 456-2000
16. Steel code :IS 800-2007
17. Seismic code :IS 1893:2016
18. Wind code :IS 875:2015

3.2 Building models in ETABS Software

The building models developed using ETABS software for different support systems are presented in Fig 5(A-C)

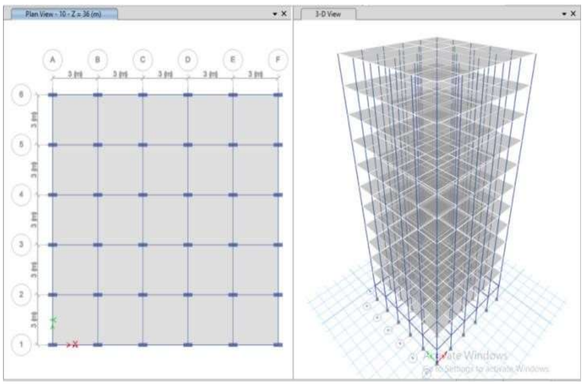

Fig 5(A) Building Model with fixed supports

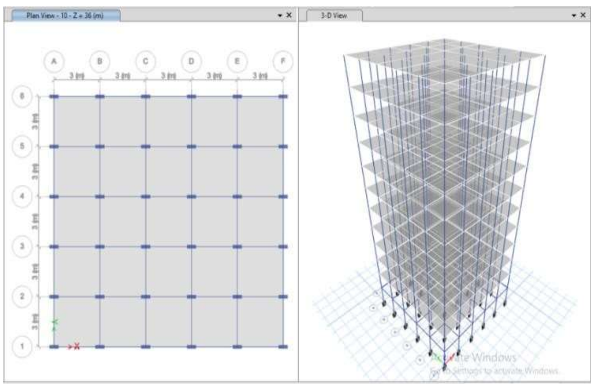

Fig 5(B) Building Model with rubber isolator at supports

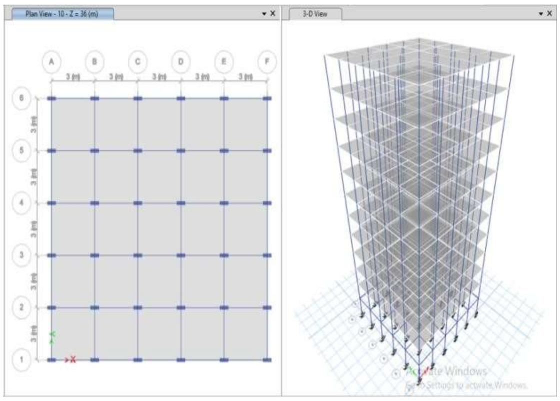

Fig 5(C) Building Model with friction isolator at supports

4. Results and analysis

RSA X

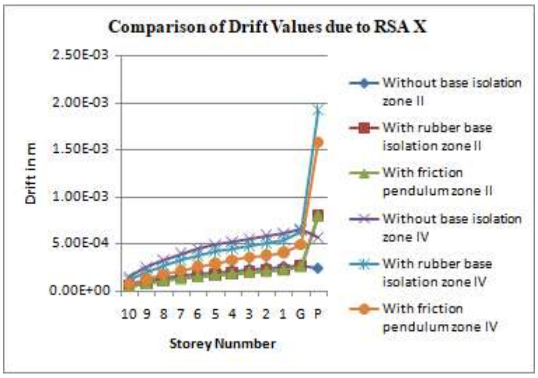

Fig 6: Comparison of Drift Values due to RSA X

The friction pendulum system building in zone II was found to have fewer values when compared to other building models. The drift values resulting from the RSA X example are depicted in the upper graph (fig. 6). In zone II condition, the intensity of seismic load is decreasing due to the friction pendulum isolation features.

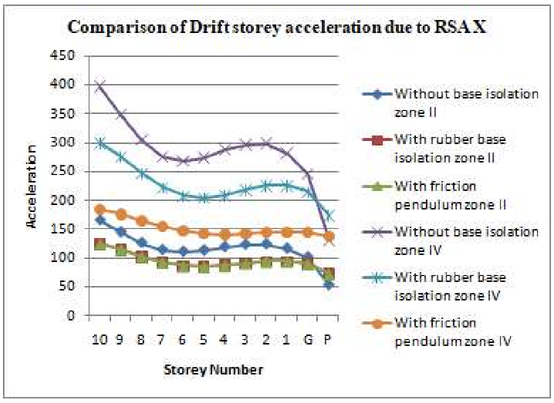

Fig 7: Comparison of drift storey acceleration due to RSA X

The structure constructed with a friction pendulum system in zone II was found to have less values when compared to other building models. The drift storey acceleration variation caused by the RSA X example is depicted in the above graph (fig. 7). When compared to rubber base isolation, the friction pendulum system has a higher seismic load resistance; as a result, the narrative acceleration values are obtained less for the friction pendulum systems.

