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Comparative Analysis of G+9 Building by Using Rubber Base and Friction Pendulum Systems in All Seismic Zones

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ABSTRACT

The base isolation procedure has been utilized to study the structures from the earthquake's harming impacts. Base isolation is achieved by installing isolators and energy absorbing devices under the superstructure, Seismic isolation provides not only structural safety, but also safety and security for people and properties in the building. Seismic isolation is also used for the retrofit of historic buildings. Seismic isolation and energy dissemination systems give an effective method of improving the seismic effectiveness of constructions through a typical seismic plan. Such strategies limit seismic loads by changing the inflexibility and damping of the constructions, though customary seismic design requires extra strength and flexibility to withstand seismic loads. Perhaps the main standards in the plan of tremor safe designs is the base detachment strategy. Seismic isolation systems can be modeled in various structural analysis programs using nonlinear or equivalent linear properties of isolators.In this present study a G+9 story building analyzed by using Rubber bearing isolation system and friction pendulum system in seismic all seismic zones namely zone II, Zone III, Zone IV and Zone V with the help of IS 1893:2016 Code in SAP 2000 Software package. The analysis is made between Rubber bearing isolation system, friction pendulum system and Fixed base building for seismic parameters like joint displacement , shear force, bending moment, building torsion, time period frequency etc. from the analytical results it was concluded that by using base isolation systems the values of base shear increased when we compared with fixed base building model. the storey shear values reduces to 35% in rubber isolation and 40% for friction pendulum models. The storey moment decreased to 25% in rubber base and 30% for friction pendulum model. The Optimum control of the parameters considered was observed when the building is damped with friction pendulum model in all the seismic zone conditions.

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

I. INTRODUCTION

The point of earthquake building assurance is to guarantee primary dependability and solace by holding inner powers and dislodging under explicit cutoff points. The most famous methodology for safeguarding buildings from the troublesome impacts of earthquakes is to hose seismic energy by restricting seismic energy by primary segments, consequently giving earthquake opposition. Notwithstanding the way that this methodology gives a specific measure of security, the design can be genuinely undermined on occasion. Another approach to protect buildings from earthquakes is to disengage them from the beginning/or add seismic energy dispersing components in essential areas inside the framework. With this methodology, more prominent insurance can be offered by appropriately arranging against earthquakes, and subsequently serious underlying misfortune can be diminished.

As we can see from the impacts of earthquakes in 1950 Assam, 1991 Uttarkashi, 1993 Maharashtra, and 2001 Gujarath, earthquakes have stayed a huge power undermining the social and monetary fate of the nations. Accordingly, it is demanded that goals that alleviate the seismic effect of buildings show a serious level of achievement in earthquakes that are anticipated. Seismic isolators and energy disseminating gadgets, which are introduced in the building appropriately to hose seismic energy or set between the base and vertical underlying designs to hose seismic energy under the ground of the construction, along these lines lessening the effect of parallel burdens on highest levels, are viewed as helpful arrangements in this sense.

Seismic disengagement is a strategy for lessening the dangerous impacts of earthquake ground shaking on structures and their materials. We utilize certain designs that will be characterized in this procedure to limit the horizontal development of constructions (Drift).

II. LITERATURE REVIEW

A.N.Lin et.al.[1992]1, The seismic impacts of inflexible establishment and base isolated concentrically propped steel outlines with one of a kind second obstruction were introduced. The establishment isolation and fixed base edges were designed utilizing different codes. The recommended design base shear for fixed base edges was set up in 1990 by the primary Engineering Association of California (SEAOC). The base confined building was worked to withstand 100%, half, and 25% of the SEAOC recommended sidelong powers, individually. For this investigation, 54 separate ground movement record records were utilized.

For different results, for example, rooftop migration, imploded boards, etc, on-straight time history investigation was utilized. Outright relative rooftop removal was found alongside these yielded casings and segments. The discoveries uncovered that utilizing 50% of the SEAOC proposed parallel power gives similarity a preferred worth over utilizing some other combination. A relative investigation of fixed and free second supported steel outlines was directed for top acquired response.

H.W. Shenton III [1993]8, relative impacts of fix reliant and base autonomous construction were thought about and examined. The referring to underlying offices relationship of California developed the solid fix establishment outline (SEAOC). The fixed base response was against the base-secluded response. As indicated by SEAOC suggestions, the base shear was fluctuating. To lead nonlinear unique examination for fixed base and base separated designs, three distinct kinds of time history, post-earthquake records were picked. SEAOC contrasted the outcomes with 25% and 50 percent of the predefined sidelong power. Distinctive sidelong powers were utilized to test the building's presentation.

Yang et al (2006)17, Two seismic cross breed control frameworks are proposed in this paper to protect building foundation from incredible earthquakes. A base-isolation instrument is joined to either a latent or dynamic mass damper in the mixture control framework. The base-isolation instrument, for example, elastomeric course, decouples level ground vibrations from the building, while the mass damper, dynamic or uninvolved, ensures the base-isolation framework's assurance and trustworthiness. The recommended cross breed control frameworks' presentation is analyzed, surveyed, and contrasted with that of an operational control framework. The proposed half and half control frameworks have seen to be exceptionally proficient in limiting the response of tall buildings during huge earthquakes based on hypothetical and computational information. Also, incorporating such crossover control frameworks is superior to setting up a functioning control framework alone.

III. METHODOLOGY

The seismic examination ought to be completed for the buildings that have absence of protection from earthquake powers. Seismic investigation will consider dynamic impacts subsequently the specific examination in some cases become mind boggling. Anyway for basic standard constructions comparable straight static examination is adequate. This kind of examination will be done for normal and low ascent buildings and this technique will give great outcomes for this sort of buildings. Dynamic investigation will be completed for the building as determined by code IS 1893-2002 (part1) (A.Swetha, Dr. H. Sudarsana Rao," Non-direct examination of multistory g + 4 building by time history strategy utilizing newmark's straight and normal speed increase technique). Dynamic investigation will be completed either by Response range strategy or site explicit Time history technique. Following techniques are embraced to complete the examination methodology.

IV. MODELING OF BUILDING

Model specifications

In the present study, analysis of G+9 multi-storied building located India has been done. Analysis has been carried out by assuming the buildings in all seismic zones. Three dimensional model of the building is prepared in SAP 2000 Software.

