Design and Analysis of Plan Symmetrical & Asymmetrical Building with or Without Base Isolation

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Abstract— Earthquake resistant structures are kind of structures which are designed to protect buildings against collapsing due to effect of earthquake; while structure can be entirely immune to damage from earthquakes, the goal of earthquake-resistant construction is to erect structures that fare better during seismic activity than their conventional counterparts. According to various building codes, earthquake resistant Buildings are intend to with stand the largest earthquake of a certain probability that is likely to occur at their position. This means that the loss of people should be reduced or minimized by preventing collapse of the buildings for rare earthquakes while the loss of the functionality should be limited for more frequent ones. In this report, Base Isolation is used for the construction of earthquake resistant building. Base isolation is that type of system which decreases the effect of earthquake in terms of displacement, base shear and in many others terms. Base isolation system consists of isolators which are used to reduce the effects of earthquake. At present time, the magnitude of earthquake is very high. In this thesis report, we consider Seismic Zone-IV for G+14 building for the evaluation of Time period, base shear and displacement with considering 4 models in ETAB software i.e. fixed base and isolated base. Base isolation is type of method generally known as a-state of-the-art method in which the structure above ground level, the structure is separated from the base below ground level by introducing a suspension system between the main structure and the base. This phenomena Base isolation is popularly termed as seismic isolation system which is a collection of structural elements which should substantially decouple a structure above ground level from its structure below ground level resting on a shaking ground thus protecting the building's structural integrity. The fundamental principle of this phenomena i.e. base isolation is to modify the response of the building so that the ground can shake below the building without transmitting these motions into the structure. Base isolation system deflects & absorbs the energy released from the earthquake before it is transferred to the structure.

Keywords: Earthquake Resistant Structures, Symmetrical & Asymmetrical Building, ETAB Software, Lead Rubber Bearings (LRB)

I. INTRODUCTION

An earthquake is a shaking movement of the ground, caused by the slippage or rupture of a fault within the Earth's crust. A sudden rupture or slippage along fault line results in an abrupt i.e. release of elastic energy stored in rocks. This rocks are subjected to great strain also this energy can be stored and built up over a very long time and then released in seconds or minutes.

Strain present on the rocks results in more elastic energy being stored which leads to far greater possibility of an earthquake event. The release of energy suddenly during earthquake causes low-frequency sound waves known as seismic waves to propagate along the surface of earth or through Earth's crust. Many of Hundreds people have been killed due to earthquakes despite scientists being able to forewarn and predict in advance & engineers construct earthquake-safe buildings.

Unfortunately earthquakes occur often in the countries which are unable to afford earthquake-safe construction due to lack of funds availability with them. Every year more than 3.2 million earthquakes occurs, most of these earthquakes unnoticed by humans. In contrast, a severe earthquake is most catastrophic and frightening event of nature which can occur anywhere on the surface of Earth. Although lasting only seconds, a severe earthquakes in densely populated area may have catastrophic and hazards effects causing death of hundreds of thousands of people, injuries, enormous and destruction damage to the economies of the affected area.

It is also a sudden shaking movement of the surface of the earth. It is known as a quake, trembler or tremor. Earthquakes ranges in size from that are so weak that they can't be felt to those violent enough to toss or kill people around the planet and destroy whole cities of cities. The seismic activity or seismicity of an area refers to the frequency, size and type of earthquakes experienced over a period of time. So far, there have been sixty-two earthquakes in India.

The first recorded earthquake in India was on 6th June 1505. This earthquake occurred in Saldang in Karnali zone. And the most recent one earthquake happened in India on 31st January 2018 and occurred in Kashmir, Pakistan, Afghanistan, and Tajikistan. An earthquake is measured in Richter's scale. A seismometer is a device that detects the vibrations caused by an earthquake. It plots these vibrations on a graph named seismograph. The magnitude or strength of an earthquake is measured using Richter scale. Earthquakes measuring on the Richter scale around 7 or 8 can be devastating.

II. STRUCTURES

Structure is a permanent shelter or connection which is made of materials like concrete, steel or many more metals with or without continuity is termed as structure. Additionally, because such structures are now required to perform longer than mandated by their original design, many are now woefully obsolete. Clear understanding of the condition of structures is crucial, from the points of view of both economy and safety. This chapter describes some types of structures according to their orientation.

