International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 08 | Aug 2020 www.irjet.net p-ISSN: 2395-0072

BEHAVIOUR OF IRREGULAR BASE ISOLATED RC STRUCTURE UNDER THE INFLUENCE OF SEISMIC FORCES

ASHISH ASHOK HUKKERI[1]

[2]***Prof: Parsharam Sawant***, *Department of Civil Engineering, S.G. Balekundri Institute of Technology Belagavi-590010, Karnataka, India*

Abstract – *Base isolation (BI) is a technique that has been used around the world to protect the building structure from the damaging effects of earthquake. In the present study the analysis is been performed to compare the effectiveness of base isolation in plan regular, irregular and vertical irregular multistorey reinforced concrete building. For this, 15 storied RC building has been considered and response spectrum analysis is carried out using ETABS. The results obtained from the analysis are compared in terms of time period, shear force, storey displacement and storey acceleration. Due to the presence of isolator, base shear and storey acceleration are significantly reduced in each direction (X and Y direction) as compared to fixed base building. When compared to base isolated regular building the plan irregular and vertical irregular base isolated building gives better performance.*

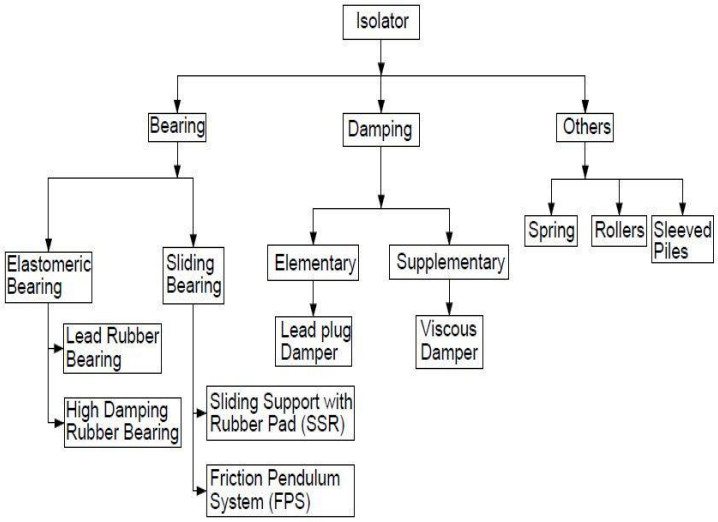
Key Words: Lead Rubber Bearing, Time Period, Shear Force, Storey Displacement and Storey acceleration.

1. INTRODUCTION

We know that the effect of earthquake on a structure cannot be completely diminished but its effect can be reduced by various techniques. From many years engineers have tried to reduce the effect of earthquake on structure and with each passing year new developments in the strengthening techniques of a structure have been developed. One of such strengthening technique is Base Isolation Technique. In this technique a suitable isolator for the structure is chosen and it is to be placed between the foundation and the base of structure. These isolators work as absorbers which absorb the earthquake force or energy and reduce its effect to above stories. The principle behind base isolation technique is to isolate the structure from the ground in such a way that the earthquake motions or the forces are not transmitted up through the building or at least greatly reduced.

2. TYPES OF ISOLATORS

There are different types of base isolators which depends on the different conditions and they are classified as shown in the flow chart below. Among these lead rubber bearing isolator has been selected for the present work.



3. LEAD RUBBER BEARING

Lead Rubber Bearing isolators are one of the most common used ones which is an example of elastomeric bearing since they are the most economical solution among other isolators. It has better efficiency in terms of damping and stiffness for gravity forces as well as earthquake forces. It consists of flexible rubber pads which has energy absorbing characters. Since LRB increases the natural period of the structure due to which there is reduction in lateral stiffness due to the lateral forces. Hence serves the purpose for base isolation. Advantages of selecting lead rubber bearing isolator over other isolators are that they are stable for longer period of time. Effective isolation can be achieved. They are insensitive to the foundation settlement and also they are economical.

