Seismic Performance Comparison of Fixed-Base Verses A Base Isolated Building

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Abstract *- The topic of this project is base isolation. The purpose of this project is to offer a relative understanding of the seismic performance enhancements that a typical steel office building can achieve through the implementation of base isolation technology. To reach this understanding, the structures of a fixed-base office building and a base-isolated office building of similar size and layout will be designed, their seismic performance will be compared.*

Keywords - Base isolation, lead-rubber bearing, reinforced concrete building, time period, floor displacement, story drift, base shear.

I. INTRODUCTION

GENERAL INTRODUCTION TO EARTHQUAKE:

The structures constructed with good techniques and machines in the recent past have fallen prey to earthquakes leading to enormous loss of life and property and untold sufferings to the survivors of the earthquake hit area, which has compelled the engineers and scientists to think of innovative techniques and methods to save the buildings and structures from the destructive forces of earthquake. The earthquakes in the recent past have provided enough evidence of performance of different type of structures under different earthquake conditions and at different foundation conditions as a food for thought to the engineers and scientists. This has given birth to different type of techniques to save the structures from the earthquakes. Base isolation concept was coined by engineers and scientists as early as in the year 1923 and thereafter different methods of isolating the buildings and structures from earthquake forces have been developed world over. Hundreds of buildings are being built every year with base isolation technique in these countries. This paper describes the development of base isolation techniques and other techniques developed around the world. As of now, in India, the use of base isolation techniques in public or residential buildings and structures is in its inception and except few buildings like hospital building at Bhuj, experimental building at IIT, Guwahati, the general structures are built without base isolation techniques. National level guidelines and codes are not available presently for the reference of engineers and builders. Engineers and scientists have to accelerate the pace of their research work in the direction of developing and constructing base isolated structures and come out with solutions which are simple in design, easy to construct and cost effective as well. Many significant advantages can be drawn from buildings provided with seismic isolation. The isolated buildings will be safe even in strong earthquakes. The response of an isolated structure can be ½ to 1/8 of the traditional structure. Since the super structure will be subjected to lesser earthquake forces, the cost of isolated structure compared with the cost of traditional structure for the same earthquake conditions will be cheaper. The seismic isolation can be provided to new as well as existing structures. The buildings with provision of isolators can be planned as regular or irregular in their plan or elevations. Researchers are also working on techniques like tuned mass dampers, dampers using shape memory alloys etc.

1.1. BASE ISOLATION

The concept of base isolation is explained through an example building resting on frictionless rollers. When the ground shakes, the rollers freely roll, but the building above does not move. Thus, no force is transferred to the building due to shaking of the ground. Now, if the same building is rested on flexible pads that offer resistance against lateral movements, then some effect of the ground shaking will be transferred to the building above. If the flexible pads are properly chosen, the forces induced by ground shaking can be a few times smaller than that experienced by the building built directly on ground, namely a fixed base building. The flexible pads are called base-isolators, whereas the structures protected by means of these devices are called base isolated buildings. In this project the lead–rubber bearings (LRB) is used as a base isolator and the performance is compared with the same building without base isolator.

