INTERNATIONAL JOURNAL OF ADVANCE RESEARCH, IDEAS AND INNOVATIONS IN TECHNOLOGY

ISSN: 2454-132X
Impact Factor: 6.078
(Volume 7, Issue 4 - V7I4-1558)
Available online at: https://www.ijariit.com

Study of seismic response between fixed and isolated bases in RC structure having plan irregularity

Rahul B. M.
rahulbm96@gmail.com
Ramaiah Institute of Technology, Bengaluru, Karnataka

B. Suguna Rao
suguna_rao@msrit.edu
Ramaiah Institute of Technology, Bengaluru, Karnataka

ABSTRACT

Base isolation technique is one of the most widely used earthquake resistant method in designing the structures. In this study, a G+15 RC structure is considered and modelled for fixed base and isolated bases i.e., Lead Rubber Bearing (LRB) and High Damping Rubber Bearing (HDRB) using Etabs v19.1.0. The models are then analysed and seismic response of the structure is obtained by using equivalent static method and response spectrum method. The results, thus, obtained is compared and graphs of storey displacement, storey drift, storey shear and storey acceleration is plotted for fixed base and isolated bases. From this study, it is evident from the analysis that, the use of base isolation systems helps the structure from being majorly damaged, especially in higher seismic zones.

Keywords: *Lead Rubber Bearing (LRB), High Damping Rubber Bearing (HDRB), Storey Displacement, Storey Drift, Storey Shear, Storey Acceleration.*

1. INTRODUCTION

Earthquakes are a significant danger to lives and to the uprightness of the foundations in seismic zones. Constructions are the most exceedingly awfully hit with the harms because of ground movements resulting from earthquake. The type of forces created during the earthquake is devastating, and goes on for a small period of time. However, individuals are bewildered with its weakness to the extent of it's season of occurrence, and it's behaviour. Further, with these turns of events, estimating the force and event of earthquake, say for a specific locale, has gotten sensibly satisfactory, in any case, this tackles just a single issue to get a secure structure. The subsequent part is the seismic design of constructions - to withstand the forces and safeguard the structure. In this present work, the concept of base isolation for earthquake resistant design of the structures is presented. The modelling and analysis of a G+15 RC building is developed and the effectiveness of the base isolation is demonstrated. This section consists of a brief literature survey that supports the concept of base isolation technique over fixed support for RC structures. Saiful Islam A. B. M. et al., (2011) in their work studied two types of isolators i.e., LRB and HDRB. Response spectrum and time history analysis methods were utilised for this purpose and was executed using SAP 2000. Anusha R Reddy and Dr. V Ramesh (2015) modal periods of different structures under isolated bases and fixed bases was considered. In this work, G+13 storey structure and G+5 storey structure is considered and modelled and studied using Etabs v13.2.1. Base shear, modal period, displacement and acceleration are compared for time history and response spectrum analysis for fixed and isolated bases buildings. Athamnia Brahim and Ounis Abdelhafid (2011) did a comparative study of LRB base isolated structure and fixed base structure for a eight storeyed structure using Etabs v9.7.0. The behaviour of isolated base structure and fixed base structure under seismic excitation are shown respectively of Northridge, El Centro and Loma Prieta. The seismic isolated system of Lead rubber bearing decreases the seismic response of structure to leave its characteristics without resorts to external energy. Devi Sreenivas and Ancy Mathew (2016) claim that the irregular buildings are more prone to damage in contrast with the regular structures. Their study concluded that the performance of the plus-shaped structure is better than that of L-shaped structure provided they have same area. Dr. R. S. Talikoti et al., (2014) modelled G+15 in SAP 2000 software and analysed for fixed base, bracing and isolator. The non-linear analysis was done by taking into account of El Centro time history ground accelereation information. Hypothetical correleation is then worked out between the fixed base and the base isolated structure and the characteristics like base shear, modal period, storey displacement, storey drift and storey acceleration. This study concludes that the time period of both LRB and HDRB structures increases in contrast with the fixed base structure, however it was found to be decreasing with bracings.

2. MATERIAL AND SECTION PROPERTY

The properties of the materials defined in the Etabs v19.1.0 software are given in the table below.

Table 1: Material property of Concrete and Rebar defined in the software

Particulars	Concrete	Rebar
Grade	M30	Fe500
Density (kN/m^3)	25	76.98
Young's Modulus (N/mm^2)	27386.12	2 x 10^5
Poisson's ratio	0.2	0.3
Co-efficient of thermal expansion	5.5 x 10^{-6}	1.17 x 10^{-5}
Shear Modulus (MPa)	11410.89	-

The properties of the base isolators i.e., Lead rubber bearing and High damping rubber bearing, designed as per IBC 2000 and Earthquake Engineering Handbook are given in the table below.