Basic parameters considered for the analysis are

1. Occupancy of the building : Residential building
2. Number of stories : G+9 (10 storied)
3. Number of bays along X axis :5no's
4. Number of bays along Y axis :2no's
5. Total Height of building : 30 m
6. Shape of building : Rectangular
7. Geometric details
   a) Ground floor height : 3 m
   b) Floor to floor height : 3 m
8. Material details
   a) Concrete Grade : M30 (COLUMNS AND BEAMS)
   b) Steel : HYSD reinforcement of Grade Fe415
   c) Bearing Capacity of Soil : 200 kN/m^2

9. Type Of Construction : Reinforced Cement Concrete Framed Structure
10. Column : 0.35 m × 0.35 m
11. Beams : 0.25 m × 0.35 m
12. Slab thickness : 0.125 m
13. Grade of concrete : M30
14. Grade of Reinforcing steel : HYSD Fe450
15. Live load : 2.5 kN/m^2(IS: 875:1987)
16. Density of Reinforced concrete : 25 kN/m^3
17. Seismic Zones : Zone VII, Zone III, Zone IV and Zone V
18. Site type : Medium (II) of IS Code 1893-2016
19. Importance factor : 1.0
20. Response reduction factor : 3
21. Damping Ratio : 5%
22. Structural class : C
23. Wind design code : IS 875: 1987 (Part 3)
24. RCC design code : IS 456:2000
25. Steel design code : IS 800: 2007
26. Earthquake design code : IS 1893 : 2016

Building models in SAP2000 Software

Fixed supports and rubber base isolator supports used for comparison will look like Figures 4.21 and 4.22 in Sap2000 software.

Fixed Base

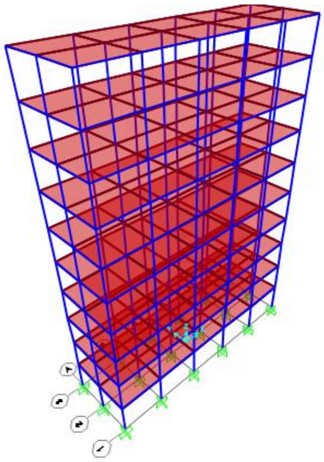


Figure Building Model with fixed supports

Rubber Base

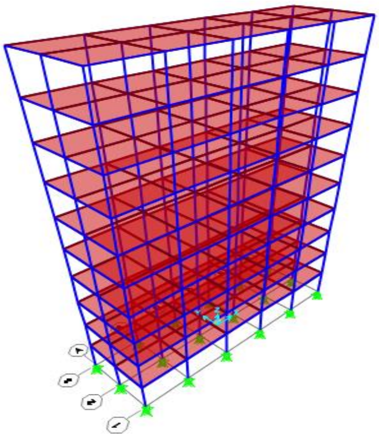
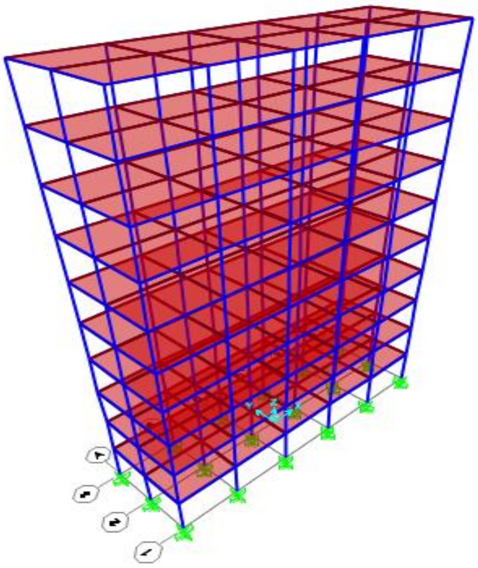


Figure Building Model with rubber isolator at supports

Friction pendulum



Building Model with friction isolator at supports

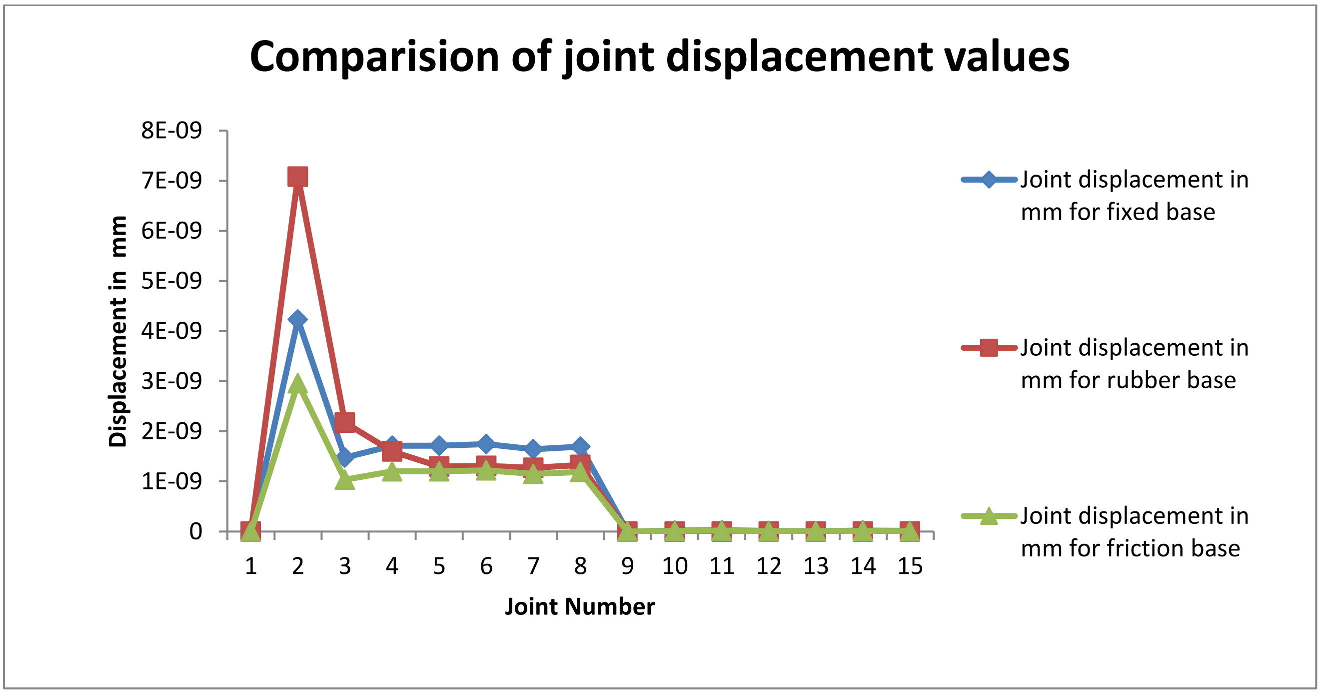
V. RESULTS AND ANALYSIS

Zone II Results

Comparison of join displacements

The joint displacement is generally observed due to the effect of seismic loading condition for the building structure (Yang et al (2006),Aseismic hybrid control systems for building structures, Journal of Engineering Mechanics), the joint displacement of G+6 building with and without using rubber base isolation systems are shown in Table 5.1 and Figure 5.1, from this results it was clearly observed that by providing the rubber base isolation the values of displacements generally decreases at the joints, the values of joint displacements increases from storey number 1 to storey number 7 due to the effect of lateral loads in high seismic zone condition.

