STUDY ON VIBRATION CONTROL OF FRAMED STRUCTURES USING BASE ISOLATION

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ABSTRACT

A large 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 one of the best solutions. The concept of protecting a building from the damaging effects of an earthquake by introducing some type of support that isolates it from the shaking ground is an attractive one and many mechanisms to achieve here results have been developed. In present research work modeling is done using SAP software , model consists of 8 storeyed ordinary moment resisting frame.1940 El Centro earthquake 0.319g data is considered for Time history analysis. By conducting Time history analysis floor displacement and roof displacement response curves of the isolated structures with fixed base are plotted which indicates that the displacement for isolated structures is more at base in comparison with fixed base and it reduces as the storey height increases. Reduction in acceleration and velocity response compared to fixed base structure.

I. INTRODUCTION

Base isolation is a passive vibration control system that does not require any external power source for its operation and utilizes the motion of the structure to develop the control forces. The application of this technology may keep the building to remain essentially elastic and thus ensure safety during large earthquakes. Structural control relies on stiffness and damping devices in a structure to control its response to undesirable excitations caused by winds and moderate earthquakes. The vibration isolator is a device that is designed to effectively isolate structures from harmful vibrations.

Lead Rubber Bearings

Lead rubber bearings are comprised of the alternating rubber and steel shim layers. These layers are joined together by means of the vulcanization process under pressure and heat to produce a composite bearing. The bearings are mounted between two thick end plates to facilitate the connection between the foundations and the isolation mat. Steel shims add vertical stiffness to the bearings and hence prevent the rocking response of an isolated structure. The shims have no effect on lateral stiffness of bearings as it is controlled by the shear modulus of the elastic material. In addition steel shims prevent rubber from bulging out under high axial compressive loads. The lead plug in combination with the rubber causes the device to demonstrate bilinear behavior. Under low service wind loads, high stiffness of the lead plug attracts most of the load and the arrangement shows high stiffness. Under extreme seismic loads lead is deformed plastically and hence the stiffness of the device drops to just the stiffness of rubber.

Frictional Pendulum Bearing

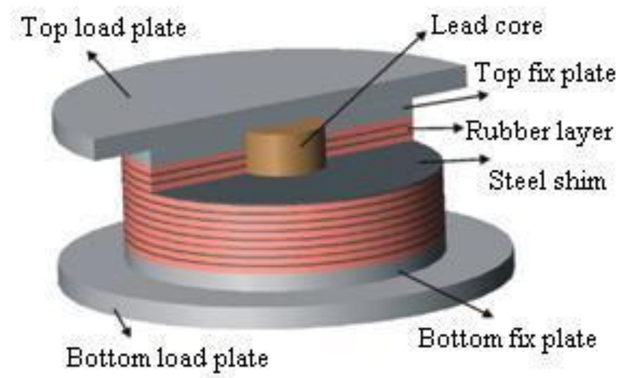

Fig. 1: lead rubber bearing

Friction pendulum bearings combine sliding with pendulum action. The schematic layout of a friction pendulum bearing is shown below. They consist of an articulated slider on a spherical concave chrome surface. The slider is covered with a polished bearing material such as Teflon. The friction coefficient between the surfaces is of the order of 0.1 at high velocity sliding and of the order of 0.05 at low velocities. Just as with the conventional sliding bearings, a friction pendulum system act as a fuse and is activated when earthquake forces exceed the value of static friction. Lateral force developed by such bearings is a combination of frictional force and the restoring force due to the rising of the building up the spherical surface. The restoring force in a bearing is proportional to the weight supported by the bearing and inversely proportional to the radius of curvature of the concave surface. Due to static friction, such bearings do not deflect under service wind loads, which is a highly desirable characteristic.

