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Seismic Response Control of Building using Rubber Isolator

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Abstract*: Base isolation (BI) is a mechanism that provides earthquake resistance to the new structure. Earthquakes are one of the natural hazards that occur due to sudden violent movement of earth's surface which releases energy and has destructive power in many parts of the world. Base isolation is one of the most powerful tools of earthquake engineering pertaining to the passive structural vibration control technologies. It limits the effects of the earthquake attack through a flexible base which decouples the structure from the ground motion, and the structural response accelerations are usually less than that of the ground acceleration. In the present work Analysis was carried out on the framed structure by the use of computer program SAP 2000 v14.2.0. The dynamic analysis of the structure has been carried out and the performance of the building with and without isolator is studied. A parametric study has also been conducted and the results can be used in the implementation of a real-time structure to improve its seismic performance.
***Keywords:* Base Isolation, Passive Vibration Control, Time history analysis.**

I. INTRODUCTION

Base isolation (BI) is a mechanism that provides earthquake resistance to the new structure. Earthquakes are one of the natural hazards that occur due to sudden violent movement of earth's surface which releases energy and has destructive power in many parts of the world. Base isolation is one of the most powerful tools of earthquake engineering pertaining to the passive structural vibration control technologies. It controls structural response in which the building or structure is decoupled from the horizontal component of the earthquake ground motion by interposing a layer with low horizontal stiffness between the structure and its foundation. A base-isolation system reduces ductility demands on a building, and minimizes its deformations. These changes improve building performance and allow much greater architectural freedom in the choice of the structural type and in its layout and detailing. Economies are increased and performance improved by using high- strength low-ductility structural configurations. According to the revised provisions of IS 1893 (Part 1): 2002 Code [3], the seismic zones of India become more vulnerable and reduced to four zones. So, it is important to design the structures with seismic resistance. In seismic isolation, the fundamental aim is to reduce substantially the transmission of the earthquake forces and energy into the structure. This is achieved by mounting the structure on an isolation system with considerable horizontal flexibility so that during an earthquake, when the ground vibrates strongly under the structure, only moderate motions are induced within the structure itself. As the isolator flexibility increases, movements of the structure relative to the ground may become a problem under other vibrational loads applied above the level of the isolator, particularly wind loads.

The main types of earthquake protective systems include passive, active and semi-active systems. In passive control systems, the devices do not require additional energy source to operate and are activated by the earthquake input. Active control systems require additional power source, which has to remain operational during an earthquake and a controller to determine the actuator output. Hybrid control systems combine features of both passive and active control systems. The primary function of an isolation device is to support the superstructure while providing a high degree of horizontal flexibility. This gives the overall structure a long effective period and hence lower earthquake generated accelerations and inertia forces.

A. Concept of Base Isolation

The basic concept of base isolation is to protect the structure from the damaging effects of an earthquake by improving dynamic response of structure. When base isolation is used, special bearings are installed between the bottom of the building and its foundation. The bearings are flexible in the horizontal direction and reduce the natural frequency of a building. The first dynamic mode of the isolated structure involves deformation only in the isolation system, and the structure above remains almost rigid. An isolated system does not absorb the vibrating energy, but rather deflects it through the dynamics of the system. It lengthens the

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natural period of vibration of the structure so that the responses are greatly reduced. In some cases, a passive damper may also use to control excessive displacement. Figure 1 represents the shifting of period by the isolator and the resulting reduction in the acceleration response.

