BENDING AND SHEAR BEHAVIOUR OF RC BUILDING WITH AND WITHOUT BASE ISOLATION USING NON LINEAR ANALYSIS METHOD

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Abstract

A huge proportion of world's population lives in regions of seismic hazards, at risk from earthquakes of varying severity and frequency of occurrence. Earthquake causes significant loss of life and damage of property every year. So, to mitigate the effect of earthquake on building the base isolation technique is one of the best solutions. Seismic isolation consists of essentially the installation of mechanisms which decouple the structure from base by providing seismic isolators. The seismic isolation system is mounted beneath the superstructure and is referred as 'Base Isolation'. Base isolation is one of the most widely accepted seismic protection systems used in building structures in earthquake prone areas. The base isolation system separates the structure from its foundation and primarily moves it relative to the upper structure. The purpose of this study is to decrease the base shear and column and beam forces and due to earthquake ground excitation, applied to superstructure of the building by installing base isolated devices at the foundation level and then to compare the different concerts between the fixed base condition and base isolated condition by using ETABS 2016v software. In this study, G+14 story RCC building is used as test model. Lead rubber bearing and high damping rubber bearing is used as base isolation structure in this study. Nonlinear time history analysis is used on both fixed and base isolated buildings. Comparative study is contains two portions. They are comparisons between fixed and base isolated buildings and comparative study of performance by two different time history data like El-Centro and Bhuj. Finally displacement and column and beam forces and moments are compared from two time histories analysis between fixed and base isolated condition. It is found that displacement is increased with base isolated building. And beam forces are decreased in base isolated than fixed base building.

Keywords: *Base Isolation, RC Building, Lead Rubber Bearing, High Damping Rubber Bearing, Nonlinear Time History Analysis.*

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1. INTRODUCTION

The earthquakes happen and are uncontrollable. So, in that sense, we have to accept the demand and make sure that the capacity exceeds it. The earth quake causes inertia forces as that ground accelerations increases, the strength of the building, the capacity, must be increased to avoid structural damage. In high seismic zones the accelerations causing forces may exceed one or even two times the acceleration due to gravity. It is easy to visualize the strength needed for the level of load, strength to resist; means than the building could resist gravity applied sideways, which means that the building could be tripped on its side and held horizontally without damage.

The present investigation is conducted to study the following

1. To understand the seismic behavior of RC building with different base isolators in between super structure and substructure.
2. To compare the various parameters with and without isolated building such as
   a. Displacement
   b. Column and beam shear forces
   c. Column and beam bending moments
3. To check effectiveness of different isolators.

2. METHEDOLOGY

2.1 Aim of the Study

The project aims at applying the progressions in the area of earth tremor engineering by providing appropriate isolation bearings to the proposed. RC building to avoid painful loss of life and property in future during probable earth tremor.

2.2 Present Method of Analysis

In this study the performance of a RC Building subjected to severe earth tremor loads was evaluated using NON Linear analyses. Based on the findings from the analysis, a base isolation system was designed for the bridge. The parameters of base isolation system were chosen using the theory of multi degree of freedom dynamic systems. Then base isolation parameters were included into the initial model and the performance of the isolated structure subjected to the same seismic loads was evaluated. The two sets of results were compared and the structural effectiveness of base isolation system for that particular building was discussed. In addition, economic and practical aspects of base isolation systems were discussed and the conclusion with regard to feasibility of the system was drawn based on both structural and economic arguments.

2.3 Time History Analysis

El-Centro earthquake of May 18 in 1940 and time0history data0for North- South component is recorded. The0instrument that0recorded the0accelerogram0was attached to0the El-Centro0terminal substation0buildings0concrete floor0and not in the free0field0location. Magnitude 6.9, Latitude and longitude are 32.733N, 115.5W.