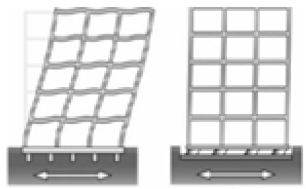

Fig-1: Fixed base and isolated base

II. MODELING OF STRUCTURE IN E-TABS

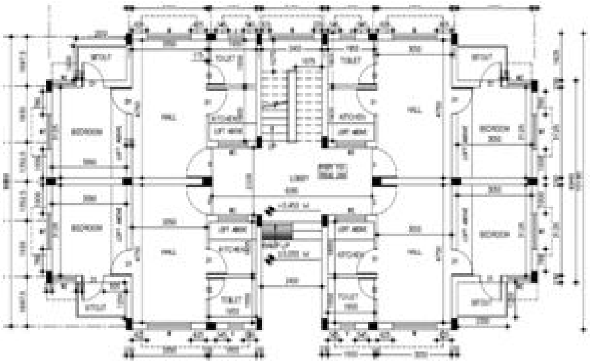

Fig-2: Building Plan

The proposed Residential building is with 12 stories located in zone 2

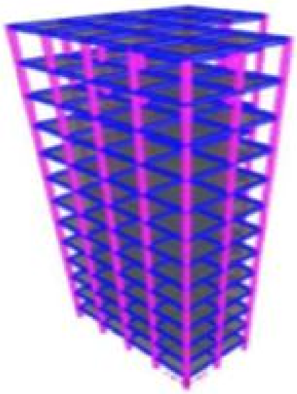

Fig-3: Three-Dimensional view of Fixed Base

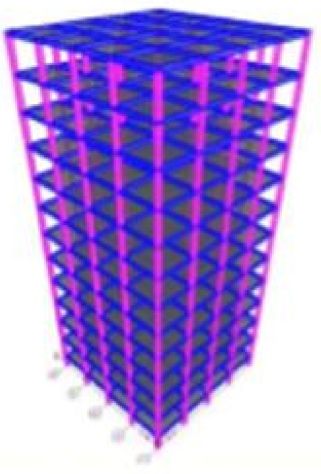

Fig-4: Model of Base Isolated Symmetric Building

III. COMPARISION OF DIFFERENT MODELS OF BUILDING

The Models are given no's to identify it further:

Type 1- Fixed base model
Type 2- Base isolated model

After the analysis is completed, results are extracted. The response of different structures will be tabulated from ETAB software. The regular model and base isolated model were also studied for different load cases and combinations. The response spectrum analysis is carried out to compare with equivalent static analysis for various parameters like displacement, drift, time period and base shear.

1. Displacement of Building (Equivalent Static Analysis) – EQX

The displacement in mm for earthquake in X direction for different story are resulted as below

Table-1: Displacements –EQX

STOREY	MODEL 1	MODEL 2
12	40.1	272.1
11	39.2	272.3
10	37.7	273.8
9	35.5	275.7
8	32.8	278.0
7	29.7	280.5
6	26.2	283.2
5	22.4	285.9
4	18.5	288.6
3	14.4	291.0
2	10.3	293.1
1	6.3	294.6
0	0.0	0.0

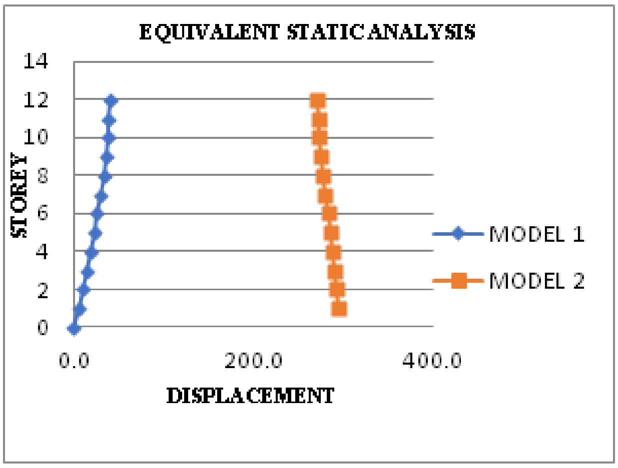

Fig-5: Comparison of story v/s displacement in X direction

2. Study of Inter Story Drift (Equivalent Static Analysis)-EQX

Table-2: Inter Story Drift

STOREY	MODEL 1	MODEL 2
12	0.00033	0.00033
11	0.00051	0.00049
10	0.00072	0.00064
9	0.00090	0.00076
8	0.00105	0.00085
7	0.00118	0.00090
6	0.00127	0.00091
5	0.00133	0.00088
4	0.00137	0.00081
3	0.00139	0.00069
2	0.00138	0.00052
1	0.00131	0.00034
0	0.00000	0.00000

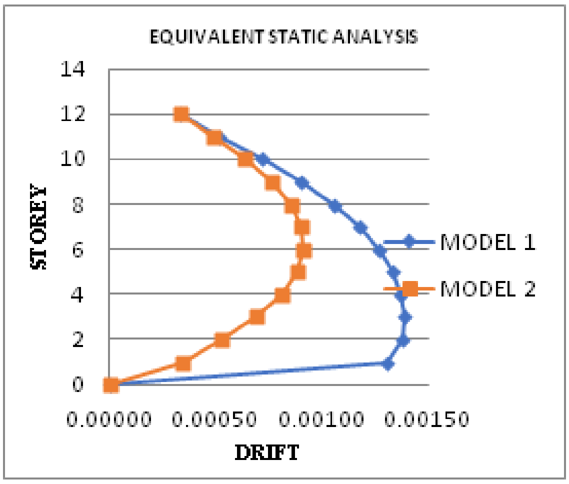

Fig-6: Comparison of Story v/s story drifts in X direction

3. Time Period (Equivalent Static Analysis): The table below shows that the different time periods for various models of earthquake in X direction

