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COMPARATIVE STUDY OF MULTI-STOREY RC BUILDING WITH AND WITHOUT BASE-ISOLATION

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Abstract- Development in the design of earthquake resistant buildings has been growing since about 100 years ago. In the design of earthquake resistant buildings, the main aspects to consider are life safety and damage reduction on architectural element caused by the earthquake. However, with the development of age, modern buildings contain sensitive and expensive equipment that become vital for business, commercial, education and healthcare. Hence, the equipment inside the building needs to be protected when the earthquake occurs. The basic principle of base isolation system is to provide flexibility in the building and at the same time provide damping to prevent amplification caused by the earthquake. By placing structure on the base isolation system, it will prevent horizontal movement of the ground transferred to the structure and produce a significant reduction in the acceleration of the earthquake.

In the present study analysis of G+3 building analysis is carried out by using base isolation system rubber base system. The results like storey drift, storey shear, storey bending, time period, model frequency is analyzed by using Response spectrum analysis.

Key words: **Rubber base, friction pendulum, storey drift, storey shear, storey bending, time period, model frequency.**

I. INTRODUCTION

The most extensively used methods today are the methods which are based on the separation of the building and the ground, allowing a horizontal movement on the foundations of the building/on the bearings of vertical structural members. These systems will be called base isolation systems in general. Since seismic isolators are placed between the superstructure and the ground or to separate certain parts of the building, this type of seismic isolation is also defined as external isolation. Seismic isolation technologies developed on the basis of this principle and extensively used during the past decade, comprise passive control systems classified above.

The base isolations systems in general, consists of a bearings allowing the horizontal movement, a damper controlling the displacements and members providing rigidity under lateral loads. Bearings member has behaviour rigid enough to transfer loads vertically and horizontally flexible. This behaviour changes the period of base isolation system along with the superstructure, thus the whole structure and helps to decrease inertia forces. The decrease in inertia forces when compared with traditionally designed buildings depends on the dynamic characteristics of the building in traditional buildings, the shape of response spectra curve in buildings with seismic isolation. The additional ductility to change the first mode period causes big displacements in the superstructure when compared to seismic isolation system.

Rubber bearing system

These systems also have steel laminated rubber types and steel laminated rubber types with lead nucleus, along with the ones made of rubber and neoprene. The natural and artificial rubber bearings, which were used in bridge bearings, have later been developed and have been named elastomeric bearings. These bearings, which are used as seismic isolators, are widely used. The rubber laminated isolators are formed through vulcanization of thin steel plates to rubber plates (Fig.6). The more developed of those are laminated rubber types with lead nucleus. Lead Laminated Rubber Bearing systems are constituted by steel/rubber laminated layers with a lead nucleus embedded in the middle, and they are highly developed seismic isolators.

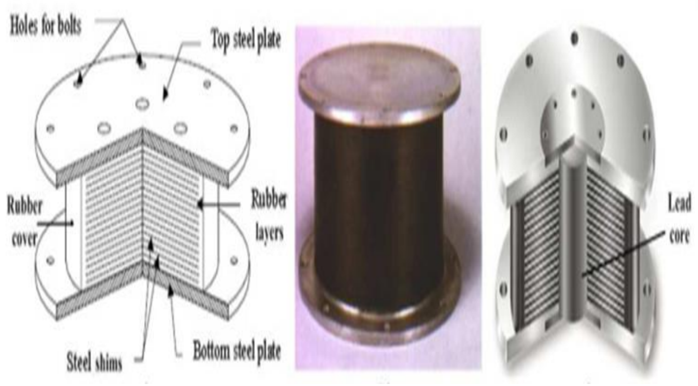

Figure 1: Rubber bearing system

II. METHODOLOGY

Response spectrum method

This method is also known as modal method or mode superposition method. It is based on the idea that the response of a building is the superposition of the responses of individual modes of vibration, each mode responding with its own particular deformed shape, its own frequency, and with its own modal damping.

