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COMPARATIVE STUDY ON SEISMIC RESPONSE OF RCC BUILDINGS WITH BASE ISOLATION TECHNIQUES

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ABSTRACT:

In the present study three structures without base isolation and with base isolation devices are considered such as lead rubber bearings (LRB) and elastomeric bearings(ELB) are considered in modeling of buildings of height G+7 RCC structures having material properties M30 grade for concrete and Fe415 for reinforcing steel and structures dimensions are length = 5x10 m = 50m, width = 5x6 = 30m and heights of G+7 is 24 m from the plinth level, the support conditions are chosen to be fixed base and foundation depth is considered as 2.0m below the ground level structures are modeled using ETABS in seismic zones II, III, IV, V as per IS 1893-2002 method used for seismic load generation linear static .the base isolation devices are arranged in storey1 or plinth level in the structures, The results are shown in terms of graphs and tables.

INTRODUCTION

The naturally occurring ground movement which eventually goes on creating disasters such as failure of structure and fatality is known as Earthquake. The energy that is discharged from those seismic activities makes waves, these waves are called as primary waves and secondary waves. These waves cause ground movement transmitted to the structure via foundation. Depending on the intensity of these vibrations, cracks and settlement is caused to the structure.

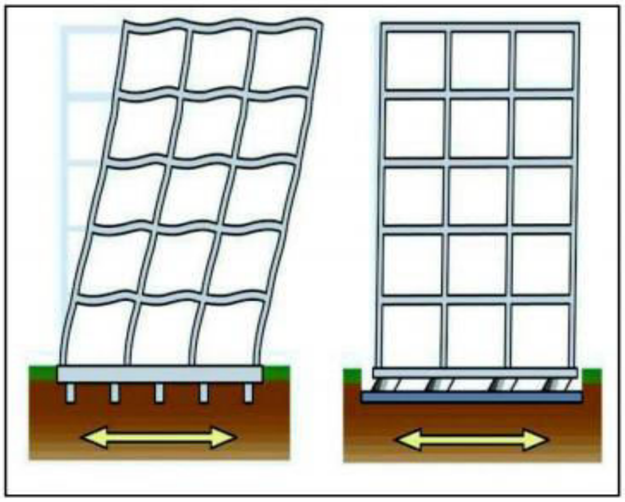

Fig 1.1: displacement of regular and base isolated structure

Base = a part that supports from beneath or serves as a foundation for an object or structure.

Isolation = the state of being separated, and is that of decoupling a structure from its foundation, separating the superstructure from the columns or piers.

Fig 1.2: base isolation arrangement

The successful seismic isolation of a particular structure depends on the appropriate choice of the base isolation devices. The basic features of an isolation system are identified as: An increased flexibility so that the natural period of the structure is increased sufficiently to shift the frequency of the structure out of the range of dominant frequency of earthquake. It is also necessary to provide an adequate seismic gap (between the structure and the surrounding foundations) which can accommodate the isolator displacements.

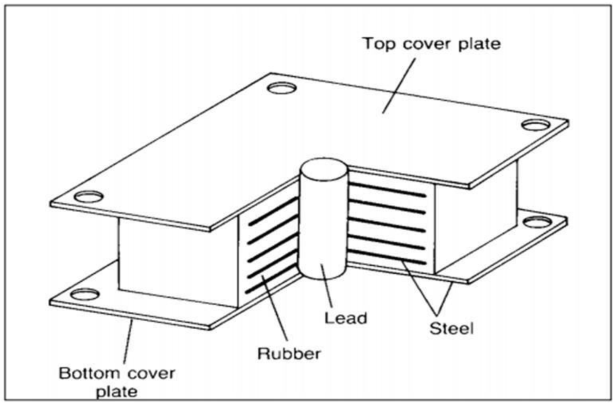

Fig 1.3: lead rubber isolator parts

1.1 Load transferring between bearings:

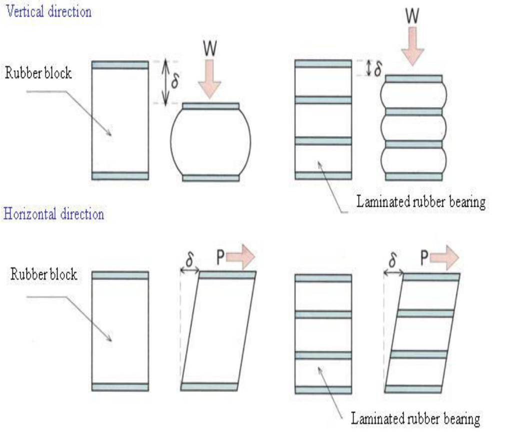

Fig 1.4: load and displacement of bearings

1.2 Laminated Rubber (Elastomeric) Bearing

Laminated rubber bearings are constructed of alternating rubber layers bonded to intermediate reinforcing plates that are typically steel as illustrated by the schematic of a deformed bearing shown in Fig. The total thickness of rubber provides the low horizontal stiffness need to achieve the period shift whereas the spacing of the steel shim plates controls the vertical stiffness of the bearing for a given shear modulus and bonded rubber area.

