

## Effect of Lead Rubber Bearing on Seismic Response of Regular and Irregular Frames in Elevation

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### Abstract

Base isolations are acknowledged as an effective seismic protective system for structural systems of buildings. This study investigates the effectiveness of lead rubber bearing (LRB) on the nonlinear response of the steel moment resisting frames subjected to real ground motions. To this aim, 12-storey regular and irregular steel frames in elevation upgraded with LRB were studied by evaluating the local and global deformations. LRB was modeled by considering three key parameters of isolation period, effective damping ratio, and stiffness ratio. Two-dimensional model of the base isolated frames were created and a series of time-history analyses were carried out by different earthquake ground motions. The seismic behaviour of the base and isolated frames was measured by the variation of isolator displacement, acceleration, inter storey drift ratio, relative displacement, roof drift ratio, normalized base shear, base moment, and hysteretic curve. The supremacy of the base-isolated frames over the base frames was discussed accordingly. The results prove a substantial elongation of the building period, as well as a reduction in the building displacement, the roof acceleration, the inter-storey drift ratio and the base shear force of isolated building relative to fixed-base building.

**Key words:** *Seismic isolation, Rubber bearing isolation system, friction pendulum system modeling in SAP2000, story drift, shear force, bending moment, building torsion.*

### 1. Introduction

The purpose of earthquake prevention of buildings is to provide the structural safety and comfort by controlling the internal forces and displacement within the particular limits. The common method for protecting the structures against the destructive effects of earthquakes is to damp the seismic energy for limiting the seismic energy by the structural elements, thus providing the resistance against the earthquake. In spite of using this method for a certain level of protection, the structure could be damaged for real sometimes. Another method for protection of the structures against the earthquake is to isolate the building from the ground and/or to install seismic energy dissipating elements at the appropriate places of the building. With this method, better protection could be provided, by designing correctly against the earthquake and therefore significant structural damage level could be minimized.

The earthquakes have been carried on to be an important factor that threatens the social and economic future of the countries, as we can

observe the results of them. Thus, it is insisted on the resolutions that minimize the seismic effects of the buildings should demonstrate a high performance level in the expected earthquakes. The seismic isolators and energy dissipating devices are seen to be effective solutions within this context, which are placed in the building appropriately to damp the seismic energy or placed between the foundation and vertical structural systems damping the seismic energy under the ground of the building, thus decreasing the effects of lateral loads on top floors. Application of earthquake protection systems in buildings whether will be constructed and were constructed -especially the historical ones-, increases the importance of these technologies.

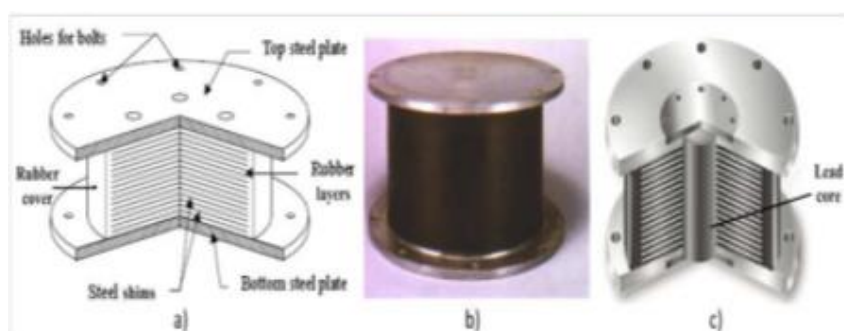
#### 1.1 Seismic isolation

Seismic isolation is a technique used to reduce the effects of earthquake ground shaking on structure, their components and protect them from damaging. In this technique we use some

hardwires that I will describe later to reduce structures lateral movement (Drift).

Seismic isolation is one of the most important concepts for earthquake engineering which can be defined as separating or decoupling the structure from its foundation. In other words, seismic isolation is a technique developed to prevent or minimise damage to buildings during an earthquake. In this essay, the concept of base isolation will be explained by giving some examples from other engineering and sport branches. These examples are automobile suspension systems and some defence techniques in boxing. Additionally, some experiments and analytic graphs will be demonstrated to provide better understanding of the concept of base isolation.

### 1.2 Rubber Bearings isolation



**Fig.No.1 Lead rubber bearing isolation.**

The main objectives of the present research are to study the seismic behavior of G+9 building by using IS 1893:2002 code with the help of response spectrum method in SAP2000, to study the G+9 building with different base isolation systems namely Rubber bearing isolation and friction pendulum bearing isolation in different seismic zones i.e., Zone II, Zone III, Zone IV and Zone V, to compare the results of seismic analysis of building with different base isolation systems with fixed base building in different seismic zones and hence to identify the good earthquake resistant and effective system with the help of analysis results like joint displacements, shear, bending, torsion, base shear and time period.

### 2. Literature Studies

**a. Gyawali et al. (2020)**, In this research, GF+4 storied regular, plan irregular and vertical irregular building models were considered for both fixed

base and base isolation in SAP. Response spectrum method analysis under IS1893:2002 was The SAP analysis results were compared and validated by ETABS software. The base shear value in LRB building was reduced up to 45 to 50% as compared to fixed base building. Top story displacement of building was increased up to 81 to 99% by using LRB.