Joint Number	Load case	Joint displacement in mm for fixed base	Joint displacement in mm for rubber base	Joint displacement in mm for friction base
1	RSA	0	0	0
2	RSA	4.23E-09	7.08E-09	2.96E-09
3	RSA	1.48E-09	2.17E-09	1.03E-09
4	RSA	1.72E-09	1.60E-09	1.20E-09
5	RSA	1.71E-09	1.30E-09	1.20E-09
6	RSA	1.75E-09	1.31E-09	1.22E-09
7	RSA	1.64E-09	1.27E-09	1.15E-09
8	RSA	1.69E-09	1.33E-09	1.19E-09
9	RSA	0	0	0
10	RSA	1.97E-11	1.07E-12	1.38E-11
11	RSA	2.42E-11	6.89E-13	1.69E-11
12	RSA	1.05E-11	1.16E-12	7.35E-12
13	RSA	7.16E-12	2.40E-12	5.02E-12
14	RSA	1.64E-11	2.43E-12	1.15E-11
15	RSA	1.26E-11	1.43E-12	8.82E-12

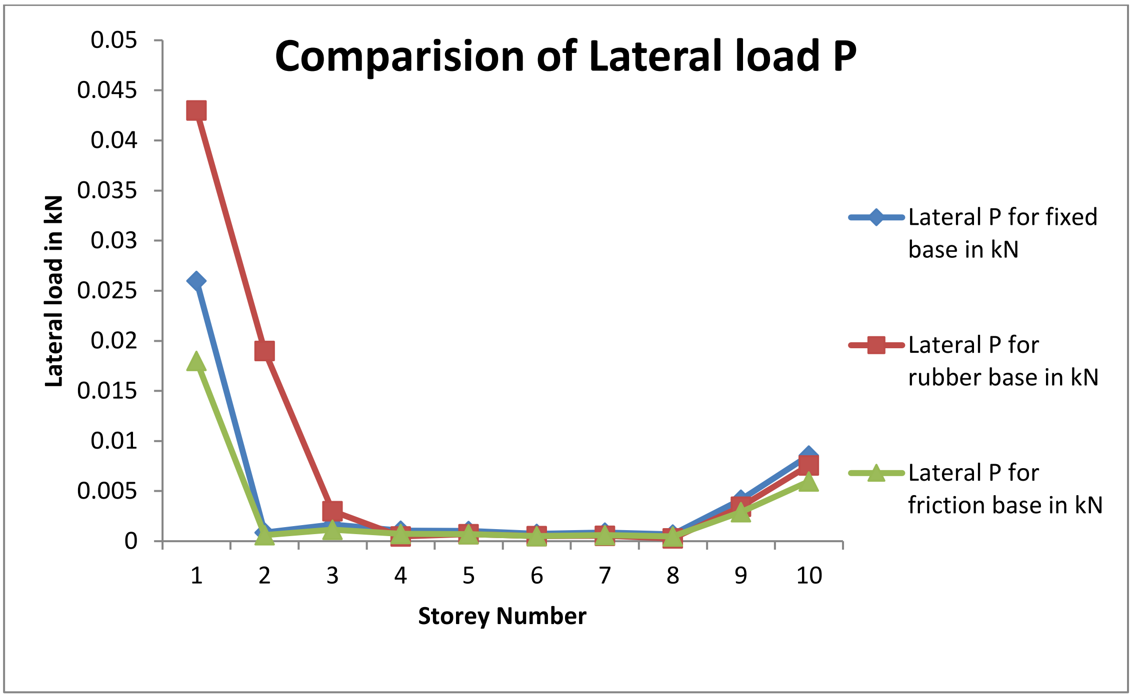


The above test results are compared for joint displacements of fixed base, rubber base and friction pendulum systems in zone II seismic condition from the above observations it was obtained as the joint displacements has higher values for rubber base than friction pendulum and fixed base models due to the effect of high intensity action of seismic loading condition the displacement values increases for the rubber base model than the remaining isolation systems.

Comparison of lateral load P

Live loads that are applied corresponding to the ground, or flat powers following up on an edge, are known as sidelong loads. They fluctuate from gravity loads like vertical and descending powers. Wind load, seismic burden, and water and ground pressure are the most well-known types of sidelong loads. Wind burden may not be a significant issue for little, enormous, low-ascent structures, yet it turns out to be more significant as buildings ascend in tallness, lighter materials are utilized, and shapes that impact wind current, for example, rooftop types, are utilized. During an earthquake, a building might be exposed to critical seismic burdens (H. W. Shenton1 III and A. N. Lin2,Relative Performance of fixed based and base confined solid edge).

Storey Number	Lateral P for fixed base in kN	Lateral P for rubber base in Kn	Lateral P for friction base in kN
Storey 1	0.026	0.043	0.018
Storey 2	0.0008698	0.019	0.0006089
Storey 3	0.001663	0.003017	0.001164
Storey 4	0.001051	0.0004719	0.0007356
Storey 5	0.001011	0.0007025	0.0007076
Storey 6	0.0007374	0.0005062	0.0005162
Storey 7	0.0008576	0.0005442	0.0006003
Storey 8	0.0006818	0.0002726	0.0004773
Storey 9	0.004144	0.003457	0.002901
Storey 10	0.008552	0.007553	0.005986

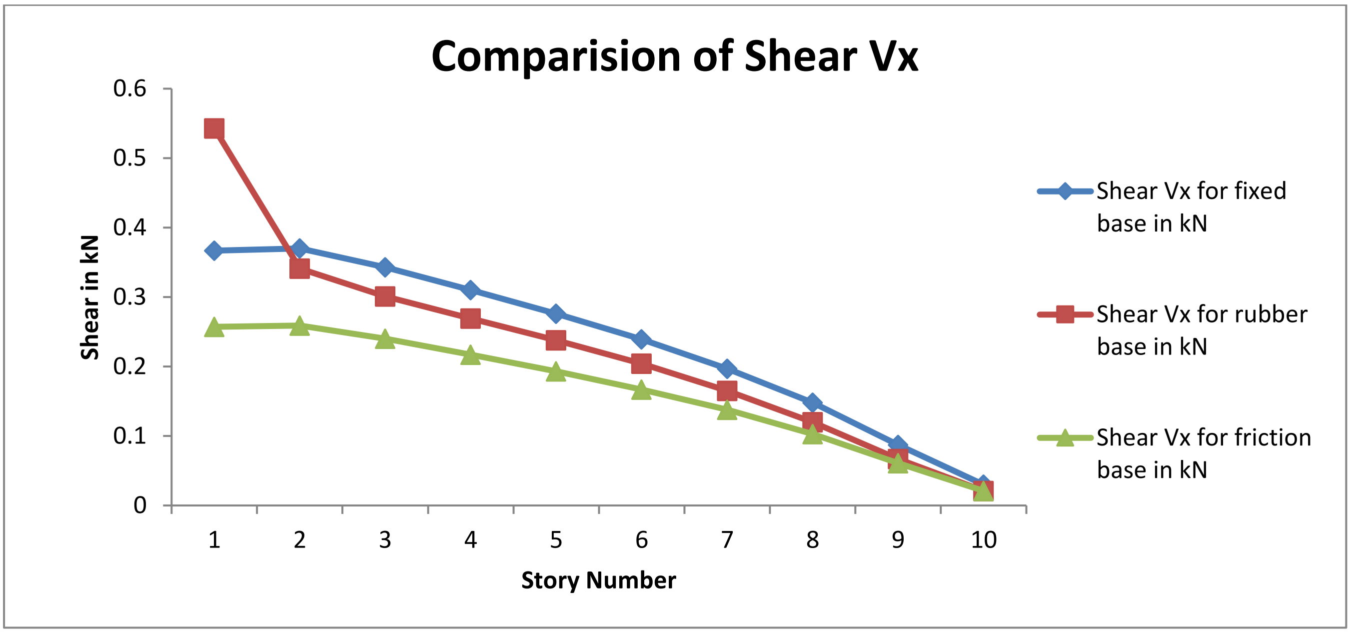


The action of lateral load conditions on G+10 building model is high in case of rubber base isolation system than the other isolation conditions in zone II seismic condition. Due to the effect of less resistance rate in rubber base model.

