

Analysis of G+20 Tall RCC Structure using Lead Rubber Base Isolator under the Effect of Seismic Forces

Akshay Umare¹, Sneha S Hukkeri²

Assistant Professor, Department of Civil Engineering, S G Balekundri College of Engineering, Belagavi, Karnataka, India¹

P.G. Student, Department of Civil Engineering, S G Balekundri College of Engineering, Belagavi, Karnataka, India²

ABSTRACT: In this project, the analysis of G+20 tall RCC structure using lead rubber base isolator under the effect of seismic forces is completed using ETABS. The type of structures analysed are RCC building with fixed base support and base isolated support. The objective of this project work is comparison of fixed support and base isolated building by using dynamic analysis. The analysis carried out by using Response Spectrum Analysis. The results are observed for both the buildings and compared for different parameters. From results it is observed that Base shear, Story shear and Story stiffness is reduced, Modal period, Story displacements, Joint displacements are increased in each story, Story drifts reduced in higher stories. Finally, concluded that, after providing LRB base isolation system, the structure stability increases against earthquake.

KEYWORDS: Lead Rubber Bearing, Base isolator, Response Spectrum Analysis, Base shear, Modal period, Story shear, Story Stiffness, Story displacement, Joint displacement

I. INTRODUCTION

Structural engineers have faced one of the most problem is earthquake when they are going to design high rise buildings. The important buildings like hospital, official buildings, school buildings, malls etc, to protect these buildings the seismic design target is to reduce the building damages after earthquake. For getting good solutions to resist earthquakes and protect these buildings many researches are done. In old days historical structures are protected from earthquake by using multilayer stones, which provides a less friction when earthquake occurs and they move in all directions without any harm to buildings. From this idea base isolation is starts.

Base isolation system which gives protection to the structure during earthquakes. Earthquakes are greatest hazards of a nature; they have caused the losses of life and several damages to the property such as man-made structures. The structural bearing technique, it reduces the seismic displacement of the buildings, the safety of a structure increases also it increases the safety of humans, during the earthquake motion. When the buildings are located in an earthquake zone, the base isolation method is effective, which improves which improves structure dynamic response.

LRB was invented in New-Zealand (1975). It consists rubber which is laminated also steel bearing and the flange plates are mounted to the structure. For building and bridge constructions lead rubber bearing is used. It is economical and practical choice for isolation building. Lead rubber bearing is flexible in horizontal direction, strong and stiff in vertical directions. By changing shape of bearings earthquake force will be absorbed. Lead rubber bearing retains original position of buildings. In lead rubber bearing by changing the lead plug numbers damping amount will be adjusted. And it also have the vertical load capacity with 5tons to 2000tons. It reduce the ground acceleration. This base isolator has low maintenance. Deformation and damages occur to the building due to the earthquake forces with un-isolated building. Base isolated building avoids damages and remains in original position when it displaces. Lead rubber bearing resist the force on the building and increases the building period and reduce the acceleration. Lead rubber bearing convert the energy to heat and resist the force on the building when lead plug slide with laminated rubber. Due to high elasticity the rubber part of isolation will stay in original shape.

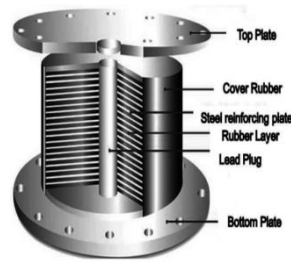


Fig 1.1 Lead Rubber Base Isolator

II. SCOPE OF PRESENT STUDY

The practical failure of damages and losses of life is really critical condition to earthquake design, putting a lesson concerned on the engineers (structural engineers). In present situations various modern arrangements have been invented to decrease the absorbance of seismic energy. The large applying and fulfilment of earthquake protection arrangements is “Base Isolation”. The technique of base isolation is largely implemented in severe earthquake zones. The intention of provider of bearing system is to reducing the transfer of seismic energy. This separation of building to its ground foundation provides flexibility to the superstructure. This allows movement of superstructure. Which improves the safety of structure.