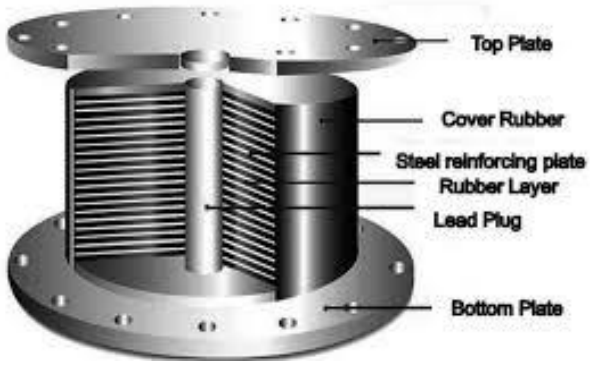


Fig.3.1. lead Rubber Bearing.

4. MODELLING AND ANALYSIS

- Building - **A**: Regular Structure
  - Model A-N = Non Isolated Structure (NIS).
  - Model A-B = Base Isolated Structure (BIS).
- Building - **B**: Plan Irregular Structure
  - Model B-N = Non Isolated Structure (NIS).
  - Model B-B = Base Isolated Structure (BIS).
- Building - **C**: Vertical Irregular Structure
  - Model C-N = Non Isolated Structure (NIS).
  - Model C-B = Base Isolated Structure (BIS).