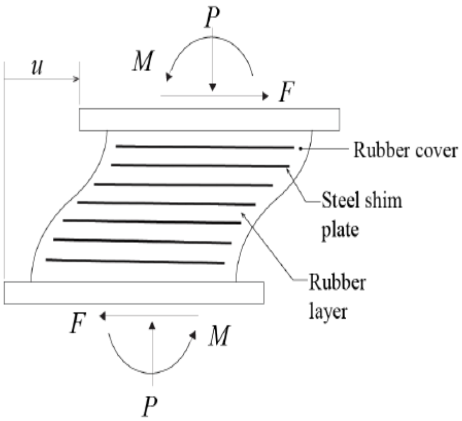

Fig 1.5: Laminated Rubber (Elastomeric) Bearing

1.3 Lead Rubber Bearing (LRB)

Lead-plug bearings are generally constructed with low-damping elastomers and lead cores with diameters ranging 15% to 33% of the bonded diameter of the bearing as shown in Figure. Laminated-rubber bearings are able to supply the required displacements for seismic isolation By combining them with a lead-plug insert which provides hysteretic energy dissipation, the damping required for a successful seismic isolation system can be incorporated in a single compact component.

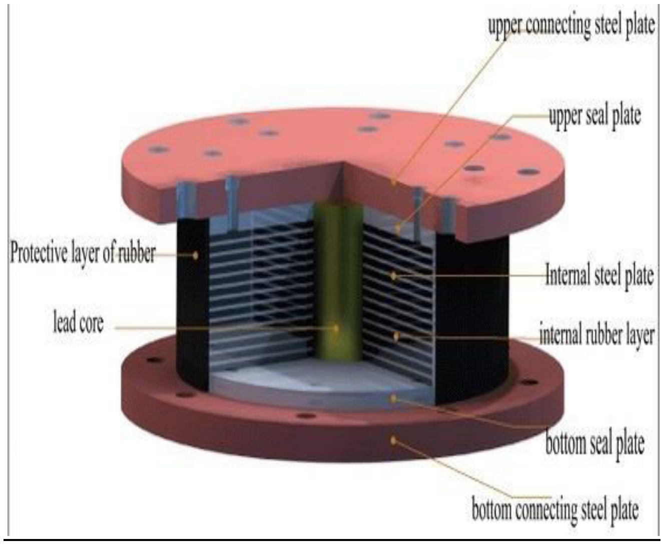

Fig 1.6: lead rubber bearing arrangement

1.4 Advantages of base isolation

[1] Reduced the seismic demand of structure, thereby reducing the cost of structure.

[2] Lesser displacements during an earthquake.

[3] Improves safety of Structures

[4] Reduced the damages caused during an earthquake. This helps in maintaining the performance of structure after event.

[5] Enhances the performance of structure under seismic loads.

[6] Preservation of property

[7] cracks in structures can be limited

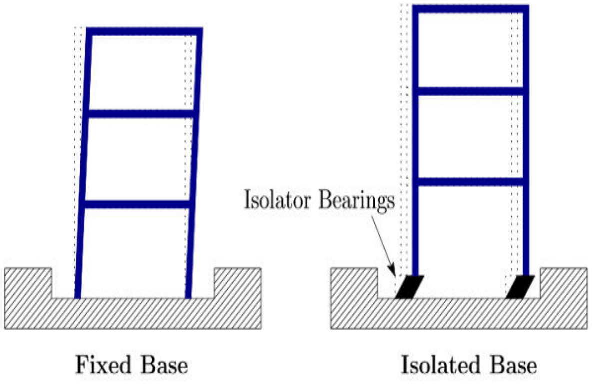

Fig 1.7: displacements in structures

1.5 Disadvantages of base isolation

[1] Base isolation can't be done on every structure, for example: it is not suitable for structures resting on soft soils.

[2] Becomes less efficient for high rise buildings.

[3] Unlike other retrofitting base isolation cannot be applied partially to the structure.

[4] Implementation is efficient manner is difficult and often requires highly skilled labours and engineers.

LITERATURE SURVEY

Dia Eddin Nassani1, Mustafa Wassef Abdulmajeed1 investigated the Seismic Base Isolation in Reinforced Concrete Structures. In order to verify the effect of base isolation system, two different structures are presented (symmetrical and non-symmetrical school buildings) in which the seismic responses of the 'fixed-base' and 'base-isolated' conditions have been compared using SAP2000. The symmetric structure consists of 5-storey reinforced concrete school building with regular plan. Slab thickness is 16 cm, the column section 55x55 cm and beam section is 30 x 70 cm. The results of the study show that the response of the structure can be reduced by using base isolation. Comparing the results of the base-isolated condition with those obtained from the fixed-base condition has shown that the base isolation system reduces the base shear force and story drifts, whilst also increasing the displacement as the following: The base shear in x-direction is equal to 3557 kN for the base-isolated condition while it is equal to 13940 kN in fixed-base condition for symmetric building. The base shear in y-direction is equal to 3506 kN for the base-isolated condition while it is equal to 14393 kN in fixed-base condition for symmetric building. The base moment in x-direction and y direction for the base-isolated condition is less than the moment for the fixed base condition. The drift ratio is (0.0007) for the base-isolated condition while it is 0.003 for the fixed-base condition.

