Seismic Analysis of Braced Frame with Different Base Condition

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Abstract: *The use of base isolators helps the structure to mitigate the lateral forces like wind and seismic etc. by expanding the vibration period of the structure. The lateral forces are also resisted by the use of special measure known as steel bracing. Steel bracing decrease the horizontal deformation by increasing the vertical stiffness and stability. In the current study, analysis of RC frames with different base conditions (Fixed, HDRB and LRB) along with different types of bracing (X type, Forward diagonal type and backward diagonal type) is carried out using response spectrum method. For this study, G+10 multi-storey building is assumed and is situated at seismic zone V. modelling and analysis of the building frame are carried out in Etabs software (2015 version). From the present study, it is observed that Lead Rubber Bearing Base isolators with completely X bracing (E type) is most suitable.*

Key words:- HDRB, LRB, Forward diagonal type , Backward diagonal type and X type, base drift, storey shear, stiffness.

1. INTRODUCTION

As India is developing country, the infrastructure of the country is modernizing rapidly and also increase in population of the country leads to growth to the population density. To meet the desire of the people of land for construction (housing, commercial building and other buildings) is fulfiled only with the vertical development i.e. multistory buildings. Along with the vertical development, it is responsibility of every engineer to mitigate the forces like seismic and wind etc. which are unfavorable for structure safety. As the height of the building increases, the deformation of the building also increases. So it is necessary to recommend special measures to reduce these kind of deformation and the base isolation technique is one of the special measures to take a run at mitigation of deformation of the building. Another measure to oppose lateral force is steel bracing, it resist horizontal forces by increasing its vertical stiffness. There are various types of bracing systems like Forward diagonal type, backward diagonal type, X type, V type, inverted V type, K type, diagonal type and so on. In the present study, the effect of base isolators i.e. HIGH DAMPING RUBBER BEARING and LEAD RUBBER BEARING along with different types of bracing i.e. Forward diagonal type, backward diagonal type and X type are located in different position of the frame member are studied. The behavior of building is studied under the following results i.e. storey drift, base shear, storey displacement and Fundamental time period of building and compared with building with fixed base without any bracing.

2. OBJECTIVE

a) Ten story building is analyzed in Etabs software without bracings and with different bracing systems.
b) Compare the reaction of different braced and unbraced frame subjected to horizontal loads.
c) Identify the effective base condition and bracing system to resist the lateral loads effectively.
d) To identify the effective type of bracing.
e) Types of bracing: Forward diagonal, backward diagonal and X types bracing systems are used.

3. MODELLING

The following are the plan and elevation of the building.

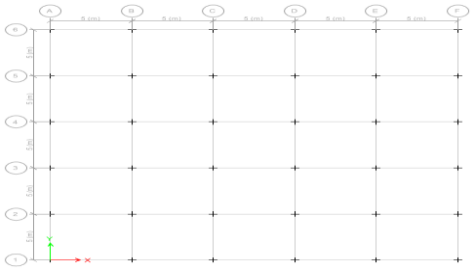

Figure-1: Plan (25x25) m.

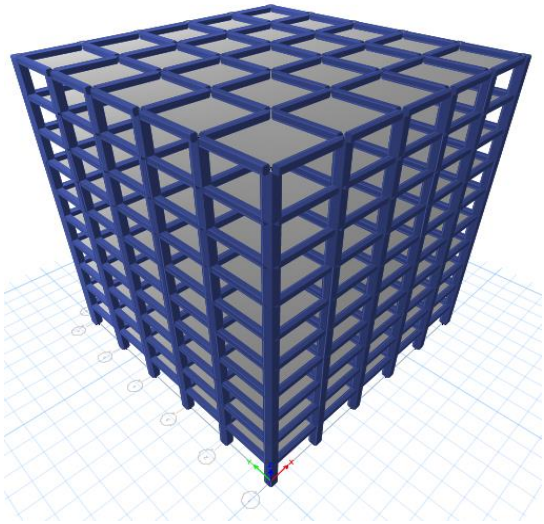

Figure-2: Elevation.