Comparison of Shear VX Values

Shear power is a power that acts the other way of the surface that is applied opposite to it. Shear pressure is the result of this. To put it another way, one segment of the surface is moved one way while another is pushed the other way.

Storey Number	Shear Vx for fixed base in kN	Shear Vx for rubber base in kN	Shear Vx for friction base in kN
Storey 1	0.367	0.543	0.257
Storey 2	0.37	0.341	0.259
Storey 3	0.343	0.301	0.24
Storey 4	0.31	0.269	0.217
Storey 5	0.276	0.238	0.193
Storey 6	0.239	0.204	0.167
Storey 7	0.197	0.165	0.138
Storey 8	0.148	0.12	0.103
Storey 9	0.087	0.067	0.061
Storey 10	0.03	0.021	0.021

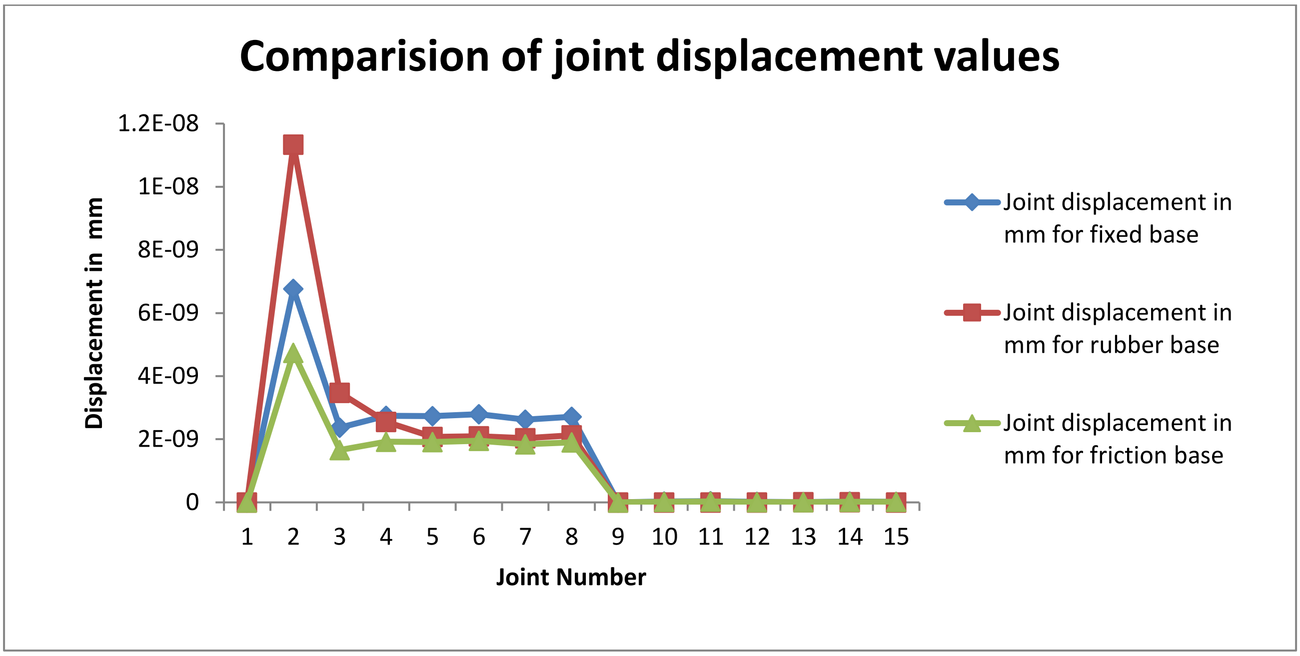


The above comparison table and graph shows the results for the shear in X direction condition. By using the seismic isolation systems namely rubber base and friction pendulum the shear values can be reduces in zone II seismic condition.

Zone III Results

1. Comparison of join displacements

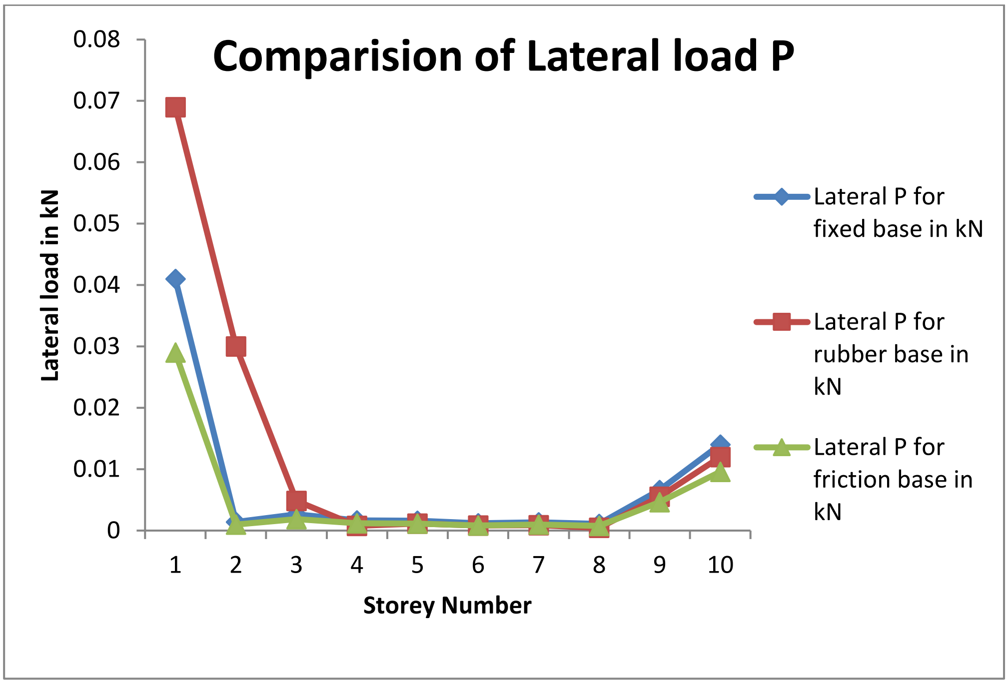
Joint Number	Load case	Joint displacement in mm for fixed base	Joint displacement in mm for rubber base	Joint displacement in mm for friction base
1	RSA	0	0	0
2	RSA	6.77E-09	1.13E-08	4.74E-09
3	RSA	2.36E-09	3.48E-09	1.66E-09
4	RSA	2.74E-09	2.55E-09	1.92E-09
5	RSA	2.74E-09	2.08E-09	1.92E-09
6	RSA	2.79E-09	2.10E-09	1.95E-09
7	RSA	2.62E-09	2.04E-09	1.84E-09
8	RSA	2.71E-09	2.13E-09	1.90E-09
9	RSA	0	0	0
10	RSA	3.15E-11	1.71E-12	2.21E-11
11	RSA	3.87E-11	1.10E-12	2.71E-11
12	RSA	1.68E-11	1.85E-12	1.18E-11
13	RSA	1.15E-11	3.84E-12	8.02E-12
14	RSA	2.63E-11	3.90E-12	1.84E-11
15	RSA	2.02E-11	2.29E-12	1.41E-11



