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OPTIMUM FRICTIONAL ELEMENT IN SLIDING ISOLATION SYSTEM

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Abstract — *In the present paper, Hospital buildings are of great importance after any natural calamity such as earthquake. The structural and non-structural components should remain operation and safe after earthquake. So to mitigate the effects of earthquake on the structure the base isolation technique is the best alternative as a seismic protective system. The basic idea of base isolation system is to reduce the earthquake induced inertia forces by increasing the fundamental period of the structure. The aim of this study is the use of High Density Rubber Bearing (HDRB) and Friction Pendulum System (FPS) as isolation devices and then to compare various parameter between fixed base condition and base isolated condition by using ETAB software. In this study four different types of buildings which include (G+20) storey with strut, (G+20) storey without strut, (G+30) with strut, (G+30) without strut having same plan are used as test models. Nonlinear time history analysis is carried out for both fixed and base isolated structure by considering earthquake ground motion records. The Indian Bhuj earthquake data are used for analysis. The result obtained shows the reduction in base shear, storey drift, storey shear in both direction and increase in the displacement and time period for the base isolated structure. Finally, Parameter such as storey displacement, storey drift, storey shear and base shear are compared and obtained results were presented by graphically format.*

Keywords- *Base Isolation, HDRB, FPS, Non-linear Time History Analysis, ETAB*

I. INTRODUCTION

The application of the base isolation techniques to protect structures against damage from earthquake attacks has been considered as one of the most effective approaches and has gained increasing acceptance during the last two decades. This is because base isolation limits the effects of the earthquake attack, a flexible base largely decoupling the structure from the ground motion, and the structural response accelerations are usually less than the ground acceleration. Seismic isolation is being used worldwide to protect the structures like buildings, bridges etc., from the destructive effects of earthquakes. In base isolation the base becomes horizontally flexible, which strengthen the structure against earthquakes. There are so many factors and suitability explained for application of base isolation techniques. The conventional technique for a seismic design of structures is to strengthen the structural members in order to protect them against strong earthquakes. The special techniques to minimize inter story drifts and floor accelerations are increasingly being adopted .Base isolation is a design methodology that serves to decouple a structure from the strong ground motions caused by earthquakes. This decoupling of the structure typically occurs at the ground level, between the super-structure and the foundation. .Base isolation is to prevent the superstructure of the building from absorbing the earthquake energy. In seismic isolation, the fundamental aim is to reduce substantially the transmission of the earthquake forces and energy into the structure. This is achieved by mounting the structure on an isolation system with considerable horizontal flexibility so that during an earthquake, when the ground vibrates strongly under the structure, only moderate motions are induced within the structure itself.Excellent reviews of earlier and recent works on base isolation system have been provided. A significant amount of the recent research in base isolation has focussed on the use of frictional element to concentrate flexibility of structural system and to add damping to the isolated structure. The advantages of a frictional type system over conventional rubber bearings are: (1) the friction forces developed at the base are proportional to the mass supported by that bearing implying that there is no eccentricity between the centre of mass of the superstructure and the centre of stiffness. Therefore, if the mass distribution is different from that which is assumed in the original design, the effect of torsion at the base are diminished, (2) the frictional isolator have no unique natural frequency and therefore, dissipate the seismic energy over a wide range of frequency input without the risk of resonance with the ground motion and (3) frictional type system ensures a maximum acceleration transmissibility equal to maximum limiting frictional force. Simplest frictional base isolation device is pure-friction without any restoring force. More advanced devices involve pure friction elements in combination with a restoring force. The restoring force in the system reduces the base displacements and brings back the system to its original position after an earthquake

II. BUILDING MODELING

In the present project, The RCC building is evaluated by using ETABS computer program. Building was designed as per IS 456-2000 code. The analysis is performed considering Time History Analysis. The Rubber Isolator & Friction Isolator are applied at base of the building and compare their result. The effect of thus various isolator are used in the building shows the various displacement storey shear, base shear, storey displacement and the story drift of each story. The various modeling of building for obtaining result are (G+20) without strut, (G+20) with strut, (G+30) without strut, and (G+30) with strut and compare result of each building. The Various Indian ground motion records used for evaluation of structure. From the analysis various displacement and story drift are evaluated and compared the result.

Building details are as follows:

1. Grade of concrete used is M20 and grade of steel is Fe 415
2. Floor to floor height is 3.5m for ground storey and 3m for other storey
3. Slab thickness is 130mm.
4. External wall thickness is 250 mm and internal wall thickness is 250 mm
5. Live load on floor is 3kN/m^2 and live load on roof is 3 KN/m^2
6. Site located in Seismic zone V
7. Building is resting on medium soil (II).
8. Take importance factor as 1.
9. Building frame type is special Moment Resisting Frame.
10. Density of concrete is 20 KN/m^3.
11. Density of concrete wall is 20 KN/m^3
12. Steel strut of X type bracing using IAS 150 x 150 x 6 mm

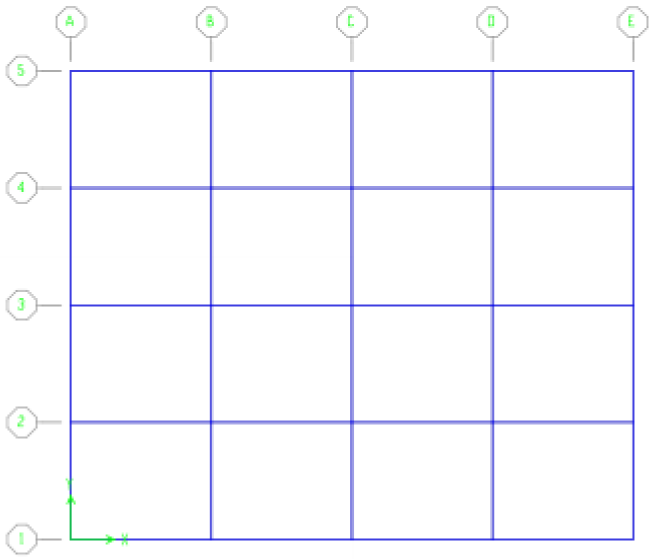

Figure.1 Plan of RCC Building

Element sizes uses for modeling are as follows:

rebmeM	Size(M)
C1	1.2X1.2
C2	1.0X1.0
C3	0.75X0.75
B1	0.45X0.3

III. RESULTS AND DISCUSSION

GENERAL

To access the performance of multi-storeyed reinforced concrete structure with different arrangement of base isolator at the base of structure such as Fixed Based, High Density Rubber Bearings (HDRB) and Friction Pendulum System (FPS) type. For this study structure are analyzed with the help of ETAB software and result were compared on key parameters like base shear, storey shear, story displacement, and story drift.

1) Results for comparative study of different isolation system.

a) Study for (G+20) storey building without strut
   i) Fixed Base (FB)
   ii) High Density Rubber Bearings (HDRB)
   iii) Friction Pendulum System (FPS)

b) Study for (G+20) storey building with strut
   i) Fixed Base (FB)
   ii) High Density Rubber Bearings (HDRB)
   iii) Friction Pendulum System (FPS)

c) Study for (G+30) storey building without strut
   i) Fixed Base (FB)
   ii) High Density Rubber Bearings (HDRB)
   iii) Friction Pendulum System (FPS)

d) Study for (G+30) storey building with strut
   i) Fixed Base (FB)
   ii) High Density Rubber Bearings (HDRB)
   iii) Friction Pendulum System (FPS)

All the analysis was done by nonlinear time history analysis. Type of analysis for all the structure is model nonlinear time history analysis considering Indian Bhuj earthquake ground motion data. The earthquake ground vibration data named Bhuj earthquake occurred at January 26, 2001. This vibration data is recorded at Ahmadabad. It has total 26706 acceleration data point at interval 0.005 sec. The PGA value for Bhuj earthquake is 0.09g.