4. PARAMETERS CONSIDERED IN THE STUDY

4.1 Types of bracing and its representation.

1. X bracing **[X]**
2. Forward diagonal bracing **[/]**
3. Backward diagonal bracing **[\ ]**

4.2 Position of bracing and its representation.

1. Without bracing. **Model-[A]**
2. With alternative X bracing. **Model-[B]**
3. With forward and backward diagonal bracing. **Model-[C]**
4. With forward diagonal, backward diagonal and X bracing. **Model-[D]**
5. With complete X bracing. **Model-[E]**

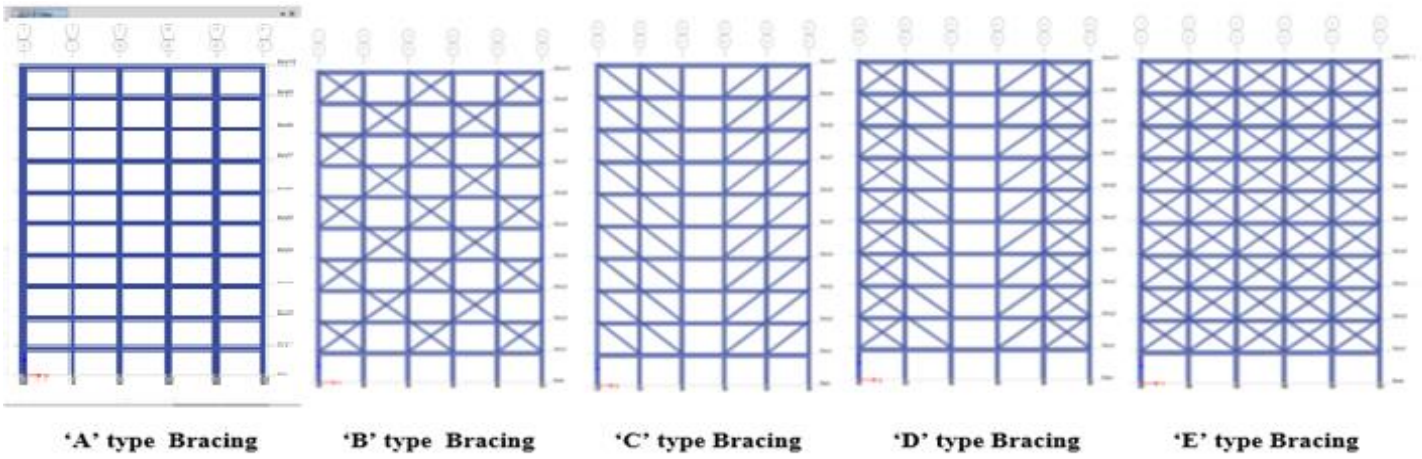

Figure-3: Types of bracing system

4.3 Types of isolators and its designation.

1. Fixed Base **F**
2. HDRB **H**
3. LRB **L**

Table 1: Building Description

Building Description	
Plan Dimension	25x25m
Number of storeys	G+10 storey
Height of typical floor	3 m
Height of Building	30m
Slab thickness	150 mm
Beam Dimension	0.300 x 0.450 m
Column Dimension	0.600 x 0.600 m

5. Results and Discussion:

5.1 Fundamental Time Period

The fundamental time period for all models obtained from the modal analysis, which estimate the time period with respect to mass and stiffness of the structure

Table 2: Fundamental time period of frame for different types of bracing and base condition.

Type of bracing	Time Period (sec)			
	IS 1893 (Part 1) : 2002 (sec)	Type of base condition		
		F	H	L
Model-[A]	0.961	1.390	2.608	2.966
Model-[B]		0.848	2.215	2.609

Model-[C]		**0.943**	**2.259**	**2.646**
Model-[D]		0.86	2.222	2.616
Model-[E]		**0.697**	**2.162**	**2.566**