According to IS-1893(Part-l):2016, high rise and irregular buildings must be analyzed by response spectrum method using design spectra. There are significant computational advantages using response spectra method of seismic analysis for prediction of displacements and member forces in structural systems. The method involves only the calculation of the maximum values of the displacements and member forces in each mode using smooth spectra that are the average of several earthquake motions. Sufficient modes to capture such that at least 90% of the participating mass of the building (in each of two orthogonal principle horizontal directions) have to be considered for the analysis. The analysis is performed to determine the base shear for each mode using given building characteristics and ground motion spectra. And then the storey forces, accelerations, and displacements are calculated for each mode, and are combined statistically using the SRSS combination. However, in this method, the design base shear (V_B) shall be compared with a base shear (V_b) calculated using a fundamental period T. If V_B is less than V_b response quantities are (for example member forces, displacements, storey forces, storey shears and base reactions) multiplied by V_B/V_b Response spectrum method of analysis shall be performed using design spectrum. In case design spectrum is specifically prepared for a structure at a particular project site, the same may be used for design at the discretion of the project authorities.

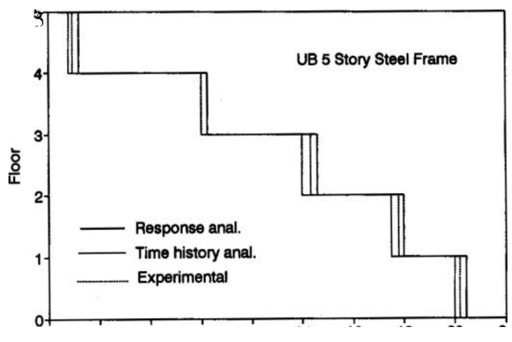

Figure 2: Response spectrum analysis, 0.6g El Centro, damping, storey shear

Problem statement

The following are the basic data considered for analysis

1. Height of typical Storey = 3 m
2. Height of ground Storey = 3 m
3. Length of the building = 14 m
4. Width of the building = 10 m
5. Height of the building = 12 m
6. Number of stores = 4 (G+3)
7. Slab Thickness = 150 mm
8. Grade of the concrete = M 30
9. Grade of the steel = Fe 600 (for retrofitting building)
10. Support = Fixed

a. Column sizes = 0.35mX0.35m

11. Beam size = 0.23mX0.35m
12. Live load = 5 KN/m^2
13. Dead load = 2 KN/m^2
14. Density of concrete = 25 KN/m^3
15. Seismic Zones = Zone 5
16. Site type = II
17. Importance factor = 1.5
18. Response reduction factor = 5
19. Damping Ratio = 5%
20. Structure class = C
21. Basic wind speed = 44m/s
22. Risk coefficient (K1) = 1.08
23. Terrain size coefficient (K2) = 1.14
24. Topography factor (K3) = 1.36
25. Wind design code = IS 875: 2015 (Part 3)
26. RCC design code = IS 456:2000
27. Steel design code = IS 800: 2007
28. Earthquake design code = IS 1893: 2016 (Part 1).

Rubber Base isolation Properties

1. Link Type = Rubber Isolator
2. U1 Linear effective stiffness (kN/m) = 2391948
3. U2 and U3 linear effective stiffness (kN/m) = 1576.4
4. U2 and U3 nonlinear effective stiffness (kN/m) = 12467.6
5. U2 and U3 yield strength (KN) = 79.49
6. U2 and U3 post yield stiffness ratio = 0.1
7. Effective damping = 0.05