The joint displacements of fixed base, rubber base and friction pendulum systems in zone III seismic condition from the above observations it was obtained as the joint displacements has higher values for rubber base than friction pendulum and fixed base models due to the effect of high intensity action of seismic loading condition the displacement values increases for the rubber base model than the remaining isolation systems.

2. Comparison of lateral load P

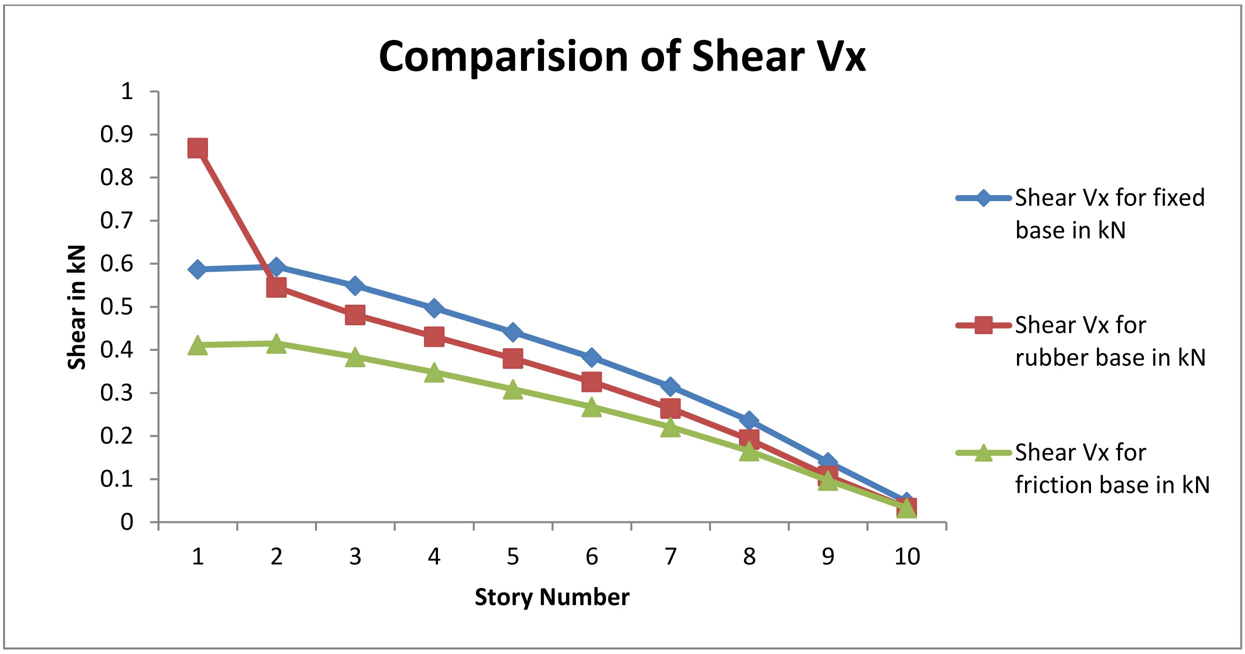
Storey Number	Lateral P for fixed base in kN	Lateral P for rubber base in kN	Lateral P for friction base in kN
Storey 1	0.041	0.069	0.029
Storey 2	0.001392	0.03	0.0009742
Storey 3	0.002661	0.004827	0.001863
Storey 4	0.001681	0.0007551	0.001177
Storey 5	0.001617	0.001124	0.001132
Storey 6	0.00118	0.00081	0.0008259
Storey 7	0.001372	0.0008707	0.0009606
Storey 8	0.001091	0.0004362	0.0007636
Storey 9	0.00663	0.005531	0.004641
Storey 10	0.014	0.012	0.009578



The action of lateral load conditions on G+10 building model is high in case of rubber base isolation system than the other isolation conditions in zone III seismic condition. Due to the effect of less resistance rate in rubber base model.

3. Comparison of Shear VX Values

Storey Number	Shear Vx for fixed base in kN	Shear Vx for rubber base in kN	Shear Vx for friction base in kN
Storey 1	0.587	0.869	0.411
Storey 2	0.593	0.545	0.415
Storey 3	0.549	0.481	0.384
Storey 4	0.497	0.431	0.348
Storey 5	0.441	0.38	0.309
Storey 6	0.382	0.326	0.268
Storey 7	0.315	0.264	0.221
Storey 8	0.236	0.192	0.165
Storey 9	0.139	0.107	0.097
Storey 10	0.047	0.033	0.033

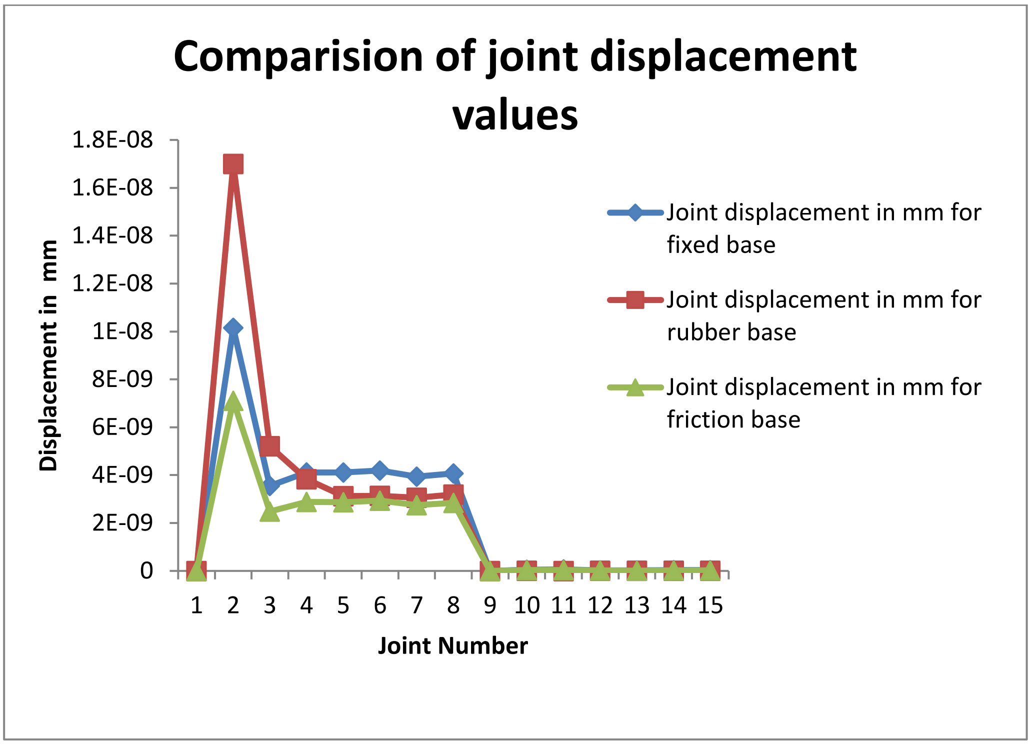


The above comparison for the shear in X direction condition is shown in above table and graph. By using the seismic isolation systems namely rubber base and friction pendulum the shear values can be reduces in zone III seismic condition.