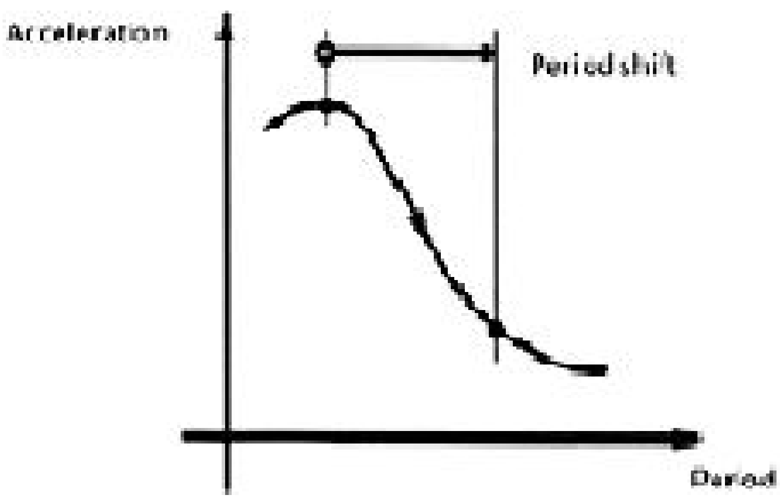

Figure 1. Period shift induced by an isolator

The main objective of this work is

1) To illustrate the basic concept and behavior of the base isolated structures.
2) To Analyze a building by providing rubber bearing and friction pendulum bearing.
3) To study and compare total base shear force, maximum absolute acceleration, velocity, displacement with respect to the fixed base and isolated base structure.

II. PROBLEM STATEMENT

For comparing a fixed base and isolated base building a Seven-storied building is modelled in the SAP 2000 software. An open frame building model with3 and 4 bays in each X and Y directions, the height of each storey as 3.2 m are modelled. Height. of building is 22.4 m, Width of building in X direction is 11m and Width of building in Y direction is 14 m. The material properties of the frame elements and the area element are defined and M25 concrete grade and Fe415 is used. The rebar material properties are also given. The beams and columns of dimensions b1 300x300, b2 300x350, c1 230x350, c2 230x400, c3 230x450 mm are given as frame elements. The slab in the building is assigned as a shell element with a thickness of 120 mm. Live load is taken as 3kN/m^2. Interior and Exterior wall thickness is taken as 150 mm and 230 mm. Soil type is taken as 1, Zone factor is V, Response reduction factor is taken as 5. And Importance factor is 1. All other data is referred from I.S.1893-2002. The SAP model of the building is shown in Figure 2.

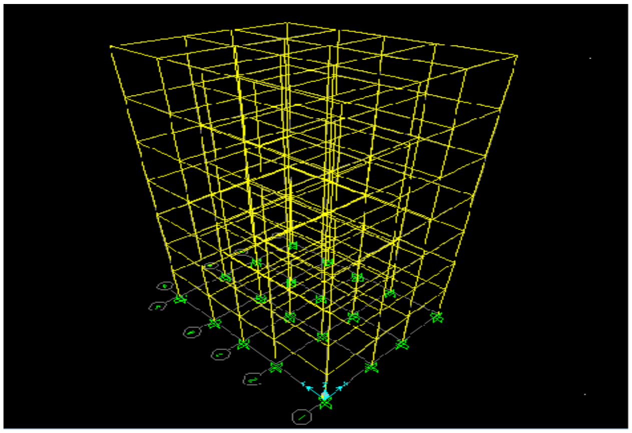

Figure 2a view of the SAP model with fixed base

Then the calculated rubber properties are given as link/ support properties in the software and the base-isolation model analysis is performed. The response of the structure with the rubber isolator and friction pendulum isolators are determined. The parameters selected to define the utilized Isolators in the SAP2000 program are as follows:

For Rubber Bearing:

Nonlinear Link Type: Rubber, U1 Linear Effective Stiffness: 1500000 kN/m, U2 and U3 Linear Effective

Stiffness: 800 kN/m, U2 and U3 Nonlinear Stiffness: 2500 kN/m, U2 and U3 Yield Strength: 80 kN, U2 and U3 Post Yield Stiffness Ratio: 0,1.