Table-3: Time Period

MODE NUMBERS	MODEL 1	MODEL 2
1	2.38	0.00
2	2.16	0.00
3	2.13	0.00
4	0.73	1.35
5	0.69	1.08
6	0.67	1.04
7	0.40	0.50
8	0.39	0.47
9	0.38	0.46
10	0.27	0.31
11	0.26	0.30
12	0.26	0.29

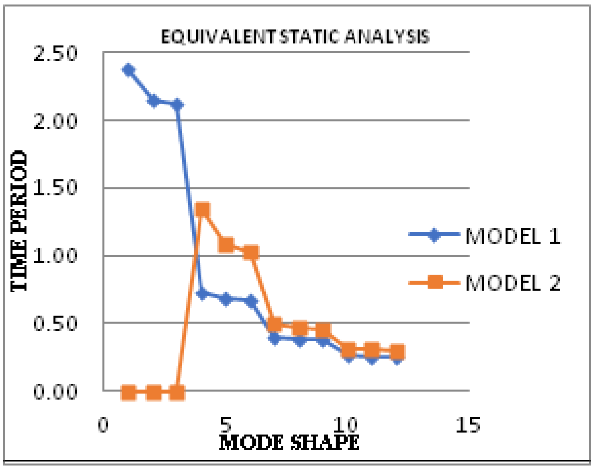

Fig-7: Comparison of mode numbers v/s time period

4. Study of Base Shear (Equivalent Static Analysis): The table below shows different base shear values for different models

Table-4: Base Shear

BASE SHEAR	
MODEL 1	MODEL 2
774.25	8.58

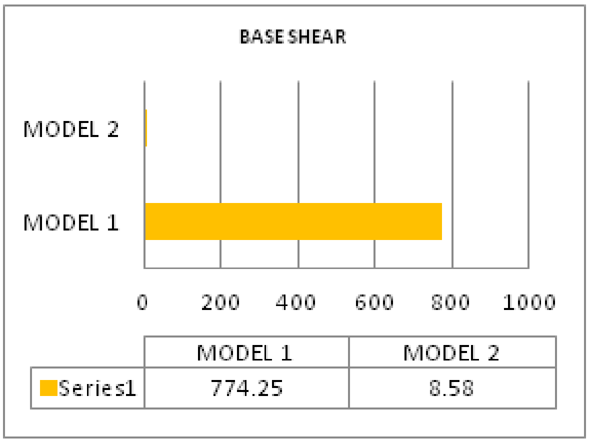

Fig-8: Comparison of base shear v/s models

5. Displacement of Building (Equivalent Static Analysis): The displacement in mm for earthquake in Y direction for different story are resulted as below

Table-5: Displacements –EQY

STOREY	MODEL 1	MODEL 2
12	50.6	261.2
11	48.7	263.2
10	46.0	266.0
9	42.5	269.2
8	38.2	272.8
7	33.4	276.7
6	28.2	280.7
5	23.3	284.8
4	18.4	288.7
3	13.6	292.3
2	9.2	295.5
1	5.1	298.1
0	0.0	0.0