Zone IV Results

1. Comparison of join displacements

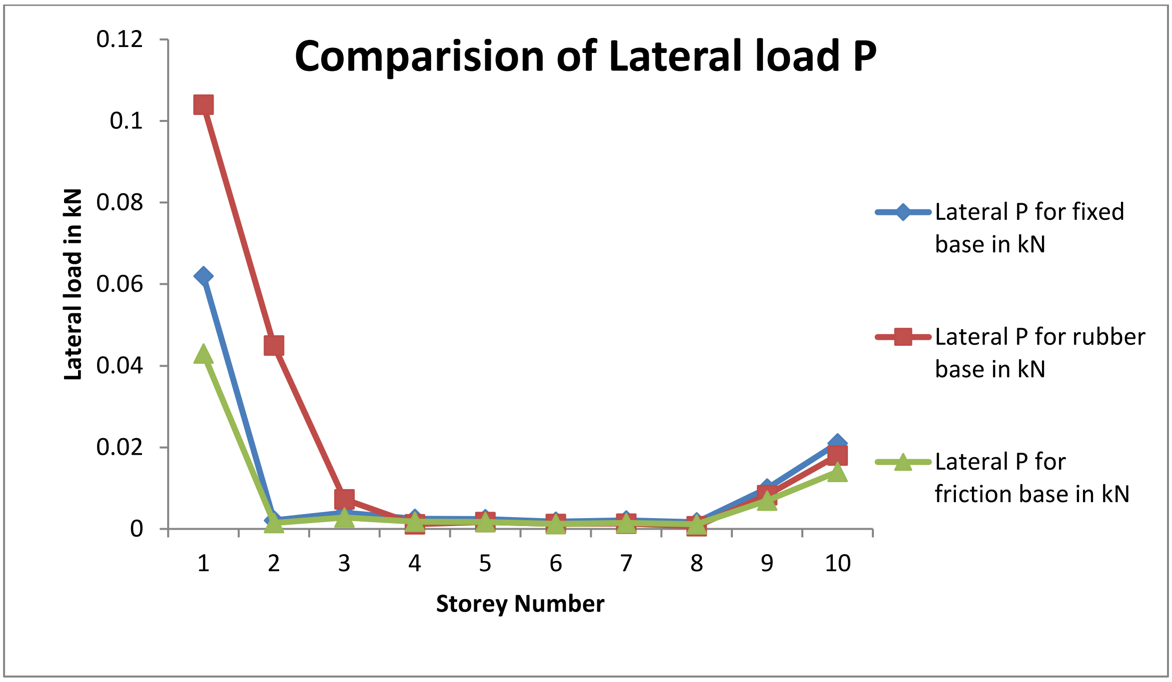
Joint Number	Load case	Joint displacement in mm for fixed base	Joint displacement in mm for rubber base	Joint displacement in mm for friction base
1	RSA	0	0	0
2	RSA	1.02E-08	1.70E-08	7.10E-09
3	RSA	3.55E-09	5.21E-09	2.48E-09
4	RSA	4.12E-09	3.83E-09	2.88E-09
5	RSA	4.11E-09	3.12E-09	2.87E-09
6	RSA	4.19E-09	3.14E-09	2.93E-09
7	RSA	3.94E-09	3.05E-09	2.76E-09
8	RSA	4.07E-09	3.19E-09	2.85E-09
9	RSA	0	0	0
10	RSA	4.73E-11	2.57E-12	3.31E-11
11	RSA	5.81E-11	1.65E-12	4.06E-11
12	RSA	2.52E-11	2.77E-12	1.76E-11
13	RSA	1.72E-11	5.76E-12	1.20E-11
14	RSA	3.94E-11	5.84E-12	2.76E-11
15	RSA	3.02E-11	3.43E-12	2.12E-11



The joint displacements of fixed base, rubber base and friction pendulum systems in zone IV seismic condition from the above observations it was obtained as the joint displacements has higher values for rubber base than friction pendulum and fixed base models due to the effect of high intensity action of seismic loading condition the displacement values increases for the rubber base model than the remaining isolation systems.

2. Comparison of lateral load P

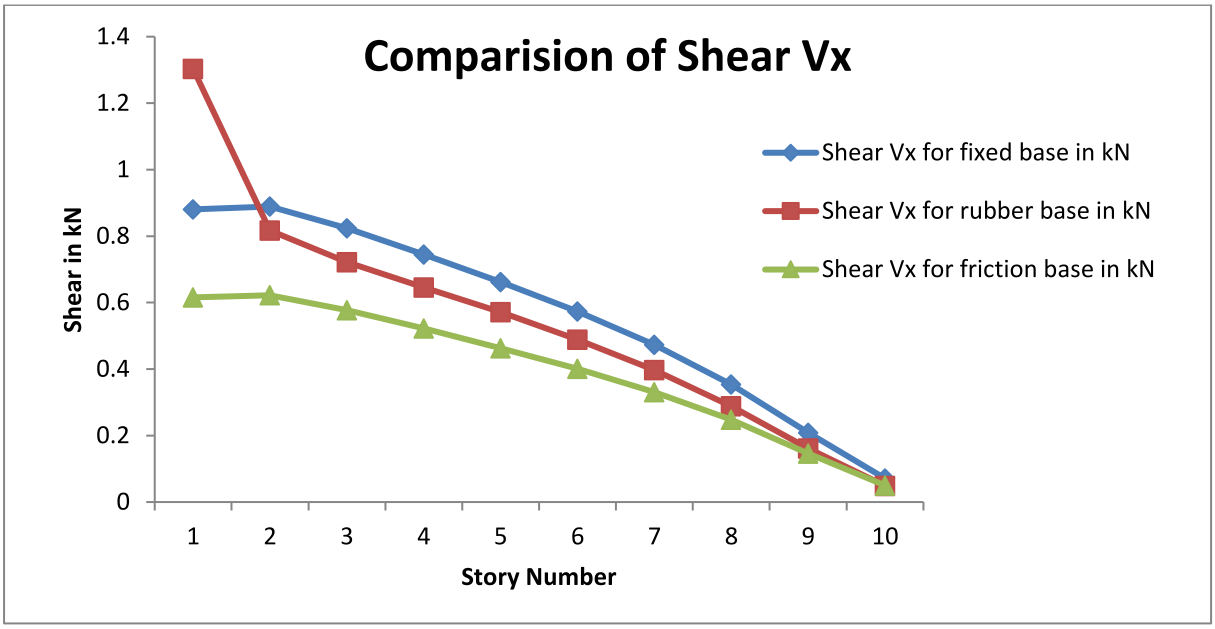
Storey Number	Lateral P for fixed base in kN	Lateral P for rubber base in kN	Lateral P for friction base in kN
Storey 1	0.062	0.104	0.043
Storey 2	0.002088	0.045	0.001461
Storey 3	0.003991	0.00724	0.002794
Storey 4	0.002522	0.001133	0.001766
Storey 5	0.002426	0.001686	0.001698
Storey 6	0.00177	0.001215	0.001239
Storey 7	0.002058	0.001306	0.001441
Storey 8	0.001636	0.0006542	0.001145
Storey 9	0.009945	0.008296	0.006961
Storey 10	0.021	0.018	0.014