Sameer S. Shaikh1, P.B. Murnal2 found the effects of Base Isolation at Different Levels in Building The purpose of the investigation is to compare in a quantitative manner the relativePerformance of fixed building and base isolation placed at different levels. A three story building is modeled to compare the response of the two using SAP2000. Time history analysis is conducted for the 1994 Northridge and 1940 El-Centro earthquakes. The analysis result shows that when isolator position is shifting it significantly affects the response quantities. It is possible to arrive at optimum location of the isolator so as to get the maximum benefit of base isolation. No. of bays in X = direction spanning 5m-5. No. of bays in Y = direction spanning 8m-8i.e. plan dimensions are 25X64m he analysis of fixed base and base isolator at different levels three storey building is performed in this paper. An exhaustivestudy has been performed on the performance of base isolated structures. The behavior of building structure resting on laminated rubber bearing is compared with fixed base structure under maximum capable earthquake. Seismic base isolation can reduce the seismic effects and therefore floor accelerations are reduced by lengthening the natural period of vibration of a structure via use of rubber isolators between the column and the foundation and above the beam for plinth and first floor level. However in case the deformation capacity of the isolators exceeded, isolator may rupture or buckle. Therefore it is vitally important to accurately estimate the peak base displacements in case of major earthquakes, particularly if the base isolated building is likely to be stuck by near-fault earthquakes. Based on the analysis carried out, it is concluded that seismic base isolation is a successful technique that can be used in earthquake resistant design.

MODELLING& METHODOLOGY

3.1 modeling of structures in ETABS

In the present study three G+7 structure models with foundation depth of 2.0m and bay widths in length is 5m each, and along width is 5m, support conditions are assumed to be fixed at the bottom or at the supports/footings. The structures having length = 10x5 = 50m, width = 6x5 = 30m and height = 26 m. The structures modeled in ETABS structural analysis and design software by considering various loads and load combinations by their relative occurrence are considered the material properties considered are M30 grade concrete and Fe415 reinforcing steel bars. in the present study the structures are modeled with and without base isolation devices at the plinth level to determine the severity of earthquake with different magnitudes in all zones (II,III,IV and V) the plans and elevations of the structures are shown in the figures below.