A: RESULT FOR ALL BUILDINGS

A.1: Results for (G+20) Storey Building without Strut

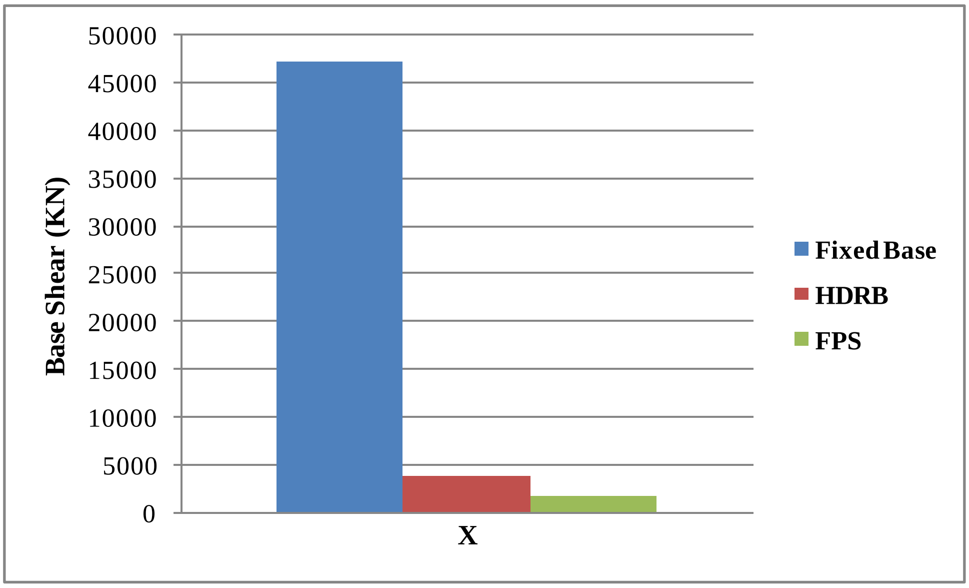

Figure.1 Base Shear in X-Direction

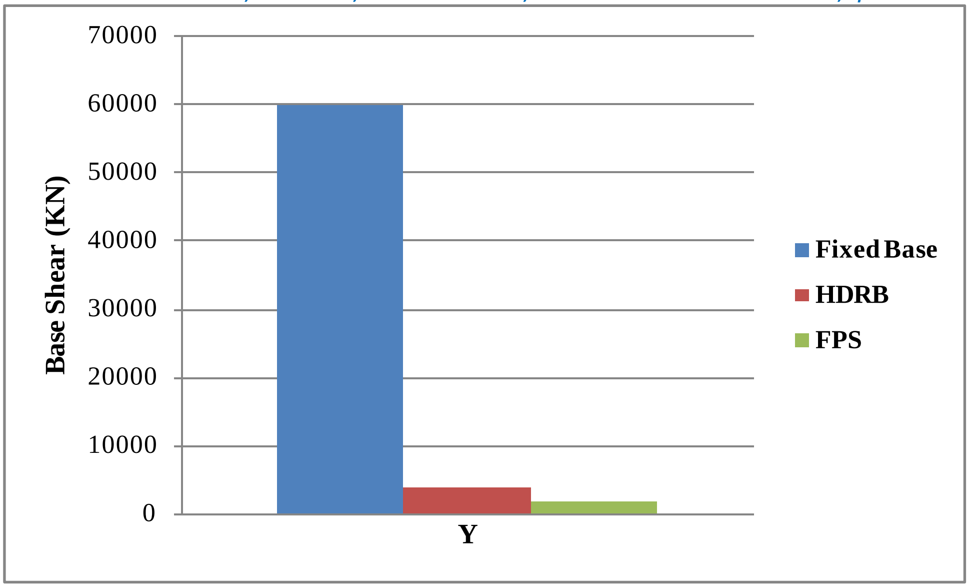

Figure.2 Base Shear in Y-Direction

From Figure 1 it is seen that base shear in X-direction is reduced by 96% and From Figure 2 in Y direction it is reduced by 97% for the case of Friction Pendulum System when compared with fixed base. The base shear in X-direction is reduced by 91% and in Y-direction it is reduced by 93% for the case of High Density Rubber Bearing When compared with fixed base.

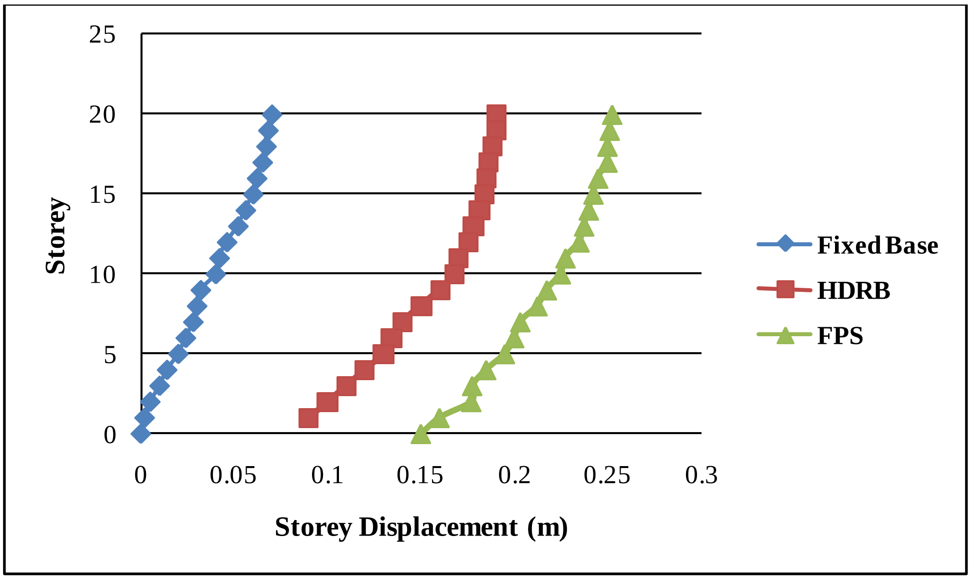

Figure.3 Storey Displacement in X-Direction

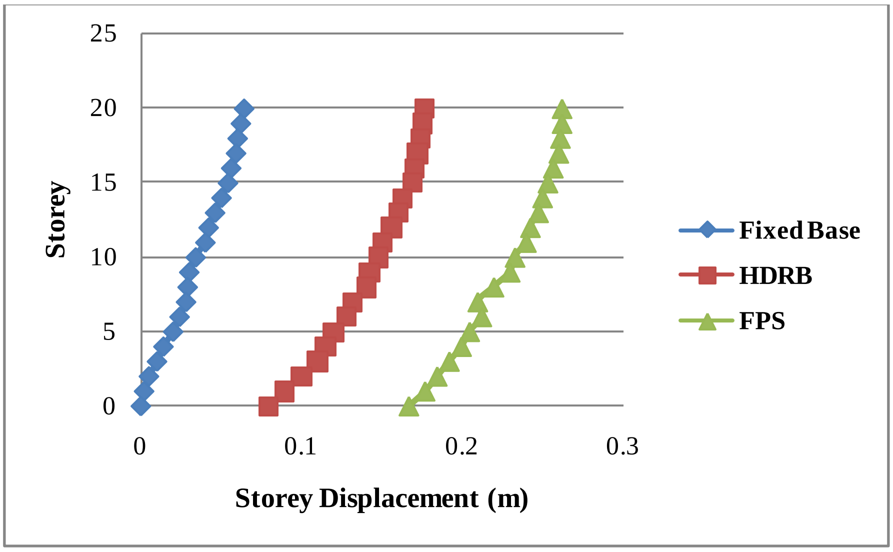

Figure.4 Storey Displacement in Y-Direction

From Figure 3 and 4 it is seen that base displacement given by friction pendulum system isolator compared to the high density rubber type isolator. But maximum top displacement is given by high density rubber bearing type isolators.

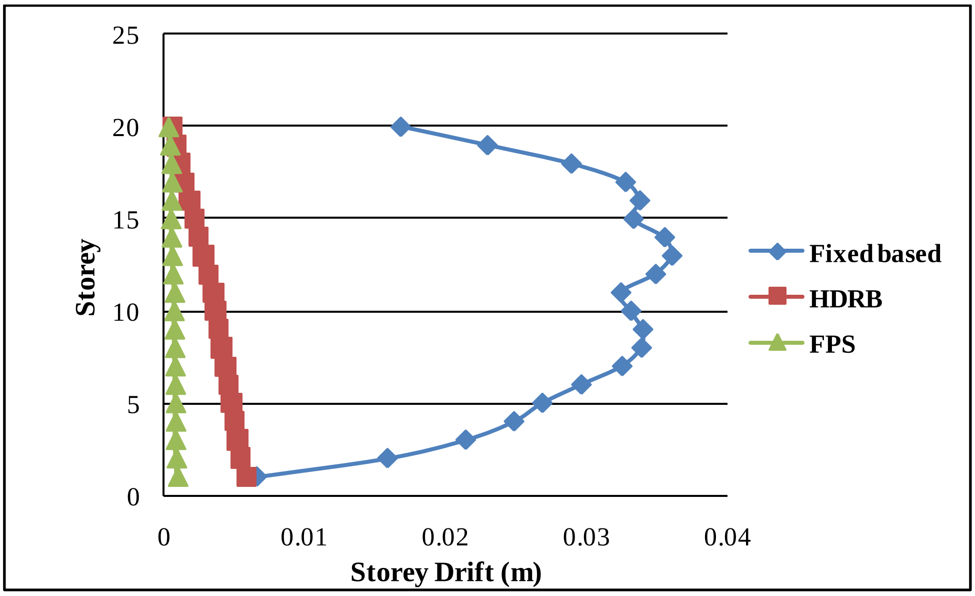

Figure.5 Storey Drift in X-Direction

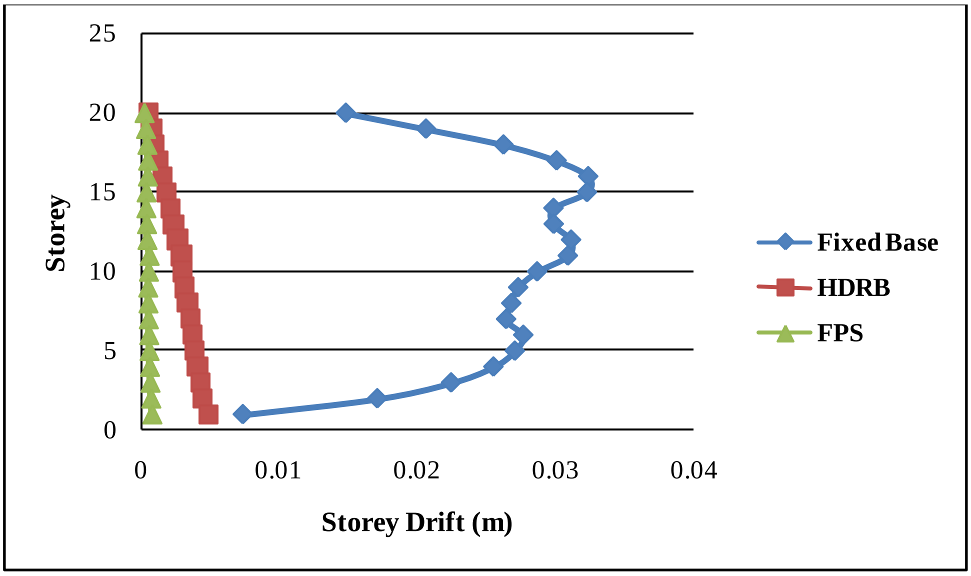

Figure.6 Storey Drift in Y-Direction

From Figure 5 and 6 it is seen that storey drift was greatly reduces by friction pendulum type isolator compared with high density rubber bearing. Both type of isolator reduce drift at greater extent compared with fixed base structure.