The action of lateral load conditions on G+10 building model is high in case of rubber base isolation system than the other isolation conditions in zone IV seismic condition. Due to the effect of less resistance rate in rubber base model.

3. Comparison of Shear VX Values

Storey Number	Shear Vx for fixed base in kN	Shear Vx for rubber base in kN	Shear Vx for friction base in kN
Storey 1	0.88	1.303	0.616
Storey 2	0.889	0.817	0.622
Storey 3	0.824	0.722	0.577
Storey 4	0.745	0.646	0.522
Storey 5	0.662	0.571	0.463
Storey 6	0.573	0.489	0.401
Storey 7	0.473	0.397	0.331
Storey 8	0.354	0.288	0.248
Storey 9	0.208	0.161	0.146
Storey 10	0.071	0.049	0.05

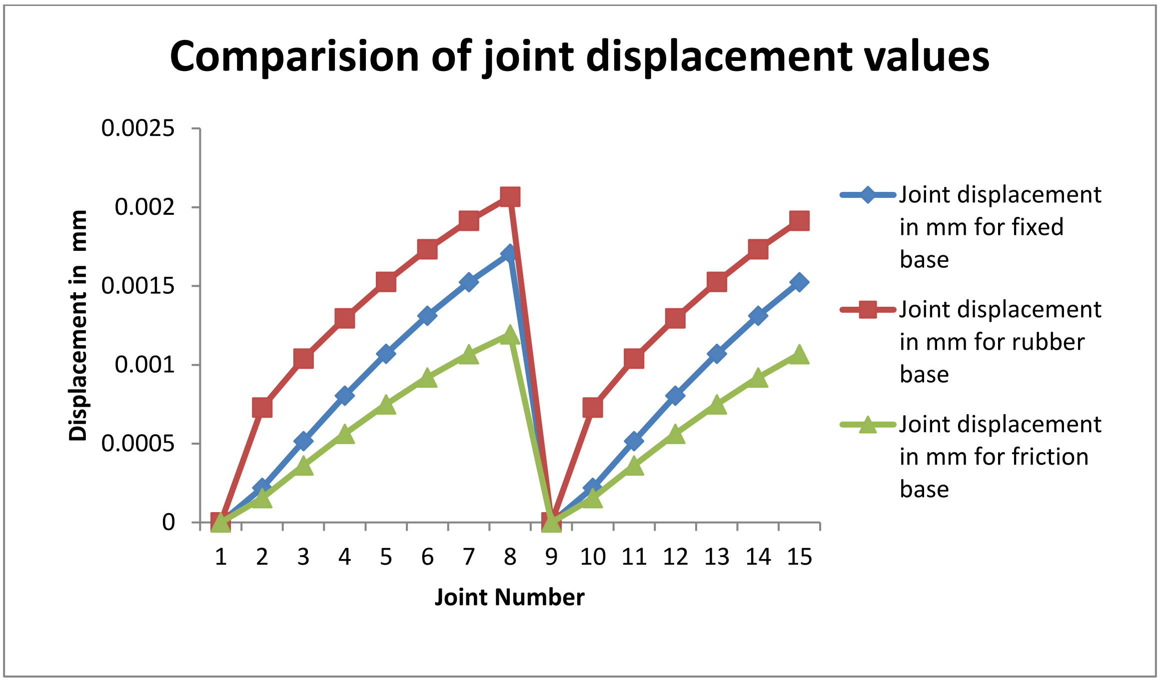


The above comparison for the shear in X direction condition is shown in above table and graph. By using the seismic isolation systems namely rubber base and friction pendulum the shear values can be reduces in zone IV seismic condition.

Zone V Results

1. Comparison of join displacements

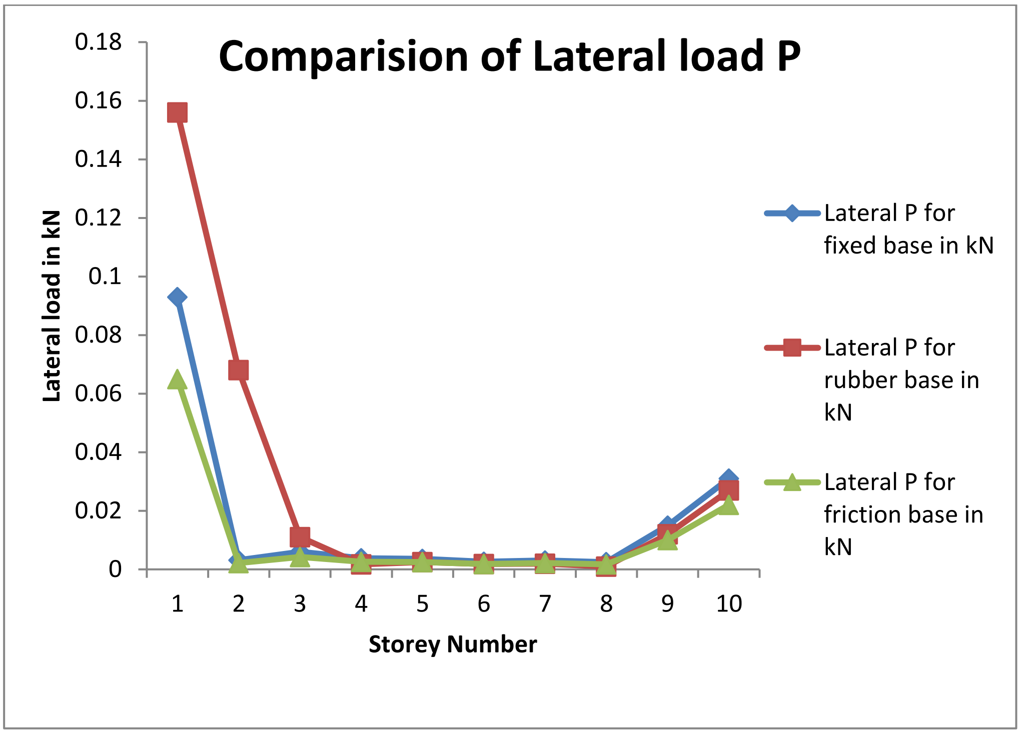
Joint Number	Load case	Joint displacement in mm for fixed base	Joint displacement in mm for rubber base	Joint displacement in mm for friction base
1	RSA	0	0	0
2	RSA	0.00022	0.00073	0.000154
3	RSA	0.000517	0.00104	0.000362
4	RSA	0.000804	0.001295	0.000563
5	RSA	0.001071	0.001526	0.00075
6	RSA	0.001312	0.001733	0.000919
7	RSA	0.001525	0.001914	0.001068
8	RSA	0.001706	0.002066	0.001194
9	RSA	0	0	0
10	RSA	0.00022	0.00073	0.000154
11	RSA	0.000517	0.00104	0.000362
12	RSA	0.000804	0.001295	0.000563
13	RSA	0.001071	0.001526	0.00075
14	RSA	0.001312	0.001733	0.000919
15	RSA	0.001525	0.001914	0.001068