NBI: G+7 building without base isolation device

LRBI: G+7 building with lead rubber base isolation device

ELBI: G+7 building with elastomeric isolation device

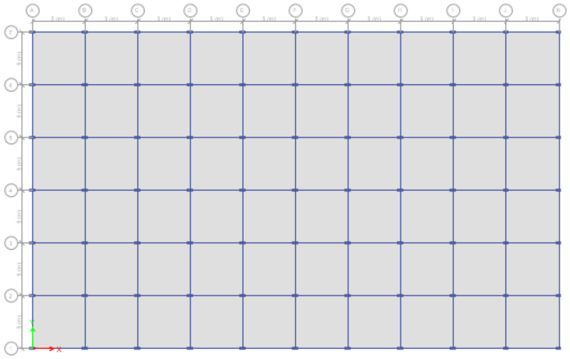

Fig 3.1: floor plans of structures

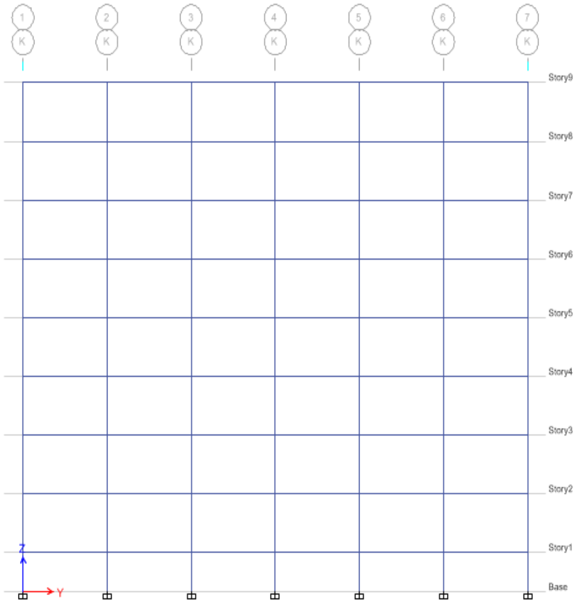

Fig 3.2: elevation of structures without base isolation along width

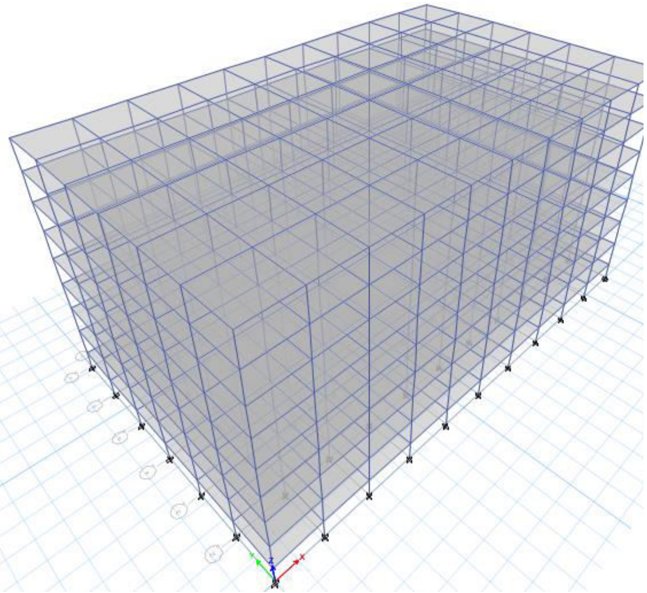

Fig 3.6: 3d view of structures without base isolation

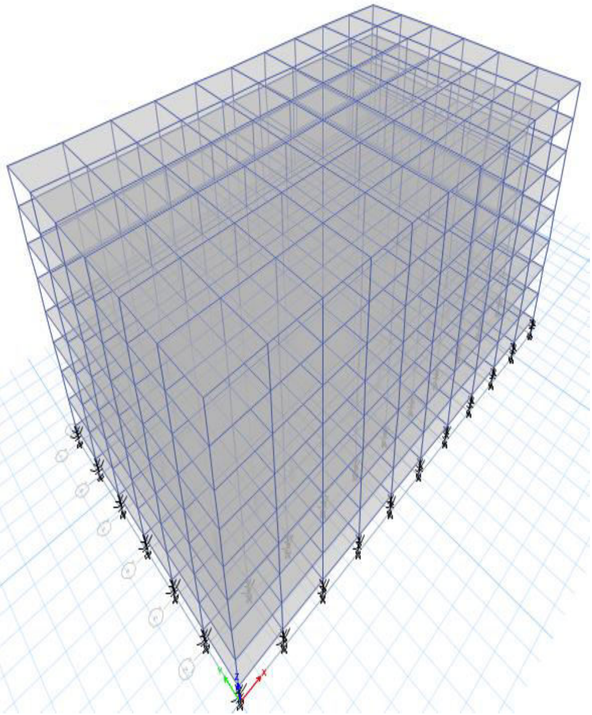

Fig 3.7: 3d view of structures with base isolation

Table 3.1: Design data used in modeling and analysis of structures

Materials	M30, Fe415
Beam	230x500
Columns	300x600
Supports	Fixed
Stories	G+7
Foundation depth	2.0m
Floor to floor height	3.0m
Length	10x5m = 50m
Width	6x5m = 30m
Zones	2,3,4,5
Types of bearings	Lead rubber bearings, elastomeric bearings
Method	Linear static analysis
Software	ETABS
Loads	DL,LL,EL, load combinations

3.2 IS codes used in analysis and Design of structures

[1] IS 1893:1984,"Criteria for earthquake resistant design of structures", Bureau of Indian Standards, New Delhi, India.

[2] IS 456: 2000,"Plain reinforced concrete-code of practice", Bureau of Indian Standards, New Delhi, India.

[3] IS 875-5: 1987,"Code of practice for design load combinations for buildings and structures", Bureau of Indian Standards, New Delhi, India

Table: 3.2 design parameters used in analysis and modeling

Parameters	**Values**
Type of building	Residential
Live load	3kN/m^2
Member load	11.0kN/m
Slab thickness	130mm
Response reduction(R)	5
Importance factor	1
Soil type	II
Slabs	Shell elements
Columns	Frame elements
Beams	Frame elements

3.3 Loads and load combination considered for analysis

In the limit state design of reinforced and prestressed concrete structures, the following load combinations shall be accounted for:

1) 1.5(DL+LL)

2) 1.2(DL+LL+EL)

3) 1.5(DL+EL)

4) 0.9DL+1.5EL

3.4 Loads and load combinations considered in analysis of structures using ETABS

1. DL
2. LL
3. ELX
4. ELY
5. 1.5(DL+LL)
6. 1.2(DL+LL+ELX)
7. 1.2(DL+LL+ELY)
8. 1.5(DL+ELX)
9. 1.5(DL+ELY)
10. 0.9DL+1.5ELX
11. 0.9DL+1.5ELY