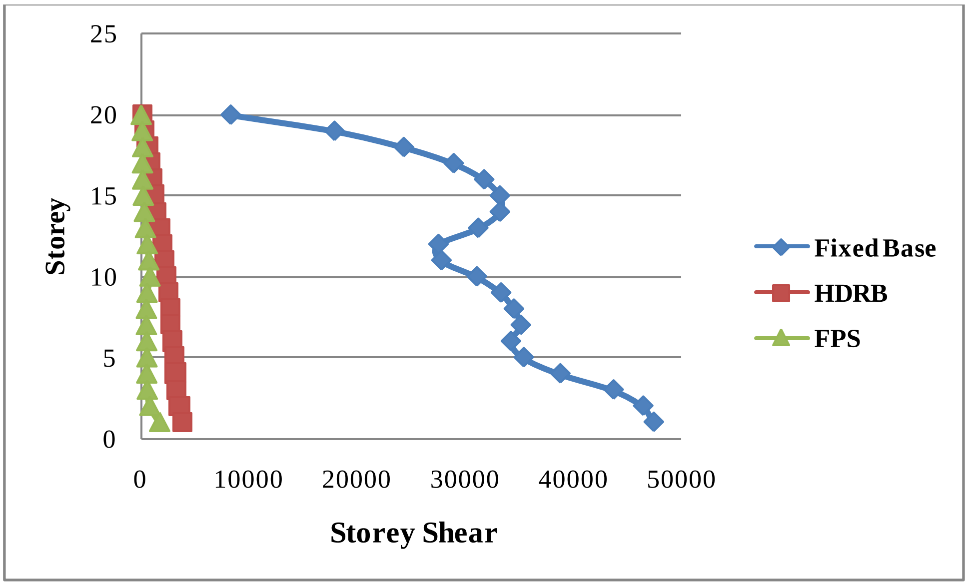

Figure.7 Storey Shear in X-Direction

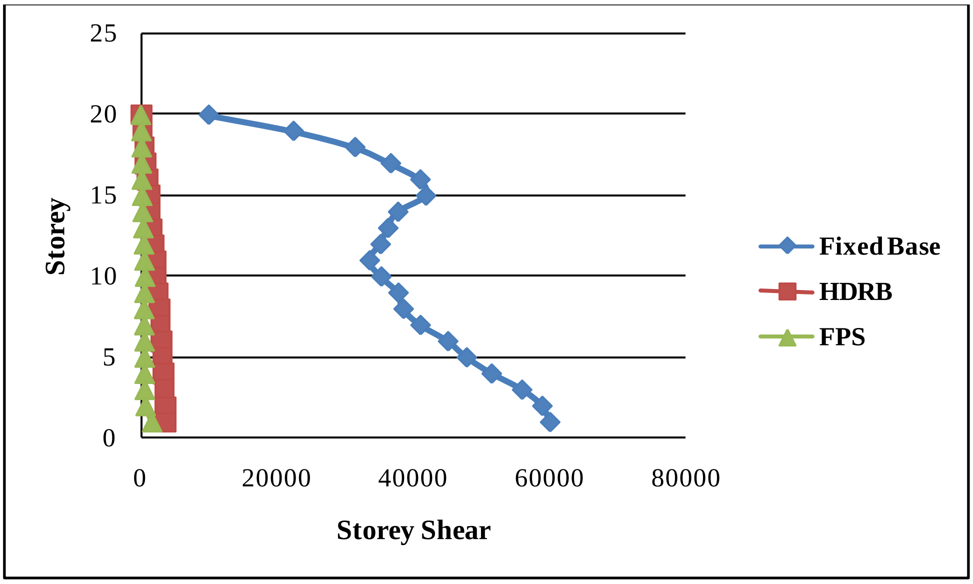

Figure.8 Storey Shear in Y-Direction

From Figure 7 and 8 storey shear was greatly reduces by the use of friction pendulum type isolator compared with high density rubber bearing isolator. It was 50% reduce storey shear in friction pendulum type isolator than density rubber bearing isolator as friction pendulum type isolator compared with density rubber isolator. Both types of isolators reduce storey shear at greater extent compared with fixed base structure.

A.2 Results for (G+20) Storey Building with Strut

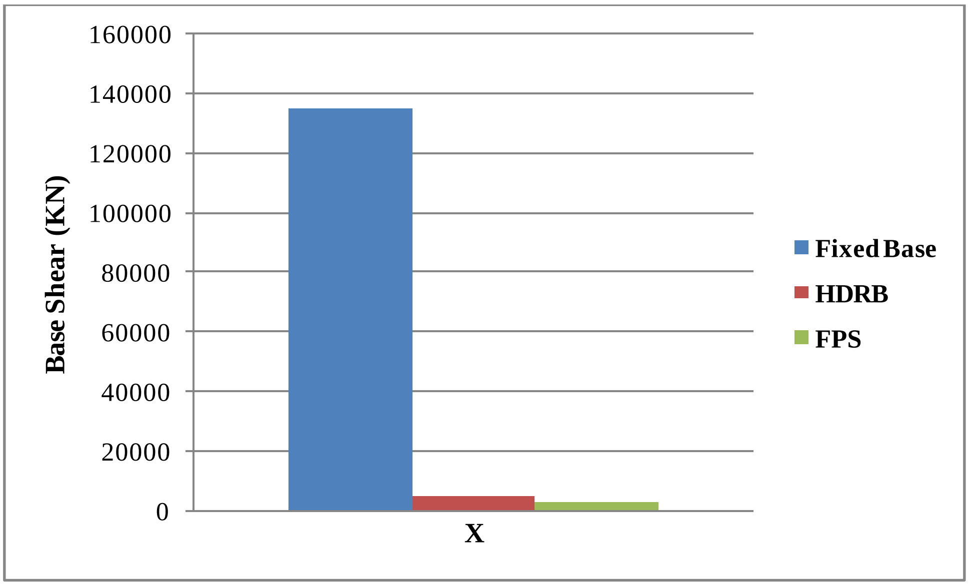

Figure.9 Base Shear in X Direction

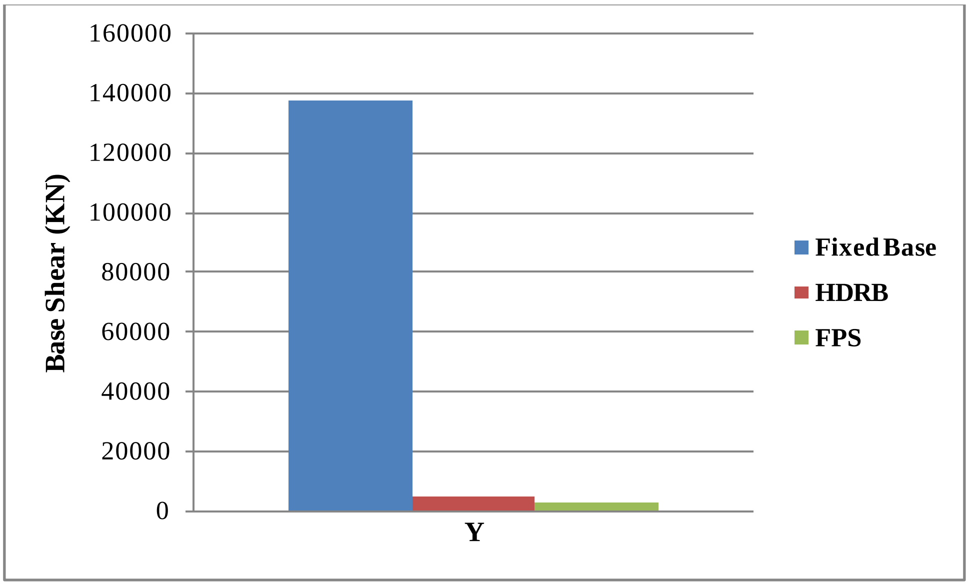

Figure.10 Base Shear in Y Direction

From Figure 9 and 10 it is seen that the base shear in X and Y direction is reduced by 98% for the case of Friction Pendulum System when compared with fixed base. The base shear in X and Y direction it is reduced by 95% for the case of High Density Rubber Bearing when compared with fixed base.