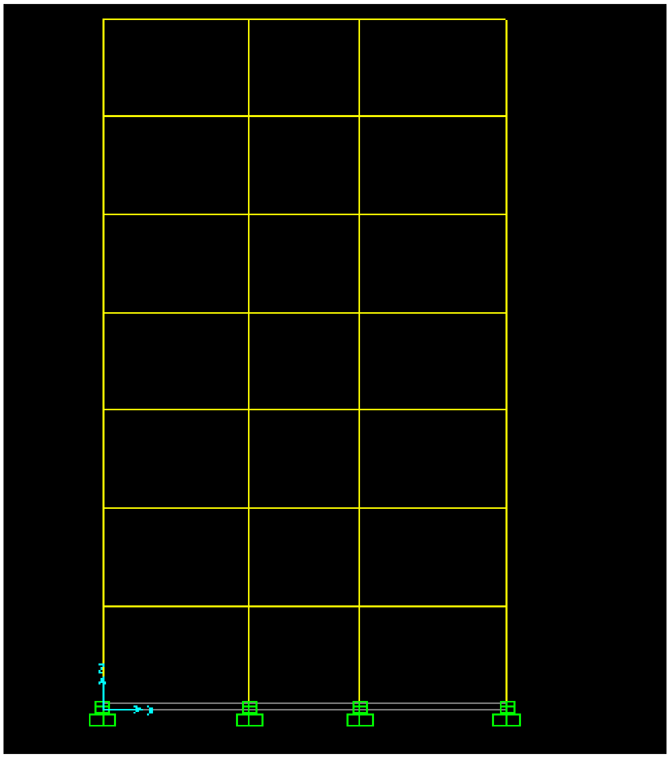

Figure 2b. View of rubber isolated base

III.RESULTS

Analysis is done for both X and Y direction for fixed base and isolated base and is also carried for different storey heights of the building for the same building plan i.e. each floor. The isolator in each case varies in its total height and its single layer thickness depends on the vertical loads on the columns. The corresponding increase in time verses displacement by using time history analysis is represented by graph for fixed, rubber and friction beraring base in X and Y direction.