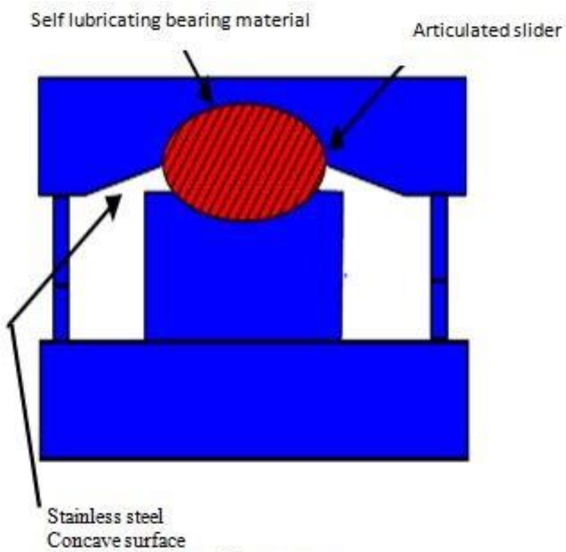

Fig 2: frictional pendulum system

II. METHODOLOGY

A. MODELLING

Modelling is carried out using SAP2000 (Structural Analysis Programming) software of version 14.2.4.

B. SALIENT FEATURES OF THE BUILDING

The 8 storey building sits on a 25mx25m area. The storey height is 3m with a slab thickness of 150mm at each floor. The column and beam cross section used in this structure is 300x600mm and live load on each floor is taken as 3 kN/m2. Wall thickness is taken as 230mm. M25 and Fe415 are taken as the material properties. Seismic zone is taken as V as per IS 1893(Part I):2002.

Method of analysis is static (Equivalent Static Analysis) and dynamic (Time History Analysis)

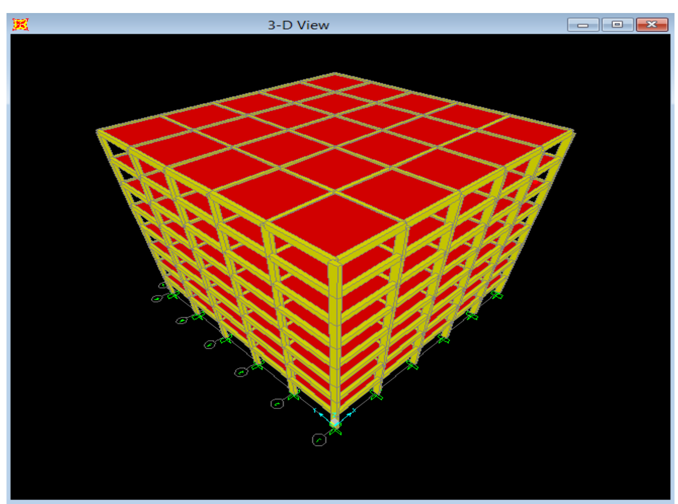

Fig 3: 3D extruded view

III. RESULTS AND DISCUSSIONS

A. **BASE SHEAR**

B. Base shear is estimate of the maximum expected lateral force that will occur due to seismic ground motion at the base of the structure. It has been observed that base isolation process is very effective in reducing the base shear as compared to conventional fixed base structure. As a result the potential damage to the bottom level of eight-storey frame structure is reduced. The seismic demand of the structure to be considered during design is drastically decreased. Reduction in base shear is 63.03% for FPB and 63.03% for LRB with 15% damping