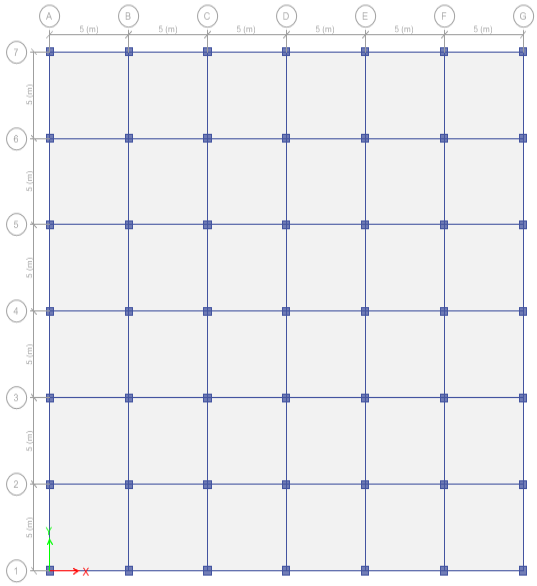


Fig 4.1: Typical floor Plan of Plan Regular building

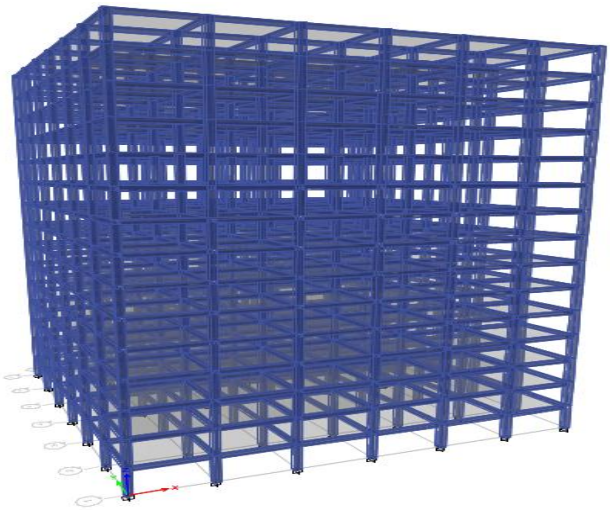


Fig 4.2: 3d view of the Plan Regular building

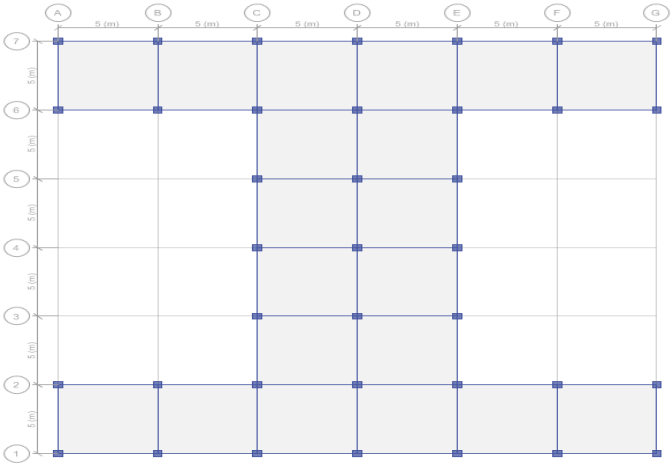


Fig 4.3: Typical floor Plan of I-Shape Plan Irregular building.

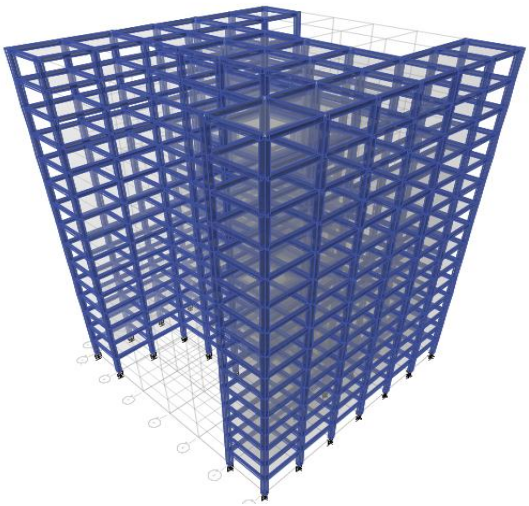


Fig 4.4: 3d view of the I-Shape Plan Irregular building

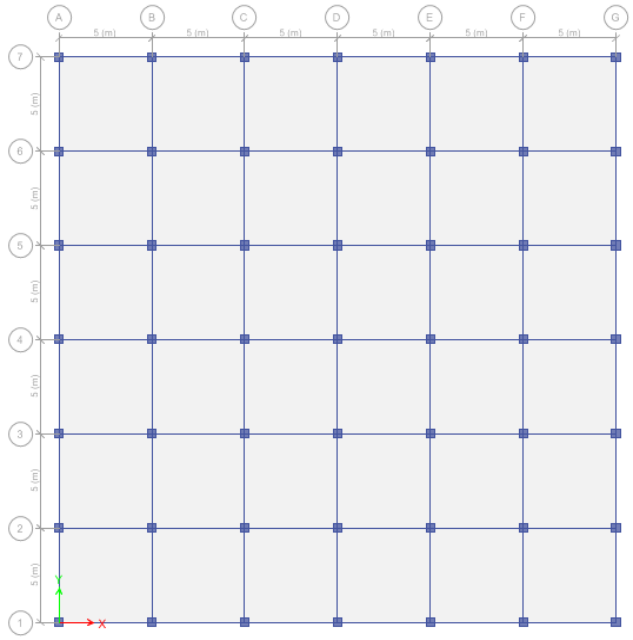


Fig 4.5: Typical floor Plan of Vertical Irregular building

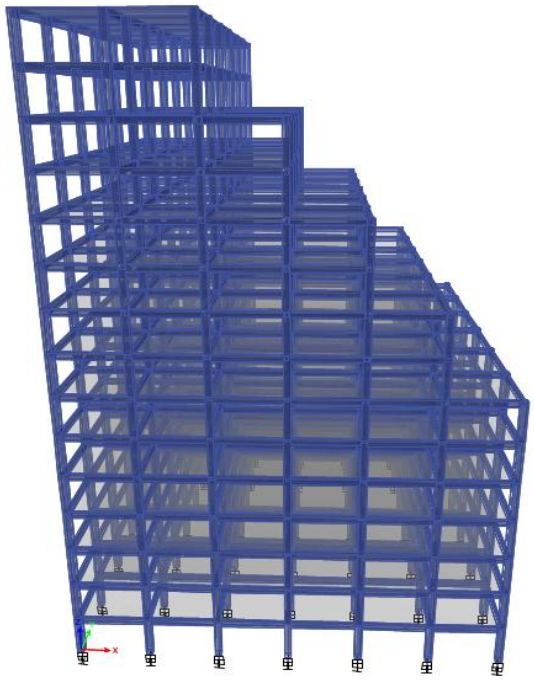


Fig 4.6: 3d view of the Vertical Irregular building

5. RESULTS AND DISCUSSIONS:

5.1. STOREY DISPLACEMENT

Table 5.1: Storey Displacement (mm)