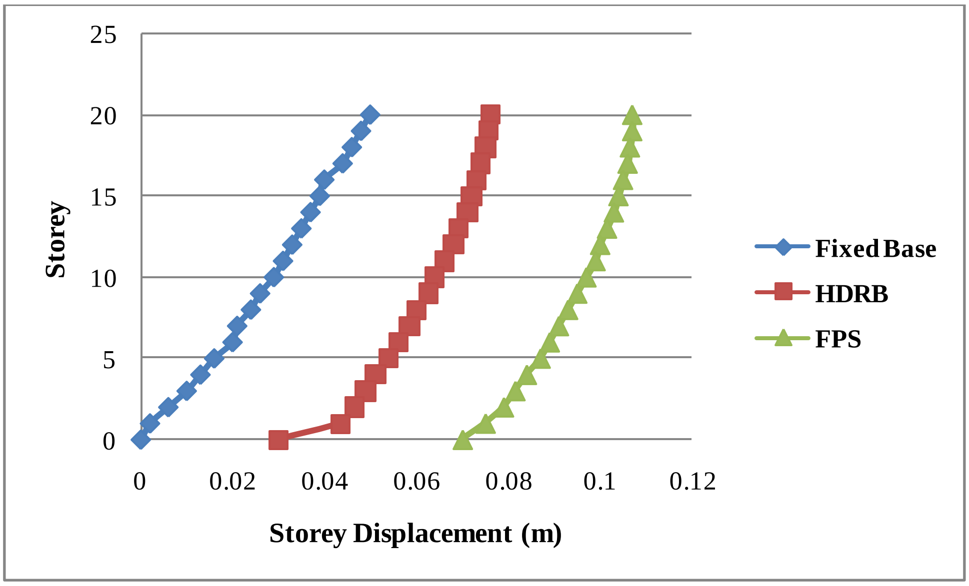

Figure.11 Storey Displacement in X Direction

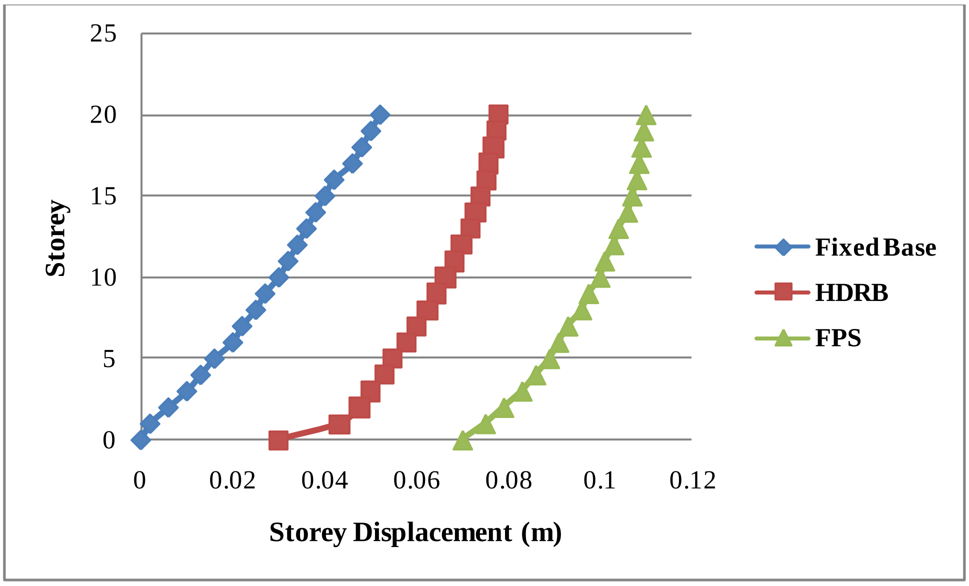

Figure.12 Storey Displacement in Y Direction

From Figure 11 and 12 it is seen that maximum base displacement is given by friction pendulum system type isolator than high density rubber bearing type isolator when it compared with fixed base structure. Maximum top displacement is given by high density rubber bearing type isolator. Maximum top and base displacement given by friction pendulum system isolator compared to the high density rubber bearing type isolator compared with fixed base structure.

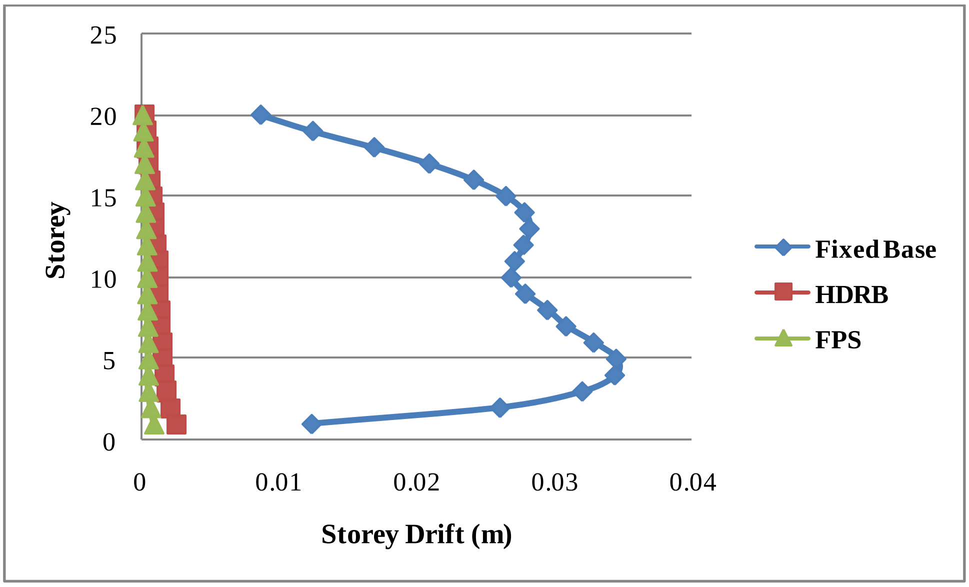

Figure.13 Storey Drift in X Direction

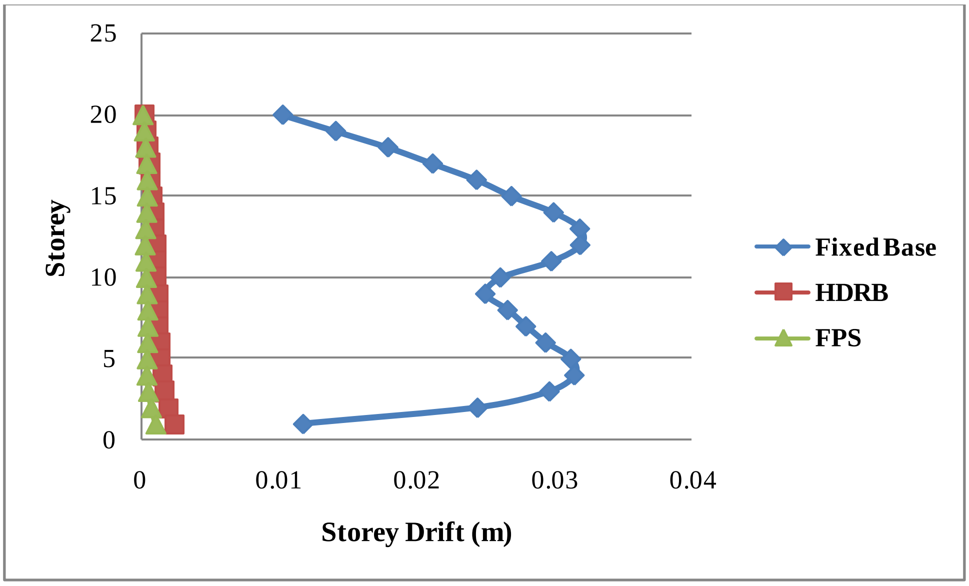

Figure.14 Storey Drift in Y Direction

From Figure 13 it is observed that storey drift is greatly reduce when friction pendulum system type isolator used as base isolator compared to high density rubber bearing type isolator. Both types of isolators reduce the storey drift compared to fixed base structure. Same Conclusion was made for Figure 14