The above graph shows the joint displacement for zone V seismic condition from this results it was observed the displacement values has less intensity in friction pendulum than rubber base and friction pendulum building systems in zone V seismic condition.

2. Comparison of lateral load P

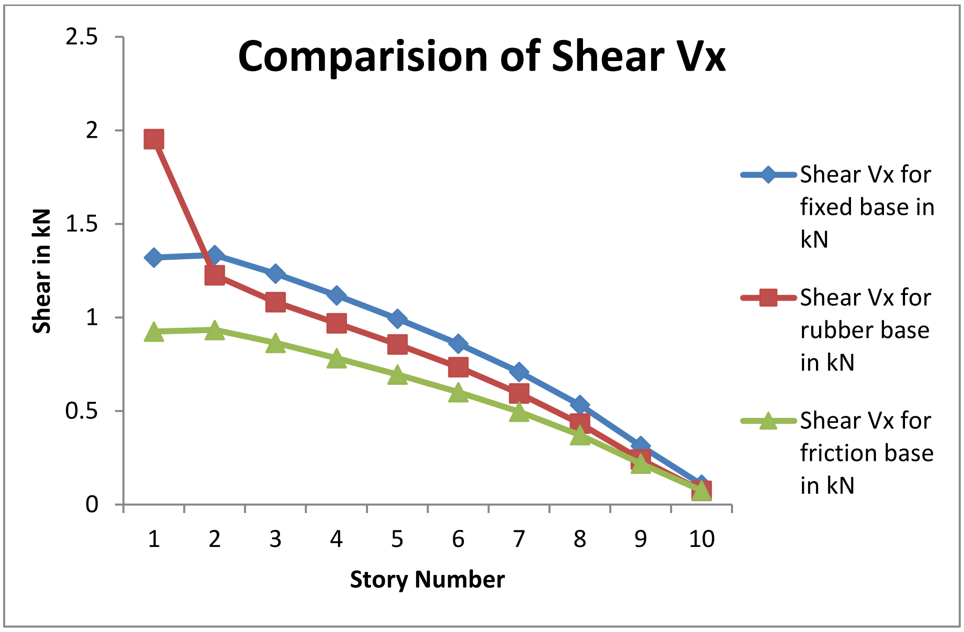
Storey Number	Lateral P for fixed base in kN	Lateral P for rubber base in kN	Lateral P for friction base in kN
Storey 1	0.093	0.156	0.065
Storey 2	0.003131	0.068	0.002192
Storey 3	0.005987	0.011	0.004191
Storey 4	0.003783	0.001699	0.002648
Storey 5	0.003639	0.002529	0.002547
Storey 6	0.002655	0.001822	0.001858
Storey 7	0.003088	0.001959	0.002161
Storey 8	0.002454	0.0009814	0.001718
Storey 9	0.015	0.012	0.01
Storey 10	0.031	0.027	0.022



The action of lateral load conditions on G+10 building model is high in case of rubber base isolation system than the other isolation conditions in zone IV seismic condition. Due to the effect of less resistance rate in rubber base model.

3. Comparison of Shear VX Values

Storey Number	Shear Vx for fixed base in kN	Shear Vx for rubber base in kN	Shear Vx for friction base in kN
Storey 1	1.32	1.954	0.924
Storey 2	1.334	1.226	0.934
Storey 3	1.235	1.083	0.865
Storey 4	1.118	0.969	0.782
Storey 5	0.993	0.856	0.695
Storey 6	0.86	0.734	0.602
Storey 7	0.709	0.595	0.497
Storey 8	0.532	0.433	0.372
Storey 9	0.313	0.241	0.219
Storey 10	0.107	0.074	0.075



The above comparison for the shear in X direction condition is shown in above table and graph. By using the seismic isolation systems namely rubber base and friction pendulum the shear values can be reduces in zone V seismic condition

VI.CONCLUSION

From analysis results it is observed that base isolation technique is very significant in order to reduce seismic response of both plan irregular and vertical irregular models as compared to fixed base building and control damages in building during seismic action.

1. Storey shear decreased when the building is damped with Lead Rubber isolation and friction pendulum .
2. By providing the rubber base isolation at the base the storey shear values are increased by 32% in X direction and 38% in Y direction. But for the friction pendulum isolation the shear values are decreased by 42% in both the X and Y direction system.
3. Storey Moment decreased when the building is analyzed with Lead Rubber isolation system friction pendulum in all seismic zones .
4. By providing the rubber base isolation at the base the storey moment values are decreased by 25% in X direction and 30% in Y direction. But for the friction pendulum isolation the bending values are decreased by 30% in Y direction system and increased by 46% in Y direction.
5. Torsion decreased when the building is modeled with isolation system.
6. By considering the rubber base isolation at the base the torsion values are decreased for both X and Y direction condition by 0.7% and 42%.
7. Joint displacement decreased when the building is damped with Lead Rubber and friction pendulum.
8. By using the base isolation systems namely rubber base and friction pendulum the values of joint displacements increases for rubber base model by 40% and decreased by 42% for friction pendulum systems.
9. By using isolation systems we can reduce the usage of steel by 8.7% for rubber base isolation and 30% for friction pendulum systems this is an important in building design.
10. Optimum control of the parameters considered was observed when the building is damped with Lead Rubber Dampers and friction pendulum model.

So from the work carried out it can be stated that Rubber base isolation system and friction pendulum is the best supplemental damping system to control seismic loading condition.

VII. FUTURE SCOPE OF THE STUDY

The following are the some of the future scope which is obtained from this project

1. The base isolation is may checked for high rise buildings in future studies.
2. The base isolation system with rubber base isolation can be made for loose soil condition in high seismic zone in future studies.
3. Seismic analysis studies are made in future studies with time history and push over analysis with base isolation systems.
4. The efficiency of base isolation system may increase by providing composite column system in future studies.

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