Stories	Building A		Building B		Building C	
	A - N	A - B	B -N	B - B	C - N	C - B
15	59.7	65.2	61.6	65.9	61.8	64.1
14	58.7	64.4	60.5	64.9	60	62.8
13	56.9	62.9	58.6	63.3	57.3	60.7
12	54.3	61	55.9	61.1	53.9	58.1
11	51.1	58.5	52.6	58.4	49.9	55.1
10	47.4	55.6	48.7	55.2	45.7	51.9
9	43.2	52.3	44.4	51.6	41.1	48.5
8	38.7	48.8	39.7	47.7	36.6	45.1
7	33.9	45	34.7	43.6	31.9	41.6
6	28.8	41.1	29.5	39.3	27.3	38.1
5	23.7	37.1	24.2	34.9	22.5	34.5
4	18.4	33	18.7	30.4	17.6	30.8
3	13.1	28.8	13.3	25.8	12.6	26.9
2	7.8	24.6	7.9	21.2	7.5	23
1	2.9	19.6	2.9	15.9	2.8	18.4
0	0	10.8	0	7.7	0	10.1

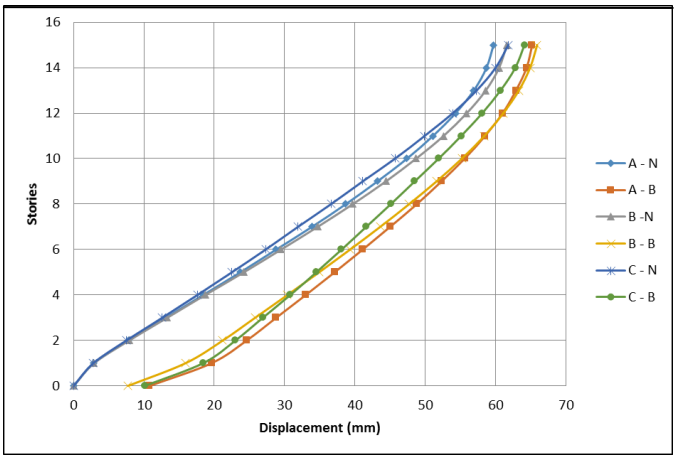


Fig 5.1: Graph showing displacement (mm) at different storey levels

Table 5.2: Storey Displacement (mm)

Stories	Building A		Building B		Building C	
	A - N	A - B	B -N	B - B	C - N	C - B
15	47.3	53.7	48.7	53.6	62.9	66.8
14	46.6	53.2	47.9	53	61.4	65.9
13	45.4	52.4	46.7	52.1	59.1	64.5
12	43.8	51.3	45	50.8	56.2	62.7
11	41.7	49.8	42.8	49.1	52.8	60.6
10	39.2	48	40.2	47.1	49.2	58.2
9	36.3	46	37.2	44.7	45.3	55.5

8	33.1	43.6	33.9	42.1	41.2	52.8
7	29.6	41	30.2	39.2	36.8	49.8
6	25.7	38.1	26.3	36	32.4	46.6
5	21.6	35	22	32.6	27.4	43.1
4	17.2	31.6	17.5	28.9	22	39.2
3	12.5	28.1	12.7	25	16.1	34.8
2	7.7	24.2	7.7	20.8	9.9	30
1	2.9	19.5	2.9	15.7	3.8	24
0	0	10.8	0	7.7	0	13.1

