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Study on Base Isolation System for Seismic Response Control

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Abstract— **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. . For this Three dimensional nonlinear time history analysis is performed on r/c building by the use of computer program SAP 2000 v12.0.0. The dynamic analysis of the structure has been carried out and the performance of the building with and without isolator is studied. The main objective here is to make seismic response control by providing Isolators and comparing between the fixed based and isolated base building. Rubber bearing and Friction pendulum bearing are used.**

I. INTRODUCTION

Base isolation (BI) is a mechanism that provides earthquake resistance to the new structure. Earthquakes are one of nature greatest hazards; throughout historic time they have caused significant loss of life and severe damage to property, especially to man-made structures. On the other hand, earthquakes provide architects and engineers with a number of important design criteria foreign to the normal design process. From well established procedures reviewed by many researchers, seismic isolation may be used to provide an effective solution for a wide range of seismic design problems. 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.

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 structue, only moderate motions are induced within the structure itself. 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.

Many kinds of isolation systems have been developed to achieve this function, such as laminated elastomeric rubber bearings, lead-rubber bearings, yielding steel devices, friction devices (PTFE sliding bearings) and lead extrusion devices, etc .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.

Dynamic Analysis shall be performed to obtain the design seismic force, and its distribution to different levels along the height of the building and to various lateral loads resisting elements. Dynamic Analysis may be performed either by the Time History Method or by the Response Spectrum Method. Time History Method shall be used on as approximate ground motion and shall be performed by using accepted principles of Dynamics. Response Spectrum Method of analysis shall be performed by using design spectrum specified in 6.4.2 as per I.S. 1893(Part1):2002

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 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.

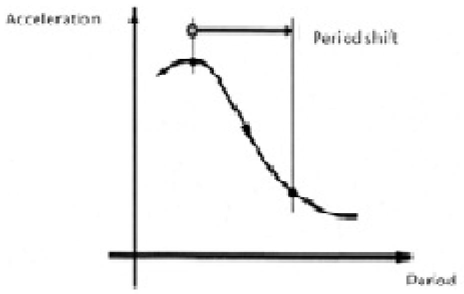

Fig. 1 Period shift induced by an isolator

The objective of this work is

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

II. DETAILS EXPERIMENTAL

For comparing a fixed base and isolated base building a Seven-storied building is modeled 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 modeled. Height .of building is 22.4m, 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 Fe-415 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 120mm. Live load is taken as 3kn/m2 .Interior and Exterior wall thickness is taken as 150mm and 230mm.Soil type is taken as 1,Zone factor is V, Response reduction factor is taken as 5.And Importance factor is 1.. The support condition at the bottom is made as fixed and the fixed-base analysis is performed considering the combination of 1.5(DL+LL).All other data is referred from I.S.1893-2002. The period for the fixed base is identified. The SAP model of the building is shown in Figure 2.

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:

ForRubber 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.
For Friction Pendulum Bearing:
Nonlinear Link Type: Friction Isolator, U1 Linear Effective Stiffness: 15000000 kN/m, U1 Nonlinear Effective Stiffness: 15000000 kN/m, U2 and U3 Linear Effective Stiffness: 750 kN/m, U2 and U3 Nonlinear Stiffness:15000 kN/m, U2 and U3 Friction Coefficient, Slow: 0,03,U2 and U3Friction coefficient, Fast : 0,05, U2 and U3 Rate Parameter: 40, U2 and U3 Radius of Sliding Surface: 2,23.(Referred from. Torunbalci1 and G. Ozpalanlar2 octo.12-17(2008))
After providing all the details the program is to be run to see the results.

III. RESULTS AND DISCUSSION

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 fig.2a,2b,2c in X and 3a,3b,3c Y direction.