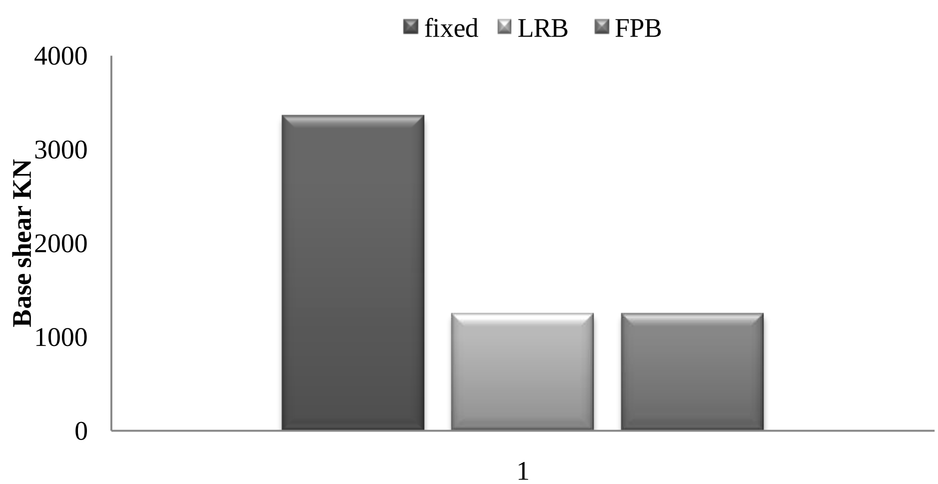

Fig 4: Base shear comparison

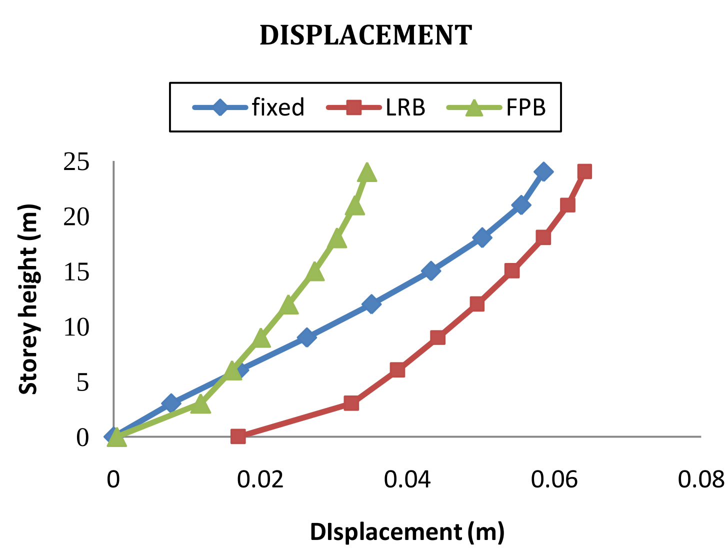

Fig 5: Displacement comparison

Displacement in fixed base structure is zero at the base and increases as the storey height increases. Whereas in isolated structures there is a small displacement at the base and increases gradually with the height.

A. STOREY DRIFT

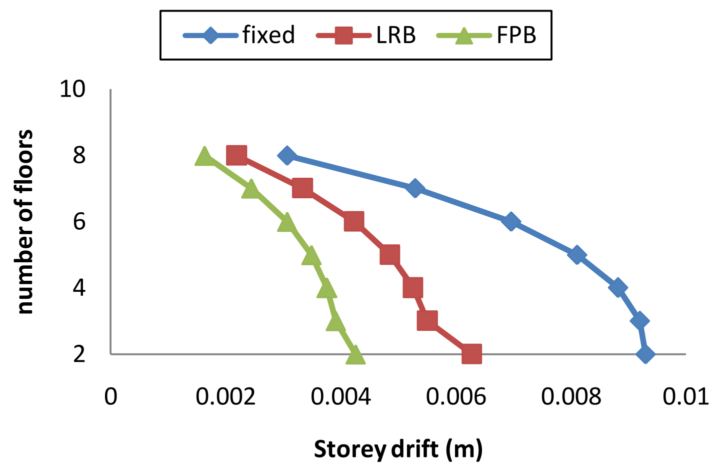

Fig 6: Storey drifts comparison

In case of fixed base building, storey drift is higher at the lower floors and it decreases drastically as we move to the top floors. In case of base isolated buildings, storey drift is comparatively lower than fixed base buildings at the lower floors and decreases as we move to the top floor.

C. SHIFT IN TIME PERIOD

Base isolation shifts the fundamental time period of the structure from the dominant period of the earthquake. Generally it shifts the time period of the structure more than 2 seconds. The dominant periods of the earthquake are in 0.2 to 0.6 second range. The severe acceleration of an earthquake is avoided due to period shift provided by isolation.

From the table below the shift in time period is shown for 3 successive modes.

Table 1- Time period response of Base-Isolated Moment Framed Structures.