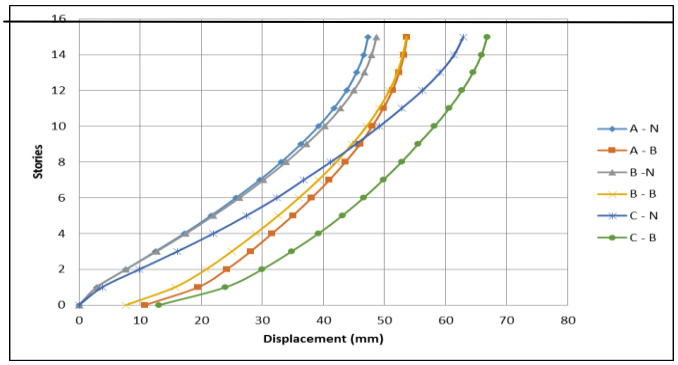


Fig 5.2: Graph showing displacement (mm) at different storey levels

OBSERVATIONS:

1. It can be seen that the displacement in case of static for both with and with isolators results in more displacement as compared to the response spectrum method.
2. It was observed that some displacement has been developed at ground floor when isolators were introduced as for the fixed structure there was zero displacement at ground level.
3. It was observed that when isolators were installed at base, the displacement of the structure increased as compared to the fixed structure.
4. It is observed that as the structure changes from uniform to irregular the displacement of the structure increases.
5. It is observed that when isolators are used the storey displacement in regular building and plan irregular building varies linearly.
6. It is observed that for fixed condition irrespective of the type of structure the variation of displacement remains same.
7. But it is observed that when isolators are introduced the displacement is more in case of vertical irregular structure as compared to both plan irregular structure and uniform structure.

5.2 NATURAL PERIOD

Table 5.3: Natural Period (sec)

Modes	Building A		Building B		Building C	
	A - N	**A - B**	**B -N**	**B - B**	**C - N**	**C - B**
1	2.633	3.407	2.871	3.449	2.42	2.966
2	2.633	3.403	2.706	3.36	2.163	2.883
3	2.544	3.316	2.699	3.288	1.728	2.236

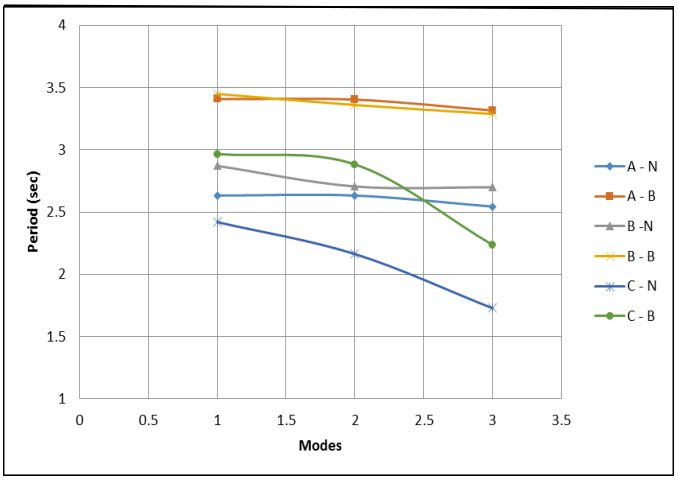


Fig 5.3: Graph showing Period (sec) Vs Modes

OBSERVATIONS:

1. It was observed that due to installation of isolator at the base the period of the structure increases as compared to the fixed based structure.
2. It is observed that when isolators are introduced in the structure, the period of the structure shifts from acceleration zone towards displacement zone.
3. It is observed that the natural period is more in plan irregular structure when compared to regular structure.
As the vertical irregularity increases the natural period of the structure reduces when compared to regular and plan irregular structures irrespective of the fixity condition.
4. On comparing fixed structure to base isolated structure, the natural period in regular building is 1.29, for plan irregular structure it is 1.20 and for vertical irregular structure it is 1.22.