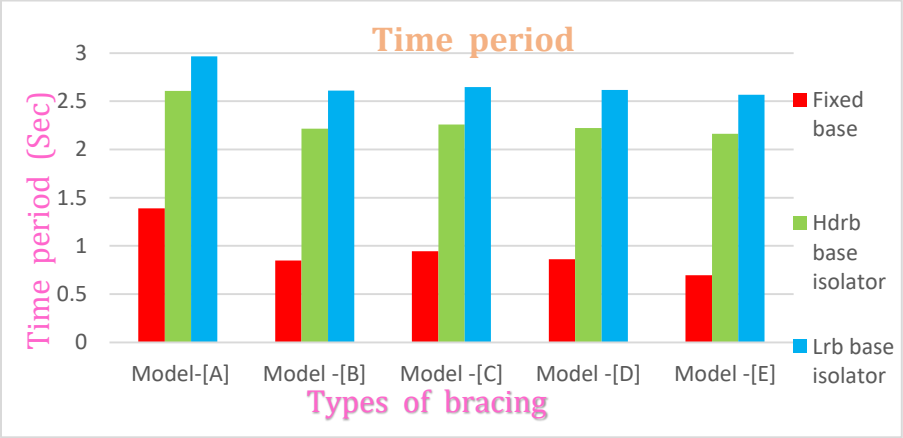

Chart- 1: Bar chart of Fundamental time period of frame for different types of bracing and base condition.

The above Chart 4 and table 2 shows the fundamental time period of the building with different bracings and without bracings.

The time period for different base condition with different position of bracing, the LRB shows the maximum time period and fixed base shows the minimum time period. The increase in time period of HDRB and LRB isolators with respect to fixed base condition is **1.8 times** and **2.12 times** respectively. Hence, fixed base is stiffer and LRB is less stiff. Among all types of bracing, E-type bracing has less time period and frames with C-type bracing has more time period which indicate E-type bracing is stiffer and frames with C-type bracing is less stiffer.

5.2 Base Shear

The seismic ground motion cause the maximum expected horizontal force at the base of the structure.

Table 3: Base Shear of frame for different types of bracing and base contion.

Base Shear			
Types of bracing	**Types of base condition**		
	F	**H**	**L**
A	1822.11	1044.47	918.23
B	3004.19	1150.151	976.67
C	**2699.07**	**1126.315**	**961.59**
D	2966.4	1147.729	974.78
E	**3677.107**	**1184.902**	**998.39**

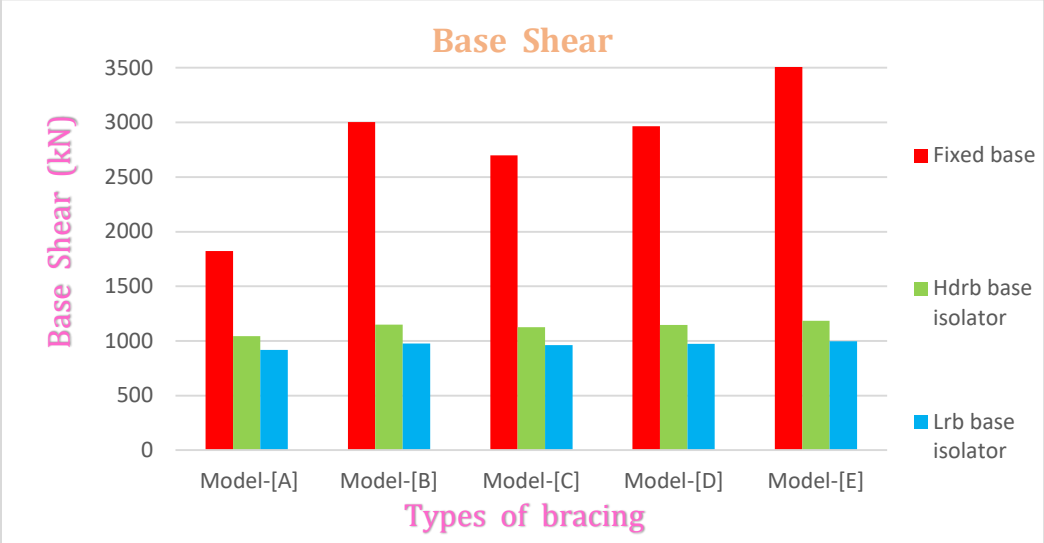

Chart 2: bar chart of Base Shear of frame for different types of bracing and base condition.

The above Chart 2 and table 3 shows the Base Shear of the building for different base condition with different bracings and without bracings.

