COMPARATIVE STUDY OF BASE ISOLATION TECHNIQUES IN REDUCING SEISMIC EFFECT IN STRUCTURES

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Abstract : It is the need of present time to build structures which can withstand against the seismic conditions.It has been observed that Occurrence of earthquake was very less in the past ,but in present time it has become common. As now a days our cities are becoming more denser , skyscrapers has been built side by side, so if any structure collapses it will also leads to damage the structure near its surrounding. To counteract this problem, our building technique is shifting from fixed to flexible structures . Flexible structures are more safe than rigid and conventional structures because they are capable of dissipating the seismic energy. As the technology is upgrading ,new techniques have came out ,among them most popular is " Base isolation technique" and it is widely used all across the world.

KEYWORDS :- Base isolation, Rigid structures, seismic effects.

INTRODUCTION :-

Earthquake resistant design of Structures depends upon strength ,stiffness and inelastic deformation capacity of a building which are enough to resist earthquake force.

This is achieved by implementing appropriate structural configuration and careful detailing of structural member. Most promising and advance technique for earthquake resistance is not to strengthen the structure ,but to reduce the earthquake generated forces acting upon it.

Two major techniques are:-

1- Base isolation
2- Energy dissipation devices.
   a- Friction Dampers
   b- Metallic Dampers
   c- Visco elastic Dampers
   d- Viscous Dampers

BASE ISOLATION:-

It is the technique of separating the structure from its foundation by introducing isolator in between them. However it is impossible to fully separate the structures from its foundation.

The aim of base isolation is to minimize the energy that is transferred from ground motion to the structure by buffering it with a bearing layer at the foundation which has relatively low stiffness .

It is most widely implemented and accepted seismic protection system . The isolator are flexible which are helpful in dissipating the seismic energy. It is more effective when applied to high stiffness low rise buildings. Base isolation technique is necessary for the following situations:-

. When structure is located in a high seismic intensity zone.
. Existing structure is unsafe.
. Minimise the damage to primary and secondary structural members.
. Cost economic of the structure with and without isolator.

Some of the types of base isolation technique:-

1- Elastometric based system
2- Isolation system based on sliding
3- Ball and Bearings

G S Hiremath (2015), base shear is low in base isolated buildings as compared to plane irregular base isolated building, the vertical irregular base isolated building has less base shear.

At higher seismic prone areas the vertical irregular buildings gives better performances with base isolation as compared to plane vertical base isolated building.

Dr.B.L.Agarwal (2016), Akhil Eliyas (2017), it is found that while providing LRB in G+4 storey buildings the base shear is reduced by 40% due to which the structure becomes stable as compared to fixed base during earthquake. Also the top storey drift is reduced by 60% in base isolated structures as compared to fixed base.

Ashish R (2016), Akhtar (2017) ,Tejas R wankhade (2017),
After a lot of research ,results shows that while using HDRB and FPS isolator , the base shear in X direction is reduced by 70% using HDRB and 94% using FPS .
In Y direction it is reduced by 70% using HDRB and 85% using FPS .
Time period of both the isolated structures is increased as compared to fixed base.
Storey drift and acceleration is also reduced as compared to that of conventional buildings.

Praveen J.V (2017), B.R Govardhan (2017),Naveen k (2017),
The performance of RC frames under fixed and isolated base in seismic zone 5 is checked.
8 different models of 20 storey were considered for analysis.
It was found that storey displacement was more in base isolated model as compared to fixed model.
Storey drift was less in base isolated model as compared to fixed model.
Storey acceleration was low in base isolated model as compared to fixed base.
The displacement was higher in base isolated model as compared to fixed base and drift was also reduced in base isolated model.