Table 2: Parameters of the base isolators

Particulars	LRB	HDRB
Vertical Stiffness (k_v)	4845934.97 kN/m	10936394.97 kN/m
Effective Damping (ξ_{eff})	12	20
Effective Stiffness (k_{eff})	5700.5 kN/m	5700.5 kN/m
Total height of bearing (h)	1.52 m	0.1832 m
Pre Yield Stiffness (k_u)	46259.9 kN	39096.3 kN
Yield Force of lead plug (Q_d)	665.12 kN	296.567 kN
Post Yield Stiffness Ratio (k_d/k_u)	0.1	0.1
Rotational Inertia (ton-m^2)	0.1424	0.019

The sectional properties of the members used in this study are different for columns and beams. However, slab considered for the whole structure is same throughout. The sectional properties defined for the members modelled in Etabs v19.1.0 are given in the table below.

Table 3: Sections used in modelling

Sl. No.	Member	Group 1	Group 2	Group 3
1.	Column	300x700mm	500x500mm	700x700mm
2.	Beam	300x750mm and 300x1000mm		
3.	Slab	150mm thickness		

3. METHODOLOGY

The model considered here is G+15 building with typical floor height of 3.2m. In the present study, RC frame with fixed base is compared with isolated base of same dimensions and also for the same plan. Modelling of the selected RC frame building in software Etabs v19.1.0. Modal analysis is carried out to note the maximum axial load on the columns in case of building with fixed base. After knowing the maximum axial load, design of the isolators is carried out. The design of isolators i.e., Lead rubber bearing (LRB) isolator and high damping rubber bearing (HDRB) is carried out using the IBC 2000 and Earthquake Engineering Handbook. Restraints of the fixed base are then removed and calculated isolator parameters are then assigned in link properties. For present work, for the same model i.e., G+15 building, three models are carried out. They are Model 1 RC frame with fixed base, Model 2 RC frame with LRB and Model 3 RC frame with HDRB. For both lead rubber isolator and high damping rubber isolator shape considered is circular. Also, the zone considered for the structure is zone V, importance factor 1, soil type is medium (II) and response reduction factor is 5. Storey displacement, storey drift, storey shear, storey acceleration and time period are some of the parameters that are compared with fixed base and isolated base.

4. RESULTS

4.1 Modal Analysis

From the modal analysis mode shapes and natural period of all models can be obtained, calculation of the natural period is on the basis of stiffness and mass of the structure.