It is observed that, the base shear is reduced in frames with base isolation models, LRB has reduction of **49.606%** whereas HDRB has reduction **42.678%** base shear with respect to fixed base condition. The reduction in base shear in models with base isolated compare to models with fixed base models is due to higher time period. The type of bracing considered E-type bracing has higher base shear for all base condition and C-type bracing shows the least base shear for all base condition. Compare to the base isolator, LRB base isolator is more flexible compare to HDRB isolators and fixed base. Compare to type of bracing, E-type bracing is stiffer. Hence LRB base isolator with E-type bracing is the best.

5.3 Storey Displacement.

The displacement of the structure in lateral direction due to some external force to reduce the displacement caused by lateral load by using bracing systems.

Table 4: Displacement of frame for different types of bracing and base condition.

Displacement			
Types of bracing	Type of base condition		
	F	H	L
A	31.8	23	20.2
B	18.9	9.696	8.261
C	**21.5**	**11.87**	**10.27**
D	19.74	10.32	8.928
E	**15.9**	**7.052**	**5.997**

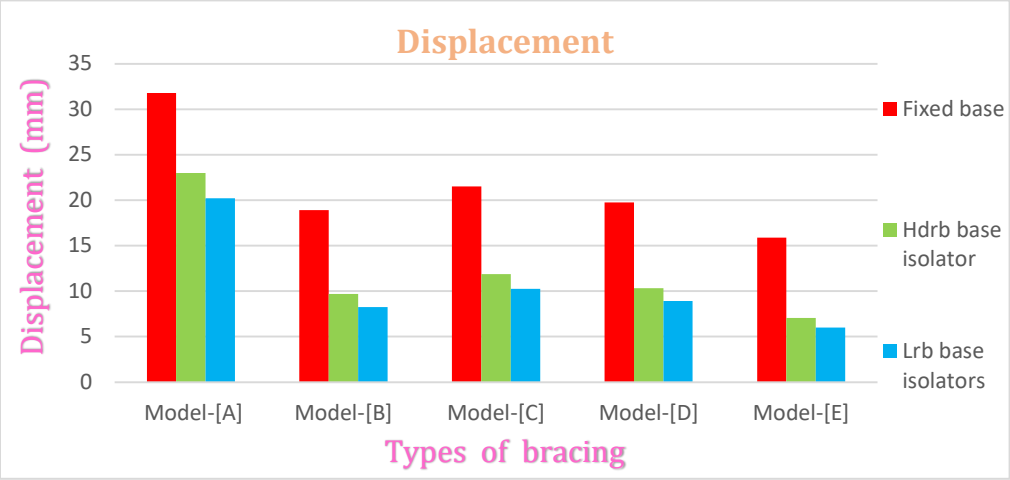

Chart 3: Bar chart of storey displacement of frame for different types of bracing and base condition.

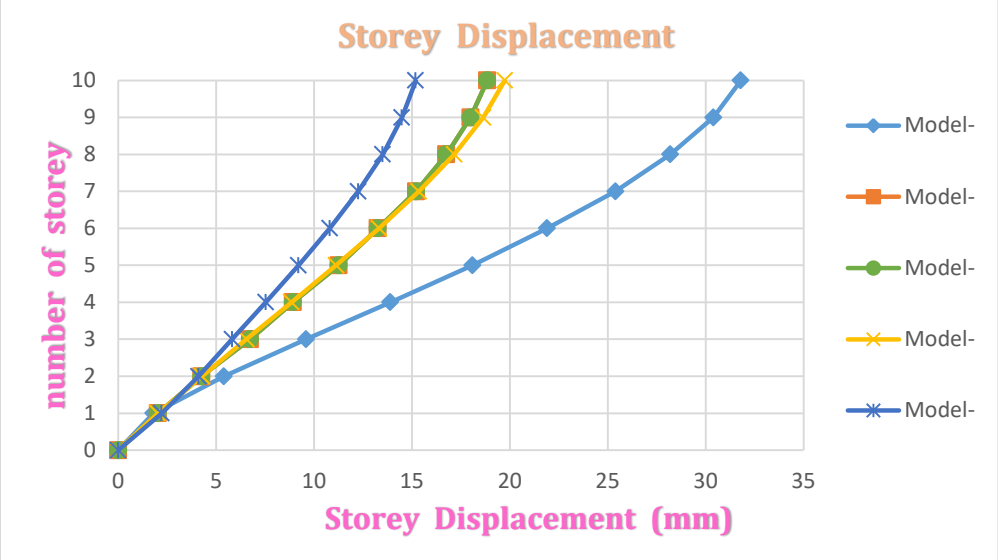

Chart 4: Variation of storey displacement for fixed base condition and types of bracing.