DESIGN PARAMETERS :-

Section properties

CONCRETE	M25
REINFORCEMENT	Fe415
HEIGHT OF BUILDING	45.5 m
NUMBER OF STORY	G+15
HEIGHT OF EACH STORY	3m
HEIGHT OF BOTTOM STORY	3.5 m
DIMENSION OF BUILDING	20m X 20m
BEAM SIZE	300mm X 450 mm
COLUMN SIZE	350mm X 500 mm
SLAB THICKNESS	150 mm
HEIGHT OF ISOLATOR FROM BASE	500 mm

Seismic consideration

SEISMIC ZONE	V
ZONE FACTOR	0.36
IMPORTANCE FACTOR	1.5
RESPONSE REDUCTION FACTOR	5

Three isolators are considered in designing:-

1- HIGH DAMPING RUBBER BEARING (HDRB)

U 1 (stiffness in X direction)	2855317.347 KN/ M
U 2 & U 3 (stiffness in Y & Z directions)	2379.40 KN/M
U 2 & U 3. Non linear (Y & Z direction)	2005.639 KN/M
YIELD STRENGTH	193.50 KN/M
DAMPING	0.10

2- LEAD RUBBER BEARING (LRB)

U 1 (stiffness in X direction)	15000000 KN/ M
U 2 & U 3 (stiffness in Y & Z directions)	800 KN/M
U 2 & U 3. Non linear (Y & Z direction)	250 KN/M
YIELD STRENGTH	80 KN/M
DAMPING	0.10

3- FRICTION PENDULUM SYSTEM (FPS)

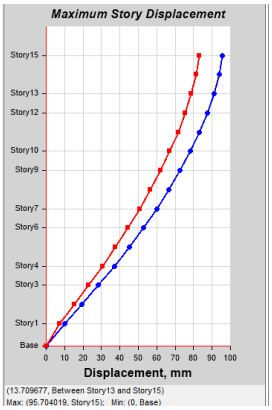
U 1 (stiffness in X direction)	15000000 KN/M
U 1 Non linear (in X direction)	15000000 KN/M
U2 & U3 (stiffness in Y & Z direction)	750 KN/M
U2 & U3 Non linear	15000 KN/M
FRICTION COEFFICIENT (Slow)	0.03
FRICTION COEFFICIENT (Fast)	0.05
RATE PARAMETER	40
RADIUS OF SLIDING SURFACE	2.23

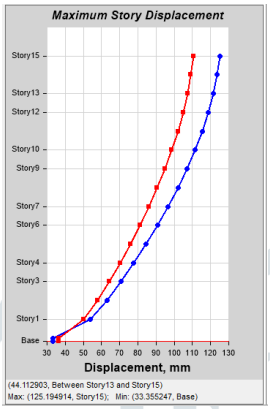
ANALYSIS AND RESULT:-

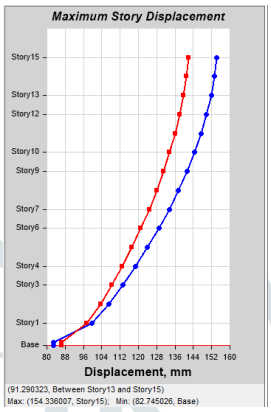
The analysis was carried out by response spectrum analysis.

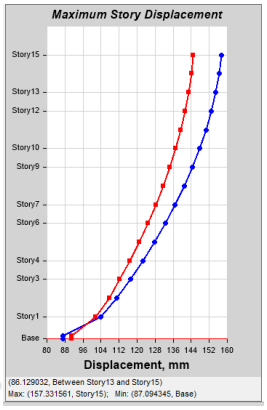
1- STORY DISPLACEMENT

FIXED	HDRB	LRB	FPS









Tabulated Plot Coordinates

Story Response Values

Story	Elevation m	Location	X-Dir mm	Y-Dir mm
Story15	45.5	Top	95.704	83.191
Story14	42.5	Top	93.87	81.385
Story13	39.5	Top	91.138	78.826
Story12	36.5	Top	87.56	75.538
Story11	33.5	Top	83.233	71.603
Story10	30.5	Top	78.244	67.099
Story9	27.5	Top	72.659	62.089
Story8	24.5	Top	66.528	56.616
Story7	21.5	Top	59.882	50.706
Story6	18.5	Top	52.736	44.372
Story5	15.5	Top	45.102	37.623
Story4	12.5	Top	36.991	30.472
Story3	9.5	Top	28.423	22.949
Story2	6.5	Top	19.439	15.127
Story1	3.5	Top	10.113	7.227
Base	0	Top	0	0

