Base Isolation In Seismic Structural Design

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***Abstract*---Numerous attempts on research and development for anti seismic structures or the structures that can withstand seismic hazards and lend some ground resistance in earthquakes haven't yielded any satisfactory conclusions. Even though after decades of study and implementation of advanced designing, execution and maintenance tactics in high rise structures, many construction aspects have found a new ways to deal with structural hazards, yet the concerns of seismic hazards are relatively found unanswered. These seismic hazards are prime matter of concern in Earthquake prone zones or the seismic zones worldwide.**

Over the period of time the research on structural dynamics, study and analysis of the same are carried on using series of earthquake movements by means of varying the earthquake or the seismic intensity. Studies shows those analyses were being performed on a fixed based structures, whereas here it could also be performed on isolated structures with nonaligned isolator elements. As per the analyses with effect of isolated structures, it was discovered that the isolators minimize the lateral load imposed on the structure and in accordance to that it also tend to reduce the size of the building components.

Base isolation has turned out to be a trending design over past few years; here we take a detailed glance at the designing, working, testing as well as the suitability of base isolation design as per Indian Standards. The study would also comprise use of new designing software's for the analysis taking a building structure as a model in consideration for case study and later concluding the subject post results. The probable merits of base isolation over the conventional approach of dynamic analysis will be discussed.

Key words — Sap2000, Time History Analysis, Base Isolation, Lateral displacement,

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. Inertia force is induced in structure because of this earthquake movement as result damage of the structure increases with the ground motion. It's permissible to the engineers to use ductility to attain more deformation on the structure than the permitted elastic limit by increasing small sum of forces. The maximum point at which the structure can deform and come to its original shape is called as Elastic limit. If building deforms more than its elastic limit, it forms cracks in the structure. However, ductility will induce some acceptable damage to the structure. But if more elasticity is introduced to the structure, it may tend to increase the overall cost and decrease the damage by increasing the strength, which in turn will be harmful to the components of the building with less strength.

Earthquakes are unanticipated phenomena if the structure is located in seismic zones. The structural engineer has to step in so as to save lives and cause minimal damage to the structures in times of earthquake. The recent development for anti seismic designs is base isolation, which may not reduce the ground movement but would help in keeping the impact of ground movement to its minimal extend.

Base isolation system is the frequently adopted earthquake resistance system. It reduces the effect of ground motion and thus leads to nullify the effect of earthquake to on the structure. Base isolation has become popular in last couple of decades in its implementations in buildings and bridges. Base isolation has become a traditional concept for structural design of buildings and bridges in high risk areas. Many are being already constructed and many are under construction. When Base Isolation in a seismic Structural Design of earthquake occurs, the ground moves laterally and damages the structure. Bifurcating the structure form the ground by introducing flexible isolation system between the foundation and the structure is the solution to this problem. This system will absorb the shock impact effects of earthquake with the help of its flexibility. This way the seismic energy transmitted to the structure will be reduced to greater extent and the structure will remain stable for a relative period. Base isolation increases the natural period of the structure and so reduces the displacement of the structure during seismic event. Rubber bearing and lead rubber bearing are prime factors used to introduce flexibility in the structure. This increased the natural period of the structure and base displacement is more than prearranged limit. Though, base isolation not always liable to work against the strong earthquakes as it may result in larger displacement at the base of the structure.

as suggested in its name –

Base = a part that supports from beneath or serves as a

foundation for an object or structure.

Isolation = the state of being separated, and (definition according to Concise Oxford Dictionary), is that of decoupling a structure from its foundation, separating the superstructure from the columns or piers .