DL = DEAD LOAD

LL = LIVE LOAD

ELX = EARTHQUAKE LOAD ALONG X DIRECTION

ELY = EARTHQUAKE LOAD ALONG Y DIRECTION

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RESULTS AND DISCUSSION

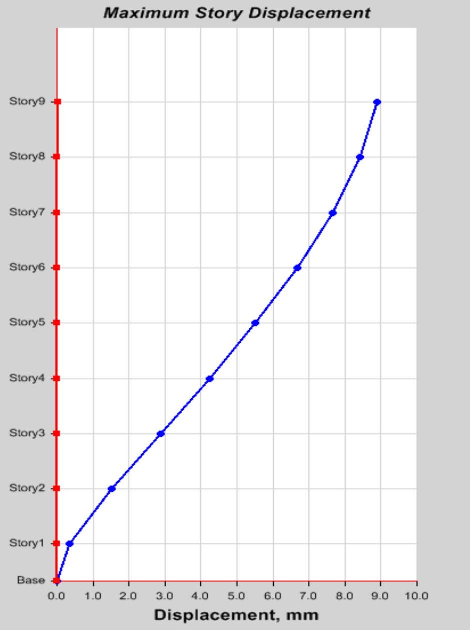

Fig 4.1: storey displacements along length in zone-2

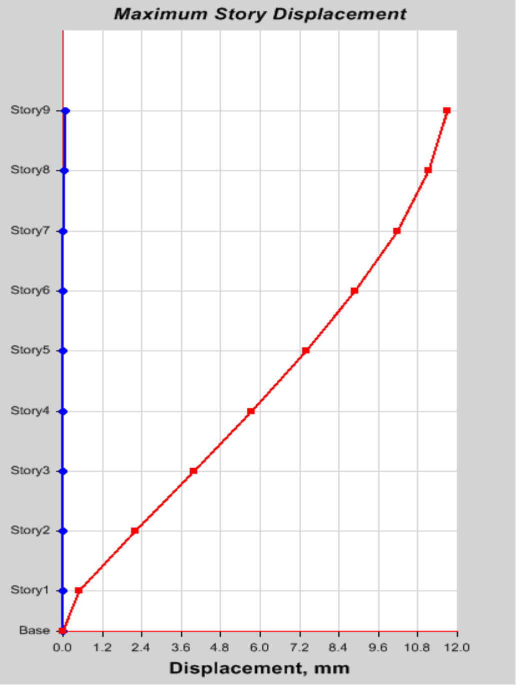

Fig 4.2: storey displacements along width in zone-2

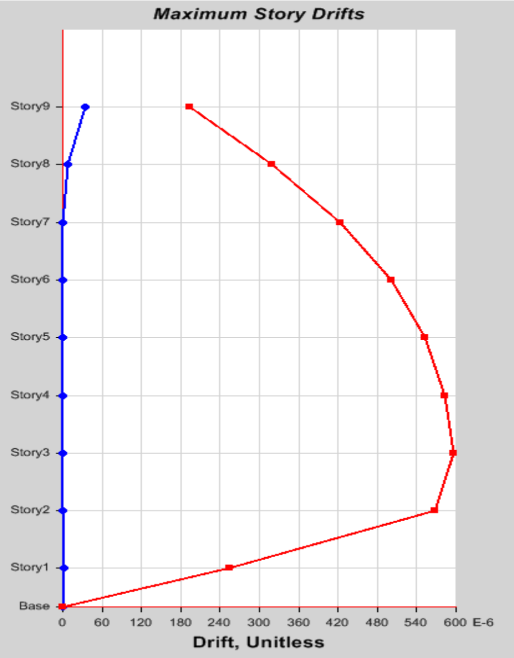

Fig 4.3: storey drift along width in zone-2

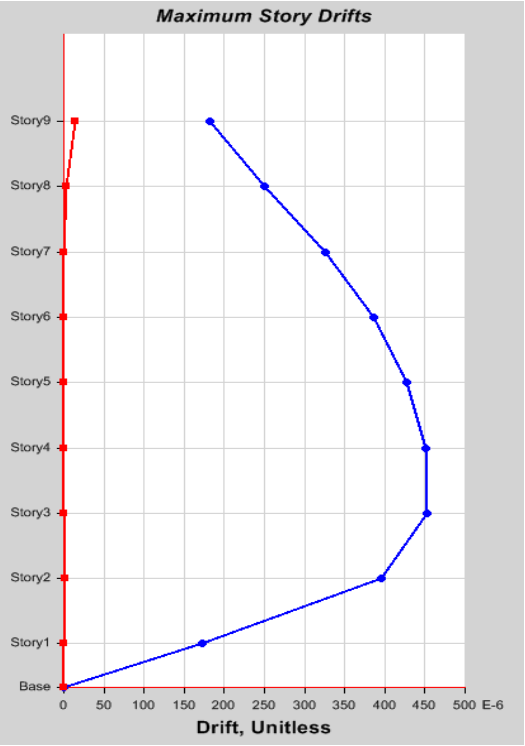

Fig 4.4: storey drift along length in zone-2

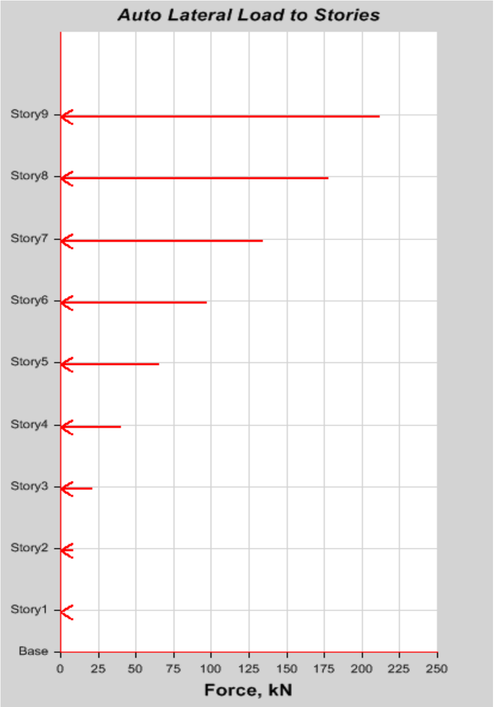

Fig 4.5: lateral load on storey along width in zone-2

Table 4.1: joint displacements along-X- Z2

Story	Load Case	UX	UY	UZ	RX	RY	RZ
		mm	mm	mm	Rad	rad	rad
Story9	EL+X	5.904	-0.01	-0.849	0.000214	0.000167	-0.000000194
Story8	EL+X	5.58	0.001	-0.831	0.000109	0.000148	0.000001
Story7	EL+X	5.1	-0.001	-0.789	0.000121	0.000209	4.065E-07
Story6	EL+X	4.449	-0.000287	-0.725	0.000115	0.000248	2.745E-07