Tabulated Plot Coordinates

Story Response Values

Story	Elevation m	Location	X-Dir mm	Y-Dir mm
Story15	45.5	Top	125.195	110.589
Story14	42.5	Top	123.72	109.216
Story13	39.5	Top	121.584	107.32
Story12	36.5	Top	118.818	104.91
Story11	33.5	Top	115.456	102.013
Story10	30.5	Top	111.529	98.656
Story9	27.5	Top	107.069	94.865
Story8	24.5	Top	102.103	90.664
Story7	21.5	Top	96.659	86.078
Story6	18.5	Top	90.76	81.127
Story5	15.5	Top	84.429	75.831
Story4	12.5	Top	77.685	70.203
Story3	9.5	Top	70.54	64.246
Story2	6.5	Top	62.958	57.882
Story1	3.5	Top	53.978	50.225
isolation	0.5	Top	33.355	36.293
Base	0	Top	33.355	36.293

Tabulated Plot Coordinates

Story Response Values

Story	Elevation m	Location	X-Dir mm	Y-Dir mm
Story15	45.5	Top	154.336	141.822
Story14	42.5	Top	153.3	140.905
Story13	39.5	Top	151.791	139.632
Story12	36.5	Top	149.819	137.999
Story11	33.5	Top	147.397	136.014
Story10	30.5	Top	144.536	133.686
Story9	27.5	Top	141.245	131.021
Story8	24.5	Top	137.536	128.031
Story7	21.5	Top	133.421	124.722
Story6	18.5	Top	128.91	121.106
Story5	15.5	Top	124.013	117.189
Story4	12.5	Top	118.738	112.978
Story3	9.5	Top	113.084	108.466
Story2	6.5	Top	107.007	103.577
Story1	3.5	Top	99.656	97.568
isolation	0.5	Top	82.745	86.595
Base	0	Top	82.745	86.595

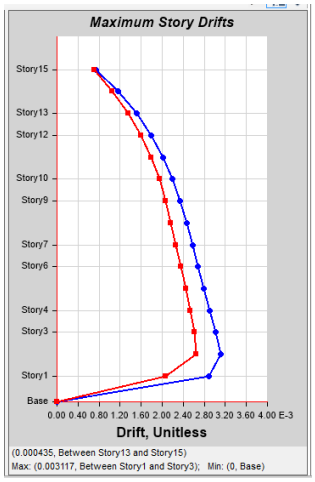
Tabulated Plot Coordinates

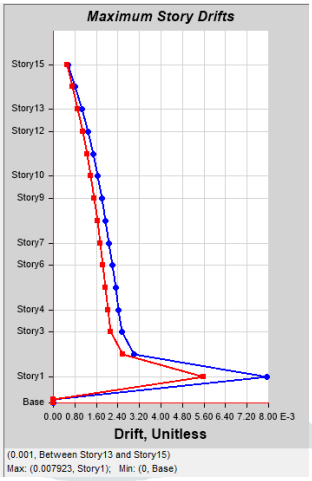
Story Response Values

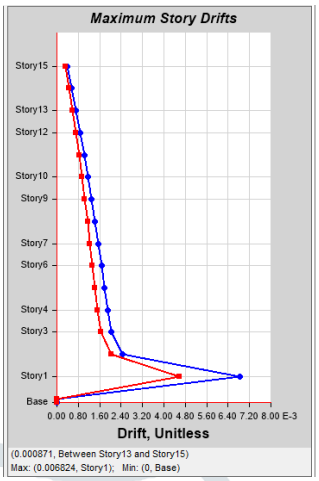
Story	Elevation m	Location	X-Dir mm	Y-Dir mm
Story15	45.5	Top	157.332	144.989
Story14	42.5	Top	156.321	144.076
Story13	39.5	Top	154.85	142.837
Story12	36.5	Top	152.927	141.248
Story11	33.5	Top	150.564	139.316
Story10	30.5	Top	147.77	137.048
Story9	27.5	Top	144.556	134.452
Story8	24.5	Top	140.93	131.535
Story7	21.5	Top	136.905	128.307
Story6	18.5	Top	132.489	124.775
Story5	15.5	Top	127.691	120.947
Story4	12.5	Top	122.518	116.829
Story3	9.5	Top	116.968	112.411
Story2	6.5	Top	110.996	107.619
Story1	3.5	Top	103.758	101.717
isolation	0.5	Top	87.094	90.931
Base	0	Top	87.094	90.931