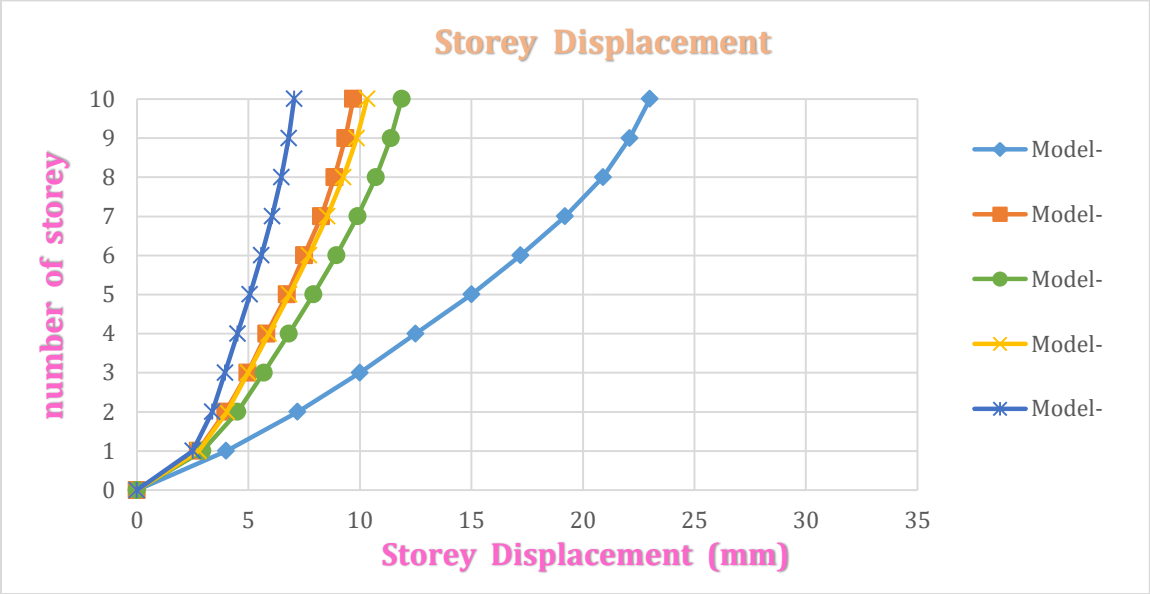

Chart 5: Variation of storey displacement for HDRB base condition and types of bracing.