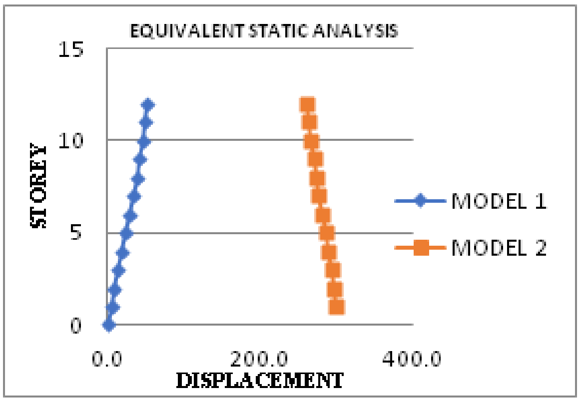

Fig-9: Comparison of story v/s displacement in Y direction

6. Study of Inter Story Drift (Equivalent Static Analysis)-EQY

Table-6: Inter Story Drift -EQY

STOREY	MODEL 1	MODEL 2
12	0.00079	0.00084
11	0.00094	0.00094
10	0.00121	0.00110
9	0.00144	0.00123
8	0.00163	0.00132
7	0.00176	0.00136
6	0.00162	0.00137
5	0.00165	0.00132
4	0.00162	0.00123
3	0.00147	0.00109
2	0.00137	0.00088
1	0.00115	0.00075
0	0.00000	0.00000

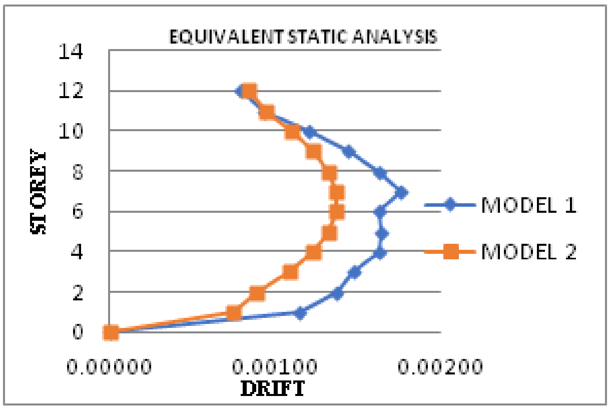

Fig-10: Comparison of Story v/s Story drifts in Y direction

7. Studies on Displacement (Response Spectrum Analysis): The displacement in mm for earthquake in X direction for different story are resulted as below

Table-7: Displacements –SPECX

STOREY	MODEL 1	MODEL 2
12	32.1	113.1
11	31.5	111.7
10	30.3	111.8
9	28.5	112.1
8	26.2	112.4
7	23.5	112.8
6	20.5	113.2
5	17.7	113.7
4	14.6	114.2
3	11.3	114.6
2	8.2	115.1
1	4.9	115.4
0	0.0	0.0

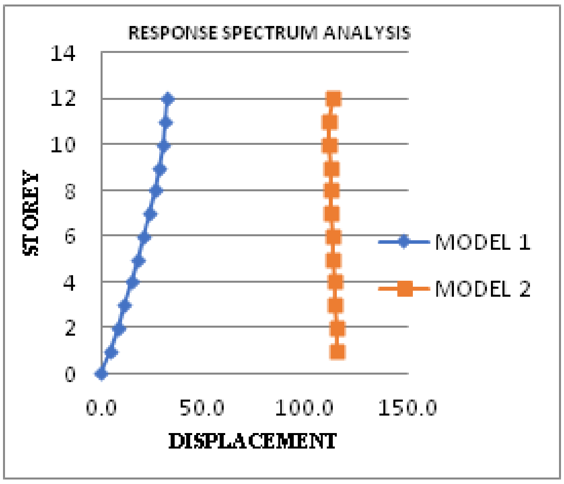

Fig-11: Comparison of story v/s displacement for different models in X direction

8. Study of Inter Story Drift (Response spectrum Analysis) - The results of Different model with different story is compared as follows

Table-8: Inter Story Drift-SPECX

STOREY	MODEL 1	MODEL 2
12	0.00030	0.00005
11	0.00052	0.00007
10	0.00076	0.00009
9	0.00094	0.00011
8	0.00107	0.00013
7	0.00117	0.00015
6	0.00102	0.00016
5	0.00109	0.00017
4	0.00115	0.00017
3	0.00108	0.00015
2	0.00111	0.00012
1	0.00105	0.00007
0	0.00000	0.00000