III. METHODOLOGY

Planning of G+20 RCC structure using AutoCAD 2015. Software used for analysis and design of structure is ETABS. The analysis carried out by using Response Spectrum Analysis. Structure is modelled, after that loads are applied as per code provisions. Calculation of a Dead load for different members using IS:875(Part I). Calculation of Live load using IS: 875(Part II). For response spectrum analysis method, spectrum used from UBC 1997. Firstly, analysis of fixed support building is done; from that maximum vertical reaction is noted from support reactions results. Once maximum vertical reaction is taken, and then LRB is designed. Properties of LRB is calculated. For base isolation structure, the LRB properties are used as link properties. Then analysis of isolated base structure. Checking behaviour after analysis. Then results are tabulated and represented in terms of table and using graphical representation.

3.1 Modelling and Analysis

3.1.1 Material Properties

Grade of Concrete = M35

Grade of Steel = Fe500

3.1.2 Properties Of Building Elements

- | | |
|-------------------------------|--------------------------|
| 1. Beam | = 0.23 X 0.45m |
| 2. Beam(Staircase Landing) | =0.38 X0.6m |
| 3. Column | =0.45 X 0.45m(6-20floor) |
| 4. Column | =0.45 X 0.53m(3-5floor) |
| 5. Column | =0.45 X 0.6m(0-2floor) |
| 6. Slab thickness | =0.15m |
| 7. Main wall thickness | =0.23m |
| 8. Partition wall thickness | =0.15m |
| 9. Shear wall thickness(Lift) | =0.23m |

3.1.3 Earthquake parameters for structure according to UBC 1997

- | | |
|---------------------------|-----------------|
| 1. Seismic zone (Z) | =Zone III |
| 2. Soil profile type | =S _D |
| 3. Seismic coefficient Ca | =0.36 |

- 4. Seismic coefficient $C_v(C_{VD}) = 0.54$
- 5. Importance factor(I) = 1.25
- 6. Response reduction factor(R) = 8.5(SMRF)
- 7. Seismic source type = B
- 8. Near source factor $N_a = 1$
- 9. Near source factor $N_v = 1$
- 10. Damping coefficient (B_D or B_M) = 1
- 11. Effective Damping (β_{eff}) = 5%

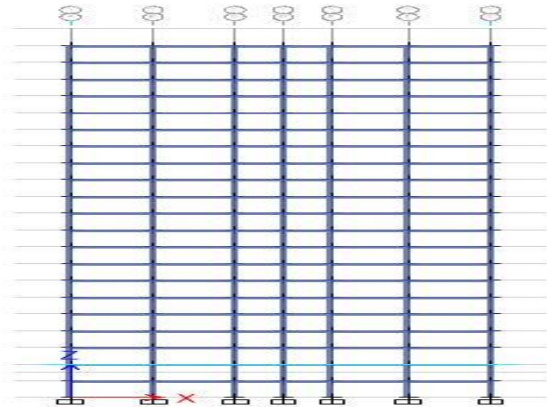


Fig 3.1 Elevation of fixed base structure

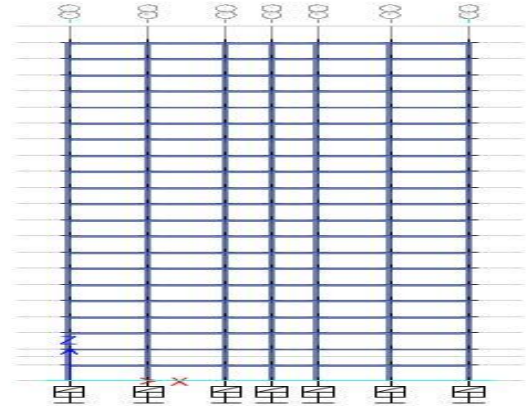


Fig 3.2 Elevation of fixed base structure

After the study of rigid support building the maximum vertical reaction is taken to design the lead rubber bearing. For rigid support analysis the higher reaction is 8029.72kN taking round up value 8030kN. By using this maximum vertical reaction base isolator such as lead rubber bearing system is constructed.