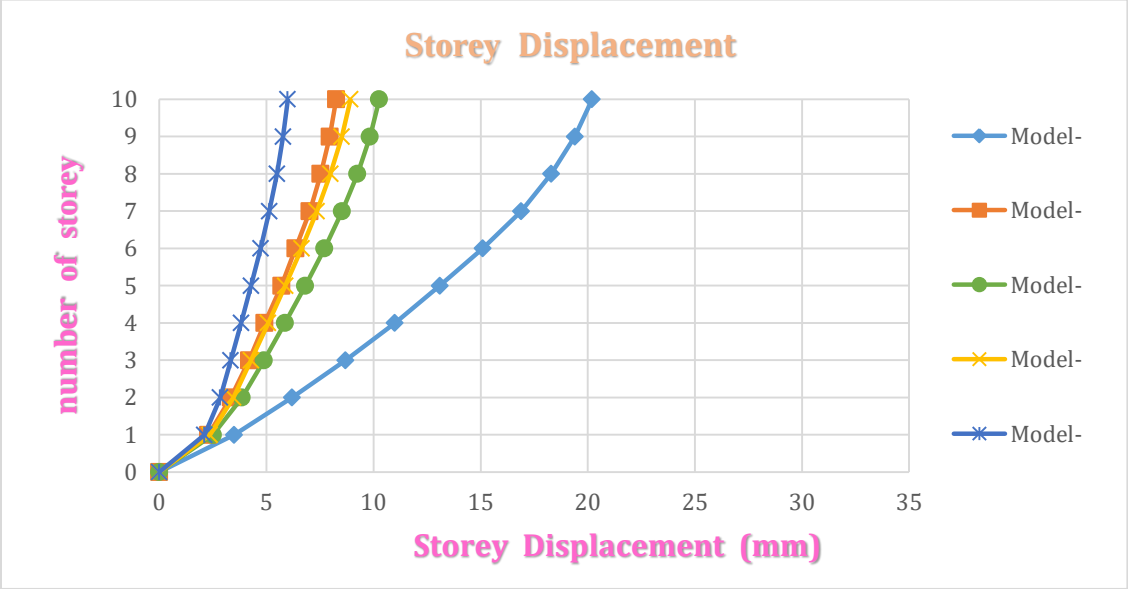

Chart 6: Variation of storey displacement for LRB base condition and types of bracing.

The above Chart 3 to Chart 6 and table 4 shows the displacement of the building with different bracings and without bracings.

The storey displacement increases as the heigth of the building increases. From above figures it can be said that models with bracing shows the less displacement than models without bracing. By using base isolators, HDRB isolators reduces the displacement by **27.67%** and LRD isolators reduces the displacement by **36.46%** with respect to fixed base model. As the displacement in the building is least for the LRB with E-type bracing shows the least storey displacement among all the other type of bracing. From the and figure (7,8 & 9) shows the storey displacement vs storey heigth, it is observed that

among base isolators, HDRB base isolator with C-type bracing shows the more displacement compare to other types of bracing and LRB with E-type bracing shows the least displacement, which can be most recommended.

5.4 Storey Drift

It is the ratio of displacement of two consecutive floors to the height of that floor. The below graph 2 and table 3 are the drift values of the building with different bracing systems and without bracing systems.

Table 5: Drift of frame for different types of bracing and base condition.

Drift			
Types of bracing	**Types of base condition**		
	F	**H**	**L**
'A'	0.001429	0.001612	0.001443
'B'	0.00086	0.001162	0.00102
'C'	**0.00086**	**0.001232**	**0.001083**
'D'	0.000856	0.001171	0.001135
'E'	**0.000705**	**0.001082**	**0.000943**