Models in ETABS

The below Figure 3 shows the G + 3 building model with fixed supports

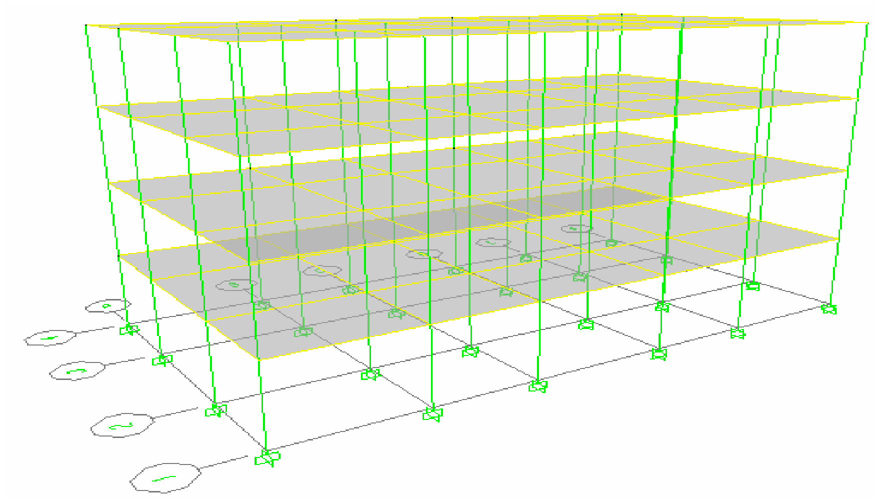

Figure 3: Fixed Supports building

The below Figure 4 shows the G + 3 building model with Rubber base isolation system