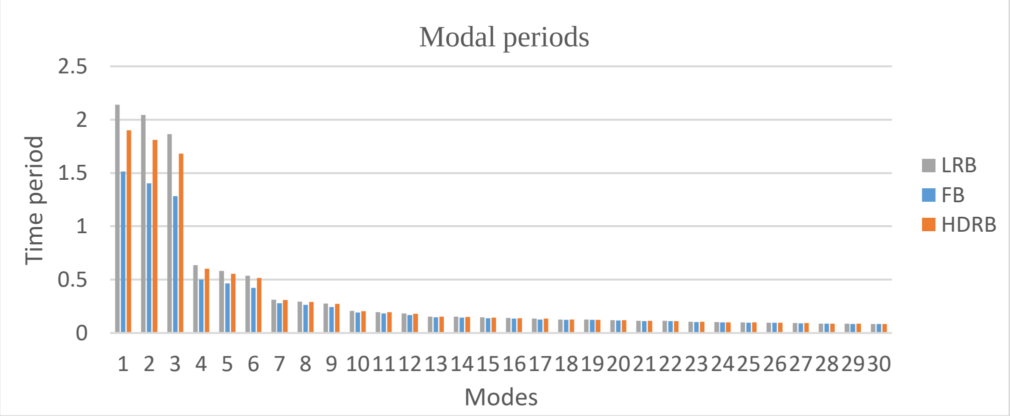

Fig 1: Time periods of the models obtained from modal analysis

4.2 Equivalent Static Method

a) Storey Displacement

Fig 2: Storey displacement of the structure in X direction

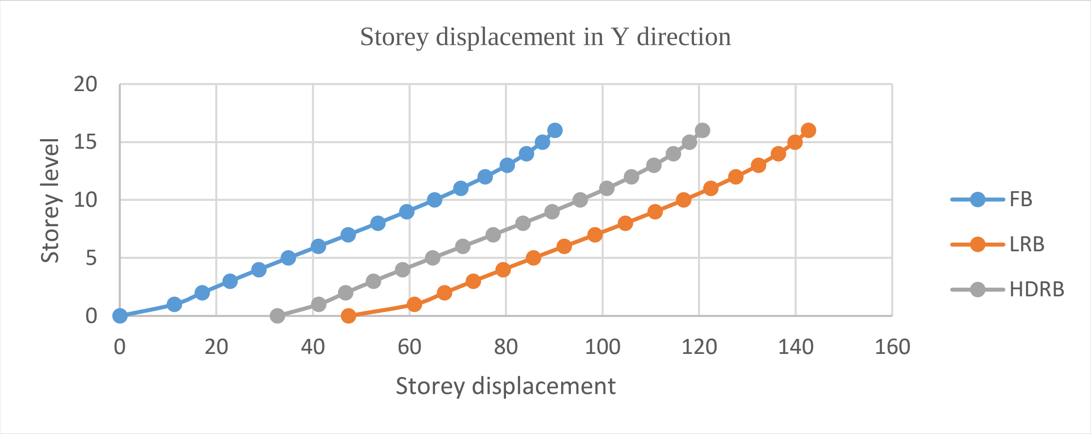

Fig 3: Storey displacement of the structure in Y direction

b) Storey Drift

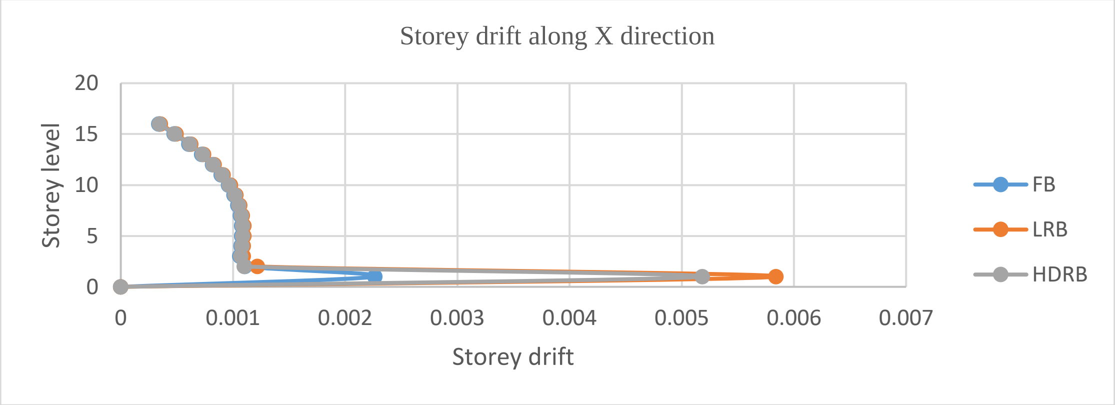

Fig 4: Storey drift of the structure in X direction

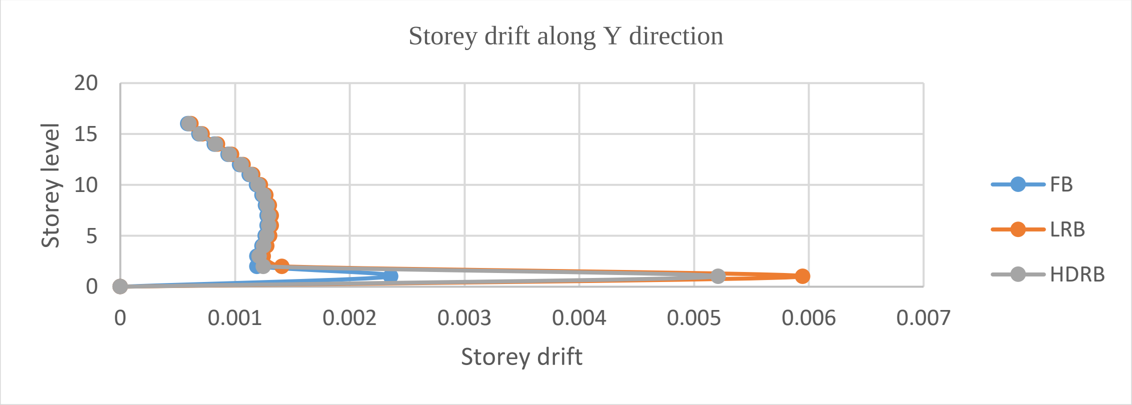

Fig 5: Storey drift of the structure in Y direction

c) Storey Shear

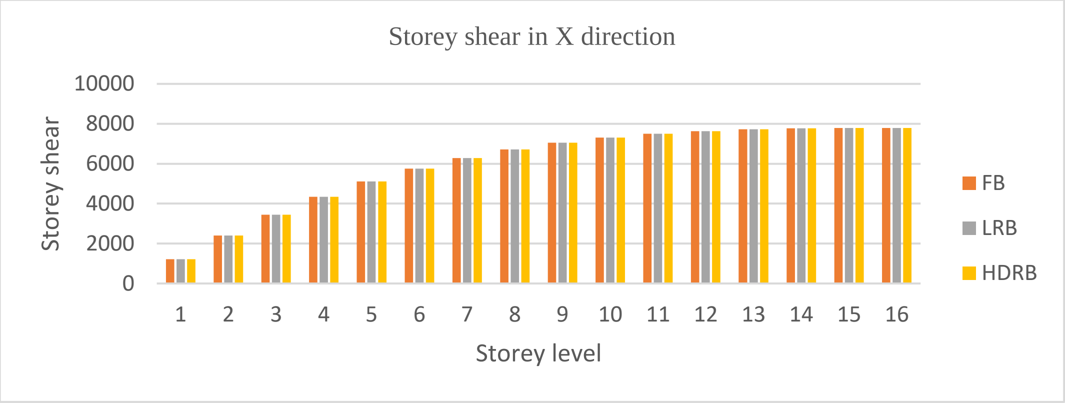

Fig 6: Storey shear of the structure in X direction

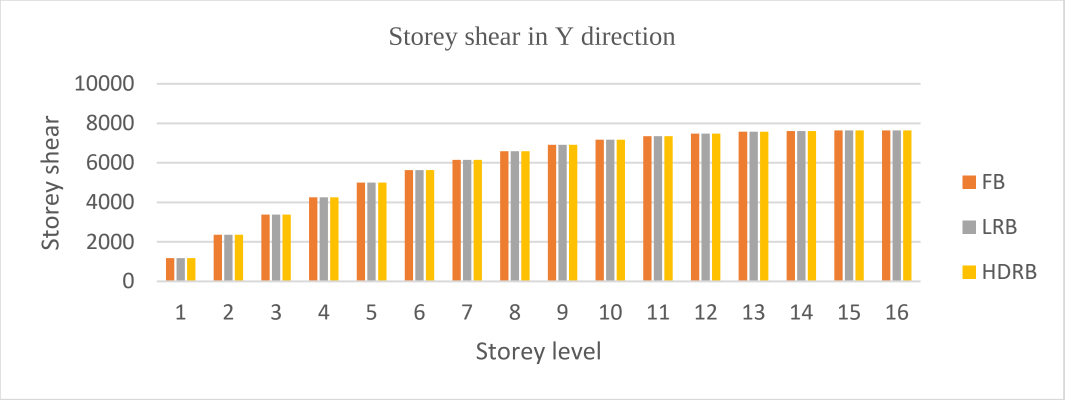

Fig 7: Storey shear of the structure in Y direction

4.3 Response Spectrum Method

a) Storey Displacement

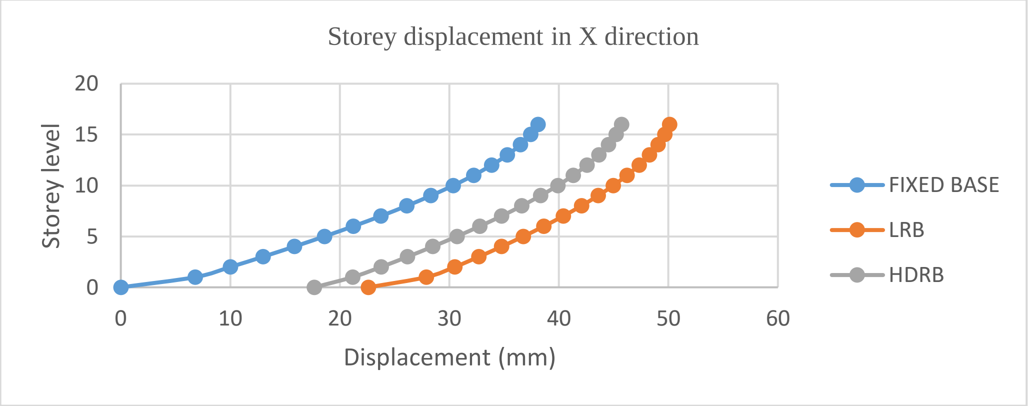

Fig 8: Storey displacement of the structure in X direction

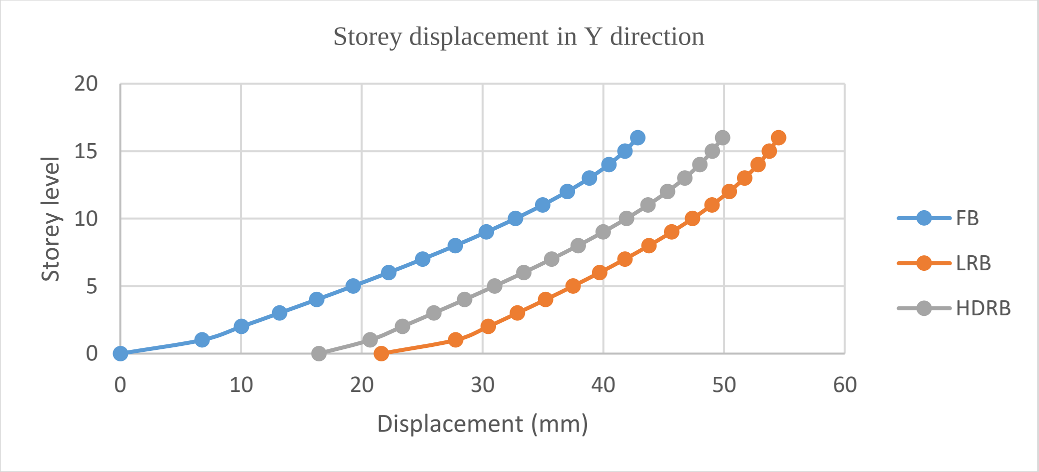

Fig 9: Storey displacement of the structure in Y direction

b) Storey Drift

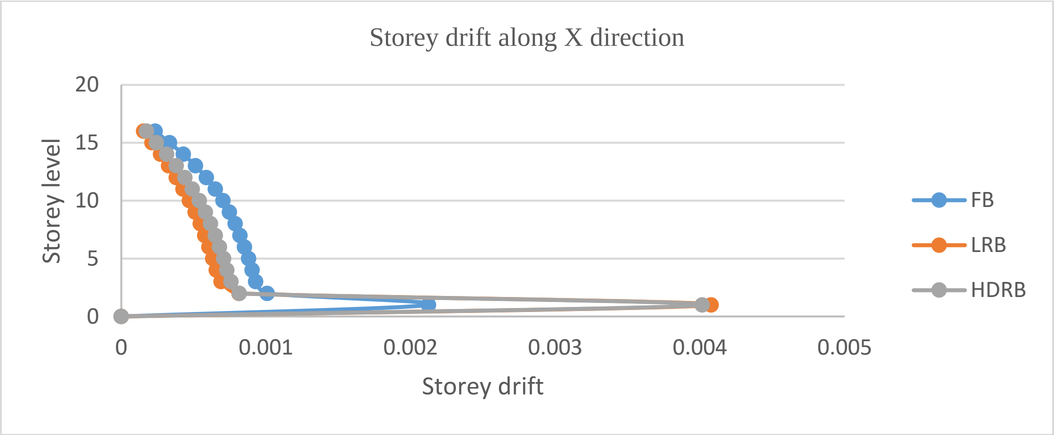

Fig 10: Storey drift of the structure in X direction

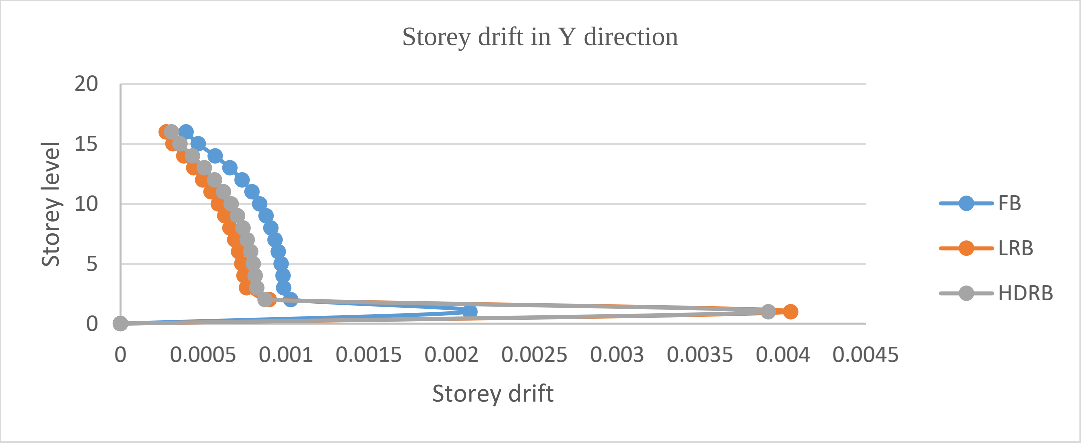

Fig 11: Storey drift of the structure in Y direction

c) Storey Shear