**b. Dr. R. S. Talikoti et al. (2014)**, here they took a detailed glance at the designing, working, testing as well as the suitability of base isolation design as per Indian Standards. The (G+15) RCC building was considered for the case study. It was modelled in SAP2000 software and analysed for fixed base, bracing and Isolator. Theoretical comparison was then worked out between the fixed base and the base isolated structure and the parameters such as base shear, mode period, storey displacement, storey drift and storey acceleration by using SAP2000.

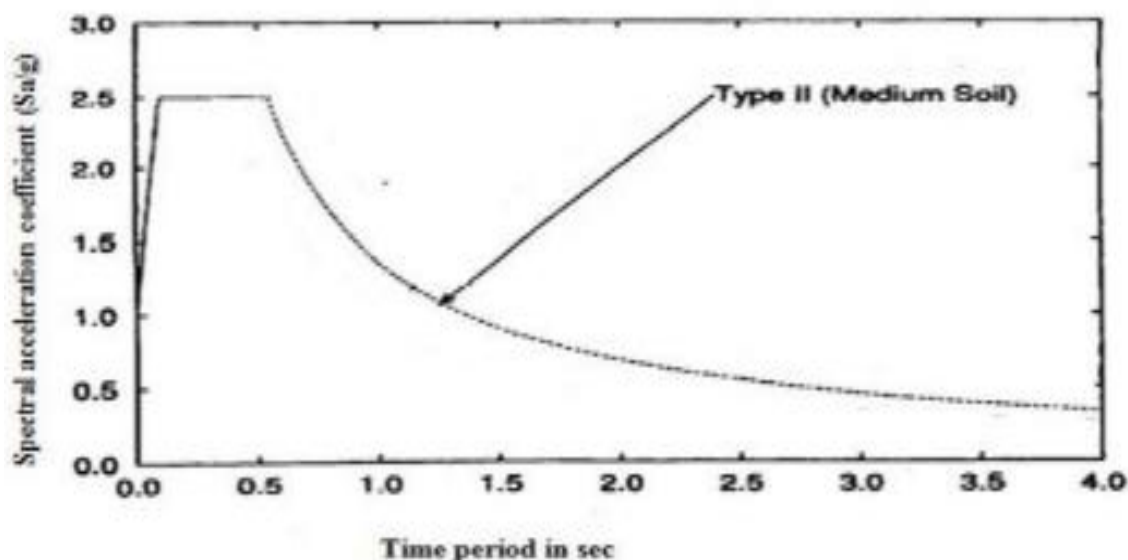
**c. Anoop Mokha, M. C. Constantinou**, Associate Member, ASCE, A. M. Reinhorn and Victor A. Zayas Members, ASCE A shake-table study of the friction-pendulum isolation system, installed in a six-story, quarter-scale, 52-kip model structure, is presented. Two bearing materials are studied, one with a peak friction coefficient of 0.075 and another of 0.095. In both cases, the isolation system has a rigid-body mode period of 1 sec. The isolated structure is found to be capable of withstanding strong earthquake forces of different frequency content. In tests with the El Centra motion, the isolated structure sustains, without any damage, a peak ground acceleration six times greater than what it could under fixed-based conditions

**d. B. Harish Kumar [2022]** , The main goal of this study is to analyse and construct a commercial building using various slab configurations, including flat slabs, grid slabs with drop panels, and conventional slabs. A structure is considered commercial if at least half of its floor area is devoted to business purposes. Buildings with various slab layouts and the impact of seismic and wind forces has been analysed by utilising SAP2000 software. The engineering software programme SAP2000 is used for structural analysis and design. The IS 456-2000 code book is used for

analysis and design, and M30 grade concrete and Fe500 steel are used. According to Design Code IS-875, dead load is taken number of issues have an impact on how well building's function, including story drift, base shear, and story displacement are key factors in determining how well structures respond to wind and seismic loads. The results are presented using tables and bar charts. Story displacement increased along with story height. In comparison to all other slab arrangements used in the wind and seismic load analyses, the results demonstrate that buildings with grid slabs are more stable.

### 3. Methodology Used

Response spectrum analysis is also known as linear dynamic statistical analysis method. This analysis generally done with the help of IS code for seismic analysis. The IS code used for this study is IS 1893:2016 (Part 1). The values of seismic zone factor, soil type are taken from the tables which are from this IS 1893:2016 (Part 1) code. The damping ratio is generally taken as 5% for this analysis. The response spectrum Graph for medium soil condition is shown in the below graph. The graph is plotted between the Time period and Spectral acceleration coefficient (Sa/g).