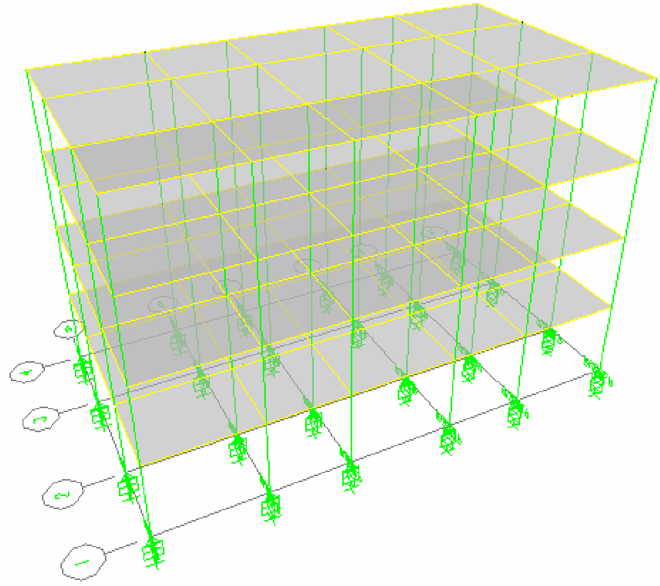

Figure 4: Rubber base isolation system

III. RESULTS AND ANALYSIS

Storey Drift

X Direction

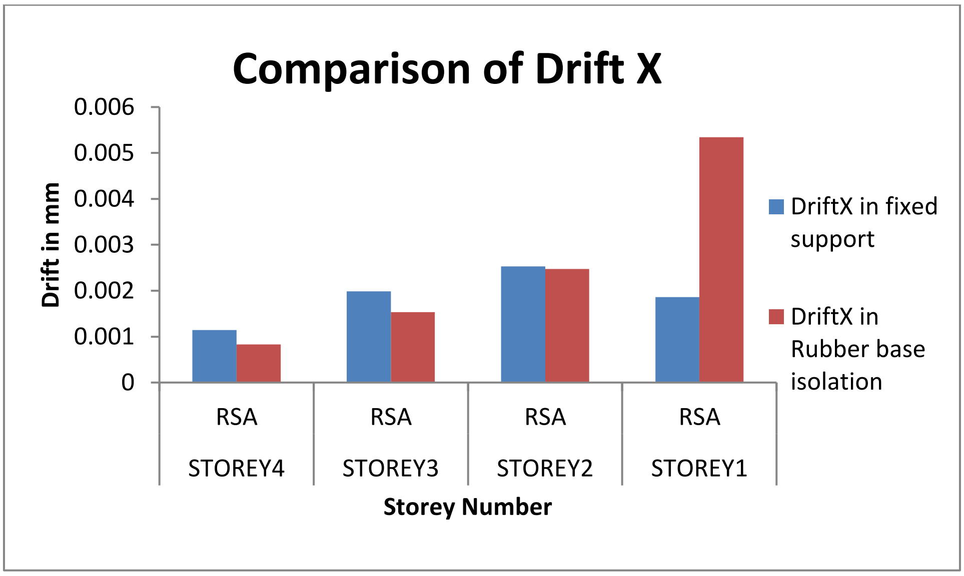

Figure 5: Comparison of Drift X

The above graph denotes the comparison of drift X for fixed support building and Rubber base isolation building from this graph it was observed that due to the effect of the rubber supports at the base the drift value is high in storey 1 for rubber base than fixed base for the remaining storey the drift value is less for the rubber isolator.

Y Direction

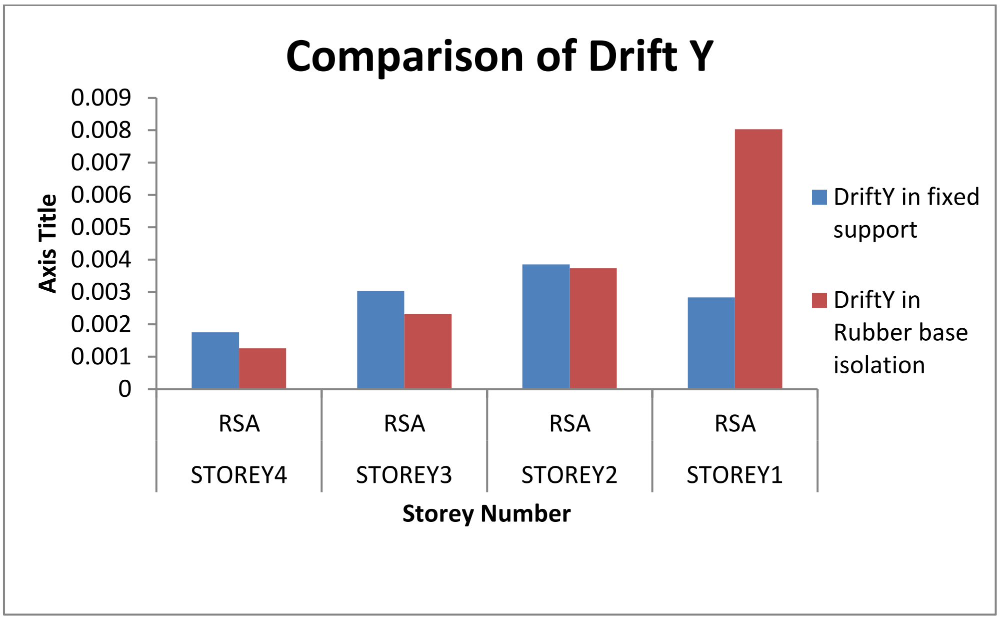

Figure 6: Comparison of Drift Y

The above graph shows the drift value in Y direction from these results it was observed that the value of drift is high in ground storey due to the effect of seismic load and due to the rubber base isolation at the base.