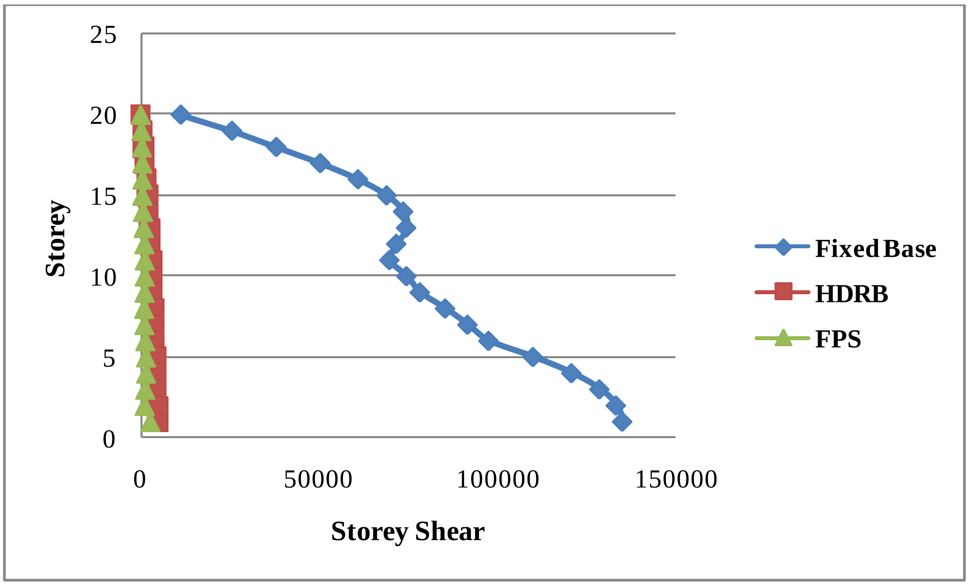

Figure.15 Storey Shear in X Direction

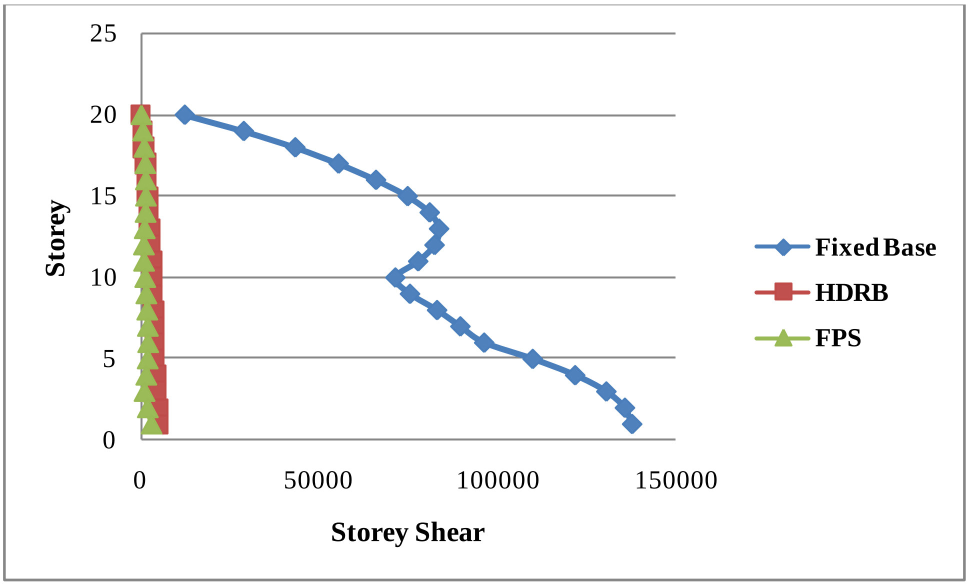

Figure.16 Storey Shear in Y Direction

From Figure 15 and 16 storey shear was greatly reduces by the use of friction pendulum type isolator compared with high density rubber bearing isolator. It was 50% reduce storey shear in friction pendulum type isolator than density rubber bearing isolator as friction pendulum type isolator compared with density rubber isolator. Both types of isolators reduce storey shear at greater extent compared with fixed base structure.

A.3 Results for (G+30) Storey Building without Strut

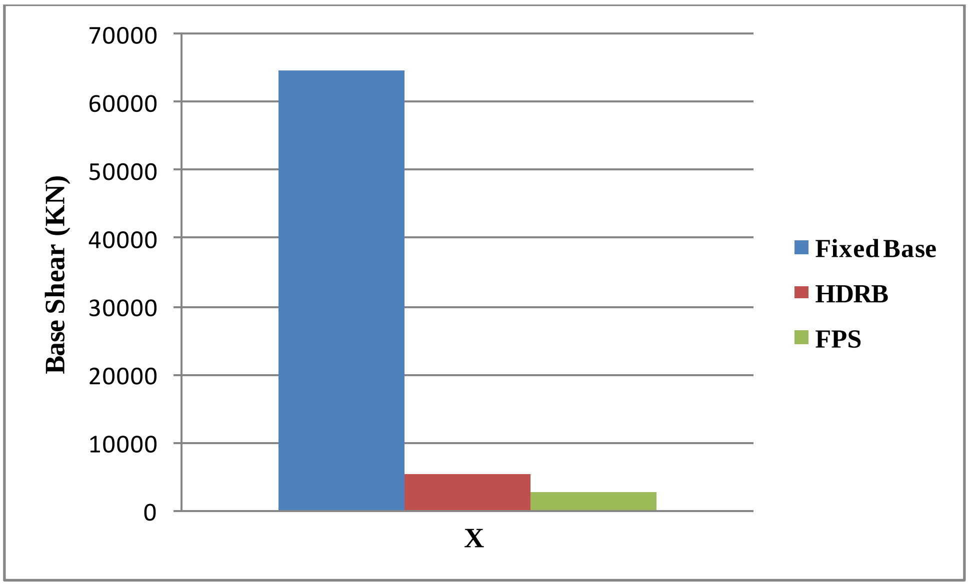

Figure.17 Base Shear in X Direction

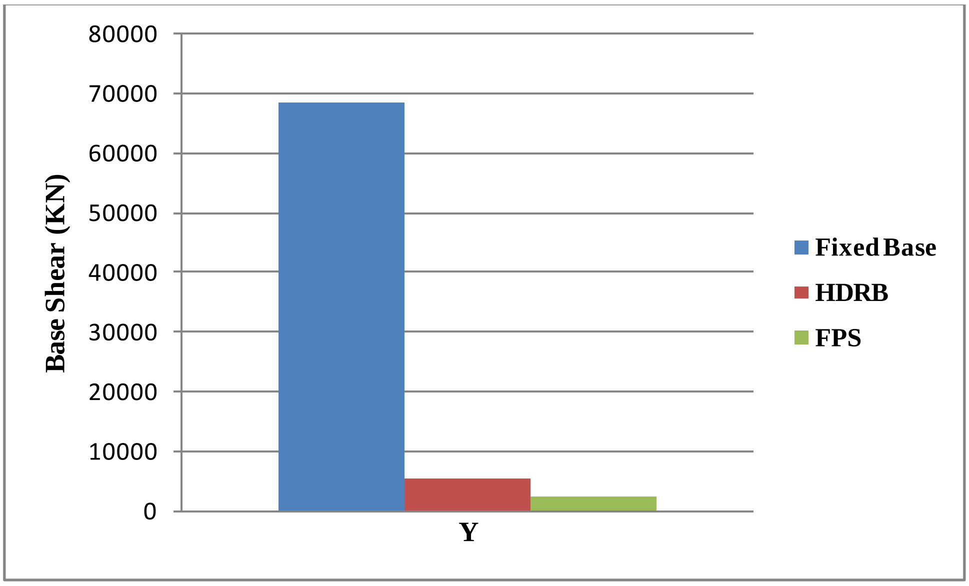

Figure.18 Base Shear in Y Direction

From Figure 17 it is seen that base shear in X-direction is reduced by 95% and From Figure 18 in Y direction it is reduced by 97% for the case of Friction Pendulum System when compared with fixed base. The base shear in X-direction is reduced by 91% and in Y-direction it is reduced by 90% for the case of High Density Rubber Bearing When compared with fixed base.