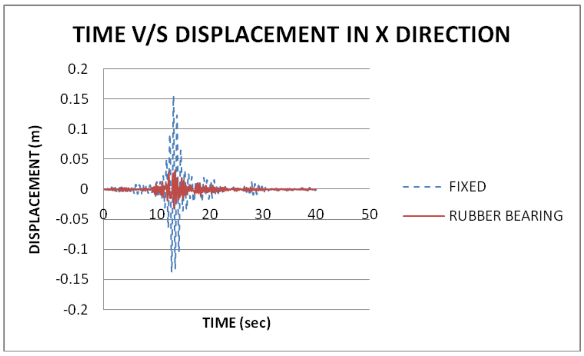

Fig 2a. For Fixed and Rubber bearing

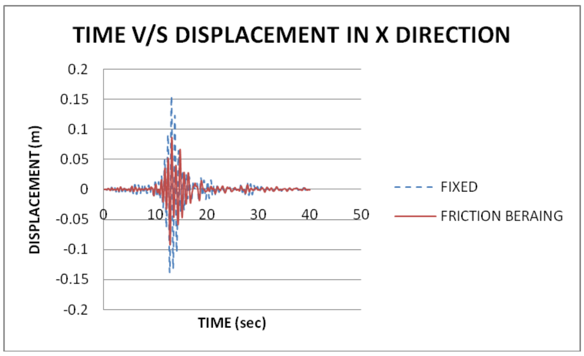

Fig 2b. For Fixed and Friction bearing

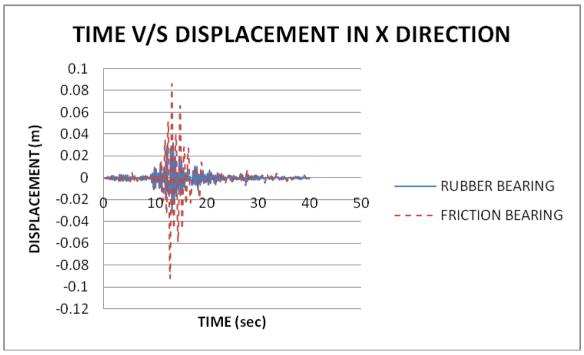

Fig 2c. For Friction and Rubber bearing

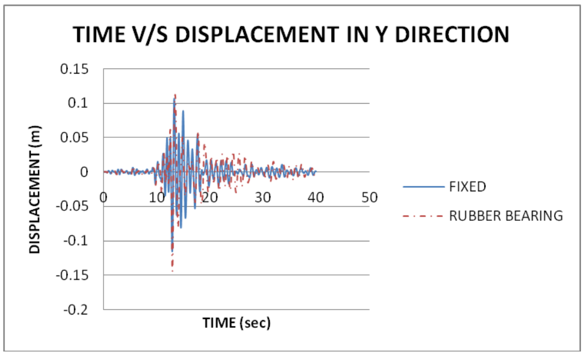

Fig 3a. For Fixed and Rubber bearing

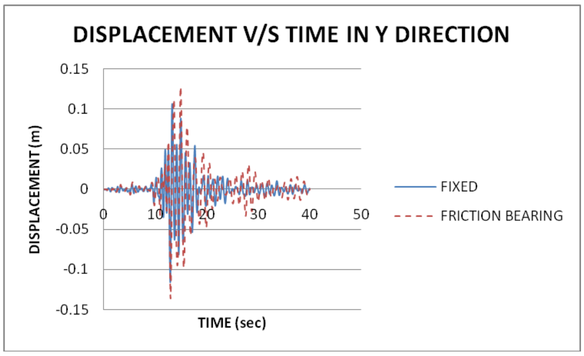

Fig 3 b. For Fixed and Friction bearing

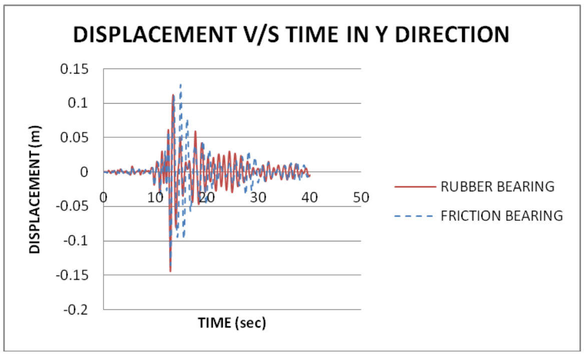

Fig 3c. For Friction and Rubber bearing

Base reaction in X and Y direction for Fixed base ,Rubber bearing and friction bearing isolators are represented byfig.4 and values are shown in table 1

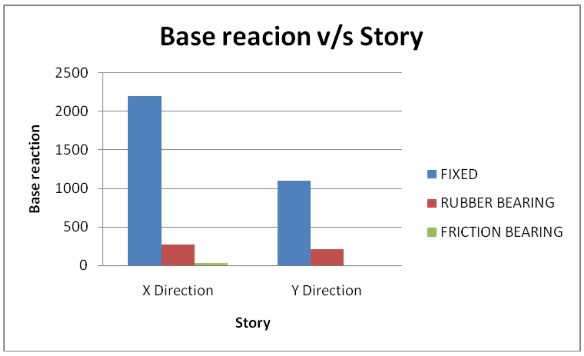

Fig 4. Base reaction v/s Story in X and Y direction

	FIXED	RB	FRB
X Direction	2200.176	268.558	33.616
Y Direction	1099.898	214.554	5.837

Table 1.BASE REACTION

Displacement with respect to story for fixed base ,rubber beraring, friction bearing are represented by fig 5 a for X direction and 5b for Y direction and values are shown in table 2