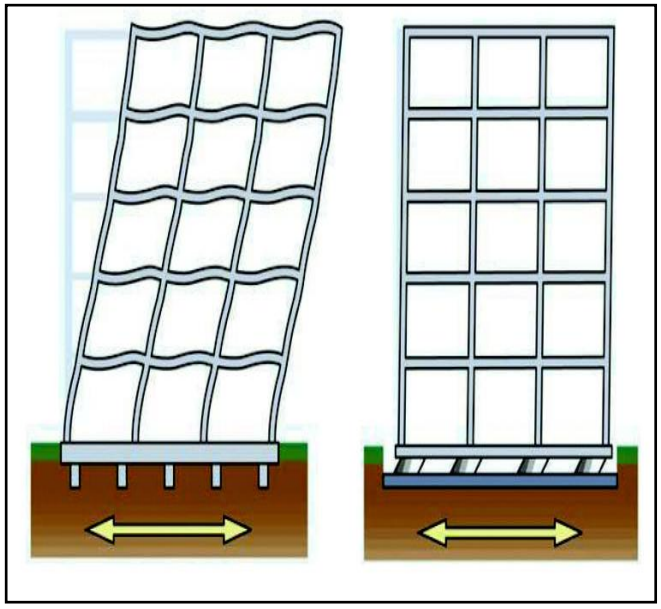

Fig. No. 01 Performance Of Building with & without Isolation

II. THE CONCEPT OF BASE ISOLATION

Basic principle of base isolation is to differentiate the building from its foundation, so during the seismic action, building is stays unaffected from the ground motion. In other words, even though ground moves aggressively, the building will tend to move ideally as a rigid body rather than collapsing. This reduces the floor hastening and storey gliding and so the building components are left less harmed. In the model, separation is total but practically, there is some co relation between the ground and the building which provides flexibility to the structure. Any stiff structure will have short period. During the ground movement, amount of acceleration entrusted in the structure is the same of ground acceleration that results in zero displacement between the structure and the ground. In other words, ground and structure will move with equal amount.

Flexible structure will have longer life span. In this particular type of structure, when the ground moves, no acceleration is introduced in the structure. Displacement between the structure and the ground is the same to the amount of ground displacement. In other words, ground will move but not the structure.

Base isolation increase the flexibility of the structure and hence increases the period of the structure which is due to the isolators. The effect of period shift is shown in figure introducing the base isolation in the structure increases the displacement and eventually decreases the acceleration in the structure as the stiffness of the structure also decreases. Generally, the isolation is placed at the base of the structure, Base isolation protects the building components of the superstructure during earthquakes. The acceleration in the superstructure and the inertia forces induced in the structure are reduced considerably due to isolation.

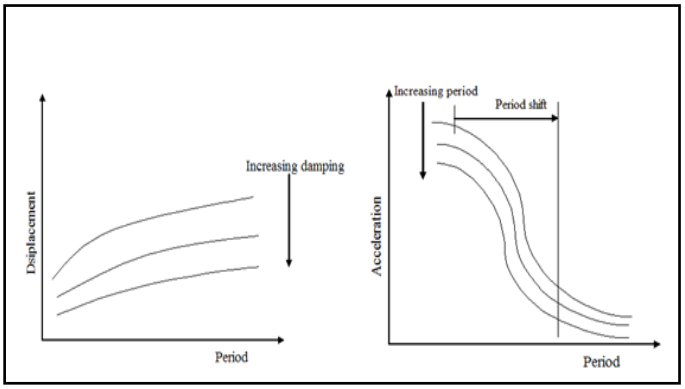

Fig. No.02 Increasing displacement and decreasing acceleration with increasing period

The principle in base isolation,

- To provide horizontally flexible as well as vertically stiff to the building.
- To lengthening the natural period of the building.
- Damping in the Isolation system reduces the displacement.
- It also reduces in the acceleration of the story.

Base isolation system should contain following:-

1. An elastic mount to add enough vibration periods to the structure to lower down the forces in the structure over.

2. An energy dissipater or damper to ease the deflection taking place between the structure and the ground.

3. Introducing the stiffness against the seismic actions and wind loads.

Base Isolation Consideration

Base isolation is required if any circumstances arise of the following:-

1. Need to increase the safety of the structure.
2. Low lateral seismic forces needed.

3. Any existing building is not capable to withstand any earthquake.

4. Withstand small earthquakes without any damage.

5. Structure will not collapse in high level earthquake but some structural and non-structural damage will occur.

III. DIFFERENT TYPES OF SEISMIC ISOLATOR

The most common use of base isolator in building is

1. Laminated Rubber (Elastomeric) Bearing.
   a. Natural and synthetic rubber bearing (*low damping*).
   b. Natural rubber bearing (*high damping*).
2. Lead Rubber Bearing (LRB)
3. Friction Pendulum (FPS) System Bearing

1. Laminated Rubber (Elastomeric) Bearing

Low Damping Rubber Bearing:-

It is made of alternate layers of natural rubber that provide flexibility and steel reinforcing plates that leads to vertical load-carrying capacity. At the top and bottom of these layers are steel laminated plates which distribute the vertical loads and transfer the shear force to the internal layer of rubber. This system of elastomeric bearing is variedly used in residential buildings, hospitals and halls constructed on the subway or railroads.