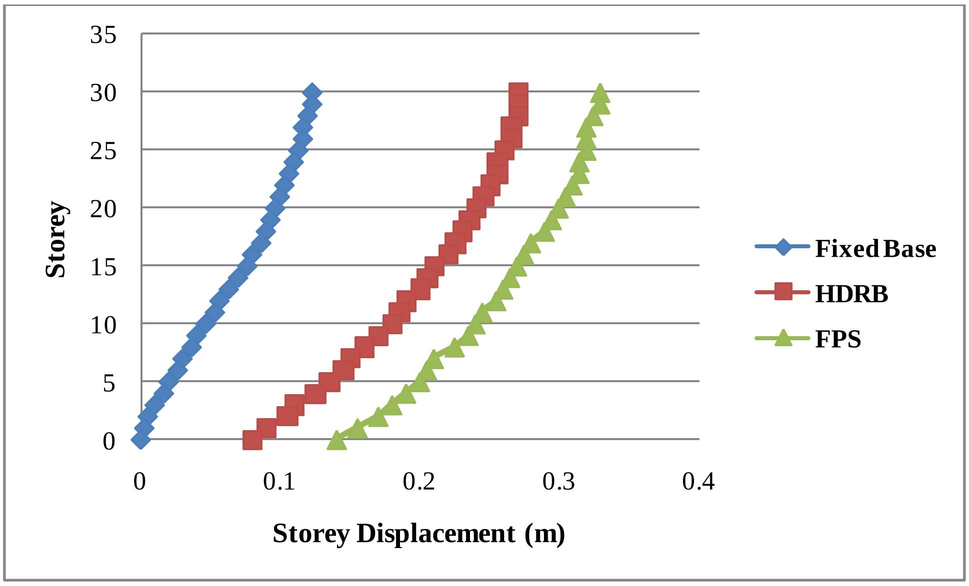

Figure.19 Storey Displacement in X Direction

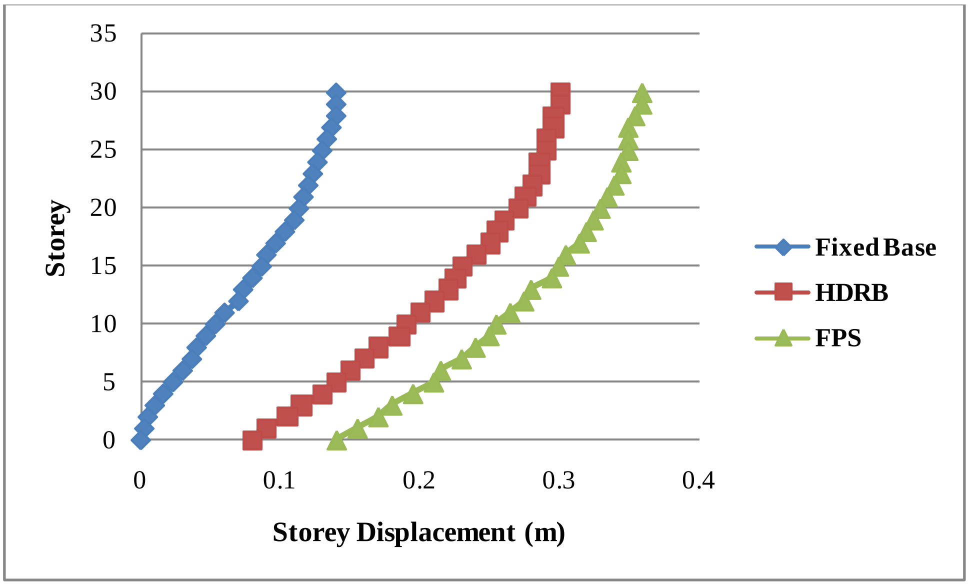

Figure.20 Storey Displacement in Y Direction

Maximum top displacement is given by high density rubber bearing type isolator. Maximum top and base displacement given by friction pendulum system isolator compared to the high density rubber bearing type isolator compared with fixed base structure. From Figure 19 and 20 it is seen that maximum base displacement is given by friction pendulum system type isolator than high density rubber bearing type isolator when it compared with fixed base structure

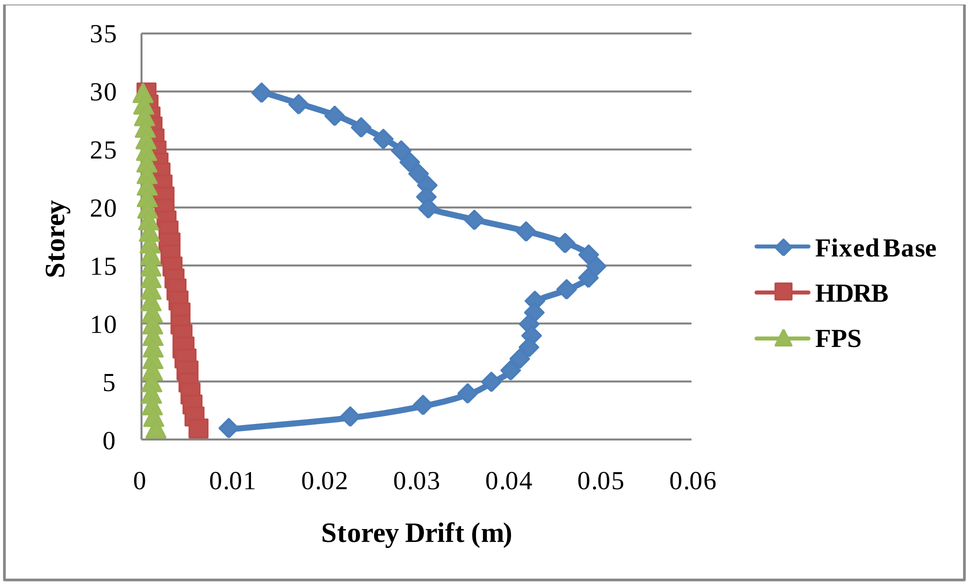

Figure.21 Storey Drift in X Direction

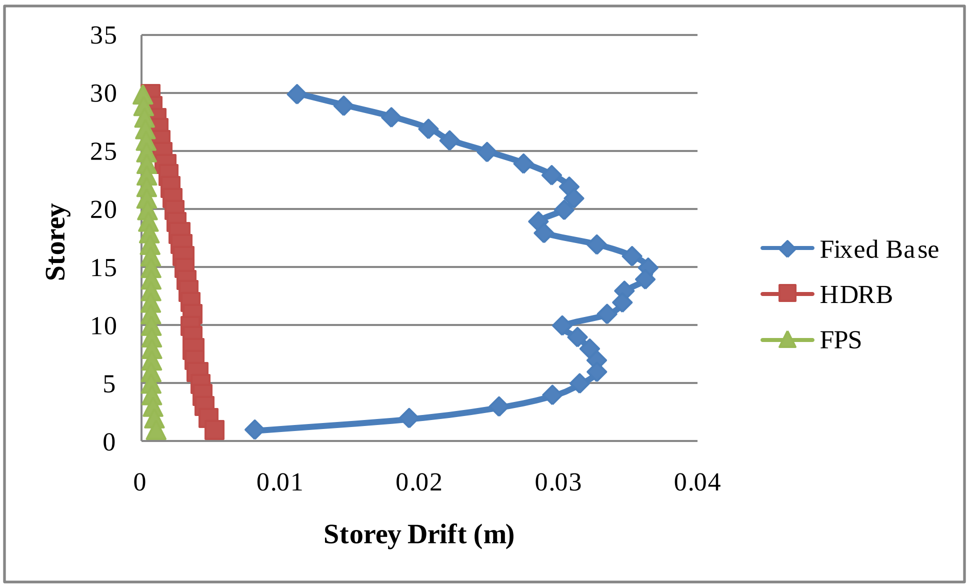

Figure.22 Storey Drift in Y Direction

From Figure 21 it is observed that storey drift is greatly reduce when friction pendulum system type isolator used as base isolator compared to high density rubber bearing type isolator. Both types of isolators reduce the storey drift compared to fixed base structure. Same Conclusion was made for Figure 22

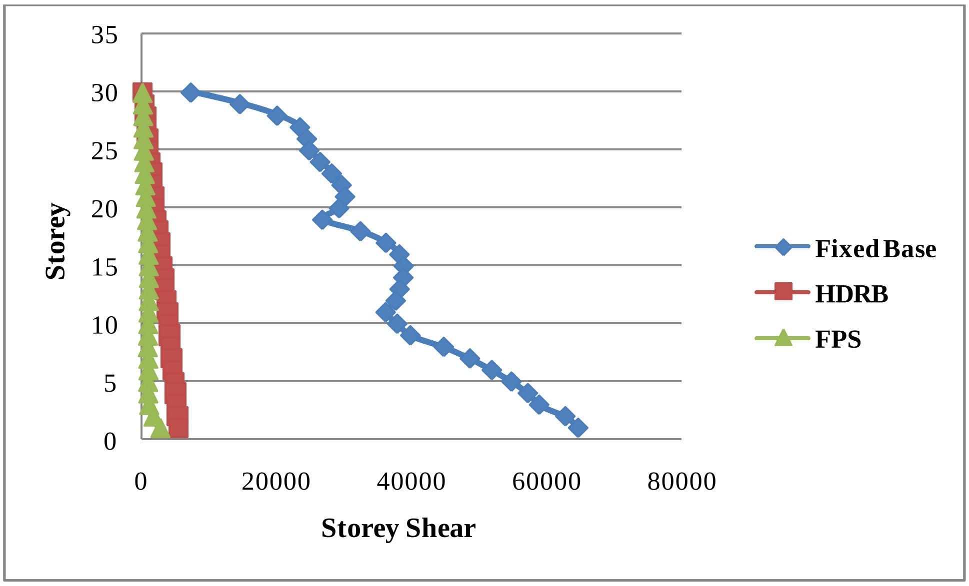

Figure.23 Storey Shear in X Direction

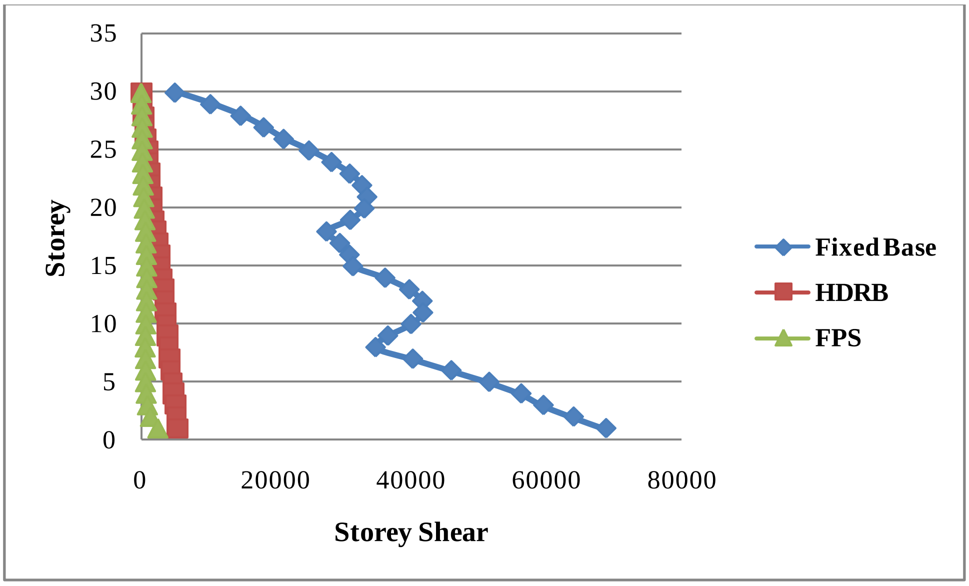

Figure.24 Storey Shear in X Direction

From Figure 4.2.3.7 and 4.2.3.8 storey shear was greatly reduces by the use of friction pendulum type isolator compared with high density rubber bearing isolator. It was 50% reduce storey shear in friction pendulum type isolator than density rubber bearing isolator as friction pendulum type isolator compared with density rubber isolator. Both types of isolators reduce storey shear at greater extent compared with fixed base structure.