A. Types of Structures (According to Orientation)

There are many kinds of structures which are according to shape, size materials used, orientation etc. But in our analysis report the type of structure is according to orientation which are given as follows-

1) Symmetrical Structures
2) Asymmetrical Structures

1) Symmetrical Structure:

The Symmetry is defined as the balanced distribution and arrangement of equipment of equivalent forms and spaces on opposite sides of a dividing line or plane, or about a center or axis. While an axial condition can exist without a symmetrical condition being simultaneously present, a symmetrical condition cannot exist without implying the existence of the axis or center about which it is structured.

The axis is established by two points; a symmetrical design or condition requires the balanced arrangement of equivalent patterns of form and space on opposite sides of a dividing line or plane, or about a center or axis. To understand the symmetry, it is simply one shape that is flipped exactly like another.

In architecture, the symmetry refers to the geometry of a building, as the building is same on either side of the axis i.e. on x-axis & y-Axis. The symmetry is of two kinds named Bilateral and Radial and these are commonly used in architecture by creating two sides as mirror images of each other, and can be vertical i.e. up and down axis or can be horizontal i.e. across the axis.

2) Asymmetrical Structure:

Asymmetry is the absence of continuity along the axis or up and down side of axis, or a violation of, symmetry (the property of an object being invariant to a transformation, such as reflection). Symmetry is an important property of both abstract & physical systems and it may be displayed in aesthetic terms or in more precise terms. The absence of or violation of symmetry that are either desired or expected can have so important consequences for a system. Something asymmetrical has two sides unmatched i.e. that don't match — it's out of whack or uneven. If you know the concept that symmetrical means that both sides of something are identical, and then it should be easy to learn that asymmetrical means the opposite: the two sides are different in some way.

III. LITERATURE REVIEW

A. Base Isolation and its Concept:

Base isolation is defined as a state-of-the-art method in which the structure (structure above ground level) is separated from the base (foundation or structure below ground level) by introducing a suspension system between the main structure and the base.

In the context of seismic design of the structures base isolation can be replaced with seismic isolation that means the structure above the ground, which is most affected during shaking of ground due to earthquake is separated from the effects of earthquake forces by introducing a mechanism that will help the structure to hover. The concept of the base isolation is quite easy to grasp. It can be explained as a bird flying during an earthquake is not affected. In simple language if structure is floating on its base, the movement of ground will have no effect on the structure.

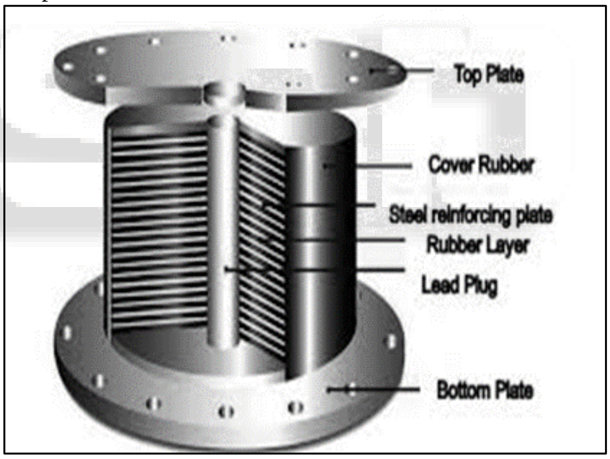
Earthquake and Wind are the most predominant loads that demands lateral design of a structure. Again, earthquake load is not controllable as well it is not practical to design a structure for an indefinite seismic demand. Only practical approach is left to accept a demand and make sure the capacity is more than the demand. The inertial force caused due to earthquake is directly proportional to the mass of structure and the ground acceleration.

Increasing ductility of any structure/building or increasing the elastic strength of the structure is the most conventional method of handling seismic demand. Every Engineer has to increase the capacity exceed the demand. The basic principle behind the concept of base isolation is that the response of the structure or a building is modified such that the sub structure is capable of moving without transmitting minimal or no motion to the super structure i.e. structure above the ground.