3.1.4 Input values in ETABS after the Design of the LRB

- Rotational inertia I = 0.367664 kN/m
- For U1 effective stiffness(Linear) = 1694260 kN/m
- For U2 and U3 effective stiffness(Linear) = 5170.425 kN/m
- For U1 and U2 effective damping = 5%
- For U1 and U3 distance from end-J = 0.003177 m
- For U2 and U3 stiffness(Non-linear) = 47643.41 kN/m
- For U2 and U3 yield strength = 152.6644 kN

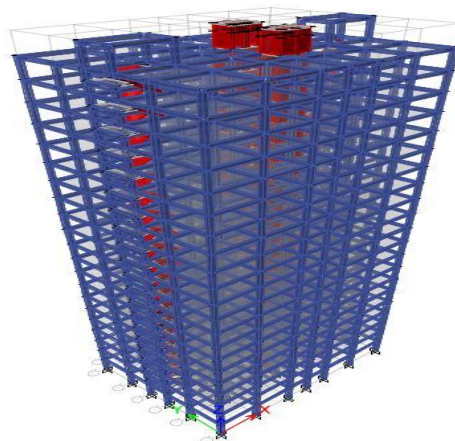
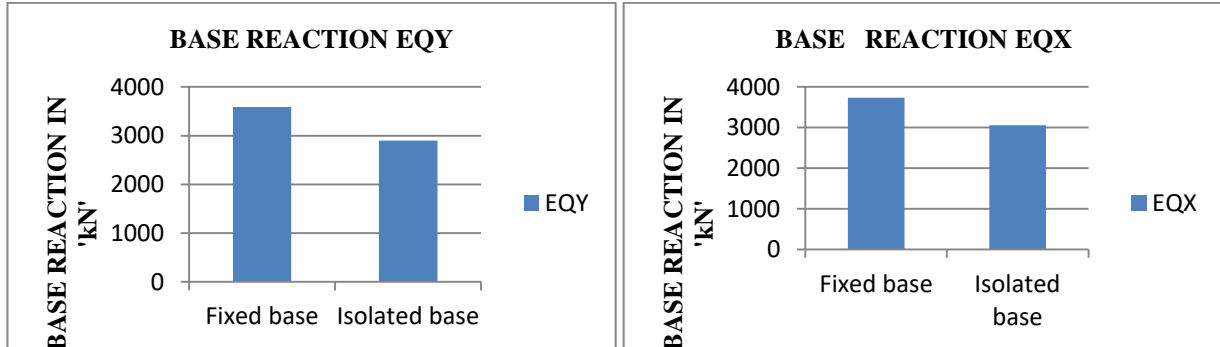