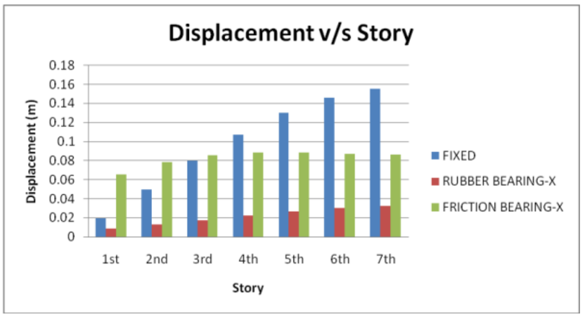

Fig 5a Displacement v/s Story in X direction

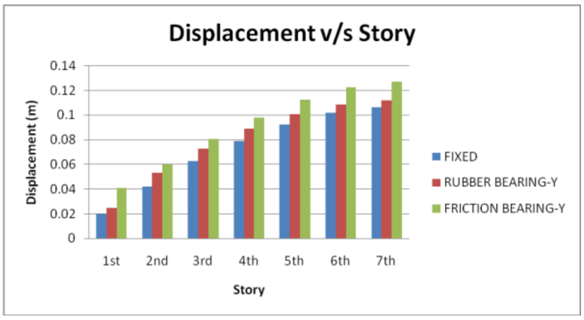

Fig 5b. Displacement v/s Story in Y direction

		JOINT DISPLACEMENT				
	Fixed U1	*Fixed U2*	*Rb U1*	*Rb U2*	*Frb U1*	*Frb U2*
Story	X	Y	X	Y	X	Y
	m	m	m	m	m	m
1st	0.019688	0.01943	0.00856	0.024781	0.065731	0.041051
2nd	0.049809	0.04222	0.01262	0.052928	0.078322	0.059677
3rd	0.080064	0.06249	0.01733	0.072985	0.085791	0.080492
4th	0.107544	0.07919	0.02223	0.089292	0.088718	0.09792
5th	0.130203	0.09239	0.02672	0.100713	0.088631	0.112487
6th	0.146413	0.10173	0.03019	0.108396	0.087336	0.122499
7th	0.155581	0.10667	0.03221	0.112042	0.086319	0.127335

Table 2

Acceleration with respect to story for fixed base ,rubber bearing, friction bearing are represented by fig 6 a for X direction and 6b for Y direction and values are shown in table 3

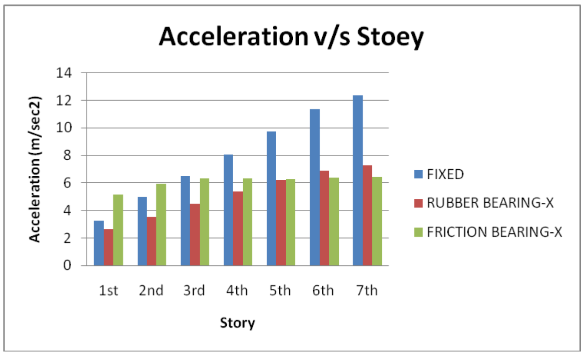

Fig 6a. Acceleration v/s Story in X direction

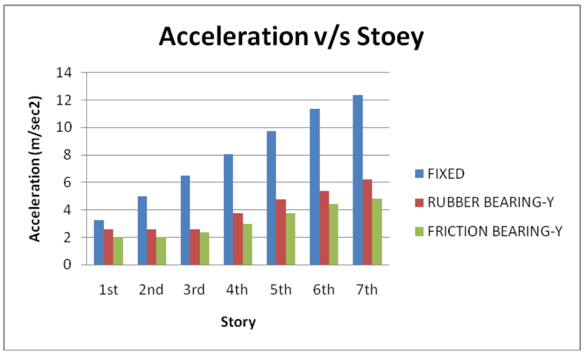

Fig 6b. Acceleration v/s Story in Y direction

		JOINT ACCELERATION				
	Fixed U1	*Fixed U2*	*Rb U1*	*Rb U2*	*Frb U1*	*Frb U2*
Story	X	Y	X	Y	X	Y
	m/sec^2	m/sec^2	m/sec^2	m/sec^2	m/sec^2	m/sec^2
1st	3.26868	2.47461	2.64427	2.58859	5.12463	2.01345
2nd	4.98295	2.64748	3.5071	2.55756	5.94795	1.98926
3rd	6.52387	3.87731	4.45245	2.57741	6.33089	2.3469
4th	8.07398	4.78505	5.39808	3.74789	6.34118	2.98273
5th	9.73806	5.13	6.24319	4.77362	6.25064	3.73975
6th	11.36987	5.13837	6.88498	5.40081	6.36227	4.40527
7th	12.37692	5.4219	7.2579	6.2219	6.43315	4.8021

Table 3

IV. CONCLUSIONS

- Base isolation system and basic concept of base isolation are studied .
- Base Isolators controls structural response in which the building or structure is decoupled from the horizontal component of the earthquake ground motion. A base-isolation system reduces ductility demands on a building, and minimizes its deformations.
- From the result, 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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