A.4 Results for (G+30) Storey Building with Strut

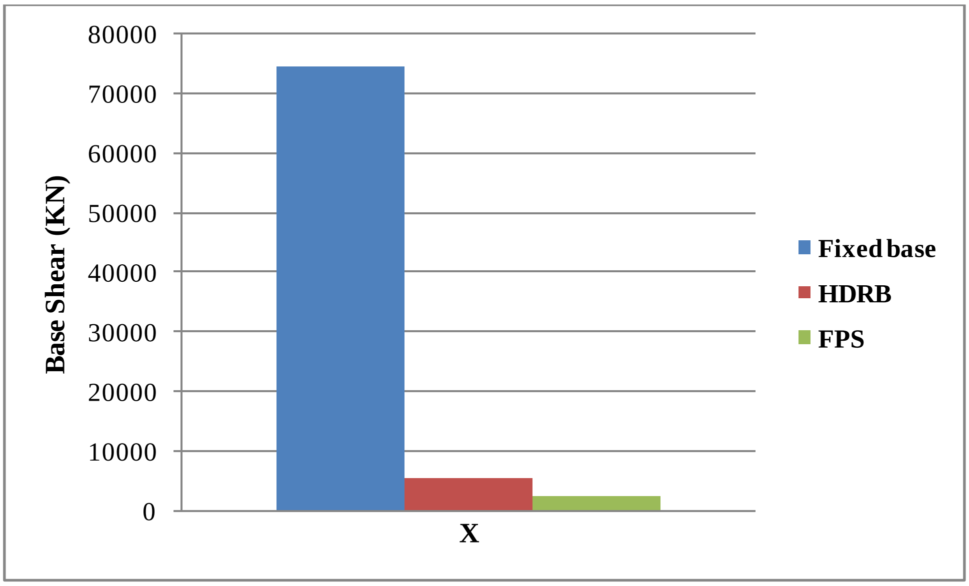

Figure.25 Base Shear in X Direction

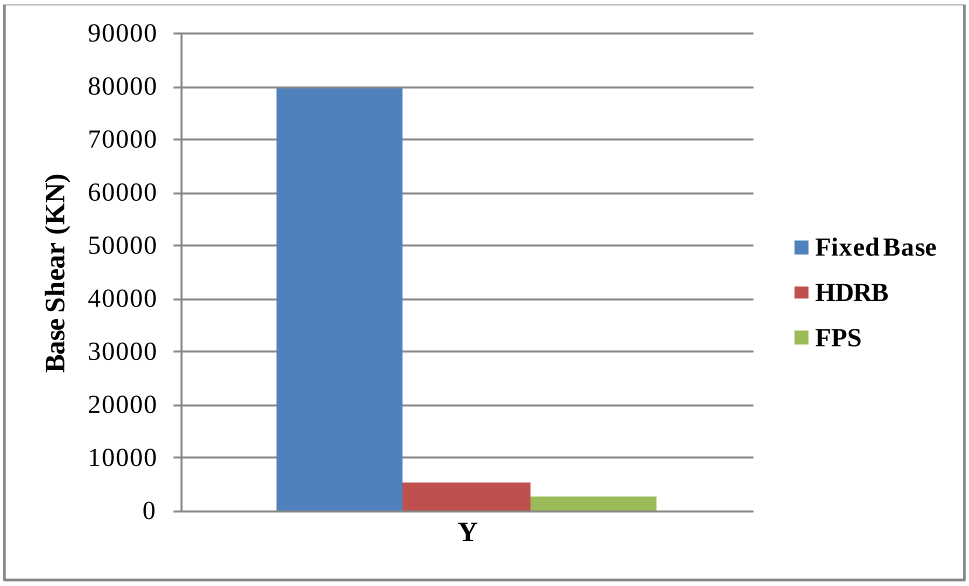

Figure.26 Base Shear in Y Direction

From Figure 25 it is seen that base shear in X-direction is reduced by 96% and From Figure 26 in Y direction it is reduced by 97% for the case of Friction Pendulum System when compared with fixed base. The base shear in X-direction is reduced by 93% and in Y-direction it is reduced by 94% for the case of High Density Rubber Bearing When compared with fixed base.

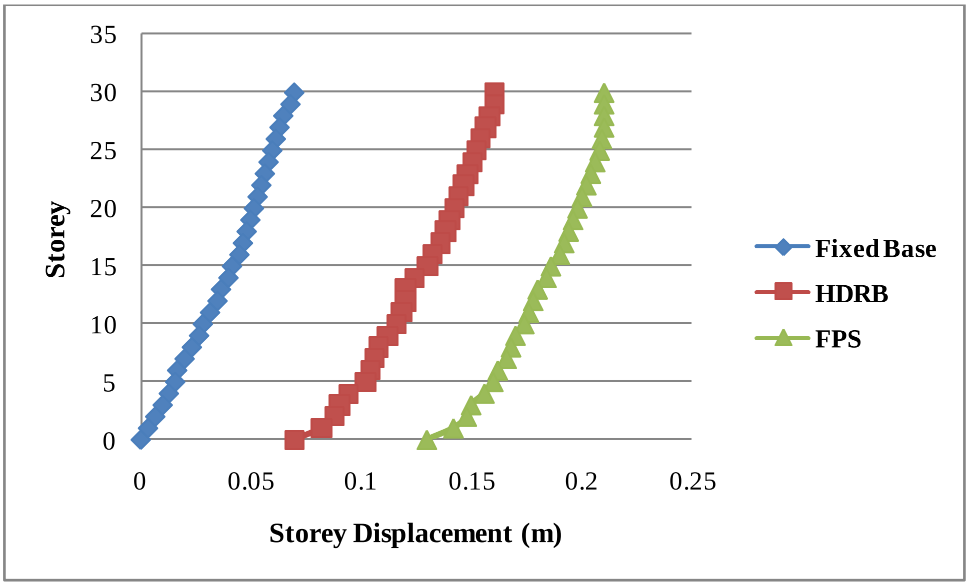

Figure.27 Storey Displacement in X Direction

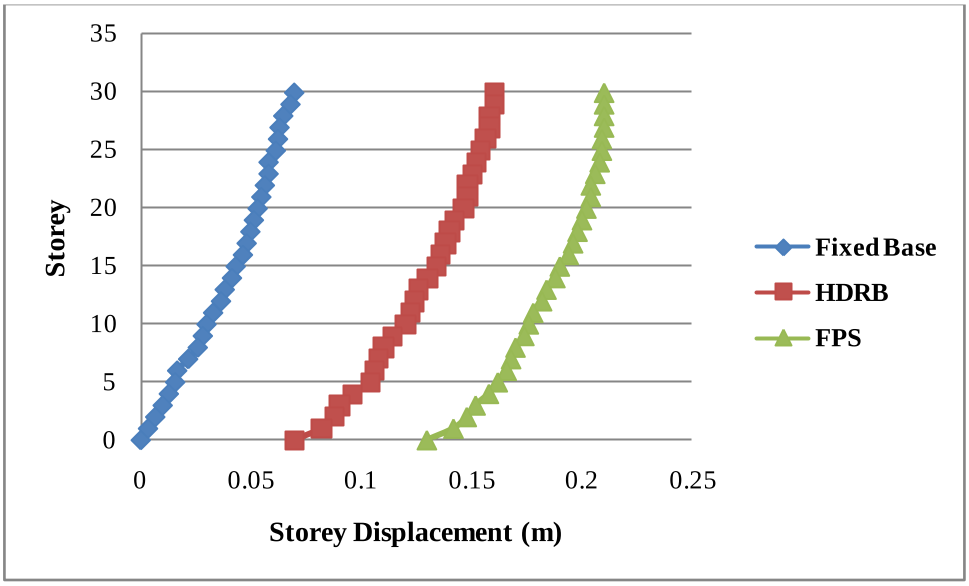

Figure.28 Storey Shear in X Direction

Maximum top displacement is given by high density rubber bearing type isolator. Maximum top and base displacement given by friction pendulum system isolator compared to the high density rubber bearing type isolator compared with fixed base structure. From Figure 27 and 28 it is seen that maximum base displacement is given by friction pendulum system type isolator than high density rubber bearing type isolator when it compared with fixed base structure.