High Damping Rubber Bearing: -

It is similar to elastomeric bearings where the elastomeric used (either natural or synthetic rubber) provides a significant amount of damping The damping in the bearing is increased by adding extra-fine carbon block, oils or resins and other proprietary fillers

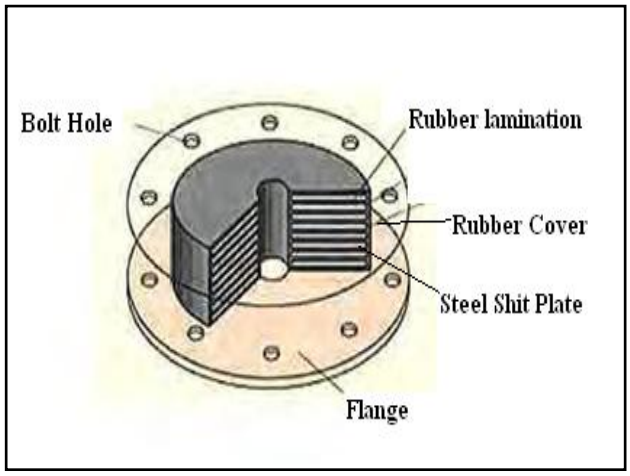

Fig. No.3 Laminated Rubber (Elastomeric) Bearing

2. Lead Rubber Bearing (LRB)

The LRB was first used in New Zealand in1975 and was from then onwards used on large scale in New Zealand, Japan and United States. These are same laminated as low-damping rubber bearings. One or more than one lead plugs are installed in the bearings which support the structure and provides along the ground flexibility to the structure.

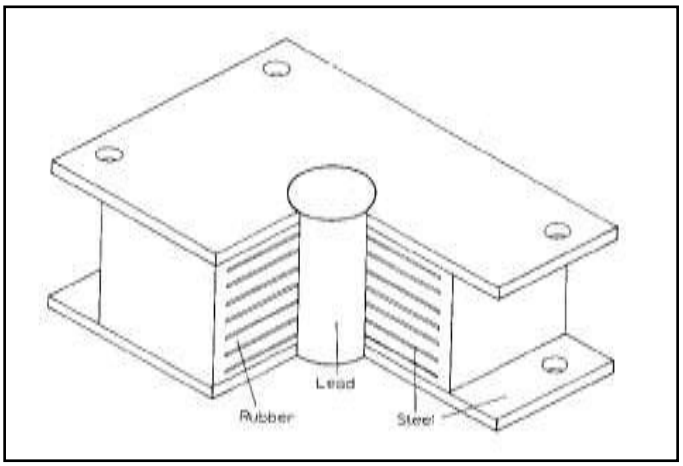

Fig. No.04 Lead Rubber Bearing (LRB)

3. Friction Pendulum bearings

Single pendulum bearing and triple pendulum bearing are two different types of friction pendulum bearings. Two horizontal steel plates slide over each other during the earthquake. In other words the ground movement only takes place on the bearing and the structure stays as it is. Those bearings are strong enough to carry the weight of the building.