**Fig. No.2** Response spectrum for medium soil type for 5% damping

In this we need to discover the size of powers finished for instance X, Y and Z and after that see the repercussions for the structure. Mix techniques combine the going with:

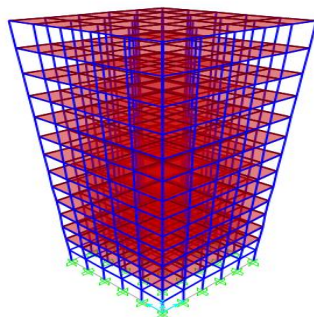
1. Absolute - crest esteems are included
2. Square foundation of the total of the squares (SRSS)

3. Complete quadratic blend (CQC) - a strategy that is a change on SRSS for firmly divided modes.

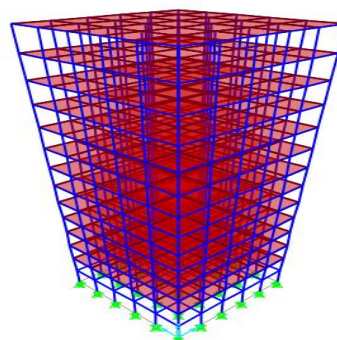
The output from the Response spectrum analysis is purely different from the linear dynamic analysis using the ground motions, in case of structure or building is irregular or high rise building this analysis of response is not accurate as we compared with other analysis and other method of Basic parameters considered for the analysis are

1. Occupancy of the building : Residential
2. Number of stories : 12 storied
3. Total Height of building : 36 m
4. Shape of building : Rectangular
5. Geometric details
  - a. Ground floor height : 3 m
  - b. floor to floor height : 3 m
6. Material details
  7. Concrete Grade : M30 (COLUMNS AND BEAMS)
  8. Steel : HYSD 415
  9. Bearing Capacity of Soil : 200 kN/m<sup>2</sup>
10. Type Of Construction :RCC
11. Column : 0.6m × 0.23 m
12. Beams : 0.45m × 0.23 m
13. Slab thickness : 0.150 m
14. Live load : 2.5 kN/m<sup>2</sup> (IS:875:1987)
15. Density of Reinforced concrete : 25 kN/m<sup>3</sup>
16. Site type : **v**
17. Importance factor : 1.0
18. Response reduction factor : 3
19. Damping Ratio : 5%
20. Structural class : C
21. Wind design code : IS 875-2015
22. RCC design code : IS 456:2000
23. Steel design code : IS 800: 2007
24. Earthquake design code : IS 1893 : 2016

Building models in SAP 2000



**Fig.no.3 Building Model with rubber isolator at supports**



**Fig.No.4 Building model with fixed at support**

analysis is needed, which is non linear static analysis or dynamic analysis. In the present study I was considered a medium rise building and regular structure for the seismic loading condition for the response analysis case.

In the present study, analysis of G+11 multi-storied building. Three dimensional model of building is prepared in SAP 2000 Software.

4. Results And Analysis

4.1 RSA X Results

I. Comparison of joint displacements

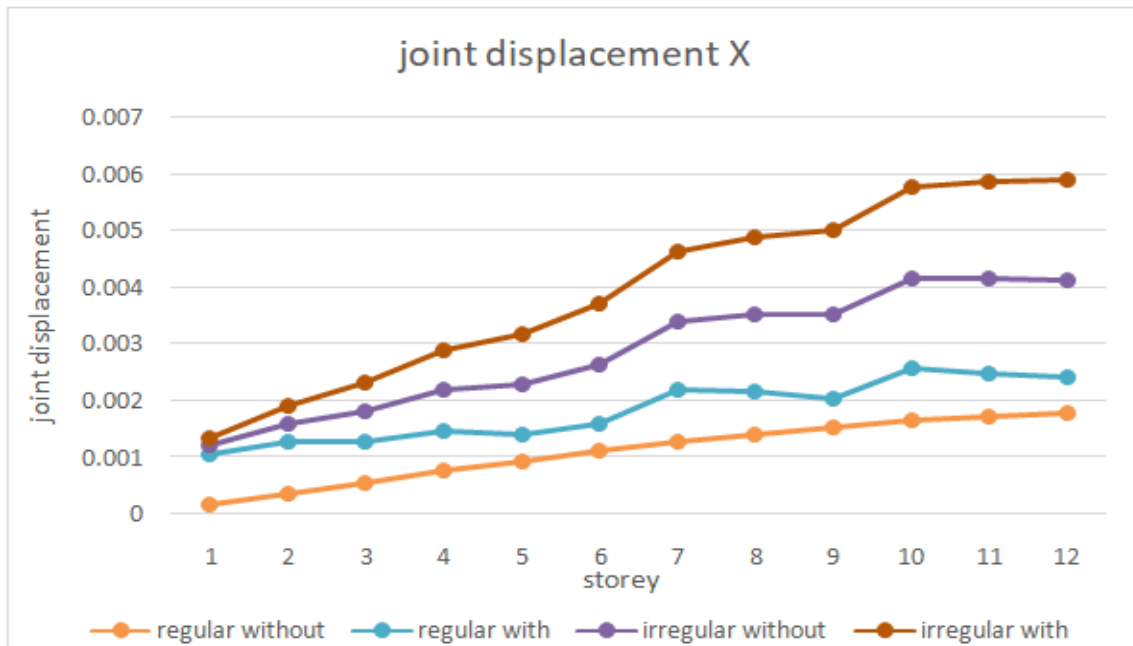


Fig.no 5 Comparison of joint displacement

The joint displacements of fixed base, rubber base for regular and irregular buildings for RSAX loading are shown in above plot from the above observations it was obtained as the joint displacements has higher values for rubber base

than fixed base models due to the effect of high intensity action of seismic loading condition the displacement values increases for the rubber base model.