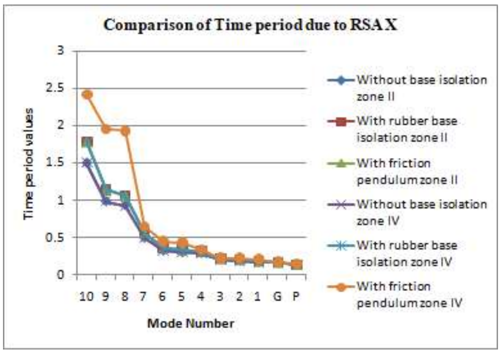

Fig 8: Comparison of time period due to RSA X

The structure constructed with a rubber base isolation system in zone IV was found to have less values when compared to other building types. The above graph (fig. 8) illustrates the fluctuation of time period caused by the RSA X situation. The model with rubber isolation takes longer to deflect the structure; as a result, the time period's value is reduced.

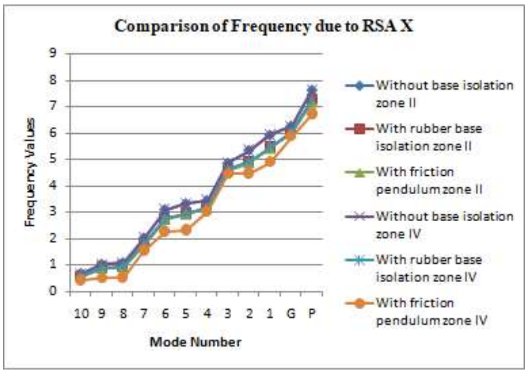

Fig 9: Comparison of Frequency due to RSA X

The structure constructed with a friction isolation system in zone IV was found to have less values when compared to other building models. The above graph (fig. 9) illustrates the fluctuation of time period caused by the RSA X situation. In order to attain high frequency values for the friction pendulum system, the frequency intensity must be opposite to the time period.

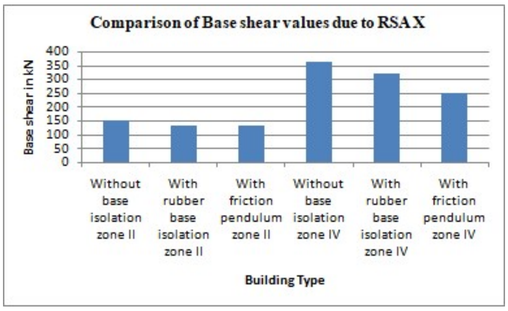

Fig 10: Comparison of Base shear values due to RSA X

The base shear variation caused by the RSA X example is depicted in the above graph (fig. 10), and it was found that, in comparison to other construction models, the zone IV rubber base isolation system building had fewer values.When compared to the friction pendulum model, the rubber base isolation system weighs less and has higher base shear values.

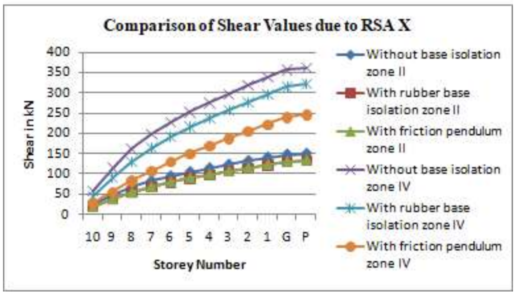

Fig 11: Comparison of Shear Values due to RSA X

The friction pendulum system building in zone II was found to have fewer values when compared to other building models. The above graph (fig.11) illustrates the variance of Comparison of Shear Values due to RSA X case. When comparing the friction pendulum system to rubber base isolation, the shear resistance is higher, which is why the shear value is lower.