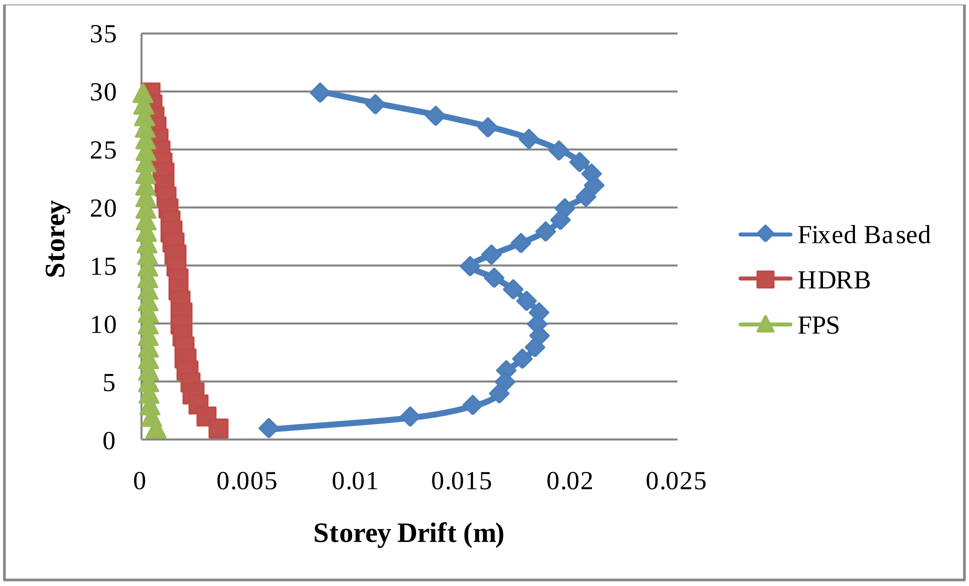

Figure.29 Storey Drift in X Direction

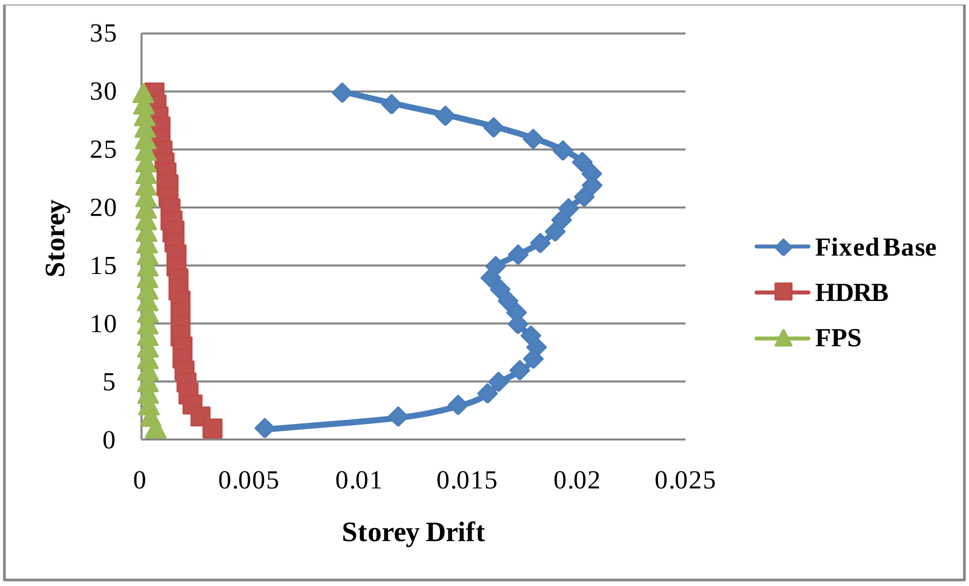

Figure.30 Storey Drift in Y Direction

From Figure 29 it is observed that storey drift is greatly reduce when friction pendulum system type isolator used as base isolator compared to high density rubber bearing type isolator. Both types of isolators reduce the storey drift compared to fixed base structure. Same Conclusion was made for Figure 30

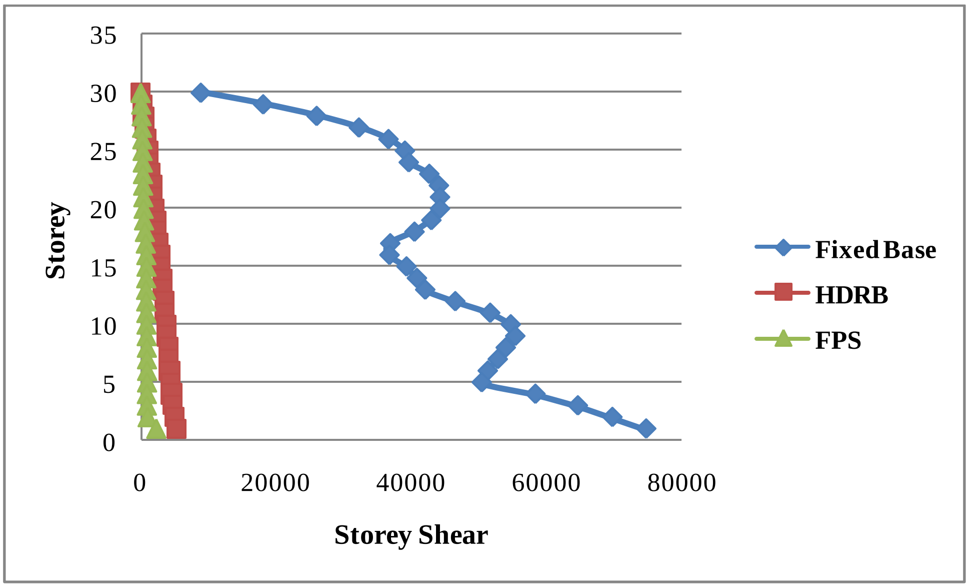

Figure.31 Storey Shear in X Direction

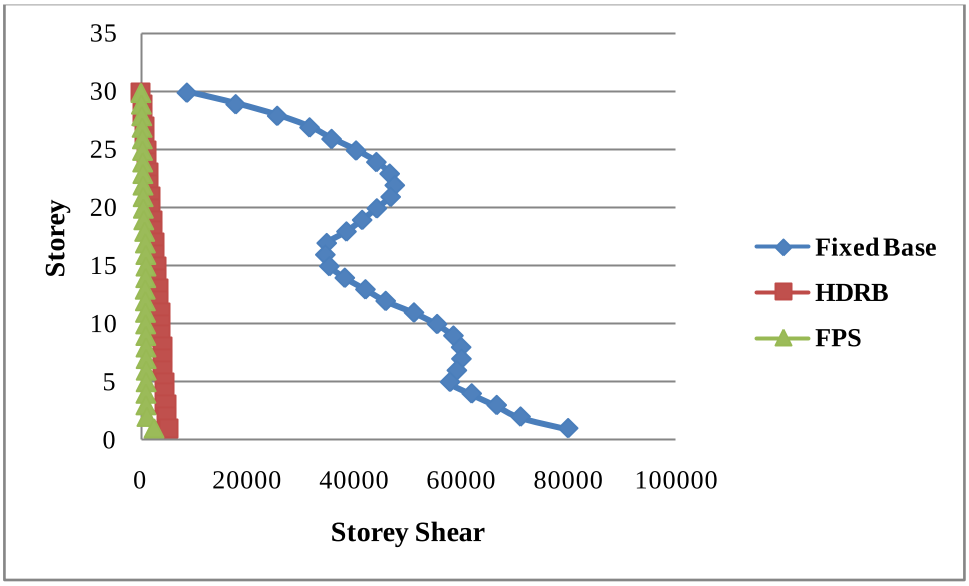

Figure.32 Storey Shear in Y Direction

From Figure 31 and 32 storey shear was greatly reduces by the use of friction pendulum type isolator compared with high density rubber bearing isolator. It was 50% reduce storey shear in friction pendulum type isolator than density rubber bearing isolator as friction pendulum type isolator compared with density rubber isolator. Both types of isolators reduce storey shear at greater extent compared with fixed base structure.

The main objective of this study is to check the effectiveness of base isolation techniques again conventional structure. To improve seismic performance of both the mid-storey & multi-storeyed structures different types of base isolation system are adopted. It is observed that there is significant reduction in values of base shear, storey drift increase in joint displacement, the time period for all base isolated structures. Also it is observed that base isolation improves the overall performance of the structure by lower down the response of the structure.

IV. CONCLUSION

From the study made and the results presented in the previous sections, the following important conclusions have been drawn within the purview of the buildings considered.

1) It is concluded that time period of the structure in case of FPS and HDRB it is increased over conventional fixed base structure.
2) It is concluded that base shear of structure reduces by the use of base isolator. But it is greatly reduces by use of FPS over HDRB.
3) It is also concluded that FPS gives maximum base displacement compared to HDRB.
4) Storey drift is reducing by both HDRB and FPS. But it is greatly reduces by the use of FPS.
5) It is seen that base isolation technique lengthens the time period of structure at greater extent for mid rise structure. But, as the number of stories goes on increasing the proportion of increment in time period of base isolated structure goes on decreasing.
6) It is concluded that as the number of storey's increase, the friction pendulum system give minimum value for top displacement. Hence, it is concluded that this type of system helps to minimize top displacement for multi storey structure.
7) It is concluded that Friction Pendulum system helps in reducing storey drift & storey acceleration at greater extent than High Density Rubber Bearing for both mid-Storey and multi-storey structure.
8) Friction pendulum system is beneficial than lead rubber bearing isolator & slightly higher than high density rubber isolator in terms of cost.

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