Storey Shear

X Direction

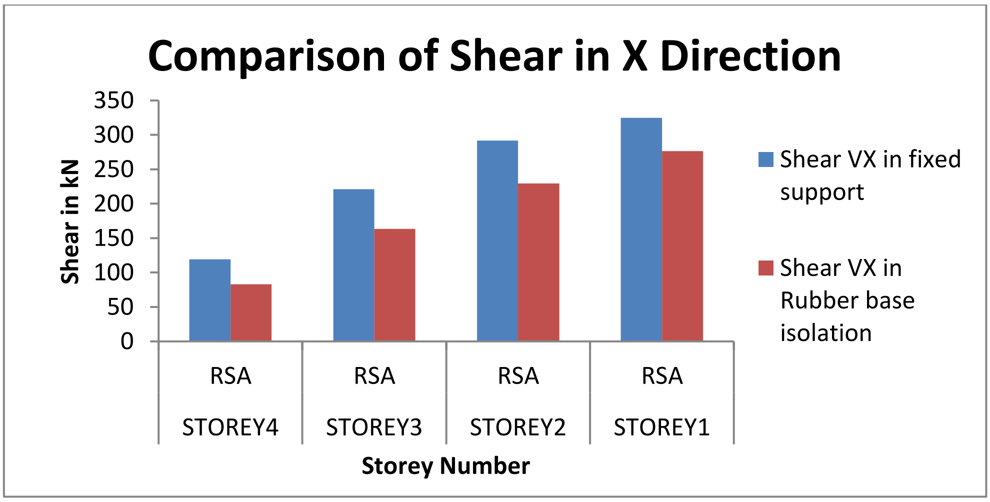

Figure 7: Comparison of Shear in X Direction

The above graph shows the storey shear values in X direction the storey shear values are increasing from storey 4 to storey 1 and it has less values for rubber base isolation system than fixed base isolation building model.

Y Direction

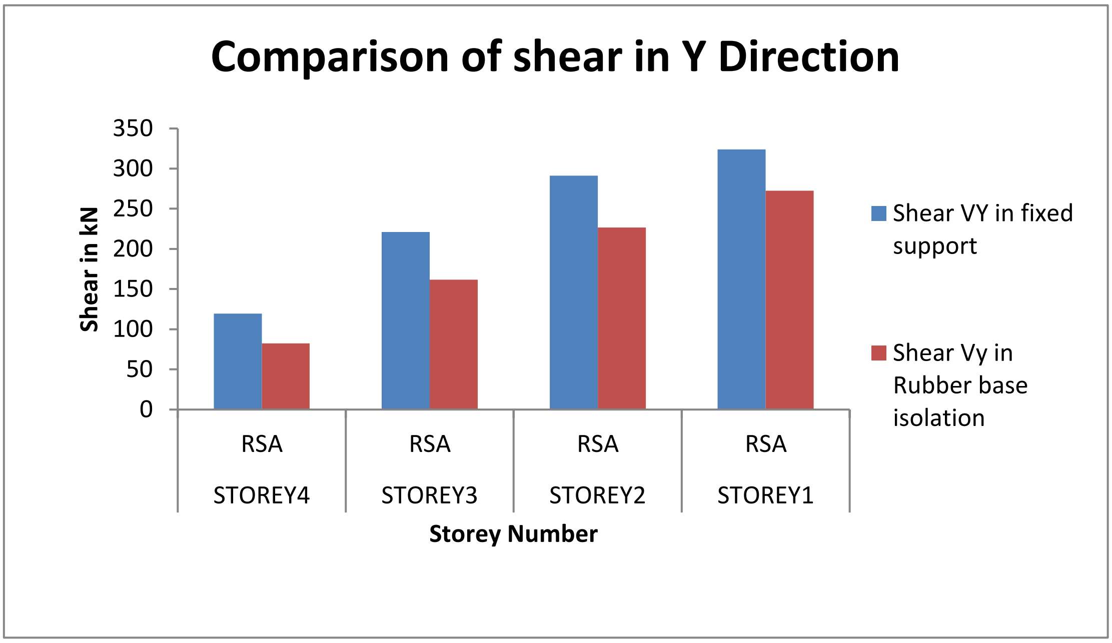

Figure 8: Comparison of Shear in Y Direction

The story shear values in Y direction are shown in the above graph the values of shear increases from storey 4 to storey 1 in both fixed base isolation and rubber base isolation systems due to the effect of seismic load condition the storey shear has less values for the rubber base isolation system building than the fixed base isolation system building model.