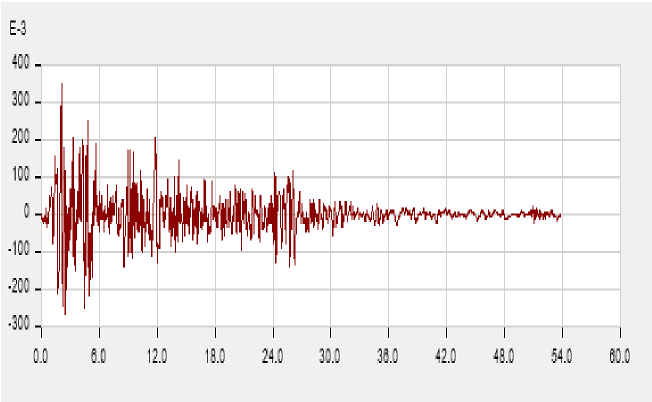

Fig 1- Graph of El-Centro Time History Data

Bhuj earthquake of January 26 in 2001 at 08:46:42.9 IST, Magnitude 7.00mb, 7.60Ms Station:0 Ahmedabad, Latitude and Longitude are 23002 N, 72038 E, accelerogram band pass0filtered between00.7 Hz0and027.0 Hz.

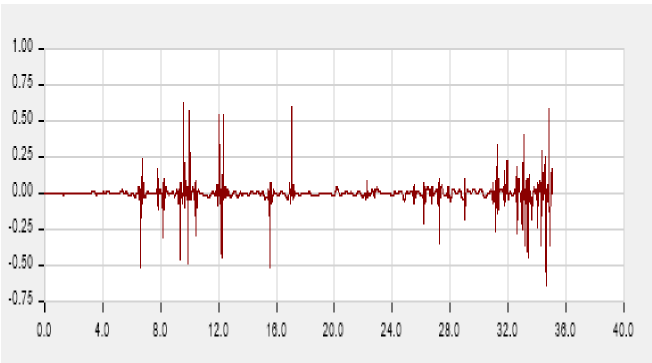

Fig 2- Graph of Bhuj Time History Data

2.4 Model

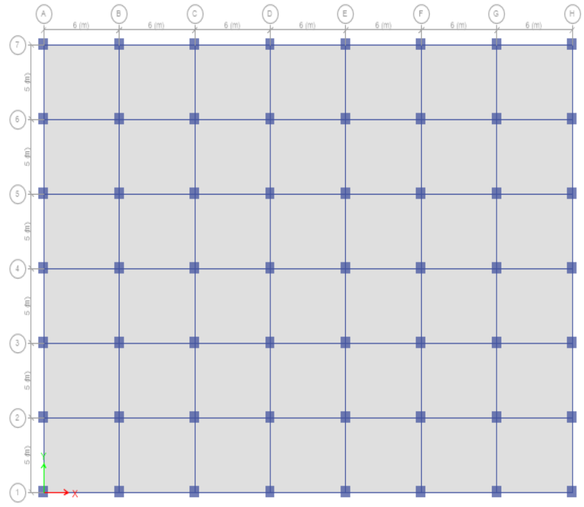

Fig3- Plan

2.5 Building Details

Number of stories	= G+14
C/C distance in X-dir	= 6m
C/C distance in Y-dir	= 5m
Foundation level to ground level	= 3m
Floor to floor height	= 3.2m
Wall thickness	= 200mm
Live load on all floors	= 3kN/m^2
Materials	= M30andFe415
Size of column	=900x900mm
Size of beam	= 300x600mm
Depth of slab	= 150mm
Seismic zone i.e, Z	= 0.24

3. ANALYSIS

For the successful design of isolating system modal analysis of non-isolated building is needed. Number of analysis for a non-isolated building is performed using ETABS software. The main aim of this is to study the displacements, forces and moments in the building under seismic loads.

Table 1- Dimensions of LRB

Dimensions of LRB:	
Diameter of the bearing, D	100 cm
Total height of the bearing, h	61.5 cm
Number of rubber layers, N	33
Thickness of individual layers, t	1.3 cm
Diameter of the lead core, dp	12 cm
Number of steel plates, Ns	32
Thickness of steel plates, ts	0.3 cm
Thickness of top & bottom cover plates	4.5 cm

Table 2- Dimensions of HDRB

Dimensions of HDRB:	
Diameter of the bearing, D	100 cm
Total height of the bearing, h	24.7 cm
Number of rubber layers, N	10
Thickness of individual layers, t	1.3 cm
Number of steel plates, Ns	9
Thickness of steel plates, ts	0.3 cm
Thickness of top and bottom cover plates	4.5 cm

4. RESULTS

The result has been discussed by considering following parameters
1) Displacement
2) Beam shear force and bending moments
3) Column shear force and bending moment

4.1 Displacement

Displacement values are taken from the top story from the time history analysis using both El-Centro and Bhuj time history data and compared with fixed and isolated base building.