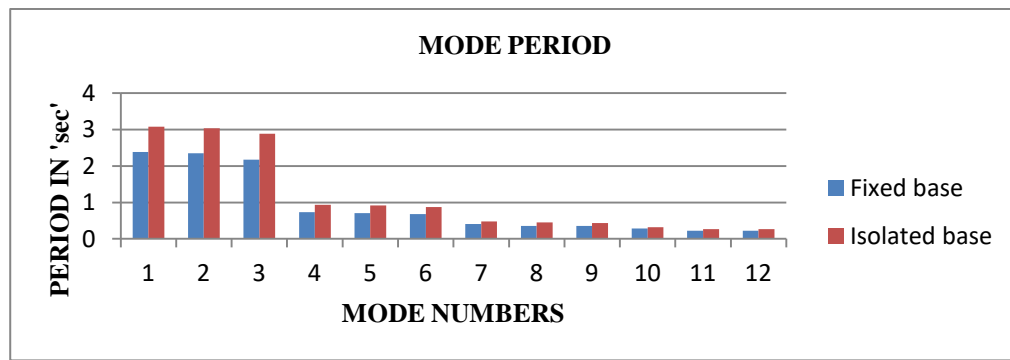
Fig 3.3 3D view of G+20 RCC Structure

IV. EXPERIMENTAL RESULTS

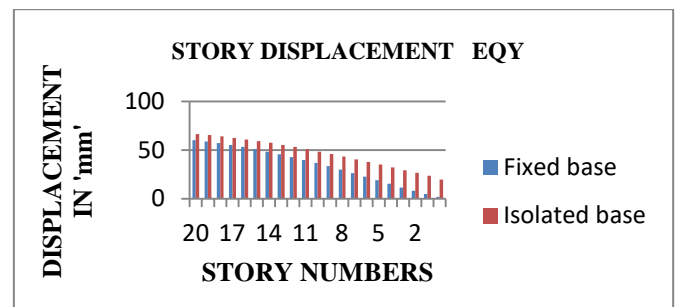
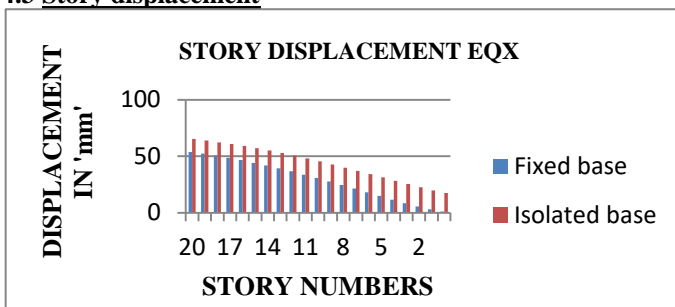
4.1 Base shear



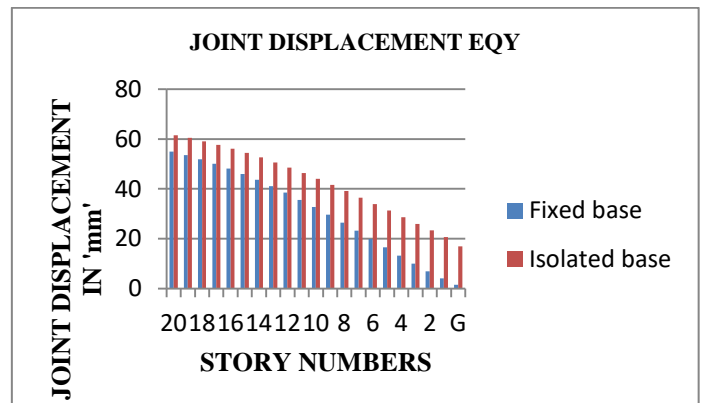
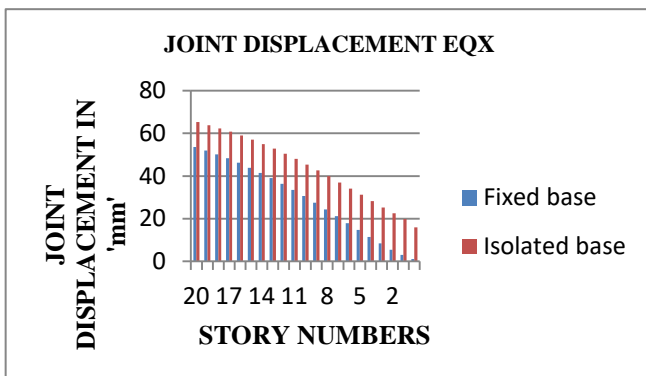
4.2 Mode period



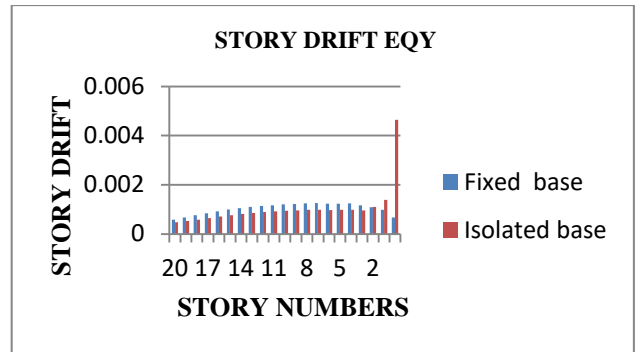
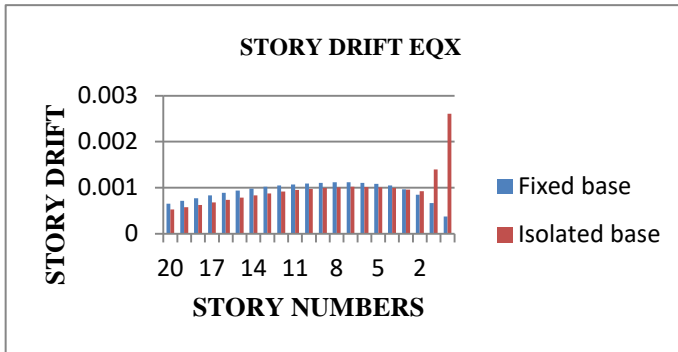
4.3 Story displacement