Storey Bending

X Direction

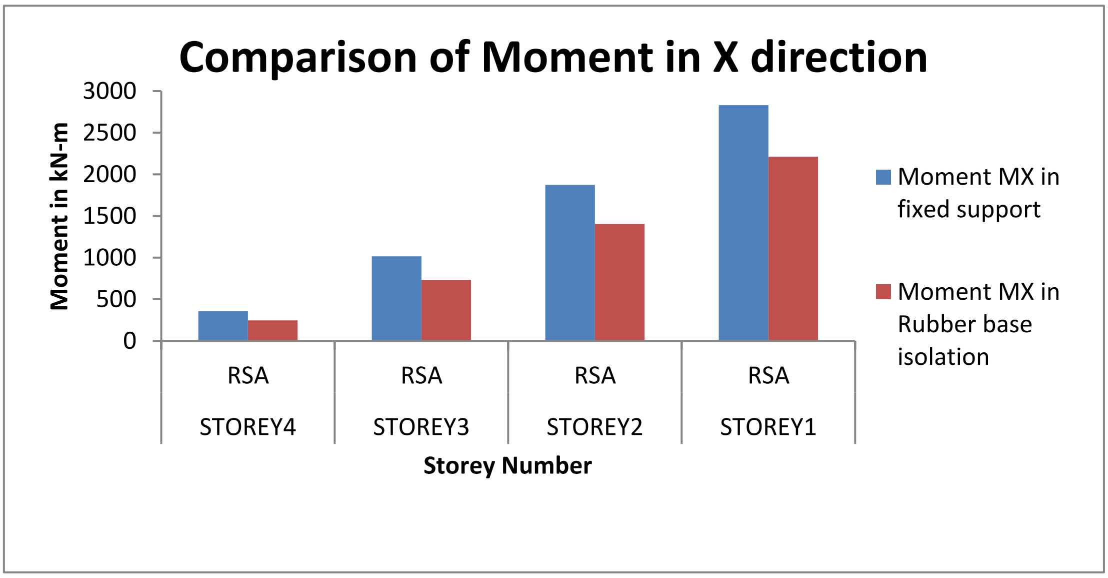

Figure 9: Comparison of Moment in X Direction

The above graph shows the comparison of moment in X for different storey due to the effect of seismic loading condition. The building models are analyzed with fixed base and rubber base isolation systems in both the cases the storey moment value is increasing from storey 4 to storey 1 it has less values for rubber base isolation model than fixed base isolation system.

Y Direction

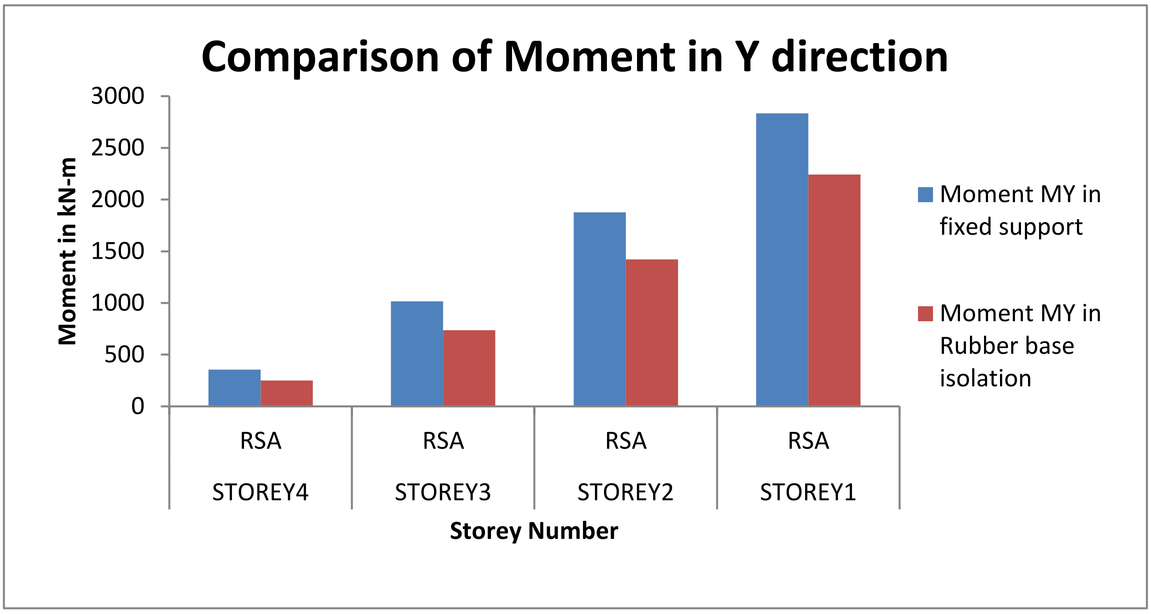

Figure 10: Comparison of Moment in Y Direction

The above graph shows the comparison of moment in Y for different storey moment value is increasing from storey 4 to storey 1 it has less values for rubber base isolation model than fixed base isolation system.