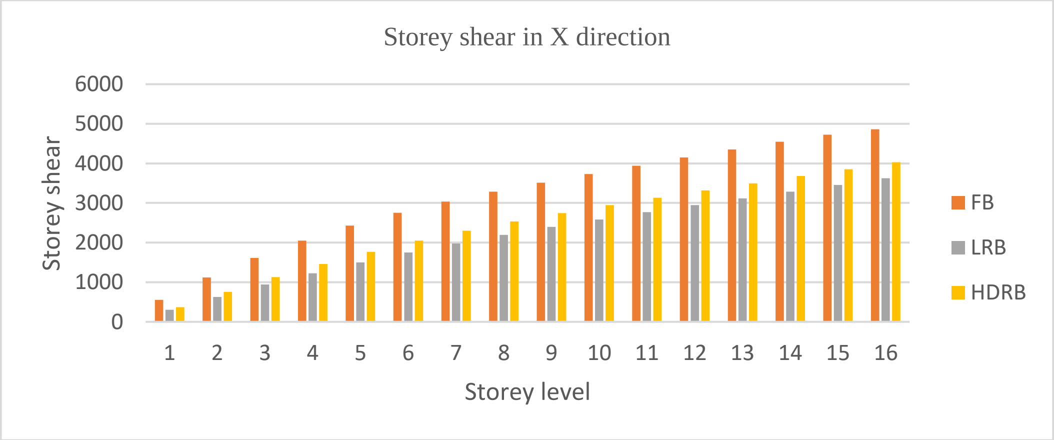

Fig 12: Storey shear of the structure in X direction

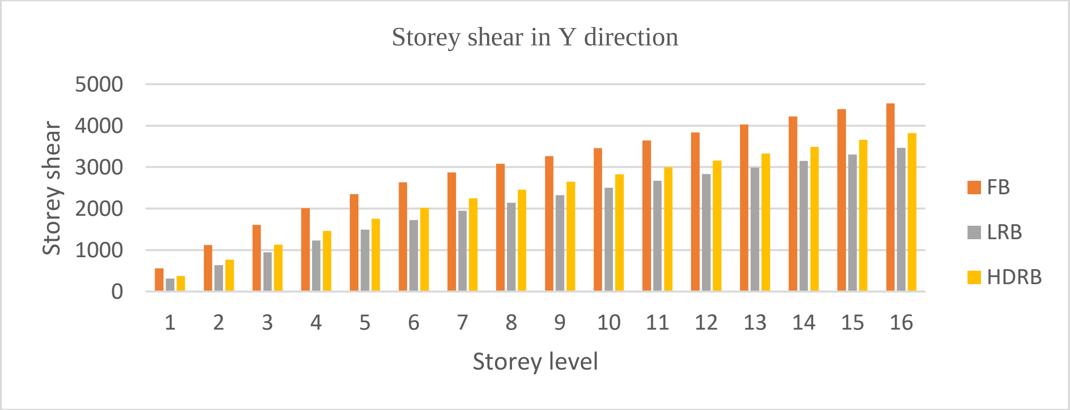

Fig 13: Storey shear of the structure in Y direction

d) Storey Acceleration

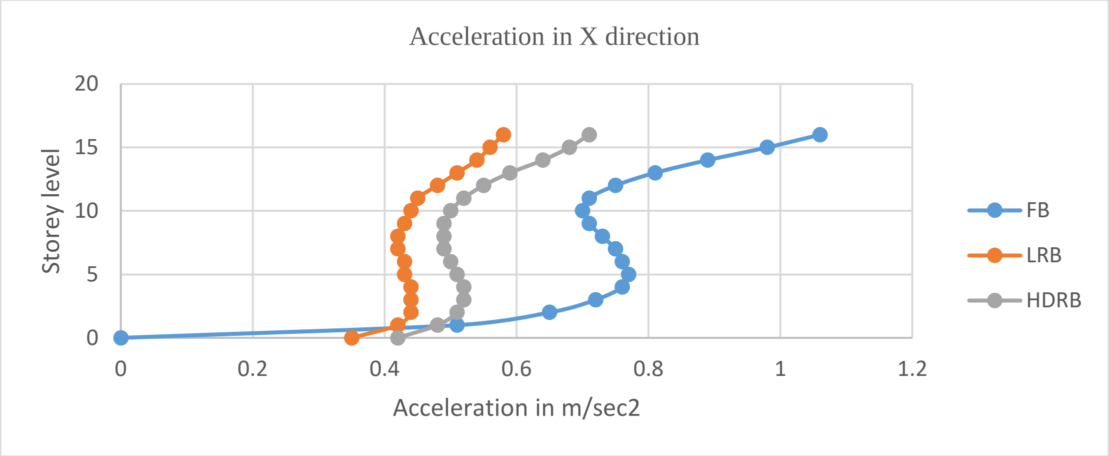

Fig 14: Storey acceleration of the structure in X direction

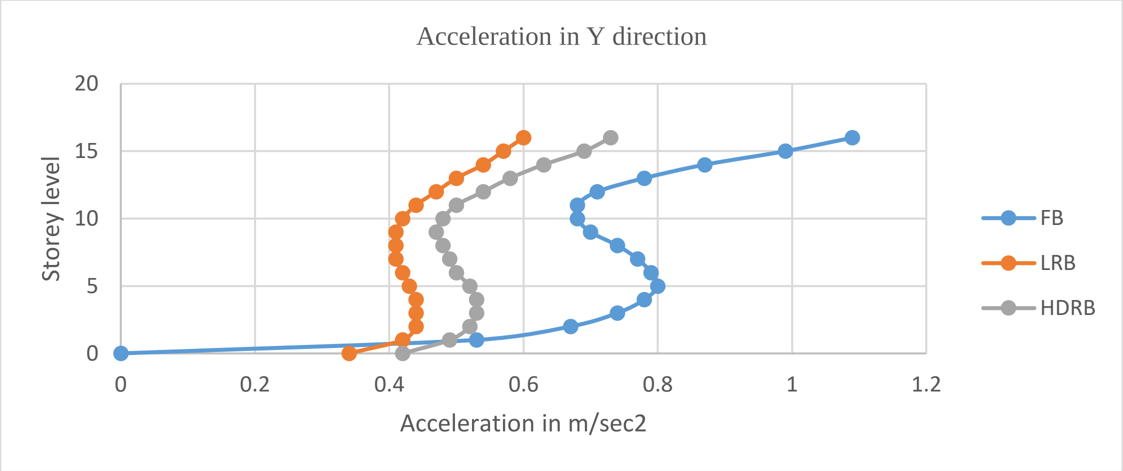

Fig 15: Storey acceleration of the structure in Y direction

5. CONCLUSION

In this present work, the design of the base isolation systems and their effects on the response of the structure is studied under earthquake loads. Storey displacement, storey shear, storey drift and storey acceleration are the parameters used for comparison which are obtained from the Equivalent static analysis and Response spectrum analysis. Results have been discussed and the following conclusions are drawn out from this work.

- The natural periods of the isolators i.e. Lead rubber bearing (LRB) is increased by 41% and High damping rubber bearing (HDRB) is increased by 25% compared to Fixed base (FB). The time period is maximum in LRB, followed by HDRB.
- As the time period and displacement increases, the acceleration and base shear will decrease. As a result of decrease in the accelerations acting on superstructure are damped at base level, the internalforces in superstructures are reduced.