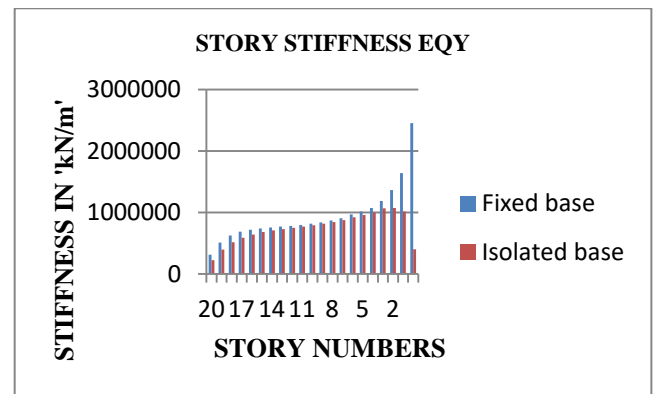
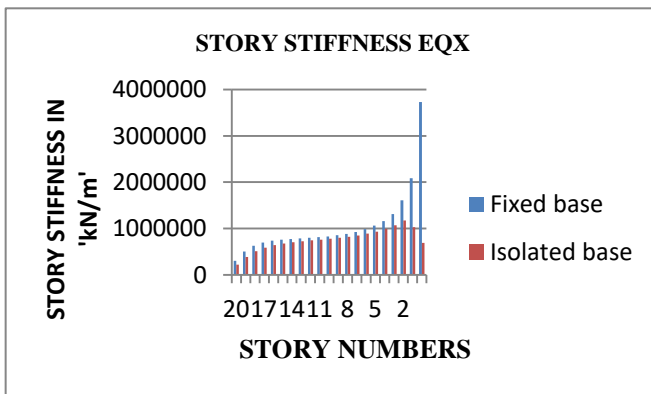
4.4 Joint displacement



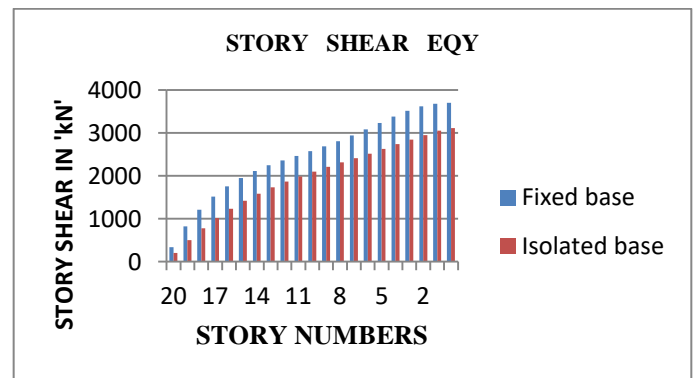
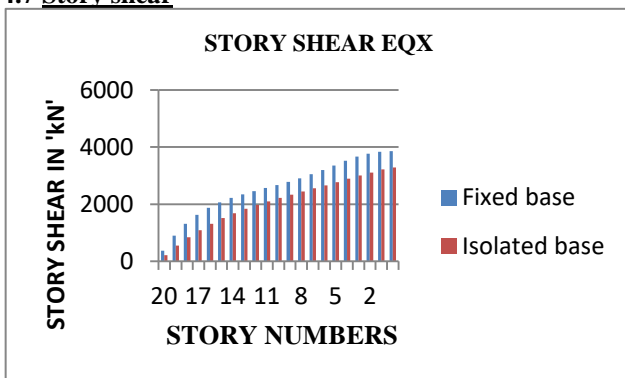
4.5 Story drift



4.6 Story stiffness



4.7 Story shear



V. CONCLUSION

5.1 Base shear

Comparison of fixed base building with base isolated building in X direction

- The base shear is reduced by 18.23% in base isolated building.

Comparison of fixed base building with base isolated building in Y direction

- The base shear is reduced by 19.15% in base isolated building.

5.2 Mode period

Comparison of fixed base building with base isolated building

- Mode period is increased by 22.63% in base isolated building.

5.3 Story displacement

Comparison of fixed base building with base isolated building in X direction

- For Ground Floor(GF) the story displacement is increased by 93.64% in base isolated building.
- For 20th Floor the story displacement is increased by 17.48% in base isolated building.