Story5	EL+X	3.677	-0.00006035	-0.641	0.000111	0.000276	1.956E-07
Story4	EL+X	2.822	0.0001741	-0.538	0.000105	0.000293	1.479E-07
Story3	EL+X	1.919	0.0003228	-0.416	0.000099	0.000298	1.532E-07
Story2	EL+X	1.014	0.00005092	-0.275	0.000091	0.000287	4.131E-07
Story1	EL+X	0.226	-0.001	-0.117	0.000083	0.000201	3.869E-07
Base	EL+X	0	0	0	0	0	0

Table 4.2: joint displacements along Y- Z2-NBI

Story	Load Case/Combo	UX	UY	UZ	RX	RY	RZ
		mm	Mm	Mm	Rad	rad	rad
Story9	EL+Y	0.02	7.764	-1.076	0.000152	0.000096	4.85E-08
Story8	EL+Y	-0.008	7.414	-1.055	-0.000006	0.000034	0.000001
Story7	EL+Y	-0.002	6.78	-1.009	-0.000047	0.00004	4.498E-07
Story6	EL+Y	-0.002	5.934	-0.935	-0.000092	0.000039	3.067E-07
Story5	EL+Y	-0.002	4.934	-0.834	-0.000123	0.000038	2.161E-07
Story4	EL+Y	-0.002	3.83	-0.706	-0.000145	0.000036	1.475E-07
Story3	EL+Y	-0.002	2.664	-0.55	-0.00016	0.000034	1.044E-07
Story2	EL+Y	-0.002	1.471	-0.366	-0.000169	0.000032	1.867E-07
Story1	EL+Y	-0.001	0.338	-0.156	-0.000113	0.000029	1.619E-07
Base	EL+Y	0	0	0	0	0	0