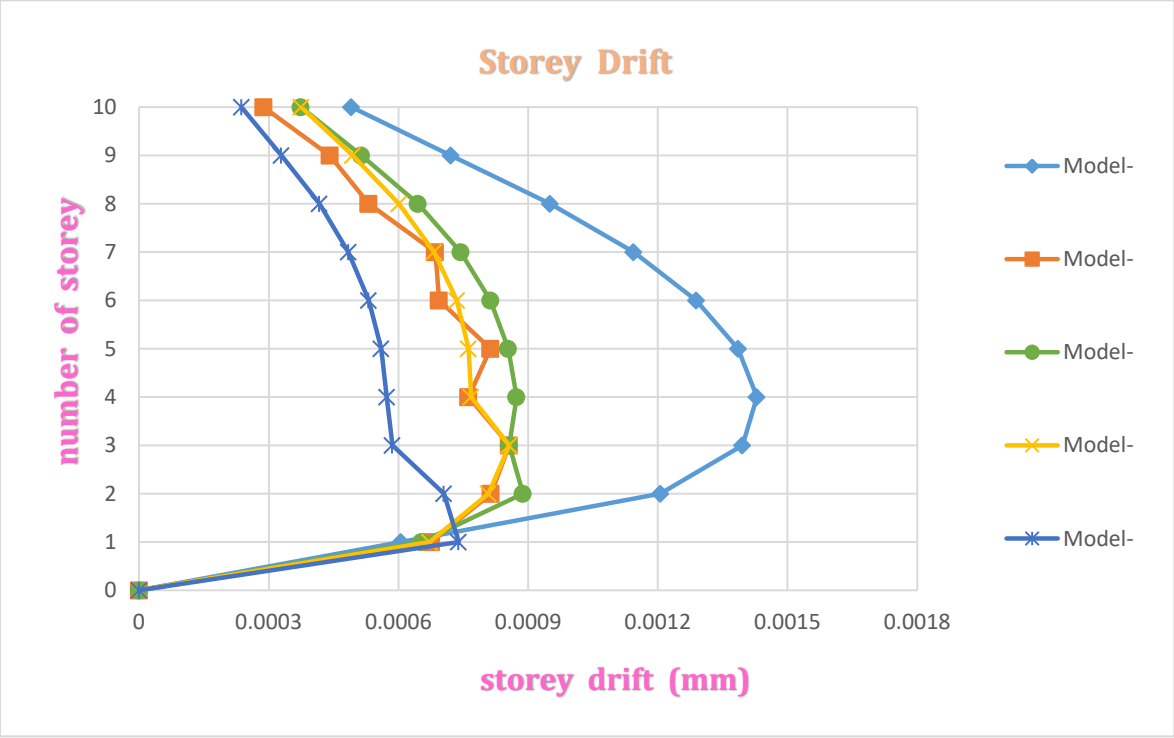

Chart 7: Variation of storey drift for fixed base condition and types of bracing.

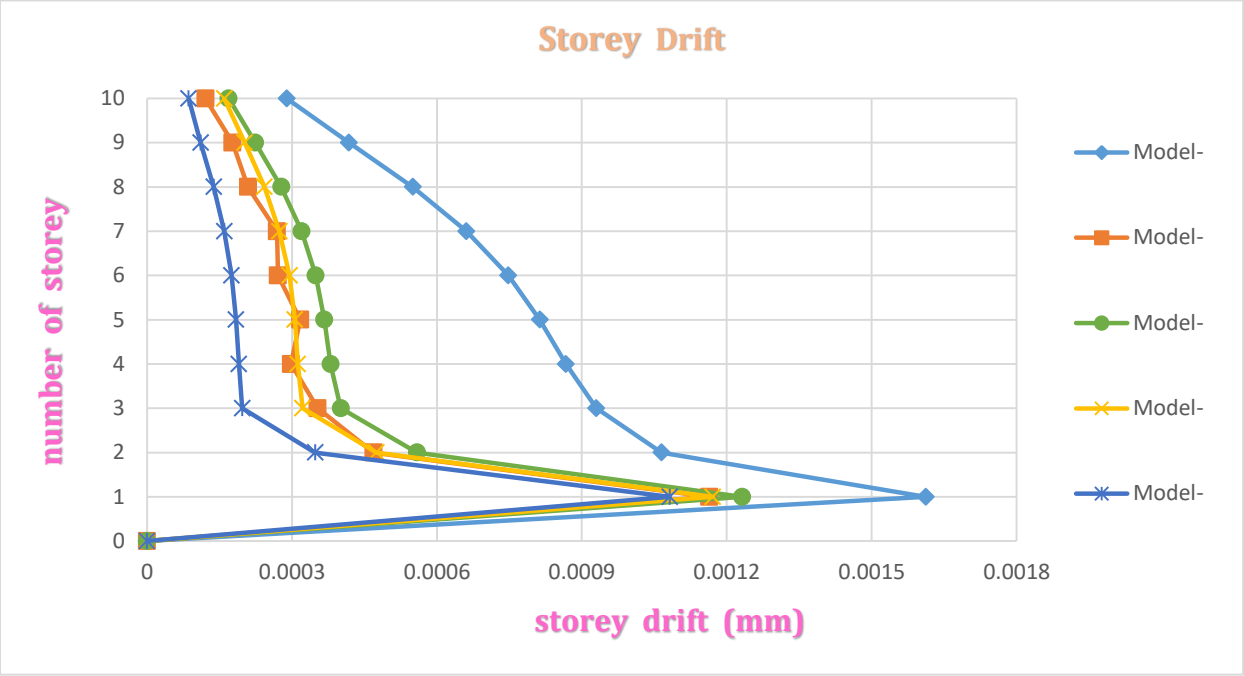

Chart 8: Variation of storey drift for HDRB base condition and types of bracing.