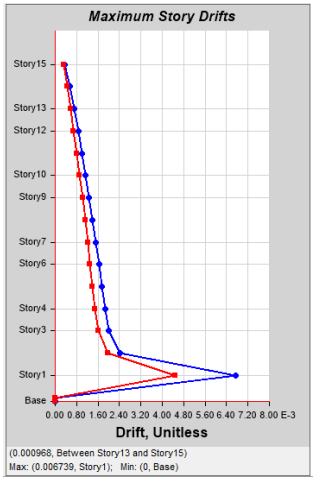
2- STORY DRIFT

3- STORY SHEAR

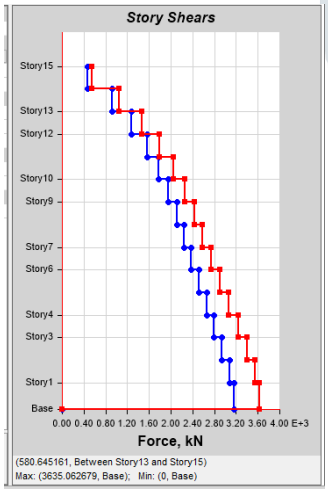


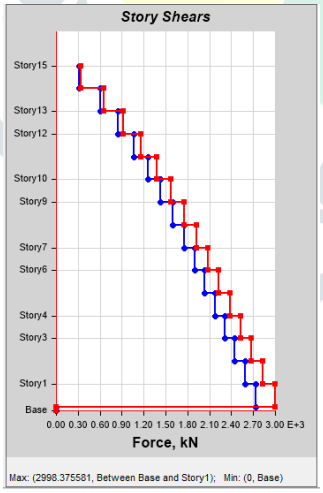


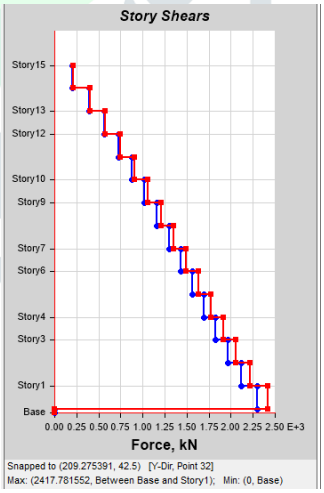


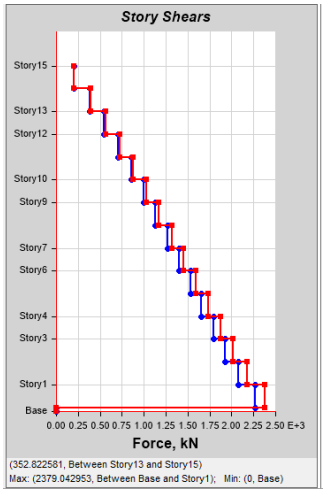


FIXED BASE	HDRB	LRB	FPS









FIXED BASE	HDRB	LRB	FPS

Story	Load Case	Shear X kN	Drift X mm	Stiffness X kN/m	Shear Y kN	Drift Y mm	Stiffness Y kN/m
Story15	RSA XY	484.8939	2.251	215440.754	548.6768	2.14	256379.948
Story14	RSA XY	928.131	3.494	265646.529	1059.0553	3.158	335368.307
Story13	RSA XY	1284.1204	4.568	281131.047	1471.1097	4.077	360845.357
Story12	RSA XY	1567.4401	5.427	288826.837	1800.2191	4.822	373313.921
Story11	RSA XY	1793.3909	6.108	293611.158	2063.6107	5.414	381192.223
Story10	RSA XY	1978.8631	6.654	297377.307	2273.8463	5.876	386942.062
Story9	RSA XY	2137.3919	7.105	300829.791	2449.6151	6.247	392111.785
Story8	RSA XY	2281.9429	7.496	304417.641	2609.5747	6.563	397615.198
Story7	RSA XY	2421.1465	7.855	308229.778	2765.6804	6.852	403615.992
Story6	RSA XY	2562.8372	8.205	312363.928	2928.8456	7.138	410288.726
Story5	RSA XY	2710.0237	8.556	316729.025	3104.024	7.432	417633.917
Story4	RSA XY	2863.1866	8.912	321272.531	3283.622	7.721	425277.194
Story3	RSA XY	3015.7402	9.252	325971.23	3456.8437	7.966	433959.168
Story2	RSA XY	3153.8803	9.576	329361.885	3606.928	8.038	448735.799
Story1	RSA XY	3254.1012	10.383	313406.476	3699.4397	7.338	504132.89