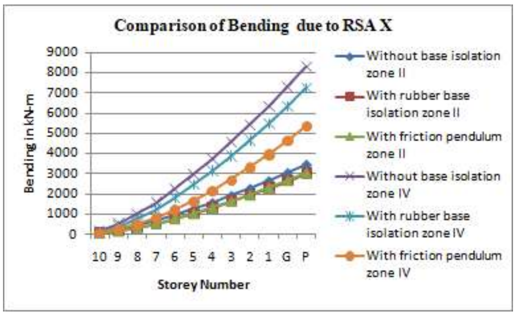

Fig 12: Comparison of bending Values due to RSA X

The friction pendulum system building in zone II was found to have fewer values when compared to other construction models. The above graph (fig. 12) illustrates the variance of Comparison of bending values due to RSA X case. When comparing the friction pendulum system to rubber base isolation, the bending resistance is higher, which is why the bending values are found as being less.

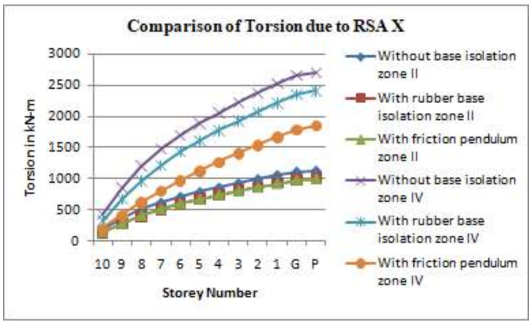

Fig 13: Comparison of Torsion due to RSA X

The building constructed with a friction pendulum system in zone II was found to have fewer values when compared to other building types. The above graph (fig. 13) illustrates the variance of Comparison of Torsion due to RSA X situation. When comparing the friction pendulum system to rubber base isolation, the torque resistance is higher, which explains why the bending values are found as being less.

RSA Y Results

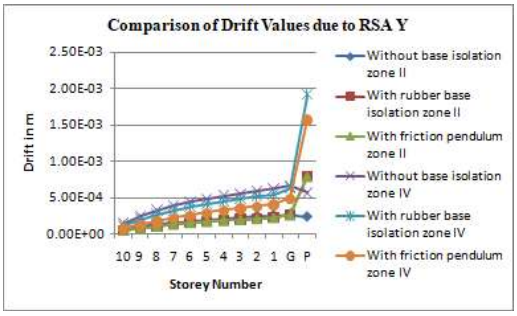

Fig 14: Comparison of Drift Values due to RSA Y

The building constructed with a friction pendulum system in zone II was found to have fewer values when compared to other building types. The above graph (fig. 14) illustrates the fluctuation of drift values due to the RSA Y situation. In zone II conditions, the intensity of seismic load is decreasing due to the friction isolation qualities.

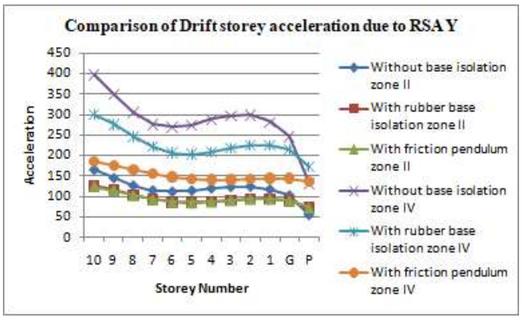

Fig 15: Comparison of Drift storey acceleration due to RSA Y

The structure constructed with a friction pendulum system in zone II was found to have less values when compared to other building models. The drift storey acceleration variation caused by the RSA Y scenario is depicted in the above graph (fig. 15).When compared to rubber base isolation, the friction pendulum has a higher seismic load resistance; as a result, the narrative acceleration values for the friction pendulum system are lower.

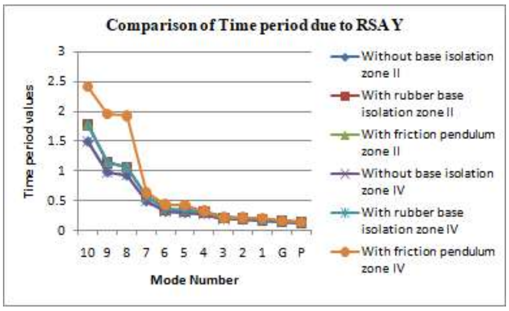

Fig 16: Comparison of Time period due to RSA Y

The structure constructed with a rubber base isolation system in zone IV was found to have less values when compared to other building types. The above graph (fig. 16) illustrates the fluctuation of time period caused by RSA Ycase. The model constructed with rubber base isolation will deflect the structure more slowly, which lowers the time period value.