5.3 STOREY FORCES

Table 5.4: Storey Forces (kN)

Stories	Building A		Building B		Building C	
	A - N	A - B	B -N	B - B	C - N	C - B
15	258.26	199.83	172.62	141.68	157.23	117.96
14	604.32	467.62	422.42	346.71	385.22	289.00
13	902.71	698.51	637.81	523.49	614.58	461.07
12	1156.96	895.24	821.33	674.12	842.01	631.70
11	1370.61	1060.56	975.54	800.69	1056.58	792.67
10	1547.17	1197.18	1102.99	905.29	1256.13	942.38
9	1690.19	1307.85	1206.23	990.02	1433.48	1075.43
8	1803.19	1395.28	1287.79	1056.97	1587.83	1191.23
7	1889.70	1462.23	1350.24	1108.23	1715.50	1287.01
6	1953.27	1511.41	1396.12	1145.88	1817.31	1363.39
5	1997.41	1545.57	1427.99	1172.04	1888.00	1416.43
4	2025.66	1567.43	1448.38	1188.77	1933.25	1450.37
3	2041.55	1579.72	1459.85	1198.19	1958.70	1469.46
2	2048.61	1585.19	1464.95	1202.37	1970.01	1477.95
1	2050.38	1586.56	1466.22	1203.42	1972.84	1480.07

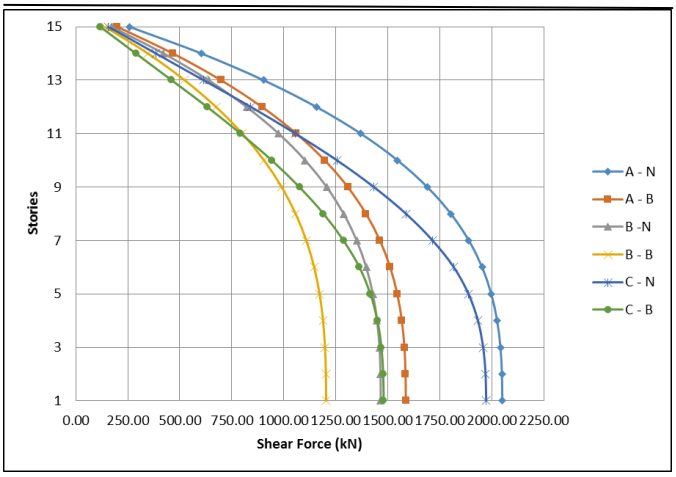


Fig 5.4: Graph showing storey shear forces (kN)

Table 5.5: Storey Forces (kN)

Stories	Building A		Building B		Building C	
	A - N	A - B	B -N	B - B	C - N	C - B
15	256.03	136.29	176.64	106.18	164.90	76.04
14	592.75	330.06	423.35	266.49	385.98	188.84
13	844.45	499.07	602.35	402.07	565.46	298.68
12	1018.65	642.03	723.36	512.15	711.18	404.34
11	1149.57	764.69	816.91	603.46	841.72	504.64
10	1265.63	874.07	902.99	683.75	978.18	606.41
9	1374.73	974.30	982.33	757.13	1111.05	709.34
8	1476.45	1066.99	1054.04	824.83	1240.82	815.60
7	1571.42	1153.32	1122.26	887.75	1369.08	923.13
6	1659.24	1234.25	1187.18	946.70	1498.95	1033.27
5	1742.02	1310.00	1246.79	1001.61	1613.49	1135.32
4	1829.44	1381.05	1307.23	1052.80	1720.69	1228.77
3	1925.42	1449.69	1374.76	1102.75	1830.96	1315.99
2	2009.36	1518.49	1436.07	1153.82	1926.83	1399.92
1	2048.89	1584.48	1465.40	1202.08	1972.31	1477.55