FIXED BASE

Story	Load Case	Shear X kN	Drift X mm	Stiffness X kN/m	Shear Y kN	Drift Y mm	Stiffness Y kN/m
Story11	eqx	892.8267	3.046	293067.796	0	9.091E-05	0
Story10	eqx	995.4814	3.34	298004.31	0	7.922E-05	0
Story9	eqx	1078.6093	3.571	302011.049	0	6.753E-05	0
Story8	eqx	1144.6025	3.746	305571.449	0	5.584E-05	0
Story7	eqx	1195.9006	3.87	308991.065	0	4.339E-05	0
Story6	eqx	1235.0258	3.952	312488.61	0	3.714E-05	0
Story5	eqx	1264.6625	4.002	315975.927	0	4.959E-05	0
Story4	eqx	1287.8622	4.052	317824.312	0	0.001	0
Story3	eqx	1308.7257	4.571	286307.785	0	0.004	0
Story2	eqx	1335.7753	10.899	122556.131	0	0.032	0
Story1	eqx	0	0	0	0	0	0
Story16	RSA XY	267.8681	1.504	178053.708	290.7627	1.402	207329.975
Story15	RSA XY	539.2593	2.264	238195.035	587.1648	1.999	293743.544
Story14	RSA XY	787.1651	3.002	262241.738	860.2802	2.6	330880.224
Story13	RSA XY	1011.0698	3.67	275515.834	1108.6848	3.151	351796.817
Story12	RSA XY	1213.0934	4.27	284125.252	1333.5827	3.649	365515.037
Story11	RSA XY	1396.8164	4.808	290508.817	1537.5088	4.093	375651.661
Story10	RSA XY	1565.8376	5.294	295759.376	1723.7994	4.49	383924.43
Story9	RSA XY	1723.4368	5.736	300440.512	1896.0863	4.846	391259.63
Story8	RSA XY	1872.2261	6.142	304846.628	2057.9155	5.168	398182.724
Story7	RSA XY	2014.5296	6.516	309149.005	2212.6182	5.464	404981.057
Story6	RSA XY	2152.6894	6.868	313456.795	2363.4879	5.74	411751.049
Story5	RSA XY	2289.3429	7.209	317551.974	2513.7409	6.02	417591.981
Story4	RSA XY	2427.7895	7.596	319597.401	2666.343	6.39	417236.256
Story3	RSA XY	2572.2881	8.969	286806.578	2824.9115	7.669	368351.622
Story2	RSA XY	2732.4229	22.136	123438.811	2997.4129	15.319	195663.539
Story1	RSA XY	0	0	0	0	0	0