Building Torsion

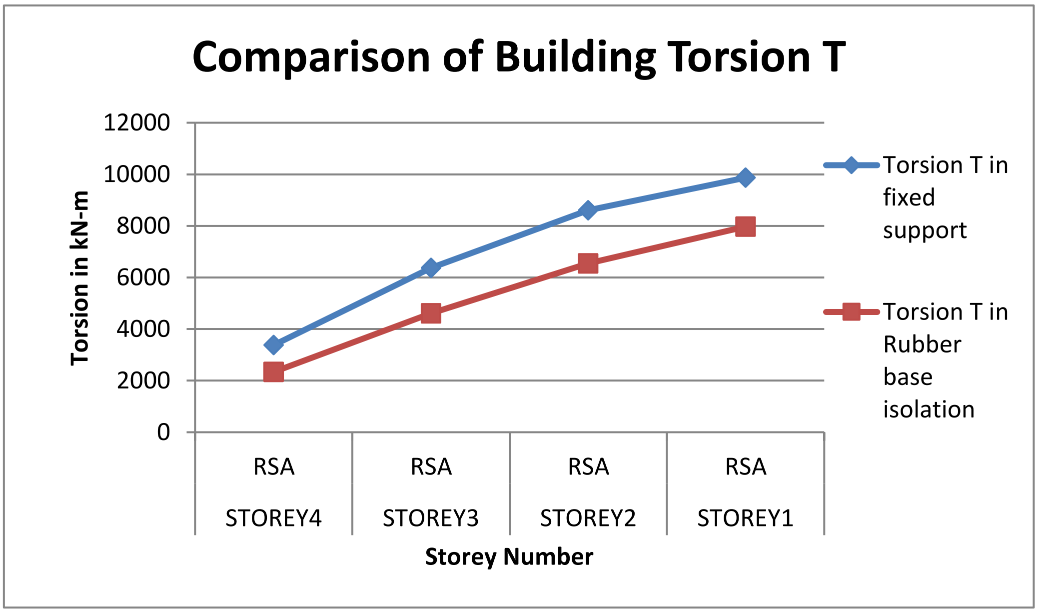

Figure 11: Comparison of Building Torsion T

The comparison of building torsion values as shown in the above graph from this observation it was concluded that due to the effect of seismic loading condition the building torsion values are less for the rubber base isolation model than fixed support building model for G+3 building structure.