Comparison of fixed base building with base isolated building in Y direction

- For Ground Floor (GF) the story displacement is increased by 89.79% in base isolated building.
- For 20th Floor the story displacement is increased by 9.2% in base isolated building.

5.4 Joint displacement

Comparison of fixed base building with base isolated building in X direction

- For Ground Floor (GF) the story displacement is increased by 93.08% in base isolated building.
- For 20th Floor the joint displacement is increased by 17.79% in base isolated building.

Comparison of fixed base building with base isolated building in Y direction

- For Ground Floor(GF) the joint displacement is increased by 91.12% in base isolated building.
- For 20th Floor the joint displacement is increased by 10.73% in base isolated building.

5.5 Story drift

Comparison of fixed base building with base isolated building in X direction

- For Ground Floor(GF) the story drift is increased by 85.69% in base isolated building.
- For 20th Floor the story drift is reduced by 19.11% in base isolated building .

Comparison of fixed base building with base isolated building in Y direction

- For Ground Floor(GF) the story drift is increased by 85.57% in base isolated building.
- For 20th Floor the story drift is reduced by 16.20% in base isolated building.

5.6 Story stiffness

Comparison of fixed base building with base isolated building in X direction

- For Ground Floor(GF) the story stiffness is reduced by 81.50% in base isolated building.
- For 20th Floor the story stiffness is reduced by 26.86% in base isolated building.

Comparison of fixed base building with base isolated building in Y direction

- For Ground Floor(GF) the story stiffness is reduced by 83.53% in base isolated building.
- For 20th Floor the story stiffness is reduced by 27.69% in base isolated building.

5.7 Story shear

Comparison of fixed base building with base isolated building in X direction

- For Ground Floor(GF) the story stiffness is reduced by 14.79% in base isolated building.
- For 20th Floor the story stiffness is reduced by 41.66% in base isolated building.

Comparison of fixed base building with base isolated building in Y direction

- For Ground Floor(GF) the story stiffness is reduced by 15.86% in base isolated building.
- For 20th Floor the story stiffness is reduced by 41.16% in base isolated building.

Finally it is concluded that after LRB is provided as base isolation system it increases the structures stability against earthquake.

5.8 Remodelling of structure after conclusion

The Lead Rubber Bearing (LRB) structure is remodelled. Section properties are reduced in LRB base isolated structure and then the building is remodelled and analysed. Results were compared.

5.8.1 Section Properties

- | | |
|---------------------------|--------------------------|
| 1.Beam | = 0.23 X 0.38m |
| 2.Beam(Staircase Landing) | =0.38 X0.53m |
| 3.Column | =0.45 X 0.45m(6-20floor) |
| 4.Column | =0.45 X 0.45m(3-5floor) |
| 5.Column | =0.45 X 0.53m(0-2floor) |



5.8.2 Comparison of % variation of parameters in fixed base building with remodelled LRB base isolated building

- The base shear is reduced by 29.08% in remodelled base isolated building.
- Mode period is increased by 33.28% in remodelled base isolated building.
- Story displacement is increased by 26.6% in remodelled base isolated building.
- Story drift is reduced by 12.08% in remodelled base isolated building.
- Story stiffness is reduced by 41.82% in remodelled base isolated building.
- Story stiffness is reduced by 49.33% in remodelled base isolated building.

Table 5.1 % variation of parameters in fixed base building with LRB base isolated models

Parameters	Fixed base	% variation in LRB isolated compared with Fixed base	% variation in Remodelled LRB isolated compared with Fixed base
Base Shear	100	18.23	29.08
Mode Period	100	22.63	33.28
Story Displacement	100	17.48	26.6
Story Drift	100	19.11	12.08
Story Stiffness	100	26.86	41.82
Story Shear	100	41.16	49.33

Parameters	% variation in LRB isolated compared with Fixed base	% variation in Remodelled LRB isolated compared with Fixed base	Increase in %
Base Shear	18.23	29.08	10.85
Mode Period	22.63	33.28	10.65
Story Displacement	17.48	26.6	9.12
Story Drift	19.11	12.08	7.03
Story Stiffness	26.86	41.82	14.96
Story Shear	41.16	49.33	8.17

From above results it is concluded that the section properties can be reduced due to the application of LRB base isolator and also provides stability against seismic forces.