II. Comparison of Storey Shear

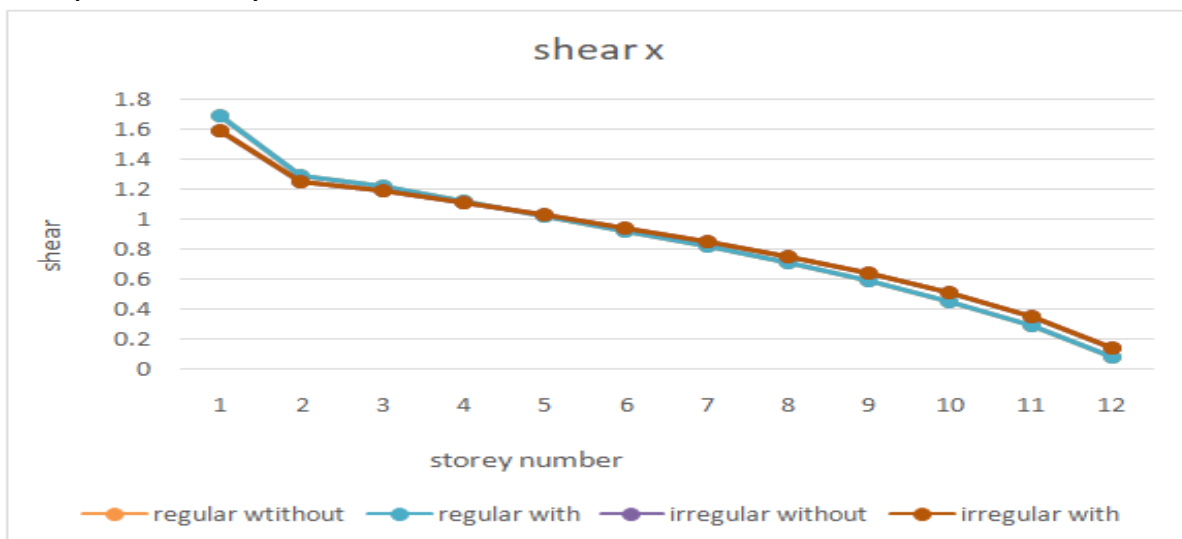


Fig.No.6 Comparison of storey shear V

The above comparison for the shear in RSA X direction condition is shown in graph. By using the seismic isolation systems namely rubber base the

shear values can be increasing in zone V seismic condition.

III. Comparison of Torsion T

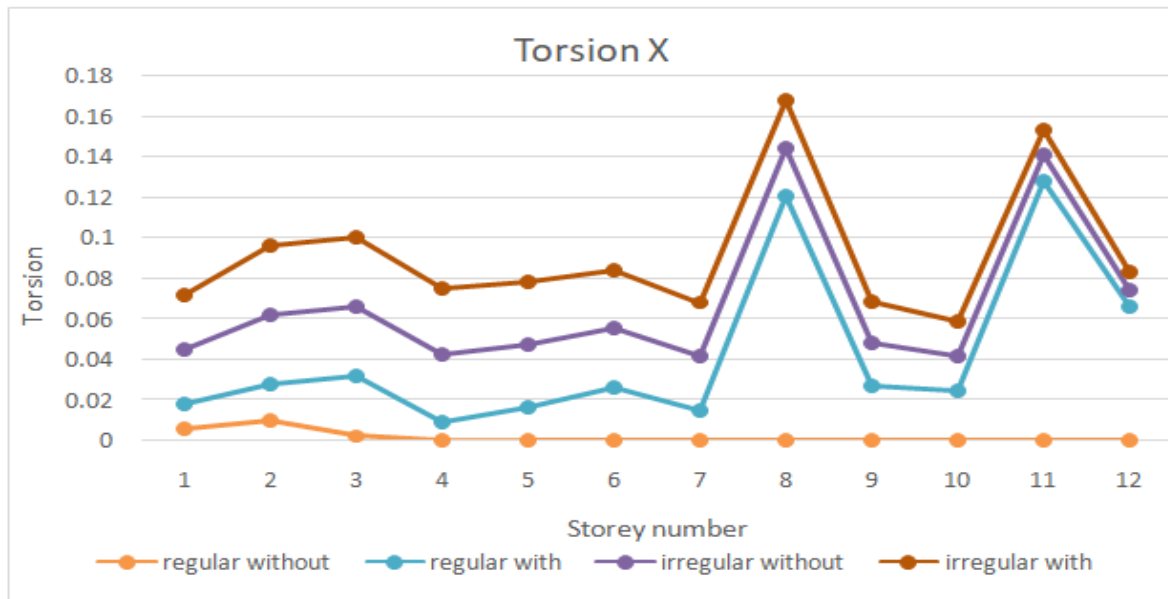


Fig.No.7 Comparison of Torsion T

The comparison of torsion due to RSA X is shown in the above graph due to the un equal forces in both direction the torsion is developed in multi storey

building the effect of seismic isolation the torsion will be increasing which is proved from above graph which is related to zone V seismic condition.