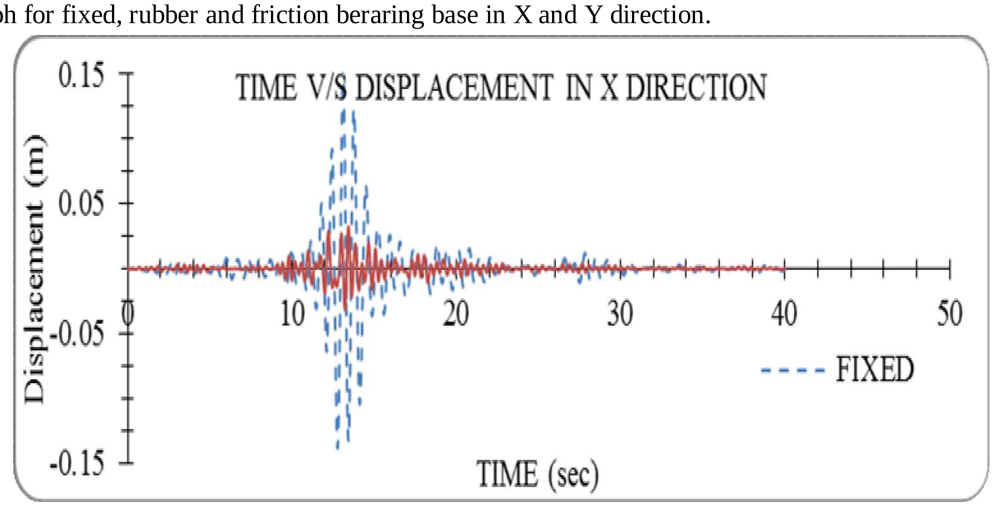

Figure 3a. For Fixed and Rubber bearing

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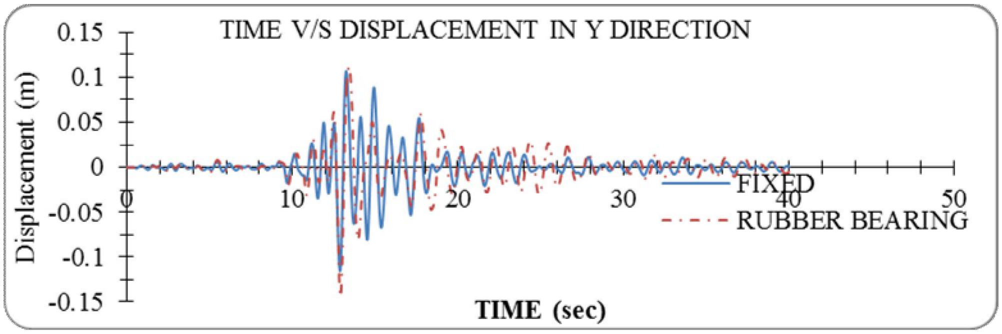

Figure 3b. For Fixed and Rubber bearing

Base reaction in X and Y direction for Fixed base, Rubber bearing isolators are represented by Figure 4 and reduction in percentage are shown in Table 1.

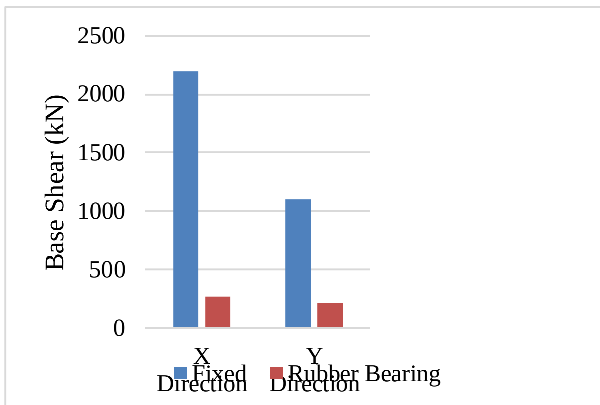

Figure 4. Base reaction v/s Story in X and Y direction

Table1. 1 Base Reaction Between Fixed and Rubber Bearing

Direction	FIXED	RB	Reduction
X	2200.176	268.558	87%
Y	1099.898	214.554	80%

Acceleration comparison with respect to story for fixed base and rubber bearing is represented by Table 2 for X direction and Table 3 for Y direction.

Table 2. Comparison of Acceleration between Fixed and Rubber bearing in X direction

	FIXED U1	RB U1	Difference	Reduction
Story	**X1**	**X1**	**X1**	**X1**
	m/sec2	m/sec2	m/sec2	m/sec2(%)
1st	3.26868	2.64427	0.62441	19.1
2nd	4.98295	3.5071	1.47585	29.61
3rd	6.52387	4.45245	2.07142	31.75
4th	8.07398	5.39808	2.6759	33.14
5th	9.73806	6.24319	3.49487	35.88
6th	11.36987	6.88498	4.48489	39.44
7th	12.37692	7.2579	5.11902	41.35

Table 3. Comparison of Acceleration between Fixed and Rubber bearing in Y direction

	FIXED U2	RB U2	Difference	Reduction
Story	**Y1**	**Y1**	**Y1**	**Y1**
	m/sec2	m/sec2	m/sec2	m/sec2(%)
1st	2.47461	2.58859	-0.11398	-1.046
2nd	2.64748	2.55756	0.08992	3.4
3rd	3.87731	2.57741	1.2999	33.52
4th	4.78505	3.74789	1.03716	21.67
5th	5.13	4.77362	0.35638	6.95
6th	5.13837	5.40081	-0.26244	-4.85
7th	5.4219	6.2219	-0.8	-12.85

IV. CONCLUSIONS

From the result, it is clearly shown that with the help of base isolators seismic response of the building is greatly reduced. By conducting the nonlinear time history 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.

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