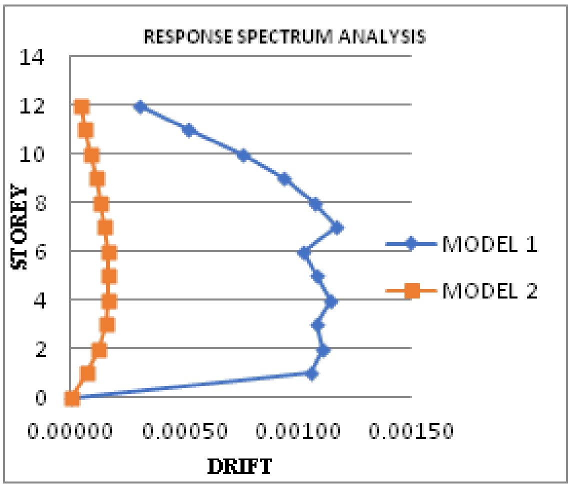

Fig-12: Comparison of Story v/s Story drifts for different models in X direction

9. Studies on Displacement (Response Spectrum Analysis)- The displacement in mm for earthquake in X direction for different story are resulted as below

Table-9: Displacements –SPECY

STOREY	MODEL 1	MODEL 2
12	40.6	120.7
11	39.2	121.0
10	37.2	121.4
9	34.6	122.0
8	31.5	122.5
7	28.0	123.2
6	24.1	123.9
5	20.4	124.7
4	16.6	125.4
3	12.6	126.2
2	8.7	126.9
1	4.9	127.4
0	0.0	0.0

Table-10: Inter Story Drift-SPECY

STOREY	MODEL 1	MODEL 2
12	0.00068	0.00014
11	0.00084	0.00016
10	0.00108	0.00019
9	0.00125	0.00021
8	0.00138	0.00024
7	0.00146	0.00026
6	0.00133	0.00027
5	0.00137	0.00028
4	0.00139	0.00027
3	0.00130	0.00025
2	0.00127	0.00021
1	0.00110	0.00016
0	0.00000	0.00000

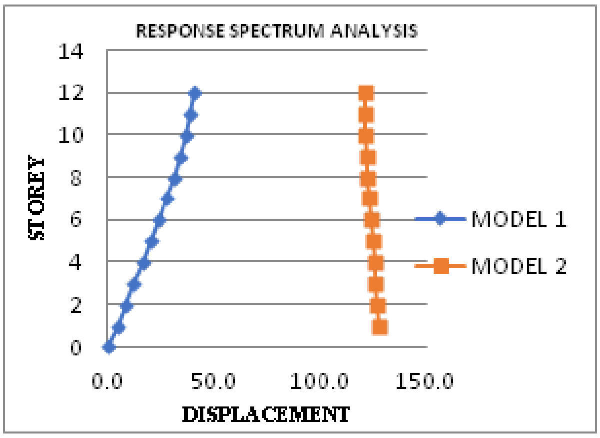

Fig-13: Comparison of story v/s displacement for different models in Y direction

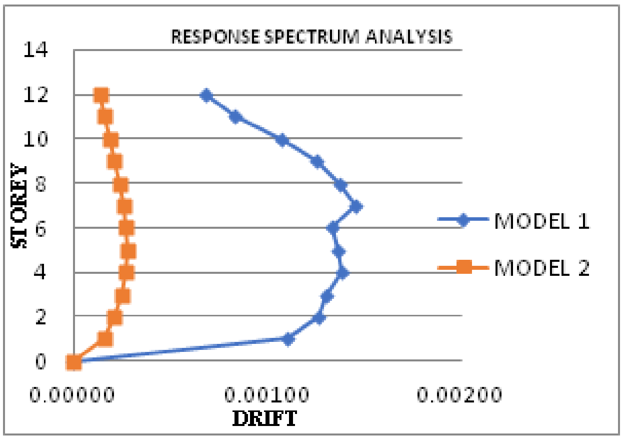

Fig-14: Comparison of Story v/s Story drifts for different models in Y direction

10. Study of Inter Story Drift (Response spectrum Analysis) The results of Different model with different story is compared as follows

IV. CONCLUSION

Response spectrum analysis has less displacement compared to equivalent static methods analysis. Building provided with base isolator has more displacement than compared to fixed base. Base shear is reduced in base isolated building, thus seismic response of building of building with base isolator is better than fixed base. Building provided with base isolator has less story drift than compared to fixed. Base isolator is found significantly efficiently effective mitigating and preventing for seismic performance of proposed building

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