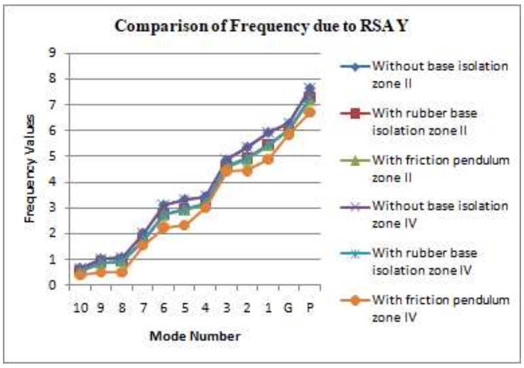

Fig 17: Comparison of Frequency due to RSA Y

The structure constructed with a friction pendulum system in zone II was found to have less values when compared to other building models. The above graph (fig. 17) illustrates the fluctuation of drift storey acceleration due to the RSA Y situation. In order to attain high frequency values for the friction pendulum system, the frequency intensity must be opposite to the time period.

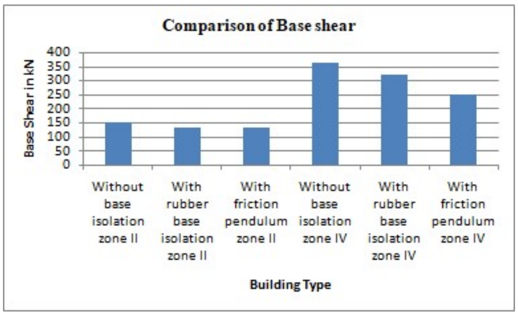

Fig 18: Comparison of Base shear

The base shear variation caused by RSA Ycase is depicted in the above graph (fig. 18), and it is noted that the building constructed in zone IV with the rubber base isolation system has lower values than the other building models. When compared to the friction pendulum model, the rubber base isolation system weighs less and has higher base shear values.

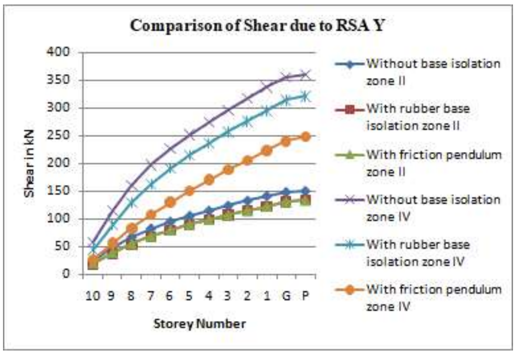

Fig 19: Comparison of Shear due to RSA Y

The friction pendulum system construction in zone II was found to have fewer values when compared to other building models. The variation of the Comparison of Shear Values owing to RSA Ycase is depicted in the above graph (fig. 19). When comparing the friction pendulum system to rubber base isolation, the shear resistance is higher, which is why the shear values are found as being lower.

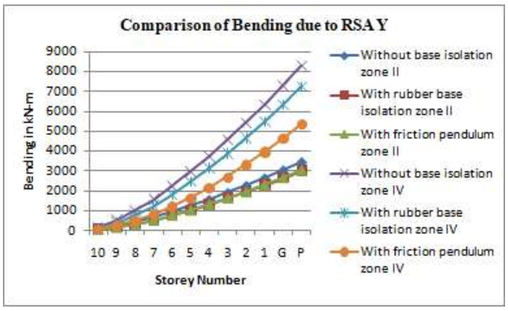

Fig 20: Comparison of Bending due to RSA Y

The friction pendulum system construction in zone II was found to have fewer values when compared to other building models. The above graph (fig. 20) illustrates the variance of Comparison of bending values due to RSA Y case. When comparing the friction pendulum system to rubber base isolation, the bending resistance is higher, which is why the bending values are found as being less.

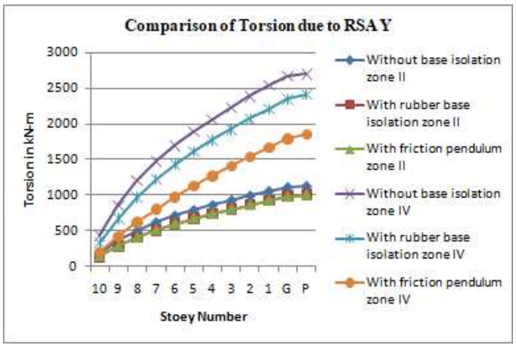

Fig 21: Comparison of Torsion due to RSA Y

The building constructed with a friction pendulum system in zone II was found to have fewer values when compared to other building types. The above graph (fig. 21) illustrates the fluctuation of Comparison of Torsion due to RSA Y case. When we compare the friction pendulum system's torsion resistance to rubber base isolation, it is higher, which explains why the torsion values are lower.