IV. Comparison of Storey moment

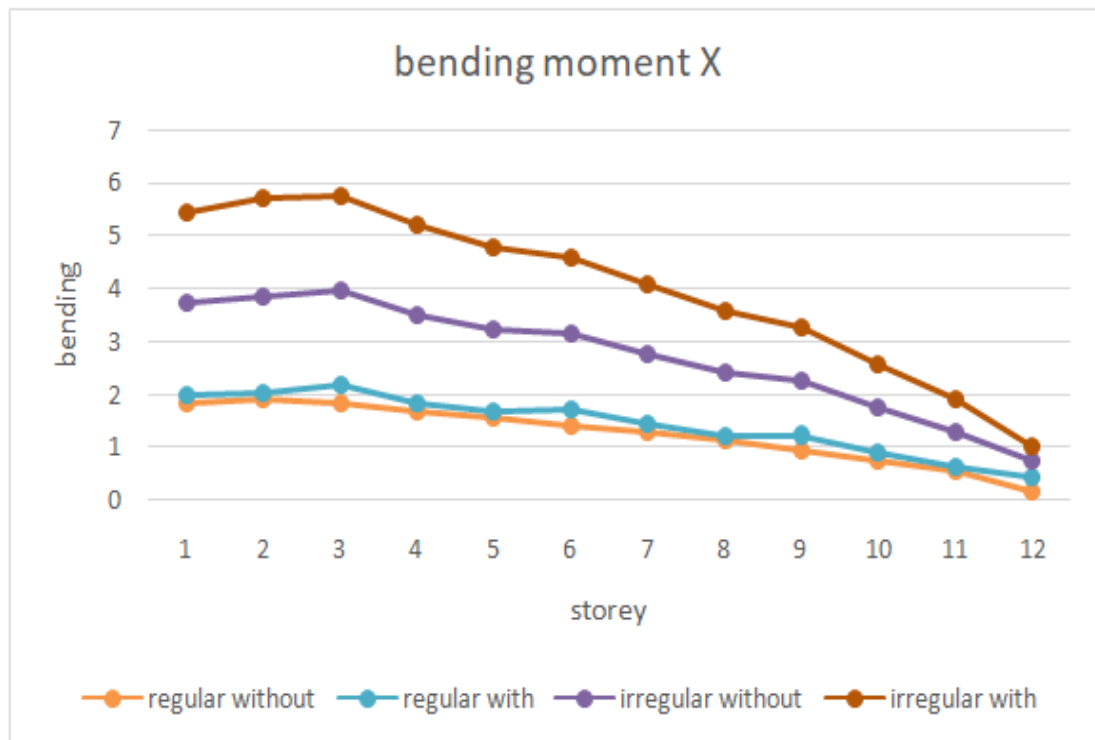


Fig.No.8 Comparison of moment M

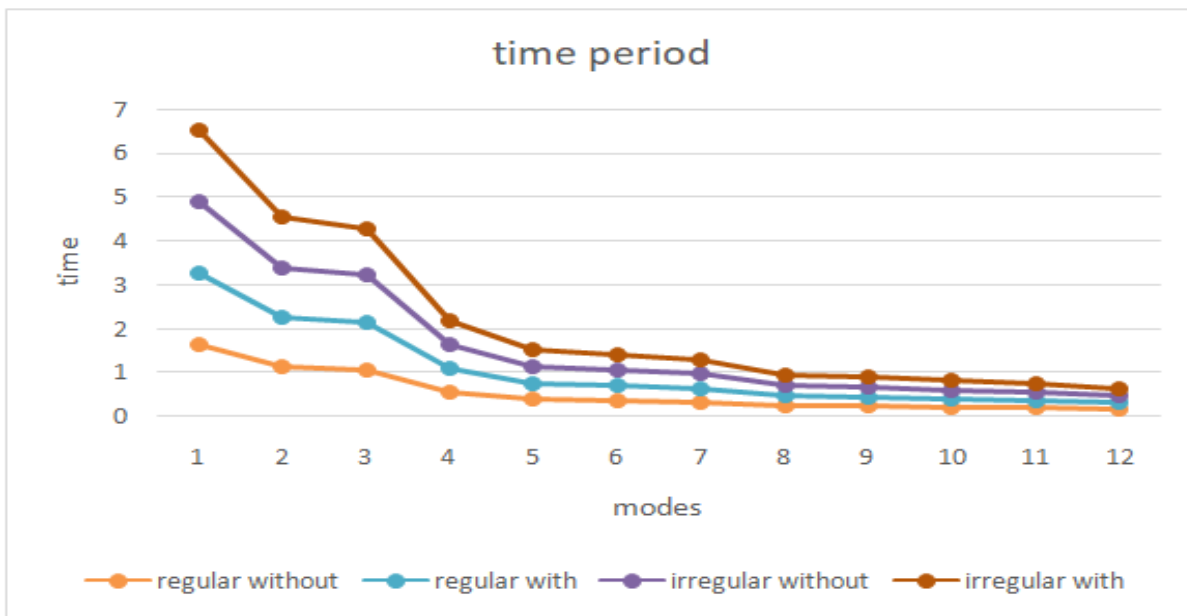
The comparison of moment due to RSA X is shown in the above graph due to the un equal forces in

both direction the torsion is developed in multi storey building the effect of seismic isolation the

torsion will be increasing which is proved from above graph which is related to zone V seismic

condition.