- The displacement results reveals that, the displacement in base isolated structures increasesas the height of the structure increases. The displacement of the base isolated structures is much higher compared to the structureswith the fixed base. For fixed base structures, displacement at base is zero. Whereas in case of isolated base structures the displacement at the base is of certain amount.
- In equivalent static method the displacement of the base isolated structures compared to fixed base structures is less than that of displacements obtained from response spectrum method. Hence, response spectrum method is significant compared to equivalent static method.
- The storey drift of the base isolated structures is more at base compared to fixed basestructures. With the increase in height, the storey drift is around same as that of fixedbase structures in equivalent static method and with the increase in height, the storey drift reduces to extreme values, when compared to the fixed base structures in case of response spectrum method.
- Implementing base isolation resulted in the decrease of the storey drift to insignificant level, so one might say that storey drift basically doesn’t exist. This decrease empowers the design to act as an ideal stiff structure. In this manner, the damage risk of the structural and non-structural elements is limited.
- Storey shear of the isolated base structure is same as that of the fixed base structures in case of Equivalent static method of analysis. The storey shear of fixed base is more when compared to isolated base structures in response spectrum method. Storey shear of base isolated structures reduces compared to fixed base structure in response spectrum analysis, compared to that of Equivalent static method of analysis.
- Response spectrum analysed results are significant when compared to results of Equivalent static analysis method.

6. REFERENCES

[1] A. B. M. Saiful Islam, Mohammed Jameel and Mohd Zamin Jummat (2011), “Study on optimal isolation system and dynamic

Structural responses in multi-storey buildings",International journal of the physical sciences vol. 6(9), pp.2219-2228.

[2] Anusha R Reddy, Dr. V Ramesh (2015), "Seismic Analysis of Base Isolated Buildingin RC Framed Structures", International Journal of Civil and Structural Engineering Research Vol. 3, Pp. 170-176.