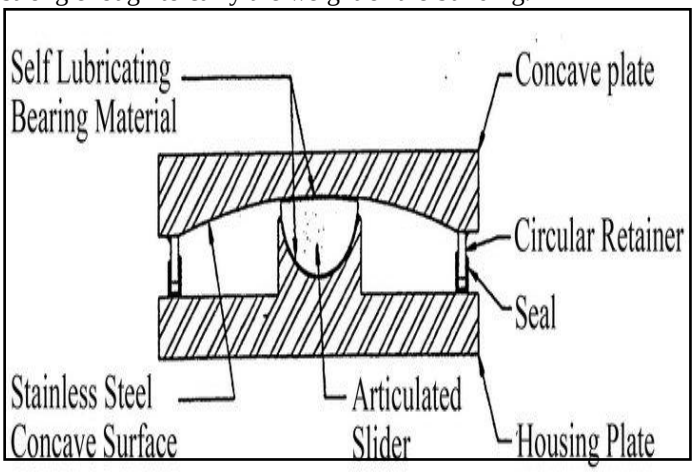

Fig.05 Friction Pendulum bearings

I. Case study of Commercial building

The (G+15) RCC building is considered for the case study. Its modeled in SAP2000 software and analyzed for fixed base, bracing and Isolator. The non-linear time intervals analysis is carried out by considering El-Centro time history ground acceleration data. Theoretical comparison is then

worked out between the fixed base and the base isolated structure and the parameters such as base shear, mode period, storey displacement, storey drift and storey acceleration by using SAP2000

Building Details :-

Table No.1 Building Data

01.	Grade of concrete	M30
02	Grade of steel	Fe415
03.	Story	G+15
04	Size of beam	230mmX450mm
05	Size of column	600mmX600mm
O6	Wall thickness	230mm
07	Slab thickness	150mm
08	Plinth height	1.5m
09	Bracing	ISA 150X150X15
09	Story height	3m
10	Live load	3KN/m
11	Floor finish	1.5KN/m

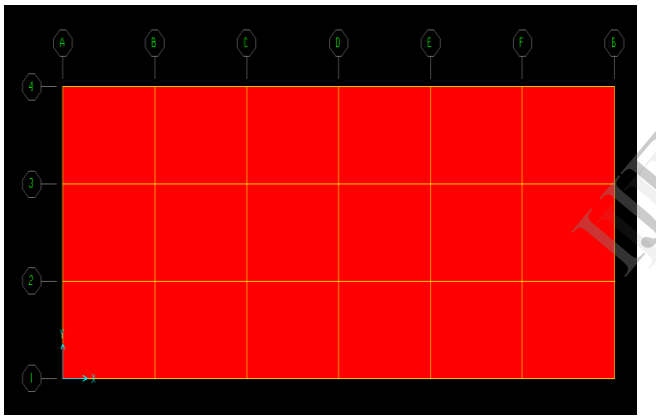

Fig. No.06 plan of building

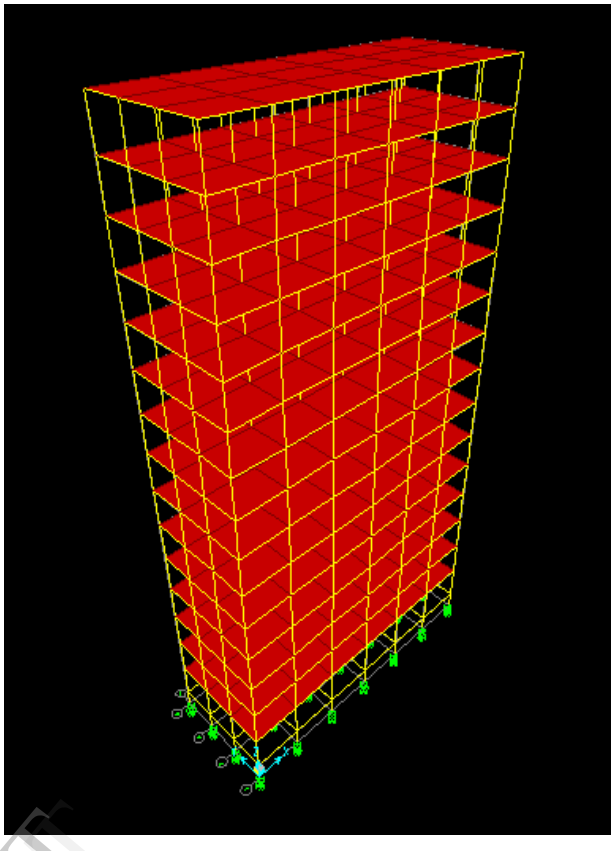

Fig. No.07 Elevation of building

IV Results

Table No.2 Time period in second

Fixed Base	LBR	HDRB	B-X	B-Y
2.65044	3.8860	3.7689	2.328414	2.389516

A. Base Shear

The graph shows (*Fig.8 & Fig.9)* the maximum base shear both in X & Y directions.