Conventionally, earthquake design of building structures is based on the concept of increasing the resistance capacity of the structures against earthquakes by employing, for example, the use of shear walls, braced frames, or moment-resistant frames. However, these traditional methods often result in high floor accelerations for stiff buildings, or large inter story drifts for flexible buildings.

B. Lead Rubber Bearings (LRB):

They are similar to NRB, but contain Lead core. The steel shims confine that the lead plug and force it to deform in shear. Along with this deformation, dissipation of energy takes place.



C. Response Spectrum Method:

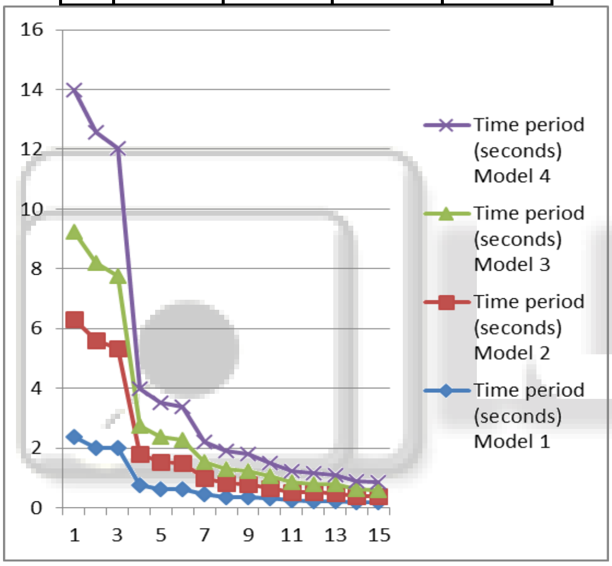
In order to design of a structure and perform seismic analysis to be built at a particular location, the actual time history record is required. However, it is unable to have such records at each and every location. The seismic analysis of structures cannot carried out by simply based on the peak value of the ground acceleration. As response of the structure depend upon the frequency content of ground motion as well its own dynamic properties. To overcome the above difficulties, earthquake response spectrum is most popular tool in the seismic analysis of structures. There are many computational advantages in using of response spectrum method of seismic analysis for prediction of member forces and displacements in structural systems. The method involves calculation of only the member forces and highest values of the displacements in each mode of vibration using smooth design spectra that are the average of several earthquake motions.

IV. RESULTS & CONCLUSIONS

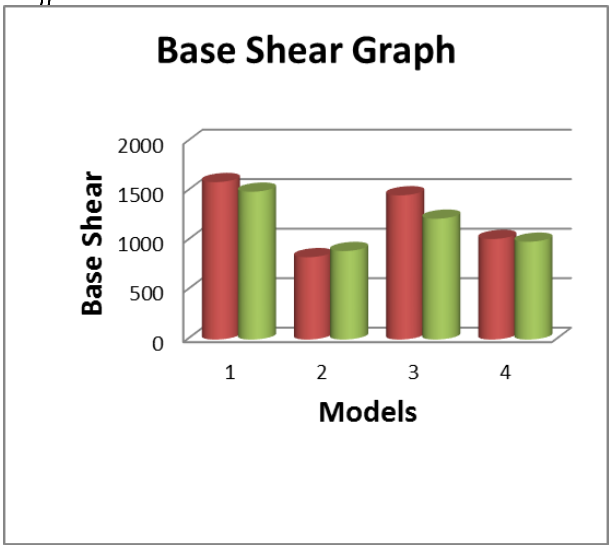
A. Results & Discussion:

1) Time Period Comparison for different modes:

	Time period (seconds)			
	Model 1	Model 2	Model 3	Model 4
1	2.379	3.935	2.916	4.771
2	1.994	3.61	2.608	4.347
3	1.987	3.339	2.442	4.267
4	0.765	1.043	0.93	1.253
5	0.634	0.914	0.828	1.134
6	0.625	0.888	0.767	1.096
7	0.445	0.55	0.541	0.665
8	0.359	0.462	0.473	0.597
9	0.347	0.457	0.428	0.56
10	0.308	0.365	0.374	0.442
11	0.24	0.297	0.32	0.389
12	0.232	0.289	0.281	0.355
13	0.228	0.267	0.281	0.323
14	0.184	0.21	0.234	0.278
15	0.174	0.208	0.221	0.25