[3] Ashish R. Akhare, Tejas R.Wankhade (2014), "Seismic Performance of RC Structure Using Different Base Isolator", International journal of engineering sciences & researchtechnology, pp. 724-729.

[4] 4.Ashish R. Mhashakhetri, Asst. Prof. S. K. Mahajan (2016), "Effect of Base Isolation System on Seismic Response of a RC Building –a Numerical Study", International Journal of Engineering Research & Technology, Vol 4 Issue 30, pp.1-3.

[5] Athamnia Brahim, Ounis Abdelhafid (2011), "Effects of seismic isolation in the reduction of the seismic response of the structure", International Journal of Applied Engineering Research, Dindigul, Vol 2, pp. 290-295.

[6] Devi Sreenivas, Ancy Mathew (2016) "Seismic Performance of Base Isolated Buildings with Plan Irregularity", International Journal of Science & Engineering, Vol 3 Issue 2, pp. 271-276.

[7] Dia Eddin Nassani, Mustafa Wassef Abdulmajeed (2015), "Seismic Base Isolation in Reinforced Concrete Structures", International Journal of Research Studies in Science, Engineering and Technology, Vol 2 Issue 2, pp. 1-13.

[8] Dr. R. S. Talikoti, et al., (2014), "Base Isolation in Seismic Structural Design", International Journal of Engineering Research & Technology, Vol. 3 Issue 7, pp.863-868.