Mode	Fixed base	Isolated base (FPB)	Isolated base (LRB)
1	1.14	1.54	2.23
2	0.83	1.07	1.92
3	0.77	1.06	1.87

D. ACCELERATION

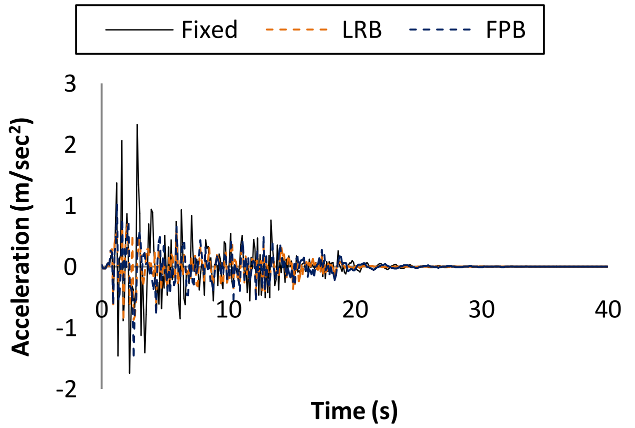

Fig 7: Time history of acceleration response at roof

Table 2- Acceleration response of base isolated structures as compared to its fixed base framed structure.

		Fixed	Isolated LRB	Isolated FPB
Maximum	Acceleration (m/s^2)	2.325	0.69	1.024
	Time (s)	2.8	2.0	1.2
Reduction			70.32%	55.95%
Minimum	Acceleration (m/s^2)	-1.741	-0.872	-1.41
	Time (s)	2.2	2.5	2.5
Reduction			49.91%	19.01%

E. VELOCITY

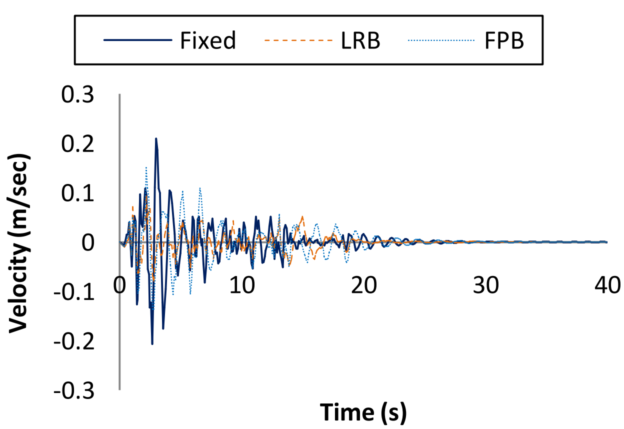

Fig8: Time history of velocity response at roof

Table 3 -Velocity response of base isolated structures as compared to its fixed base framed structure.

		Fixed	Isolated LRB	Isolated FPB
Maximum	Velocity(m/sec)	0.209	0.092	0.14
	Time (s)	3.0	2.2	2.2
Reduction			55.98%	33.33%
Minimum	Velocity(m/sec)	-0.2060	-0.078	-0.13
	Time (s)	2.7	2.8	2.8
Reduction			62.13%	36.89%

IV. CONCLUSIONS

By conducting Equivalent static analysis it was shown that base isolation increases the flexibility at the base of the structure which helps in energy dissipation due to the horizontal component of the earthquake and hence superstructure's seismic demand drastically reduced as compared to the conventional fixed base structure.

In terms of LRB the lead core present at the centre increases the energy absorption capacity of the isolator and in FPB energy is dissipated in the bearings through friction in the form of Coulomb damping.Base isolation reduces base shear by 63% for both LRB and FPB at 15% damping.

It also reduces story drift as compared to the conventional fixed base structure.

first mode time period of fixed base building is found to be 1.14 sec whereas the first mode period of isolated building (FPB) found to be 1.54sec and of isolated building (LRB) is found to be 2.23sec.

By conducting Time history analysis floor displacement and roof displacement response curves of the isolated structures with fixed base are plotted which indicates that the displacement for isolated structures is more at base in comparison with fixed base and it reduces as the storey height increases. And reduces the velocity, acceleration response by 55-70% for LRB 33-55%.

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