LIST OF BAR CHARTS

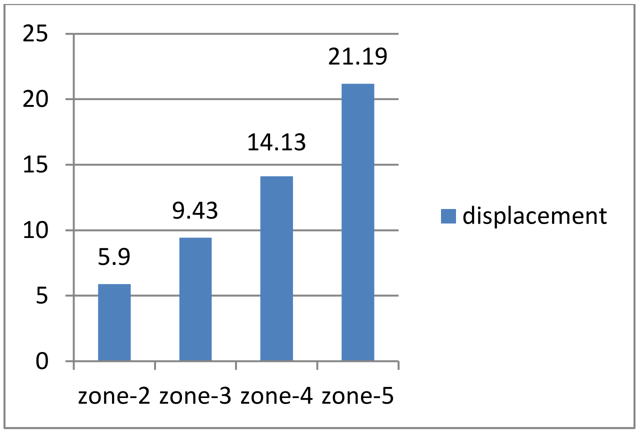

Chart 5.1: displacement along X direction in NBI

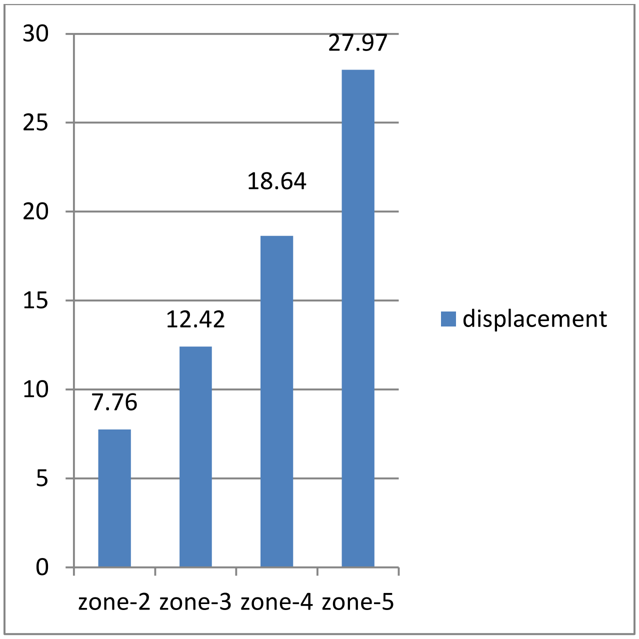

Chart 5.2: displacement along Y direction in NBI

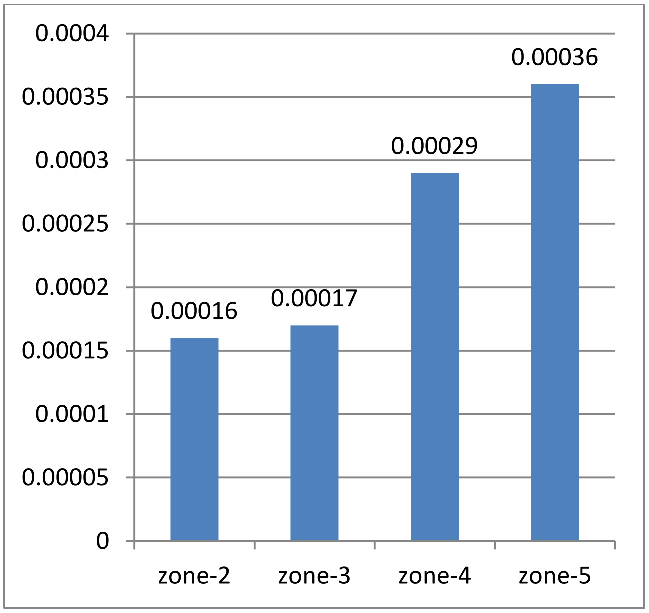

Chart 5.3: drift at storey9 along in X NBI

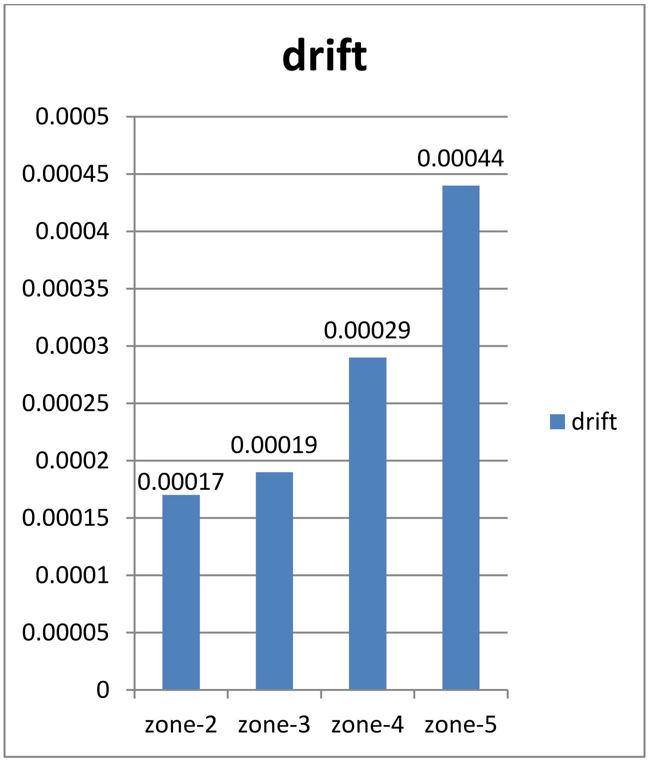

Chart 5.4: drift at storey9 along in Y-NBI

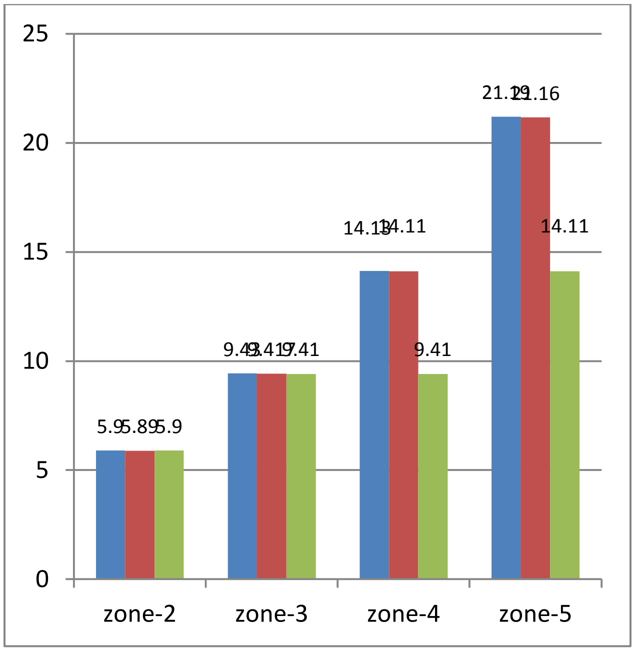

Chart 5.19: displacements along X direction with and without bearings

BLUE: NBI, RED: LRB, GREEN: ELB

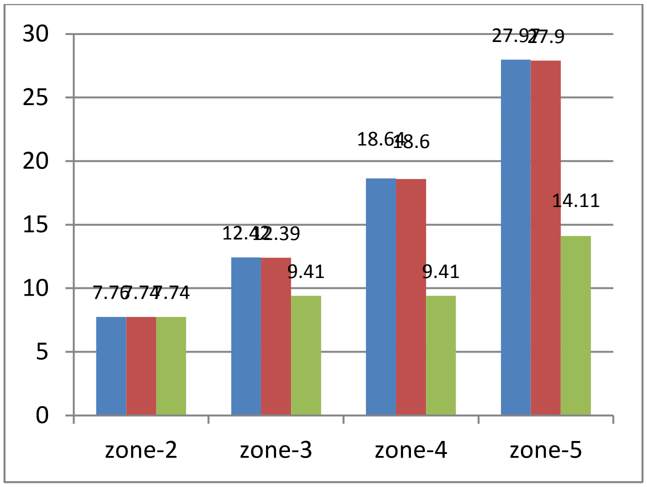

Chart 5.20: displacements along Y direction with and without bearings

BLUE: NBI, RED: LRB, GREEN: ELB'