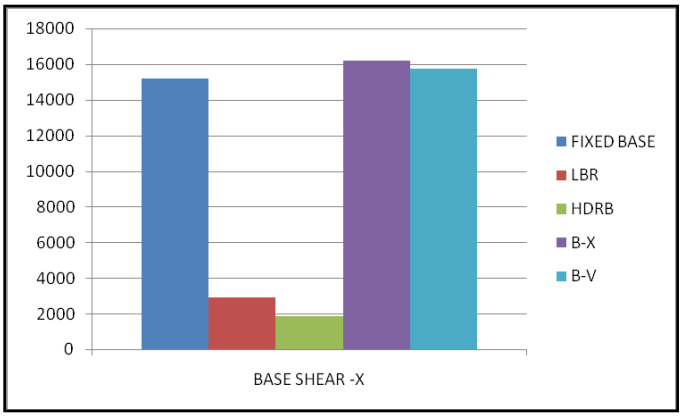

Fig. No.8 Base Shear -X

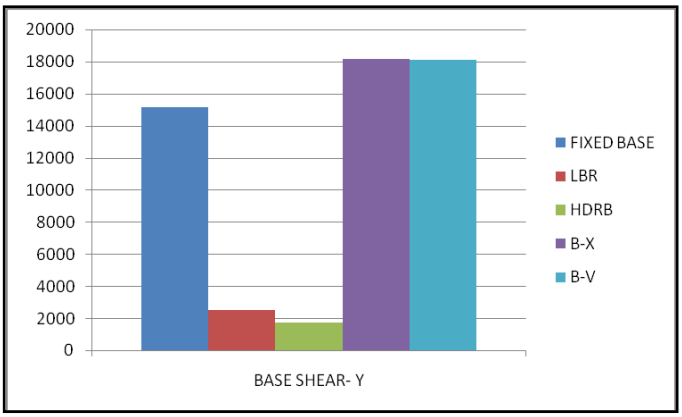

Fig. No.09 Base Shear –Y

B. Storey Displacement

The graph *(Fig.10 & Fig.11)* shows the storey displacement for the structure, both in X and Y direction respectively.