Table 2.5 - Story Stiffness

Story	Load Case	Shear X kN	Drift X mm	Stiffness X kN/m	Shear Y kN	Drift Y mm	Stiffness Y kN/m
Story15	eqx	174.6861	0.852	205051.982	0	0.0004766	0
Story14	eqx	338.7433	1.314	257756.936	0	0.0002429	0
Story13	eqx	480.1292	1.732	277166.382	0	8.103E-05	0
Story12	eqx	600.7164	2.087	287805.04	0	8.079E-05	0
Story11	eqx	702.3954	2.384	294685.1	0	7.065E-05	0
Story10	eqx	787.0826	2.626	299729.254	0	6.091E-05	0
Story9	eqx	856.7315	2.82	303831.622	0	5.106E-05	0
Story8	eqx	913.3539	2.97	307490.373	0	4.097E-05	0
Story7	eqx	959.0564	3.084	311014.657	0	2.969E-05	0
Story6	eqx	996.1136	3.166	314621.319	0	2.395E-05	0
Story5	eqx	1027.1308	3.228	318176.01	0	6.576E-05	0
Story4	eqx	1055.4667	3.298	319998.26	0	0.001	0
Story3	eqx	1086.653	3.789	286788.442	0	0.004	0
Story2	eqx	1135.907	9.287	122316.258	0	0.034	0
Story1	eqx	0	0	0	0	0	0
Story15	RSA XY	175.9603	0.963	182733.088	181.0715	0.848	213645.24
Story14	RSA XY	359.6346	1.48	243016.256	371.1522	1.234	300884.121
Story13	RSA XY	534.8784	2	267469.872	553.9548	1.636	338694.75
Story12	RSA XY	701.3345	2.493	281309.895	728.9488	2.022	360510.466
Story11	RSA XY	859.6853	2.96	290473.909	896.4513	2.39	375143.154
Story10	RSA XY	1011.1772	3.401	297310.027	1057.3204	2.738	386107.082
Story9	RSA XY	1157.2013	3.821	302888.755	1212.7625	3.07	395058.649
Story8	RSA XY	1299.2006	4.221	307772.031	1364.1978	3.386	402886.21
Story7	RSA XY	1438.6512	4.607	312269.372	1513.236	3.69	410078.855
Story6	RSA XY	1577.3355	4.983	316571.471	1661.7756	3.987	416835.594
Story5	RSA XY	1717.64	5.36	320447.687	1812.3112	4.293	422183.305
Story4	RSA XY	1863.4199	5.787	322027.957	1968.5995	4.679	420705.514
Story3	RSA XY	2022.4346	7.051	286847.198	2138.1878	5.799	368718.948
Story2	RSA XY	2219.9542	18.009	123270.293	2346.2354	11.941	196482.382
Story1	RSA XY	0	0	0	0	0	0

Table 2.5 - Story Stiffness

Story	Load Case	Shear X kN	Drift X mm	Stiffness X kN/m	Shear Y kN	Drift Y mm	Stiffness Y kN/m
Story15	eqx	170.574	0.832	204913.641	0	0.0004664	0
Story14	eqx	330.8214	1.284	257654.978	0	0.0002371	0
Story13	eqx	468.9838	1.693	277091.145	0	7.888E-05	0
Story12	eqx	586.8911	2.04	287747.922	0	7.864E-05	0
Story11	eqx	686.3921	2.33	294641.589	0	6.872E-05	0
Story10	eqx	769.3619	2.567	299696.9	0	5.918E-05	0
Story9	eqx	837.715	2.757	303809.022	0	4.952E-05	0
Story8	eqx	893.426	2.906	307476.574	0	3.958E-05	0
Story7	eqx	938.5686	3.018	311008.668	0	2.844E-05	0
Story6	eqx	975.392	3.1	314621.579	0	2.271E-05	0
Story5	eqx	1006.4902	3.163	318176.955	0	6.646E-05	0
Story4	eqx	1035.2436	3.235	319987.381	0	0.001	0
Story3	eqx	1067.3013	3.723	286669.22	0	0.004	0
Story2	eqx	1118.4472	9.144	122310.354	0	0.033	0
Story1	eqx	0	0	0	0	0	0
Story15	RSA XY	170.5881	0.938	181910.126	174.5438	0.821	212698.541
Story14	RSA XY	348.988	1.44	242367.143	358.0643	1.193	300035.771
Story13	RSA XY	519.6519	1.946	267008.967	534.9574	1.582	338055.655
Story12	RSA XY	682.2598	2.428	280989.278	704.7519	1.957	360046.124
Story11	RSA XY	837.4554	2.885	290256.757	867.7593	2.315	374816.189
Story10	RSA XY	986.4082	3.319	297168.733	1024.7922	2.656	385886.46
Story9	RSA XY	1130.4287	3.733	302802.452	1176.9883	2.98	394918.701
Story8	RSA XY	1270.8884	4.13	307724.372	1325.6926	3.291	402804.976
Story7	RSA XY	1409.2122	4.513	312247.378	1472.4455	3.591	410036.849
Story6	RSA XY	1547.149	4.887	316564.075	1619.094	3.884	416814.108
Story5	RSA XY	1687.0868	5.265	320441.261	1768.1144	4.188	422155.236
Story4	RSA XY	1832.9543	5.692	322003.97	1923.3316	4.572	420630.431
Story3	RSA XY	1992.8171	6.951	286703.989	2092.5872	5.678	368517.893
Story2	RSA XY	2193.3036	17.794	123264.032	2302.326	11.715	196530.483
Story1	RSA XY	0	0	0	0	0	0