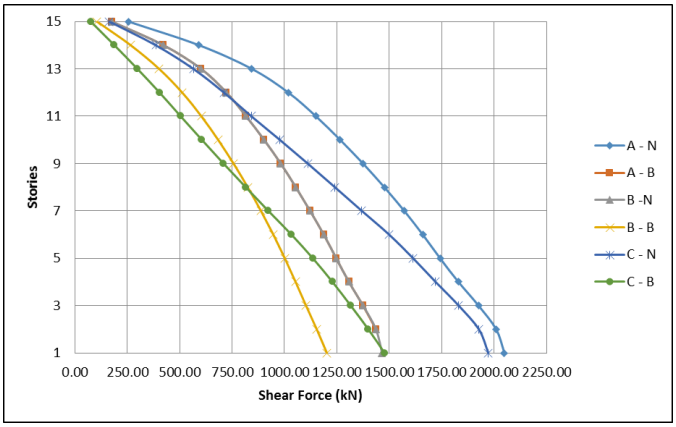


Fig 5.5: Graph showing storey shear forces (kN)

OBSERVATIONS:

1. It is observed that the storey forces are lesser for static method when compared to the response spectrum method.
2. When isolators were introduced in the structure the storey forces greatly reduced when compared to fixed base structure.
3. The storey forces greatly reduced in vertical irregular structure when compared to both regular and plan irregular structure for both static as well response spectrum method.
4. It is observed that on comparing fixed to base isolated structure by static method the Storey Force at the top storey level is reduced by 29% for regular building, 22% for plan irregular building and 33% for vertical irregular building.

5.It is observed that on comparing fixed to base isolated structure by response spectrum method the Storey Force at the top storey level is reduced by 1.87 times for regular building, 1.66 times for plan irregular building and 2.16 times in case of vertical irregular building

5.4 STOREY ACCELERATION

Stories	Building A		Building B		Building C	
	A - N	A - B	B -N	B - B	C - N	C - B
15	513.27	272.51	521.14	312.94	1273.72	767.24
14	440.94	252.39	440.14	284.92	1072.6	671.98
13	350.12	224.36	343.49	246.64	836.66	550.03
12	314.21	202.93	316.96	219.59	706.68	463.7
11	337.12	195.71	347.9	214.53	669.85	420.02
10	354.87	195.18	358.15	217.71	635.68	396.23
9	352.84	193.41	347.06	216.99	586.63	371.68
8	350.21	190.94	349.68	214.63	547.51	348.33
7	348.92	189.99	356.97	214.44	520.6	330.52
6	345.03	188.48	347.67	212.95	492.29	314.04
5	356	185.63	348.11	209.21	487.57	296.92
4	380.1	187.03	376.28	211.92	513.26	291.33
3	368.7	195.7	376.43	224.16	499.14	302.08
2	278.87	201.01	290.41	228.81	379.06	308.74
1	121.13	183.63	126.27	200.01	164.88	278.9
0	0	122.68	0	124.54	0	184.91

Table 5.6: Storey Acceleration (mm/s²)

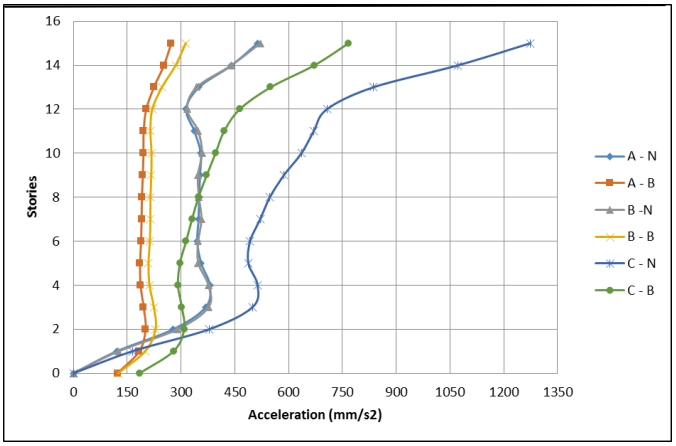


Fig 5.6: Graph showing variation of acceleration (mm/s^2) at different storey levels

OBSERVATIONS:

1. The storey acceleration for a base isolated structure is lesser compared to non-isolated structure.
2. Acceleration at ground level is zero in case of fixed structure when compared to base isolated structure which has got some acceleration.
3. It was observed that the variation of acceleration in case of regular and plan irregular is same here as in case of vertical irregular structure the acceleration is more.
4. It is observed that on comparing fixed to base isolated structures the acceleration at the top storey level reduces by 1.88 times in case of regular
Structure, 1.66 times for plan irregular structure and 1.66 times for vertical irregular structure.
5. There is linear variation of acceleration in case regular building and plan irregular building but there is great variation in case of vertical irregular structure.