5. Conclusions

1. The analysis's findings show that base isolation technique is crucial for controlling building damages during seismic activity and for reducing seismic response when compared to fixed base buildings.

2. When the building is dampened with friction pendulum and lead rubber isolation, storey shear is reduced.

3. When the building is examined using a friction pendulum system and Lead Rubber isolation system, the storey moment decreases.

4. The building's torsion lessened when it was modeled using an isolation method.

5. When the building is dampened using friction pendulum and lead rubber, joint drift values decrease.

6. We can cut the amount of steel used by 8.7% for rubber base isolation and 30% for friction pendulum systems by utilizing isolation systems.

When Lead Rubber Dampers and a friction pendulum model are used to dampen a building, the best control over the parameters under consideration is noted.

8. Based on the completed investigation, it can be concluded that the optimum supplemental damping system to regulate seismic loading situation is a friction pendulum and rubber base isolation system.

References

1. A. N. Lin, 1 Member1 and H. W. Shenton III2," Seismic performance of fixed base and base isolated steel frames, ASCE, Journal of Engineering mechanics, VOl.118, No- 5(1992).
2. H. W. Shenton1 III and A. N. Lin2,Relative Performance of fixed based and base isolated concrete frame", ASCE, Journal of Structural Engineering " VOL.119,NO- 10(1993).
3. Darragh, R., Cao, T., Cramer, C., Huang, M. and Shakal, A. (1994). "Processed CSMIP StrongMotion Records from The Northridge, California Earthquake of January 17, 1994: Release No. l, Report No. OSMS 94-0613, California Strong Motion Instrumental Program, California Department of Conservation Division of Mines and Geology, Sacramento, California.
4. Yang et al (2006), Aseismic hybrid control systems for building structures,Journal of Engineering Mechanics, Vol. 117,No. 4, April, 1991,ASCE .
5. Radmila B. Salic et al (2008), Response of lead rubber bearing isolated structure,14th world conference on earthquake engineering October 12-17,2008,China.
6. Juan C Ramallo (2008) "Smart'' Base Isolation Systems Journal of Engineering Mechanics, Vol. 128, No. 10, October 1, 2002. ©ASCE.
7. J. C. Ramallo1, et al (2008), Seismic Analysis of Fixed Based and Base Isolated Building Structures, International Journal of Multidisciplinary and Current Research,Vol 3.
8. Todd W. Erickson1 and Arash Altoontash2," Base Isolation for Industrial Structures; Design and Construction Essentials", ASCE, Structures Congress, (2010).
9. SonaliAnilduke et al (2015),Comparision Of Building for Sesmic Response by using Base Isolation ,International Journal of Research in

Engineering and Technology , Volume: 04 Issue: 06 .

10. A.Swetha, Dr. H. Sudarsana Rao," Non-linear analysis of multistorey g + 4 building by time history method using newmark's linear and average acceleration method, international journal of engineering sciences & research technology, issn: 2277-9655, (2015).
11. S.D.Darshale and N.L.Shelke," seismic Response Control of R.C.C. Structure using Base Isolation", International Journal of research in Engineering science and Technology, vol.2, No.1, (2016).
12. Minal Ashok Somwanshi (2015) "Inelastic Behavior of Steel Frames with Added Viscoelastic Dampers," Journal of Structural Engineering, ASCE, Vol. 122, No. 10, pp. 1178-1186.
13. 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
14. N Murali Krishna et al (2016), nonlinear time History Analysis of Building with Seismic Control Systems, International Journal of Science Technology and Engineering.
15. DrManjunath N Hegde et al (2016),Comparison of Seismic Behavior of Building with Fixed Base, Base Isolator and Shear Wall, International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056 Volume: 03 Issue: 10 | Oct -2016
16. Donato Cancellara, et al (2016) "Effect of Ambient Temperature on Viscoelastically Structures," Journal of Structural Engineering, ASCE, Vol. 1 18, No. 7, pp. 19551973.
17. Athanasios et al (2016) "Earthquake Simulator Testing and Analytical Studies of Two Energy-Absorbing System for Multi-storey Structures," Report No. UCB/EERC-90/03, University of California at Berkeley.