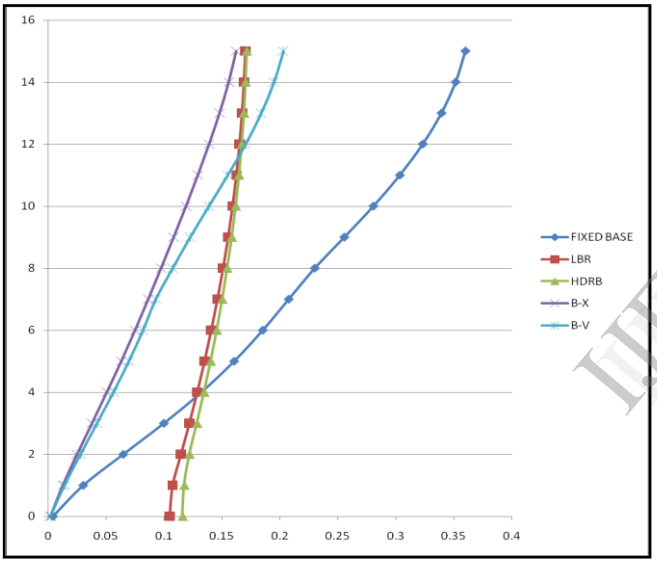

Fig. No.10 Displacement-X

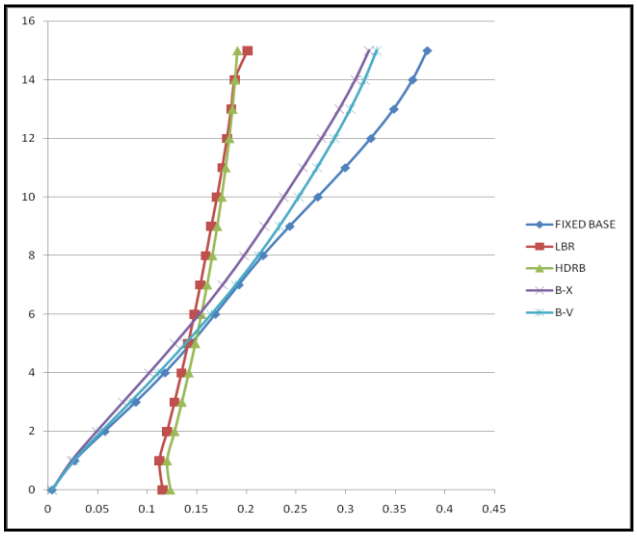

Fig. No.11 Displacement-Y

C. Storey Drift

The graph *(Fig.12 & Fig.13)* shows the storey drift for the structure, both in X and Y direction respectively

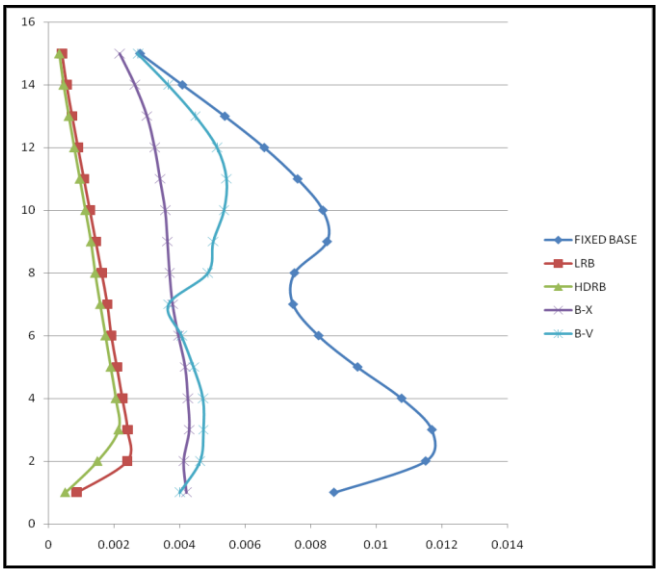

Fig. No.12 Story Drift – X

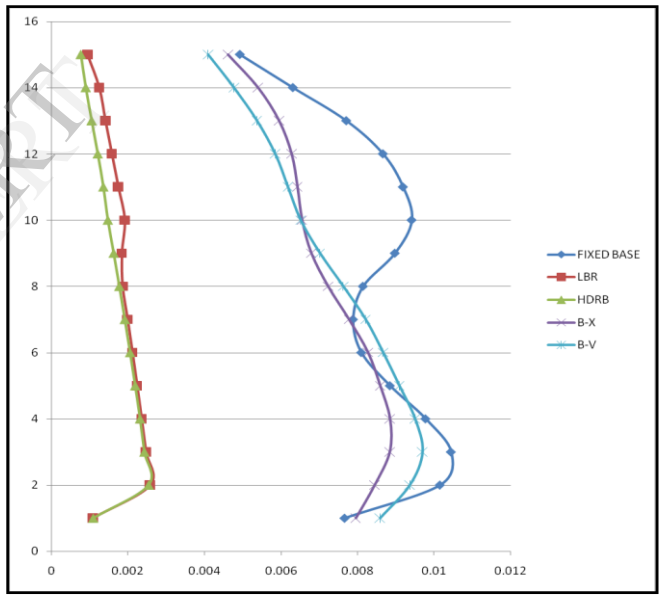

Fig. No.13 Story Drift – Y

V . CONCLUSIONS

- Effectiveness of isolation technology can be perceptible when it is compared to the results obtained from the analysis of non-isolated buildings.

- Base isolation system is an extraordinary and widely recognized advancement that is used to save innumerable lives and money spend in destruction made my earthquakes.

- From the above result base shear is decrease while the using base isolator
- Base isolator is minimize displacement and story drift in both the direction as compared with other system.
- Time period of both the base isolated structures i.e. LBR and HDRB increases as compared to the fixed base structure, but it decreases with the bracing

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