Table 3- Displacement at top story

DISPLACEMENT AT TOP STORY						
DIRECTION	**TIME HISTORY**	**FIXED (mm)**	**LRB (mm)**	**REDUCTION (%)**	**HDRB (mm)**	**REDUCTION (%)**
Displacement in X-direction	**El-Centro**	192.71	140.07	27.32	251.42	0
	Bhuj	103.99	128.73	0	159.92	0
Displacement in Y-direction	**El-Centro**	173.68	146.97	15.38	251.39	0
	Bhuj	88.58	136.52	0	168.29	0

From above table 3 it is seen that there is reduction of 27.32 % in the value of displacement in x direction for only El-Cento case only for lead rubber bearing. Therefore the value of displacement increases in base isolated building when compared to fixed base.

4.2 Beam Bending Moment and Shear Force

4.2.1 Beam Shear Forces

Table 4- Beam shear forces

BEAM SHEAR FORCES							
BEAM FORCES	**TIME HISTORY**	**POSITIONS**	**FIXED BASE (kN)**	**LRB (kN)**	**REDUCTION (%)**	**HDRB (kN)**	**REDUCTION (%)**
SHEAR FORCES IN X-DIRECTION	**EL-CENTRO**	**CORNER**	219.93	100.43	54.34	149.21	32.16
		EXTERNAL	232.7	109.6	52.90	162.89	30.00
		INTERNAL	246.57	116.14	52.90	176.77	28.31
	BHUJ	**CORNER**	240.27	102.56	57.31	146.07	39.21
		EXTERNAL	243.74	108.02	55.68	157.57	35.35
		INTERNAL	252.29	114.42	54.65	166.85	33.87
SHEAR FORCES IN Y-DIRECTION	**EL-CENTRO**	**CORNER**	275.49	116.74	57.62	197.6	28.27
		EXTERNAL	286.59	121.34	57.66	208.62	27.21
		INTERNAL	312.12	138.44	55.65	238.01	23.74
	BHUJ	**CORNER**	289.9	133.28	54.03	195.01	32.73
		EXTERNAL	297.94	138.61	53.48	202.6	32.00
		INTERNAL	303.77	149.06	50.93	226.53	25.43

From above table 4 from time history analysis it is seen that beam shear forces in X-direction for both El-Centro and Bhuj time history data the beam shear force for fixed base varies from 219.93 KN to 252.29 KN and the reduction percentage of isolated structure varies from 28.31% to 57.62%.

4.2.2 Beam Bending Moments

Table 5- Column bending moment

BEAM MOMENT	TIME HISTORY	POSITIONS	FIXED BASE (kN-m)	LRB (kN-m)	REDUCTION (%)	HDRB (kN-m)	REDUCTION (%)
BENDING MOMENT IN X-DIRECTION	EL-CENTRO	CORNER	527.02	240.43	54.38	43.3	91.78
		EXTERNAL	563.68	265.48	52.90	47.2	91.63
		INTERNAL	565.52	266.36	52.90	47.5	91.60
	BHUJ	CORNER	507.55	291.13	42.64	377.18	25.69
		EXTERNAL	513.81	301.86	41.25	412.69	19.68
		INTERNAL	515.14	302.82	41.22	414.26	19.58
BENDING MOMENT IN Y-DIRECTION	EL-CENTRO	CORNER	545.42	227.43	58.30	41.3	92.43
		EXTERNAL	592.14	258.54	56.34	46.31	92.18
		INTERNAL	598.04	263.71	55.90	47.2	92.11
	BHUJ	CORNER	506.43	284.43	43.84	357.26	29.46
		EXTERNAL	517.52	310.26	40.05	406.03	21.54
		INTERNAL	517.19	309.94	40.07	405.24	21.65

From above table 5 from time history analysis it is seen that beam bending moment in X-direction for both El-Centro and Bhuj time history data the bending moment for fixed base varies from 507.55 KN to 565.52 KN and the reduction percentage of isolated structure varies from 19.58 % to 91.78 %.