**V. Comparison of Time period in X & Y Direction :-**

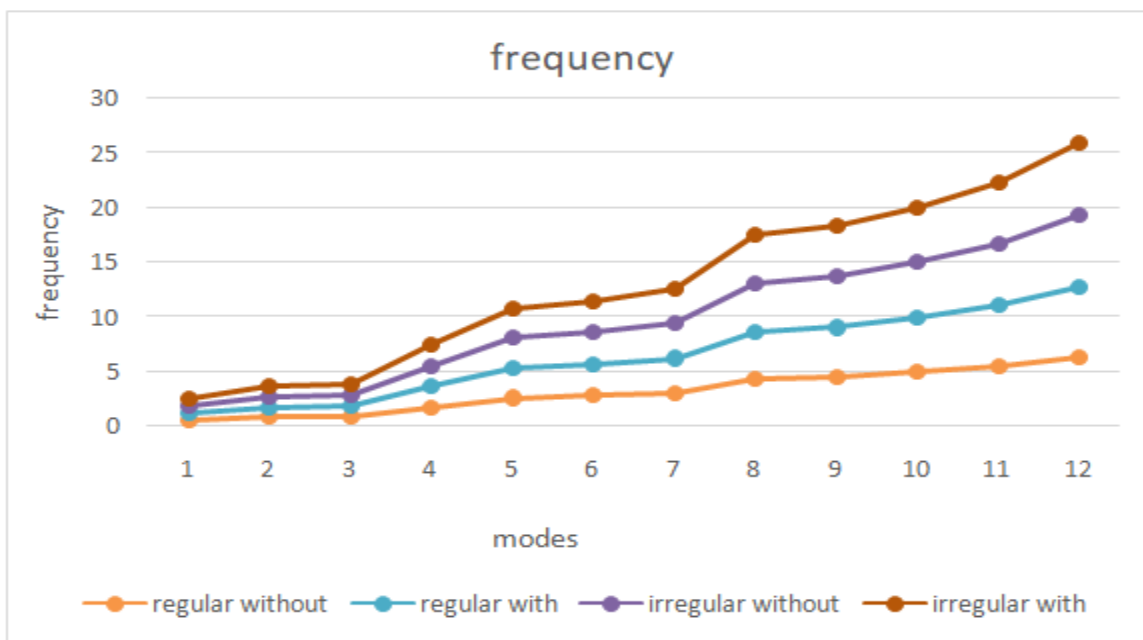


**Fig.No.9 Comparison of Time period**

From the graph it was clearly observed that the value of time period in mode for rubber base isolation system model is more than the fixed base isolation system building model due to the effect

of seismic loading condition. The values are decreasing for both the model from mode 1 to mode 12.