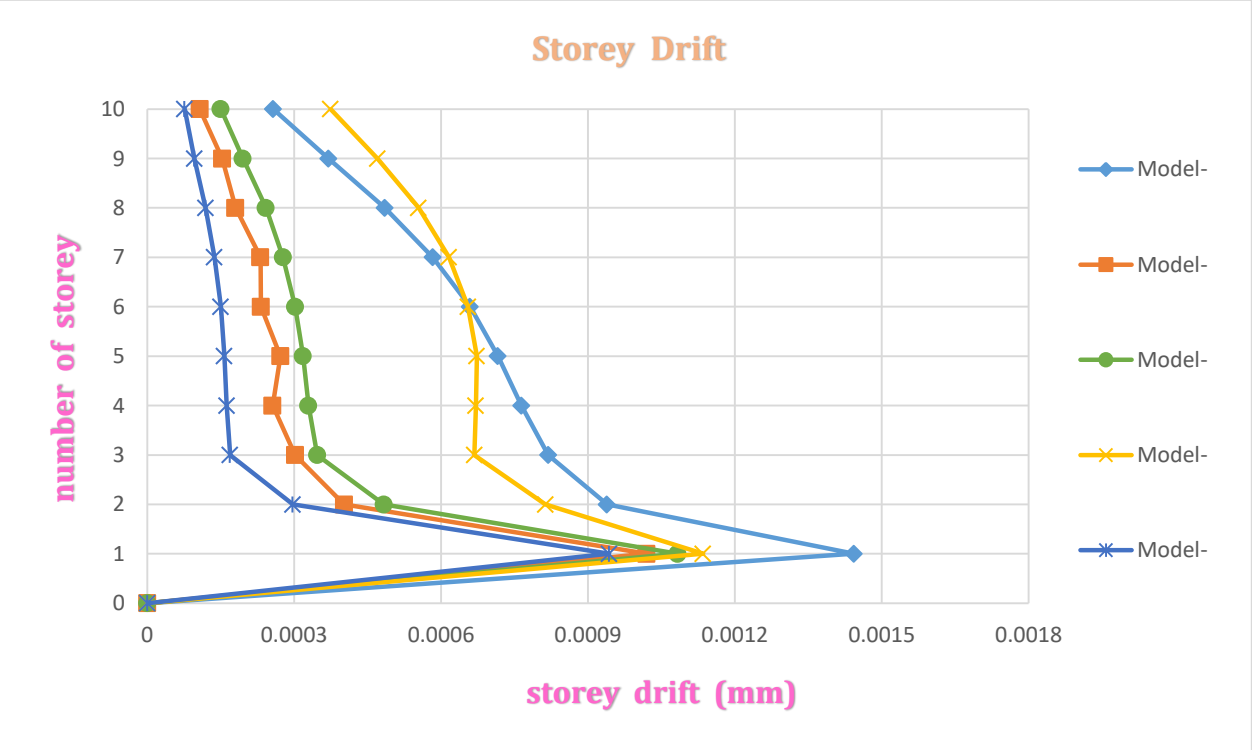

Chart 9: Variation of storey drift for LRB base condition and types of bracing.

The above Chart 7 to Chart 9 and table 5 shows the storey drift of the building with different bracings and without bracings.

The storey drift are increased upto storey 3 and then gradually decreased, reached to least storey drift at top storey in fixed base models i.e., 3rd storey for fixed base condition. It is observed that, the storey drift of base isolated models is maximum at first storey due to reduction in stiffness at base level. The storey drift of models with base isolators is less compared to models with fixed base for all the storeys, except first storey. The storey drift is increased in base isolated models by **1.12 times** and **1.01 times** for HDRB and LRB respectively. The E-type bracing has less storey drift and C-type bracing has more storey drift which indicate less .

6. CONCLUSION

1. Among base isolators, The LRB base isolator is more flexible and less stiff.
2. From all type of bracing considered E type bracing is more stiff and C-type bracing is less stiff
3. The LRB base isolator with E–types bracing is recommended as the LRB base isolator is more flexible indicate less stiffness. However, E-type bracing is stiffer which increases the stiffness of the structural member because it grasp the structure stable by interchanging the horizontal loads effectively. So hence LRB bearinf and E-type bracing is recommended.

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