[9] Er. Shubhangi Ganachari (2020), "To Study on Effect of Base Isolation on Multi-Storeyed Steel Structure", International Research Journal of Engineering and Technology, Vol 7 Issue 11, pp. 669-671.

[10] Gravalas T. Fotios (2008), "Effects of the mechanical characteristics of LRB‘s on Structural response of base isolated buildings", The 14 The World conference onearthquake engineering October 12-17, 2008, Beijing, China.

[11] H.P.Santhosh, K.S.Manjunath and K. Satish Kumar (2013), "Seismic analysis of low to medium rise building for base isolation", International journal of Research in Engineering and Technology, pp. 1-5.

[12] Jain Saksham, Gangwal Sambhav (2017), "Assessment of Seismic Response Analysis of Base Isolated RC Building frame", International Journal of Science and Research (IJSR), Vol 6 Issue 4, pp. 1396-1402.

[13] Kalantari S.M, Naderpour H. and Hoseini Vaez S.R (2008), "Investigation Of Base- Isolator Type Selection On Seismic Behavior Of Structures Including Story Drifts and Plastic Hinge Formation", The 14th World Conference on Earthquake Engineering, October 12-17, 2008, Beijing, China.

[14] Md. Arman Chowdhury, Wahid Hassan (2013), "Comparative study of the DynamicAnalysis of Multi-storey Irregular building with or without Base Isolator", International Journal of Scientific Engineering and Technology, Vol 2 Issue 9, pp. 909-912.

[15] Mital N. Desai, Prof. Roshni John (2015), "Comparative Study of Multi-Storey Buildingwith Different Base Isolators", International Journal of Innovative Research in Science, Engineering and Technology, Vol 4 Issue 8, pp. 7353-7360.

[16] Ms. Minal Ashok Somwanshi, Mrs. Rina N. Pantawane (2015), "Seismic Analysis of Fixed Based and Base Isolated Building Structures", International Journal of Multidisciplinary and Current Research, Vol 3, pp. 747-757.

[17] Nagajyothi.T, Dr. Vaishali G.Ghorpade (2015), "Design of Lead Rubber Bearing System and High Damping Rubber Bearing System for Isolated Structure for Long Time Periods for a Five Storey R.C. Building", International Journal of Engineering Sciences & Research Technology, pp. 379-387.

[18] S. M. Dhawade (2014), "Comparative Study for Seismic performance of Base Isolated& Fixed Based RC Frame Structure", International Journal of Civil EngineeringResearch, Vol 5 Number 2, pp.183-190.

[19] Sabu S. K., Chore H. S., and Patil S. B. (2014), "Effectiveness of lead rubber base isolation, for seismic resistance of buildings, supported on different soil stratas", International Journal of Electrical, Electronics and Computer Systems, Vol 2 Issue 4, pp. 53-59.

[20] Sarvesh K. Jain, Shashi K. Thakkar (2004), "Application of Base Isolation for Flexible Buildings", 13th World Conference on Earthquake Engineering Vancouver, B.C., Canada, Paper No. 1924.

[21] Saurabh P. Kharat, Dinesh N. Biradar, et al., (2018), "Case Study on Lead Rubber Isolation Bearing", International Research Journal of Engineering and Technology, Vol 5 Issue 3, pp. 3251-3254.

[22] Shameena Khannavar, M.H.Kolhar (2016), "Seismic Analysis of RC Structures using Base Isolation Technique", International Research Journal of Engineering and Technology, Vol 3 Issue 7, pp. 2320-2327.

[23] Sonali D. Anilduke, et al., (2015), "Study on Base Isolation System for Seismic ResponseControl", International Journal of Engineering Research & Technology, Vol 4 Issue 5, pp. 1605-1609.

[24] Sunny Patel, Abbas Jamani (2017), "Effect of Base Isolation on Seismic Performance of RC Irregular Buildings", International Research Journal of Engineering and Technology, Vol 4 Issue 11, pp. 26-33.

[25] Swathirani.K.S, Muralidhara.G.B, et al., (2015), "Eatrhquake Response of Reinforced Cocrete Multi Storey Building with Base Isolation", International Journal of Research in Engineering and Technology, Vol 4 Issue 10, pp. 158-167.

[26] Syed Ahmed Kabeer K I, Sanjeev Kumar K.S (2014), "Comparison of Two Similar Buildings with and without Base Isolation", International Journal of Advance research, Ideas and Innovations in technology, Vol 1 Issue 1.

[27] Vinodkumar Parma, G.S.Hiremath (2015), "Effect of base isolation in multistoried RC irregular building using time history analysis", International Journal of Research in Engineering and Technology, Vol 4 Issue 6, pp. 289-292.

[28] Xi-Yuan Zhou, Miao Han and Lin Yang (2003), "Study on Protection Measures For Seismic Isolation Rubber Bearings", ISET Journal of Earthquake Technology, Paper No.436, Vol. 40, pp. 137-160.