6. CONCLUSIONS

1. Base isolated structure is better when compared to non-isolated structure due to the response of the base isolated structure.
2. From interpretation of results, it can be concluded that when base isolators added to the structure it decouples the building from sub structure to super structure and hence provided resistance towards earthquake forces.
3. The base isolation technique is one of excellent seismic control device which controls the response of the structure in terms of displacement, shear force, storey acceleration and natural period in comparison to non-isolated structure.
4. Due to installation of base isolators at the base of the structure there will be great change in the natural period of the structure due to which there is transition of period takes place from acceleration zone to displacement zone hence making the structure flexible.
5. It is concluded that by implementing base isolation technique, it will reduce the response of the structure and thus controlling the structural damages caused by earthquake forces.
6. It is concluded that base isolation is preferable to low to medium rise structures because of increasing in period of structure the displacement will not be within its limit in such cases it is better to adopt some other strengthening technique.
7. It is concluded that irregularity in plan is acceptable compared to vertical irregularity in case of base isolation technique as we observed that there is large displacement and also storey acceleration.
8. It is concluded that the results obtained by response spectrum are more significant as compared to that of equivalent static method.
9. Also it is concluded that the reduction in storey shear is large in case of plan irregular than in vertical irregular structure.
10. Finally it can be concluded that plan irregular building will perform better under influence of seismic forces than vertical irregular building hence the base isolation technique is more suitable for regular and plan irregular building.

REFERENCES

1) Omkar Sonawane and Swapnil B. Walzade, "Effect of Base Isolation in Multi-storeyed RC Regular and Irregular Building using Time Historey Analysis" International Journal of Engineering Research & Science (IJOER) (2018).
2) Sunita Tolani and Dr. Ajay Sharma, "Effectiveness of Base Isolation Technique and Influence of Isolator Characteristics on Response of a Base Isolated Building", American Journal of Engineering Research (AJER) (2016).
3) Stefano Sorace and Gloria Terenzi, "Analysis, Design, and Construction of a Base-Isolated Multiple Building Structure", Hindawi Publishing Corporation (2014).
4) Amroyni Farissi and Bambang Budiono, "Design and Analysis of Base Isolated Structures", Research Gate (2013).
5) A. B. M. Saiful Islam, Syed Ishtiaq Ahmad, Mohammed Jameel and Mohd Humaat Zamrin," Seismic Base Isolation for Buildings in Regions of Low to Moderate Seismicity: *Practical Alternative Design"*, American Society of Civil Engineers (ASCE) (2012).
6) E. Aydin, B. Ozturk and O.F.Kilinc, "Seismic Response of Low-Rise Base Isolated Structures", 15th WCEE, (2012).
7) M. K. Sharbatdar, S.R.Hoseini Vaez, G. Ghodrati Amiri and H. Naderpour, "Seismic Response of Base-Isolated Structure with LRB and FPS under near Fault Ground Motions", ELSEVIER (2011).
8) Vojko Kilar and David Koren, "Seismic behaviour of asymmetric base isolated structures with various distributions of isolators", ELSEVIER (2009).

9) Tian Xue Min and Lu Ming, "Design of Base-Isolated Structure with Rubber-Bearing", 14th WCEE, (2008).
10) Sarvesh K. Jain and Shashi K. Thakkar, "Application of Base Isolation for Flexible Buildings", 13th WCEE, (2004).

BIOGRAPHIES

Ashish A. Hukkeri, P.G student, Dept. of Civil Engineering, S.G.Balekundri Institute of Technology, Belagavi, Karnataka, India.

Parasharam Sawant, Assistant Professor, Dept. of Civil Engineering, S.G.Balekundri Institute of Technology, Belagavi, Karnataka, India.