4.3 Column Bending Moment and Shear Force

4.3.1 Column Shear Forces

Table 6- Column shear forces

COLUMN FORCES	TIME HISTORY	POSITIONS	FIXED BASE (kN)	LRB (kN)	REDUCTION (%)	HDRB (kN)	REDUCTION (%)
SHEAR FORCES IN X-DIRECTION	EL-CENTRO	CORNER	232.21	110.48	52.42	157.37	32.23
		EXTERNAL	468.93	225.1	52.00	331.77	29.25
		INTERNAL	505.99	242.63	52.05	366.87	27.49
	BHUJ	CORNER	262.01	119.63	54.34	183.55	29.95
		EXTERNAL	405.89	230.13	43.30	345.59	14.86
		INTERNAL	429.2	247.58	42.32	370.74	13.62
SHEAR FORCES IN Y-	EL-CENTRO	CORNER	257.59	119.46	53.62	204.39	20.65
		EXTERNAL	524.29	247.68	52.76	425.84	18.78

DIRECTION		**INTERNAL**	566.42	268.17	52.66	471.32	16.79
	BHUJ	**CORNER**	294.83	125.75	57.35	165.1	44.00
		EXTERNAL	441.84	253.19	42.70	334.29	24.34
		INTERNAL	466.44	272.5	41.58	358.49	23.14

From above table 6 from time history analysis it is seen that column shear forces in X-direction for both El-Centro and Bhuj time history data the shear force for fixed base varies from 232.21 KN to 505.99 KN and the reduction percentage of isolated structure varies from 13.62% to 54.34%.

4.3.2 Column Bending Moment

Table 7- Column bending moment

COLUMN MOMENT	TIME HISTORY	POSITIONS	FIXED BASE (kN-m)	LRB (kN-m)	REDUCTION (%)	HDRB (kN-m)	REDUCTION (%)
BENDING MOMENT IN X-DIRECTION	**EL-CENTRO**	**CORNER**	2231.4	427.5	80.84	23.28	98.96
		EXTERNAL	2298.6	580.5	74.75	36.61	98.41
		INTERNAL	2294.7	604.57	73.65	39.34	98.29
	BHUJ	**CORNER**	1410.2	416.54	70.46	252.12	82.12
		EXTERNAL	1452.5	550.6	62.09	405.23	72.10
		INTERNAL	1450.1	572.16	60.54	429.4	70.39
BENDING MOMENT IN Y-DIRECTION	**EL-CENTRO**	**CORNER**	2334.6	389.59	83.31	25.09	98.93
		EXTERNAL	2331.9	402.89	82.72	26.64	98.86
		INTERNAL	2411.8	566.21	76.52	41.57	98.28
	BHUJ	**CORNER**	1295.7	407.79	68.53	250.95	80.63
		EXTERNAL	1340.3	545.08	59.33	406.71	69.66
		INTERNAL	1338.4	569.09	57.48	444.29	66.80

From above table 7 from time history analysis it is seen that column bending moment in X-direction for both El-Centro and Bhuj time history data the bending moment for fixed base varies from 1410.23 KN to 2298.62 KN and the reduction percentage of isolated structure varies from 60.54 % to 98.96 %.

5. CONCLUSION

The following conclusions are made from the investigation carried out through the analysis:

- The series of analyses has proven the benefits of base isolation.
- The base isolation substantially increases the displacement of the building and hence correspondingly reduces base shear, story drift and story acceleration, column bending moment.
- The HDRB bearing is more effective in reducing the shear force and bending moment than LRB.
- From the bending moment values in the columns it is seen that there is reduction of moments varies between 60.54 % to 98.96 % and HDRB isolated building has more reduction percentage than LRB building when compared to fixed base building.

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