VI.SCOPE FOR FURTHER STUDY

However, further study can be undertaken in the following areas:

- 1) By considering different material property analysis can be done.
- 2) By varying the story height and increasing the story number the analysis can be done.
- 3) Varying the column and beam dimensions for same models can be analysed.
- 4) For same models compare with different base isolator.
- 5) The study could be extended by including various other parameters such as soft story and torsion effects in a building.
- 6) Other methods of seismic analysis such as time history analysis, equivalent static method and also push over analysis may be carried out for further study for better and realistic evaluation of structural response under seismic forces.

REFERENCES

[1] Dr. Prof. Pravat Kumar Parhi, Dhiraj Narayan Sahoo “Base Isolation of Residential Building using Lead Rubber Bearing Technique”, International Journal of Engineering Research & Technology (IJERT), Vol. 7 Issue 05, May-2018.
 [2] Venkatesh, Mr.Arunkumar.H.R “Dynamic Analysis Of 11 Storey RC Structure By Providing Lead Rubber Bearing As Base Isolation System”, International Research Journal of Engineering and Technology (IRJET) Volume: 03, Issue: 07, July-2016.
 [3] Yagneshkumar Patel, Pradeep Kumar Pandey “Comparision of Fixed Base and Base Isolation Reinforced Concrete Structure for Seismic Response”, International Journal of Advance Engineering and Research Development Volume 4, Issue 4, April -2017.

- [4] Sarvesh K. JAIN And Shashi K. THAKKAR “Application Of Base Isolation For Flexible Buildings”,13th World Conference on Earthquake Engineering Vancouver, B.C., Canada August 1-6, 2004,Paper No. 1924.
- [5] Ajai Kumar Rai, Brajesh Mishra “A critical review on base isolation techniques for its Application as earth quake resistant buildings with Particular need/adherence in eastern Uttar Pradesh”, (2017) International Journal Of Engineering Sciences & Research Technology, Impact Factor: 4.116, IC™ Value: 3.00 CODEN: IJESS7, February - 2017, pp 234-245.
- [6] Michael D. Symans, M.EERI, William F. Cofer, and Kenneth J. Fridley “Base Isolation and Supplemental Damping Systems for Seismic Protection of Wood Structures”, Earthquake Engineering Research Institute, Earthquake Spectra, Volume 18, No. 3, pages 549–572, August 2002.
- [7] Michael D SYMANS, Glenn J MADDEN And Nat WONGPRASERT “Experimental study of an adaptive base isolation system For buildings”, 2000.
- [8] Aparna Verma, Ashutosh Gupta , Prof. Baikunth Nath “Base Isolation System: A Review”, International Journal of Engineering Science Invention ISSN (Online): 2319 – 6734, Volume 6 Issue 9,September 2017.PP. 43-46.
- [9] Miss.Sushma.G.Sawadatkar, Mr.Mandar.M.Joshi “A Review Paper on Base Isolation Technique”, International Journal for Research in Applied Science & Engineering Technology (IJRASET) ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor:6.887 Volume 5 Issue X, October 2017
- [10] Nikolay Kravchuk, Ryan Colquhoun, and Ali Porbaha “Development of a Friction Pendulum Bearing Base Isolation System for Earthquake Engineering Education”, American Society for Engineering Education Pacific Southwest Annual Conference Copyright 2008.
- [11]Md. Arman Chowdhury and Wahid Hassan, Comparative study of the Dynamic Analysis of Multi storey Irregular building with or without Base Isolator, Proc of IJSET, Volume No.2, Issue No.9, 1.Sept.2013, pp : 909-912
- [12] Is 875 (Part 1):1987, Indian Standard “Code Of Practice For Design Loads (Other Than Earthquake) For Building And Structures ”, Part 1 Dead Loads (Second Revision), Bureau Of Indian Standards , New Delhi.
- [13] Is 875 (Part 2):1987, Indian Standard “Code Of Practice For Design Loads (Other Than Earthquake) For Building And Structures ”, Part 2 Imposed Loads (Second Revision), Bureau Of Indian Standards , New Delhi .
- [14] Uniform Building Code 1997 , Volume: 02.