**VI. Comparison of frequency in X & Y Direction**



**Fig.No.10 Comparison of frequency**

4.2 RSA Y Results

I. Comparison of joint displacements

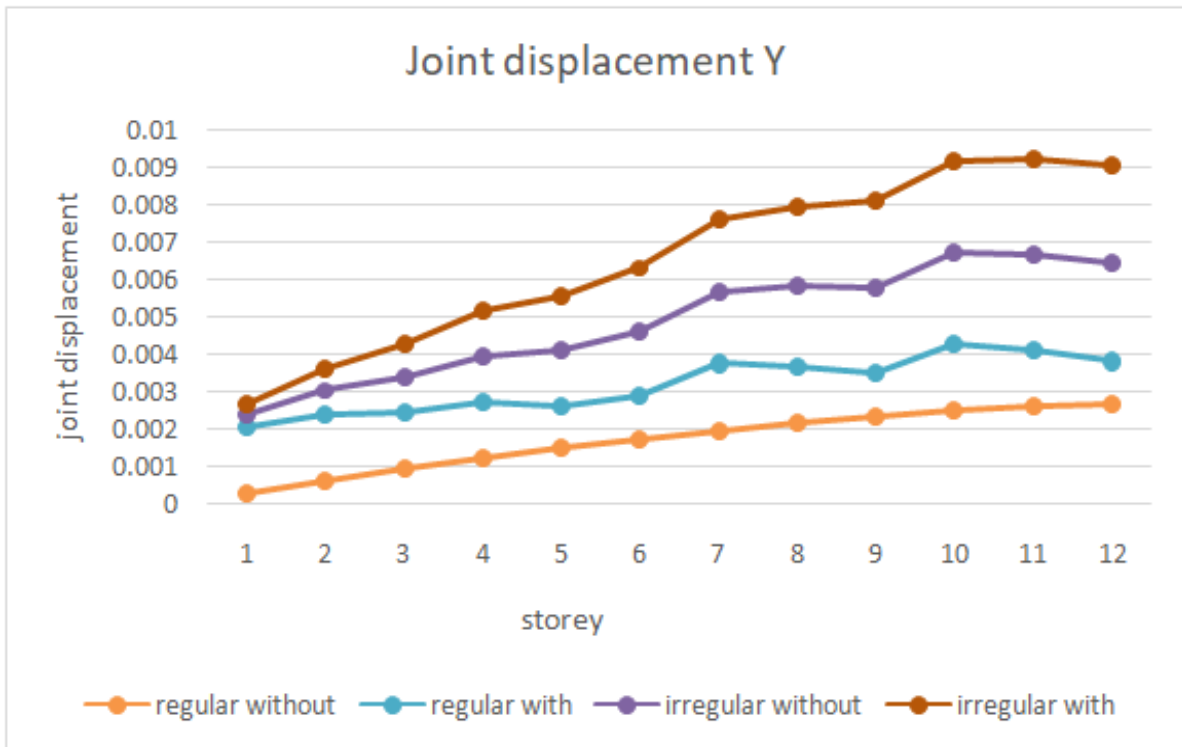


Fig.No.11 Comparison of joint displacement

The joint displacements of fixed base, rubber base for regular and irregular buildings for RSAY loading are shown in above plot from the above observations it was obtained as the joint displacements has higher values for rubber base

than fixed base models due to the effect of high intensity action of seismic loading condition the displacement values increases for the rubber base model.

II. Comparison of Storey Shear

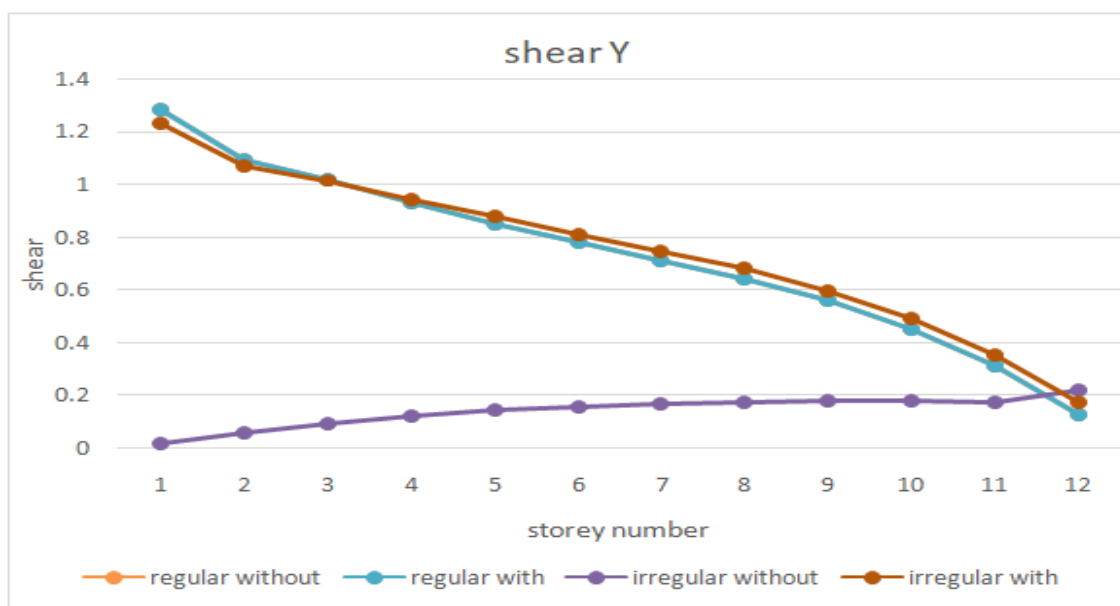
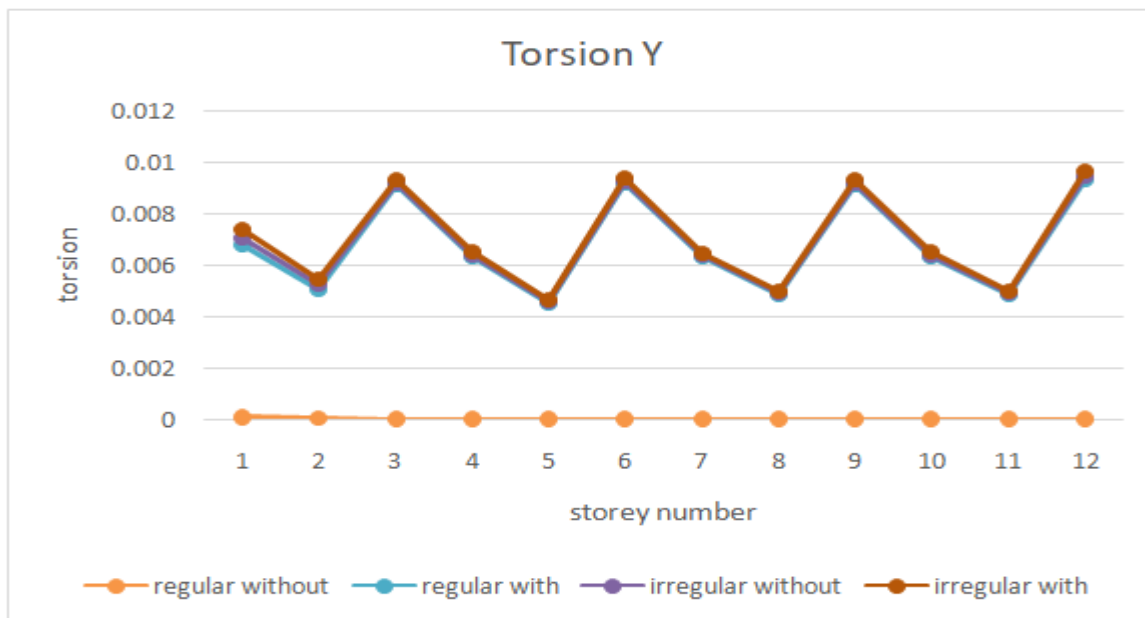