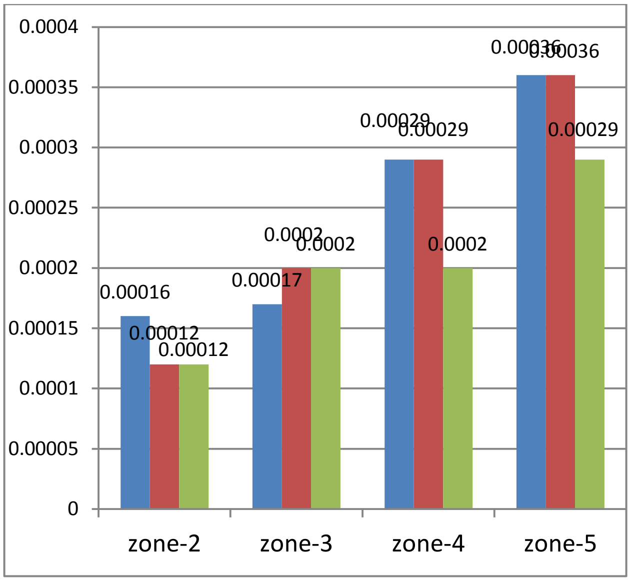

Chart 5.21: drift at storey9 along X with and without bearings

BLUE: NBI, RED: LRB, GREEN: ELB

CONCLUSIONS

The following are the conclusions drawn from the analysis results of three G+7 structure models with foundation depth of 2.0m and bay widths in length is 5m each, and along width is 5m, support conditions are assumed to be fixed at the bottom or at the supports/footings. The structures having length = 10x5 = 50m, width = 6x5 = 30m and height = 26 m. The structures modeled in ETABS structural analysis and design software by considering various loads and load combinations by their relative occurrence are considered the material properties considered are M30 grade concrete and Fe415 reinforcing steel bars. In the present study the structures are modeled with and without base isolation devices at the plinth level to determine the severity of earthquake with different magnitudes in all zones (II, III, IV and V)

Structure-1: NBI: G+7 building without base isolation device

Structure-2: LRBI: G+7 building with lead rubber base isolation device

Structure-3: ELBI: G+7 building with elastomeric isolation device

- The maximum storey displacements for structure-1, structure-2 and structure-3 in zone-II, zone-III, zone-IV, and zone-V are 9mm, 14mm, 28mm and 42mm, with the increase in the seismic intensities the structures in zone-III, zone-IV, and zone-V the storey displacements are increased by 55.56% , 211% and 366%.

- The maximum storey shear for structure-1, structure-2 and structure-3 in zone-II, zone-III, zone-IV, and zone-V are 1600kN, 2500kN, 2700kN and 4000kN with the increase in the seismic intensities the structures in zone-III, zone-IV, and zone-V the storey shear are increased by 56.25%, 68.75% and 150%.

- The maximum lateral loads acting at storey for structure-1, structure-2 and structure-3 in zone-II, zone-III, zone-IV, and zone-V are 290kN, 450kN, 500kN and 750kN with the increase in the seismic intensities the structures in zone-III, zone-IV, and zone-V maximum lateral loads acting at storey are increased by 55.17%, 72.41 % and 158.62%.

- With increase in the seismic zones the storey drifts are increased, the maximum storey drifts are found to be for structure-1, structure-2 and structure-3 in zone-II, zone-III, zone-IV, and zone-V are 0.004, 0.00048, 0.00096 and 0.00143 are found to be in limit 0.004 are per IS:1893-2002
- With increase in the seismic zones the column forces are increased, the maximum column forces are found to be for structure-1 in zone-II, zone-III, zone-IV, and zone-V are 388.66kN, 416.07kN, 452.62kN and 507kN column forces are increased by 7.05%, 16.45 % and 30.44%.

- With increase in the seismic zones the column forces are increased, the maximum column forces are found to be for structure-2 in zone-II, zone-III, zone-IV, and zone-V are 197.24kN, 211.18kN, 229.78kN and 257.67kN column forces are increased by 7.02%, 16.50% and 30.65%.

- With increase in the seismic zones the column forces are increased, the maximum column forces are found to be for structure-3 in zone-II, zone-III, zone-IV, and zone-V are 214.73kN, 229.92kN, 250.17kN and 275kN column forces are increased by 7.08%, 16.50% and 28.07%.

- The maximum support reactions at the base are found to be 55087kN for structure-1, structure-2 and structure-3 in zone-II, zone-III, zone-IV, and zone-V

- It is observed that the displacements, storey drifts, column forces and base reactions are more along the width direction-Y-direction for structure-1, structure-2 and structure-3 in zone-II, zone-III, zone-IV, and zone-V

- Lateral storey displacements at storey levels are increased with height of the structure and the seismic zone intensity for structure-1, structure-2 and structure-3 in zone-II, zone-III, zone-IV, and zone-V

- From the analysis results it is observed that the storey drifts, displacements, base and column forces are lesser in elastomeric bearing structures when compared with lead rubber and structures with no base isolators.

REFERENCES

- IS 1893:1984,"Criteria for earthquake resistant design of structures", Bureau of Indian Standards, New Delhi, India.

- IS 1893(Part1):2002,"Criteria for earthquake resistant design of structures -General provisions and buildings", Bureau of Indian Standards, New Delhi, India.

- IS 456: 2000,"Plain reinforced concrete-code of practice", Bureau of Indian Standards, New Delhi, India.