2) Comparison of Storey Displacement in X & Y direction for different models:



3) Comparison of Base Shear in different models in both directions:

Storey displacement in X-direction				
Story displacement (mm)				
No. of Stories	Model 1	Model 2	Model 3	Model 4
14	31.663	96.816	37.987	80.508
13	30.752	96.103	36.982	79.713
12	29.766	94.942	35.534	78.602
11	28.345	93.279	33.597	77.073
10	26.491	91.082	31.216	75.132
9	24.257	88.371	28.454	72.8
8	21.709	85.186	25.377	70.107
7	18.911	81.571	22.048	67.08
6	15.925	77.569	18.527	63.748
5	12.808	73.223	14.869	60.135
4	9.619	68.562	11.137	56.254
3	6.438	63.589	7.423	52.093
2	3.417	58.236	3.914	47.587
1	0.934	52.181	1.061	42.445
0	0	46.574	0	37.28

Storey displacement in Y-direction				
Story displacement (mm)				
No. of Stories	Model 1	Model 2	Model 3	Model 4
14	36.411	117.344	44.457	99.353
13	35.817	116.48	43.492	98.401
12	34.877	115.196	41.896	96.854
11	33.36	113.138	39.705	94.7
10	31.315	110.307	37.003	91.973
9	28.826	106.758	33.873	88.786
8	25.975	102.551	30.295	85.167
7	22.836	97.75	26.636	81.102
6	19.476	92.413	22.66	76.63
5	15.953	86.601	18.522	71.788
4	12.316	80.365	14.269	66.604
3	8.613	73.738	9.949	61.089
2	4.915	66.668	5.644	55.176
1	1.502	58.421	1.707	48.205
0	0	48.695	0	39.601

4) Comparison of Storey Acceleration in both directions for different models:

Storey acceleration in X-direction				
No. of Stories	Storey acceleration (m/sec2)			
	Model 1	Model 2	Model 3	Model 4
14	0.67094	0.33625	0.34173	0.20114
13	0.39897	0.31601	0.26666	0.18593
12	0.32263	0.29442	0.24013	0.17291
11	0.28694	0.27411	0.2358	0.16381
10	0.27434	0.25834	0.24116	0.15883
9	0.27756	0.24797	0.24719	0.15645
8	0.28942	0.24175	0.25113	0.15468
7	0.30345	0.23789	0.2548	0.15228
6	0.31681	0.23544	0.26092	0.14932
5	0.32449	0.23476	0.26911	0.14699
4	0.32432	0.23671	0.27561	0.14688
3	0.30737	0.24131	0.27046	0.14965
2	0.27265	0.24623	0.2489	0.15395
1	0.18852	0.24736	0.18169	0.15656
0	0	0.2427	0	0.15566

Story acceleration in Y-direction				
No. of Stories	Storey acceleration (m/sec2)			
	Model 1	Model 2	Model 3	Model 4

14	0.52729	0.32769	0.29102	0.20158
13	0.33079	0.3025	0.22988	0.18756
12	0.27035	0.27982	0.20525	0.17442
11	0.24449	0.2581	0.20673	0.16566
10	0.24249	0.24349	0.21707	0.16117
9	0.24961	0.23647	0.22422	0.15843
8	0.25653	0.23351	0.22548	0.15596
7	0.26164	0.23094	0.22467	0.15337
6	0.26795	0.22743	0.22805	0.15091
5	0.27717	0.22453	0.23902	0.1488
4	0.28791	0.22522	0.25363	0.1481
3	0.29076	0.23111	0.26207	0.14998
2	0.27303	0.23908	0.25266	0.1537
1	0.22577	0.23933	0.2174	0.15363
0	0	0.24631	0	0.14759

5) Comparison of Storey Drift in both directions for different models:

Storey Drift in X-direction				
No. of Stories	Storey Drift (m/sec^2)			
	Model 1	Model 2	Model 3	Model 4
14	0.000206	0.000239	0.000335	0.000272
13	0.00033	0.000388	0.000484	0.000391
12	0.000474	0.000555	0.000646	0.00053
11	0.000618	0.000732	0.000794	0.000669
10	0.000745	0.000903	0.000921	0.0008
9	0.000849	0.00106	0.00102	0.000921
8	0.000933	0.0012	0.00111	0.00103
7	0.000995	0.00133	0.00117	0.00113
6	0.001039	0.00144	0.00121	0.00122
5	0.00106	0.00155	0.00124	0.00131
4	0.00106	0.00165	0.00123	0.00141
3	0.001008	0.00179	0.00117	0.00153
2	0.000828	0.00203	0.000953	0.00176
1	0.000374	0.00274	0.000425	0.00236
0	0	0	0	0

Storey Drift in Y-direction				
No. of Stories	Storey Drift (m/sec^2)			
	Model 1	Model 2	Model 3	Model 4
14	0.000198	0.000288	0.000322	0.000318
13	0.000313	0.000428	0.000532	0.000515
12	0.000506	0.000686	0.00073	0.000718
11	0.000682	0.000944	0.000901	0.000909
10	0.00083	0.00118	0.00104	0.00125
9	0.00095	0.0014	0.00116	0.00125
8	0.001046	0.0016	0.00125	0.00139
7	0.00112	0.00177	0.00132	0.00153
6	0.00117	0.00193	0.00137	0.00165
5	0.00121	0.00207	0.00141	0.00177
4	0.00123	0.0022	0.00144	0.00188
3	0.00123	0.00236	0.00143	0.00201
2	0.00113	0.00276	0.00131	0.00238
1	0.000601	0.00501	0.000683	0.00434
0	0	0	0	0

6) Comparison of Storey stiffness in both directions for different models:

Storey stiffness in X-direction				
No. of Stories	Storey Stiffness (KN/M)			
	Model 1	Model 2	Model 3	Model 4
14	23041.3	20013.18	286115	256228
13	132144	113380	374115	348775
12	166329	148809	393015	374177
11	175605	162854	397429	383127
10	178889	168909	398424	387226
9	180459	172427	398634	389584
8	181505	174815	398785	391131
7	182469	176585	399238	392119
6	183686	177877	400516	392425
5	185758	178526	403958	391457
4	190356	177764	413455	387439
3	203024	173606	441714	376752
2	248670	160957	545250	346681
1	664782	166987	1477823	355653
0	0	0	0	0

Storey stiffness in Y-direction				
No. of Stories	Storey Stiffness			
	Model 1	Model 2	Model 3	Model 4
14	18120.97	14101.88	252368	224895
13	116850	103806	289104	271200
12	131090	122530	296781	283435
11	134047	128056	298425	289234
10	135336	130832	299959	292773
9	136124	132575	301058	295250
8	136712	133821	301955	297138
7	137212	134792	302773	298674
6	137691	135593	303595	299964
5	138212	136253	304541	301016
4	138981	136485	306102	301098
3	141222	134975	311246	296975
2	154362	121725	342119	266188
1	352475	96740.45	791077	211479
0	0	0	0	0

V. CONCLUSION

Based on the theoretical and modeling findings, the following conclusions can be drawn:

The main observation comes out from modeling study on the accuracy of lateral load patterns and seismic effect utilized in the Multi-Modal Pushover analysis in prediction of earthquake effect showed that the accuracy of the push over results depends strongly on properties of the structure, the load path, and characteristics of the motions in ground. The plastic hinge location varies by the change in MODAL period and type of loading. It can be located at any point along span of the members or at the end of the member. Drift index and inter-story drift should be predicted using the multi-modal (SRSS) and the elastic first mode with long period for the lateral load pattern which corresponds to the average in most cases. These kind of structures i.e. Base-isolated structure exhibit less lateral deflection. As the lateral displacement at the base is never equals to zero as well less moment values than the fixed base structure. The base isolation decouples the structure from the earthquake-induced load, and maintain long fundamental lateral period than that of the fixed base. The time period of fixed base structure and base isolated structure makes difference that the base isolated structure is more suitable than fixed base structure.

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