Fig.No.12 Comparison of storey shear V

The above comparison for the shear in RSA Y direction condition is shown in graph. By using the seismic isolation systems namely rubber base the

shear values can be increasing in zone V seismic condition.

**III. Comparison of Torsion T**

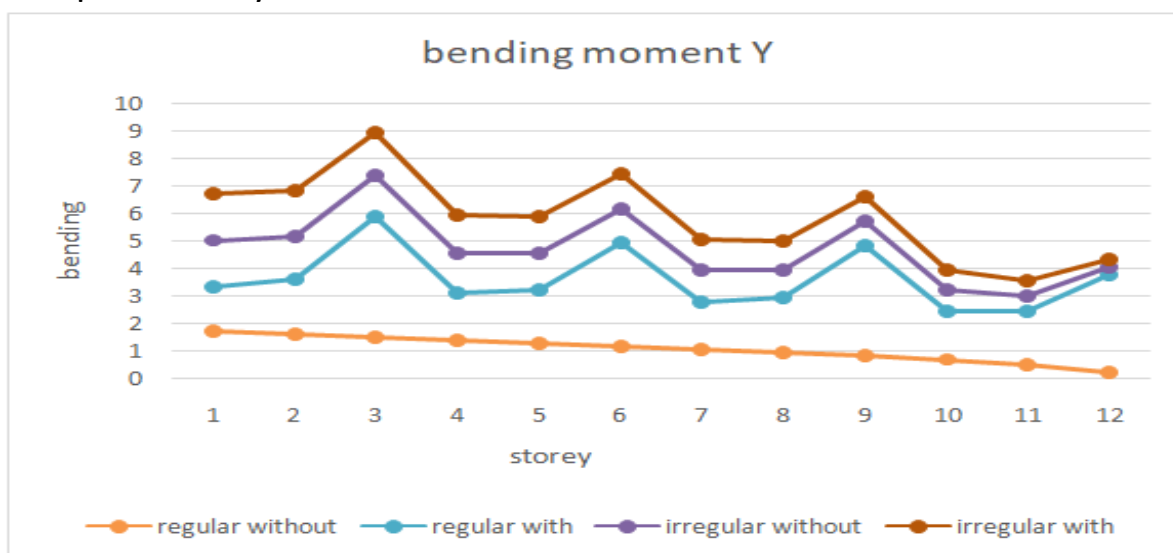


**Fig.No.13 Comparison of Torsion T**

The comparison of torsion due to RSA Y is shown in the above graph due to the un equal forces in both direction the torsion is developed in multi storey

building the effect of seismic isolation the torsion will be increasing which is proved from above graph which is related to zone V seismic condition.

**IV. Comparison of Storey moment**



**Fig.No.14 Comparison of moment M**

The comparison of moment due to RSA Y is shown in the above graph due to the un equal forces in both direction the torsion is developed in multi

storey building the effect of seismic isolation the torsion will be increasing which is proved from

above graph which is related to zone V seismic

### 5. Conclusion

From analysis results it is observed that base isolation technique is very significant in order to reduce seismic response of building with isolator as compared to fixed base building and to control damages in building during seismic action. The increase or decrease of result parameters with respect to story compared with fixed base model is discussed below.

1. Storey shear values are increased when the building is damped with Lead Rubber isolation
2. By providing the rubber base isolation at the base the storey shear values are decreased by 28.57%
3. Storey Moment is decreased when the building is analyzed with Lead Rubber isolation system
4. Storey moment values are increased by 16.88% when the building is analyzed with rubber base isolation
5. Torsion values are increased when the building is modeled with isolation systems.
6. Increase in story torsion by 44.12% have been observed for Rubber base isolation model
7. By using the base isolation systems, the values of joint displacements are increased by 15.08% for rubber base model
8. Base isolation resulted significant decrease in story lateral loads in all seismic zones. Story lateral loads are decreased by 17.95% for rubber base model.
9. Optimum control of the parameters considered was observed when the building is damped with Friction bearing isolation systems.

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