HDRB	LRB	FPS

4- BASE SHEAR

TYPE OF FOOTING	X DIRECTION (KN/M)	Y DIRECTION. (kN/M)
FIXED	3164.2522	3635.0627
HDRB	2476.1008	2767.2643
LRB	1893.1832	2028.6509
FPS	1809.8759	1936.4738

5- TIME PERIOD (sec)

MODE	FIXED BASE	HDRB	FPS	LRB
1-	2.039	2.759	3.606	3.689
2-	1.749	2.467	3.385	3.448
3-	1.627	2.274	3.044	3.104
4-	0.665	0.828	0.846	0.903
5-	0.567	0.733	0.749	0.802
6-	0.534	0.669	0.684	0.728
7-	0.386	0.444	0.428	0.459
8-	0.326	0.384	0.370	0.397
9-	0.314	0.365	0.352	0.377
10-	0.273	0.300	0.285	0.305
11-	0.228	0.256	0.242	0.261
12-	0.221	0.246	0.233	0.251
13-	0.209	0.225	0.212	0.227
14-	0.172	0.189	0.177	0.191
15-	0.169	0.183	0.172	0.185
16-	0.168	0.179	0.168	0.180
17-	0.165	0.169	0.155	0.165
18-	0.146	0.149	0.139	0.150
19-	0.144	0.149	0.139	0.149
20-	0.141	0.147	0.137	0.146

6- STORY ACCELERATION

MODE	FIXED BASE	HDRB	FPS	LRB
1-	708.99	526.3	400.43	391.92
2-	825.94	585.72	427.10	418.5
3-	886.6	641.11	473.81	465.59
4-	2257.97	1749.67	1716.99	1613.87
5-	2284.92	2027.21	1977.05	1796.80
6-	2647.80	2243.97	2192.32	2043.76
7-	2647.8	2647.53	2647.23	2647.25
8-	2647.8	2647.53	2647.23	2647.25
9-	2647.8	2647.53	2647.23	2647.25
10-	2647.8	2647.53	2647.23	2647.25
11-	2647.8	2647.53	2647.23	2647.25
12-	2647.8	2647.53	2647.23	2647.25
13-	2647.8	2647.53	2647.23	2647.25
14-	2647.8	2647.53	2647.23	2647.25
15-	2647.8	2647.53	2647.23	2647.25
16-	2647.8	2647.53	2647.23	2647.25
17-	2647.8	2647.53	2647.23	2647.25
18-	2647.8	2647.53	2647.23	2647.25
19-	2647.8	2647.53	2647.23	2647.25
20-	2647.8	2647.53	2647.23	1647.25

CONCLUSION

. Story shear reduced after the (LRB),(HDRB) & (FPS) are provided as base isolation system respectively by 60% , 45%, & 66%. which reduces the seismic effect on building.

.Base shear is also reduced after providing HDRB, LRB &FPS respectively by 22%, 45% & 50%which makes structure stable during earthquake.

. Story drift are reduced in higher stories after providing HDRB,LRB & FPS respectively by 53%,57% & 62% which makes structure safe against earthquake.

.Storey displacements are increased in every story after providing HDRB,LRB & FPS respectively by 25%, 40%,& 45%. which is important to make a structure flexible during earthquake.

.lateral loads are reduced after providing HDRB, LRB & FPS respectively by 27%, 45% & 53%. Which is good for stability of building during earthquake.

.Time period of building is increased after providing HDRB, LRB & FPS Respectively by 30% , 50% & 50%.Which ncreases the reaction time of structure during earthquake

.Story acceleration is reduced by 30% , 50%, & 47% respectively by using HDRB, LRB & FPS.Which provides the necessary flexibility.

.Both the isolators (LRB & FPS) gives better result as compared to HDRB. And among these two FPS is more effective in reducing seismic effect in structures.

.It is also observed that only 1st story of base isolated structure gets more story drift value compared to the fixed base structures.But the remaining story drift goes on decreasing

.Finally it is concluded that Base isolators increases the structures stability against earthquake and maintains the serviceability of structures hence make structure economical

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