Time period

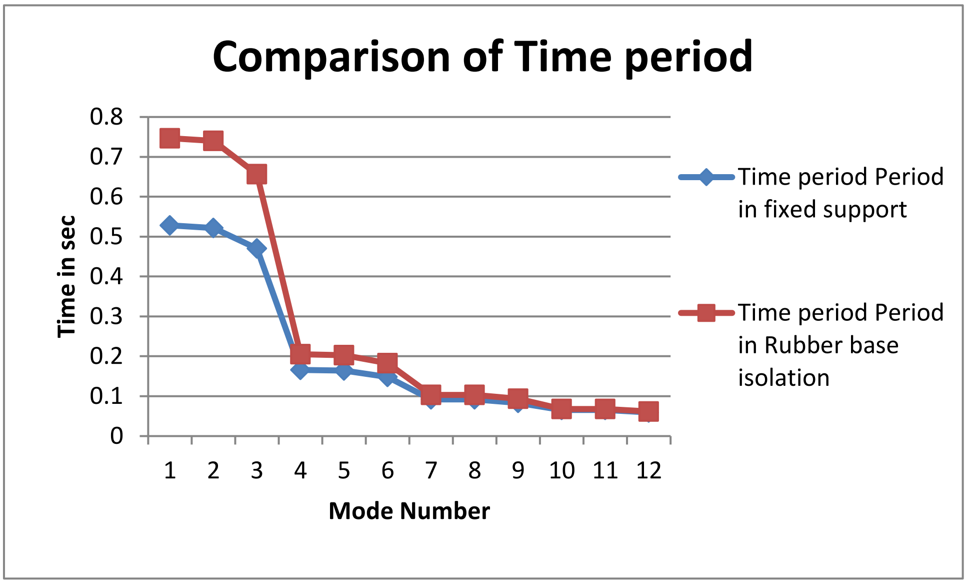

Figure 12: Comparison of Time period

The comparison of time period is shown in the above graph the time period values are decreasing from mode 1 to mode 12 it is having higher values for the modes 1 to 4 for the remaining modes it has almost same values for both rubber base and fixed base isolation system.

Model stiffness

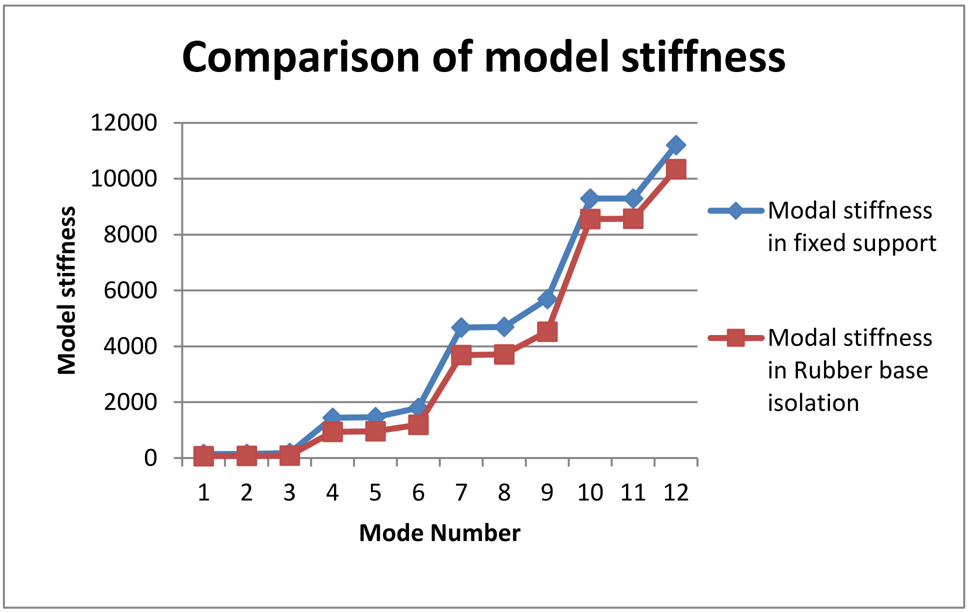

Figure 13: Comparison of Model stiffness

The above graph shows the model stiffness values for the G+3 building for both fixed base and rubber base isolation system. The values of model stiffness increase from node 1 to node 12 for both cases.

IV. CONCLUSIONS

1. Seismic isolation and energy dissipating systems present an effective way to common seismic design for improving the seismic performance of structures.

2. These techniques reduce the seismic forces by changing the stiffness and damping in the structures, whereas conventional seismic design is required for an additional strength and ductility to resist seismic forces.
3. The storey drift in both Rubber base is less when we compared with fixed base support.
4. The values of storey shear, storey bending and storey torsion has also less for Rubber base isolation support than fixed support building model.
5. Time period values decreases form mode 1 to mode 12 in all the cases
6. Model stiffness increases from mode 1 to mode 12 in all building with and without base isolation.
7. By using base isolation system of rubber bearing the values are decreasing which are related to deflection, shear, bending, torsion etc. Hence Rubber base isolation system is recommended in High Seismic Zones.

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