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COMPARATIVE PERFORMANCE OF LEAD RUBBER BEARING ISOLATOR AND FRICTION PENDULUM ISOLATOR FOR IRREGULAR BUILDINGS

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Abstract— Base isolation has been adopted and implemented as one of the promising technologies to resist the earthquake forces. The base isolation decouples the superstructure of building from the ground level by interposing structural element with low horizontal stiffness between superstructure and foundation level. This gives the structures fundamental frequency that much lower than both of its fixed base frequency and predominant frequency of earthquake ground motion. Presence of different irregularities like soft storey, weak storey, re-entrant corners, in plane discontinuity, out of plan offset etc. is major deficiency in building causing problem of stress concentration and additional torsion. Past study shows that due to the presence of these irregularities structures are more prone to damages as compared to regular structures. This research paper will be focus on to study the effect of Lead Rubber Bearing Isolator and Friction Pendulum Isolator on the irregular building. The various dynamic parameters like base shear, top floor absolute acceleration, base displacement, storey drift will be studied for different earthquake ground motions and comparative as well as parametric study between regular and irregular building will be carried out. The analytical study will be carried out by nonlinear time history analysis using SAP200 software.

Keywords— Base isolation, LRB, FPS, Irregular buildings, Time History Analysis

I. INTRODUCTION

arthquake is one of the major natural calamities to life on the earth. In the past earthquake has affected number of country and regions and damaged the mostly man-made structure. Every year earthquake takes lives of thousands of people and destroys property worth billions. After the earthquake the structure may become the non-functional which may be problematic to some public structure like hospitals, communication centres, nuclear power plant etc. which need to remain functional well after the earthquake.

Many structures constructed with utmost techniques which have undergone severe damages due to Earth quakes lead to enormous loss of life and property. This emerging problem all over the world made engineers to develop innovative systems on earthquake resistant system. The major criterion of a structure is to enhance the structural safety economically against severe damages caused due to natural calamities such as Earth quakes. If a building is said to withstand a considerable displacement, without any structural damage and had inbuilt with a suitable elasticity, then the structure is said to be a Ductile one. In this approach, less importance is given to non-structural components. Hence because of many uncertainties we develop an alternative approach called Base Isolation**.**

Base isolation decouples the superstructure of building from the horizontal components of ground motion by interposing structural element with low horizontal stiffeness between superstructure and foundation of building. This gives the the structure a fundamental frequency that is much lower than both of its fixed base frequeny and and the predominant frequency of the ground motion. This lenthening of the fundamental time period results in the avoidance of resonance and the significant decrease of the floor acceleration. When the base isolation is applied the superstructure being relatively very stiff comapred to fixed base and behaves as a rigid body. The rigid body motions of the super structure results in the reduction of base shear, floor acceleration, and storey drifts of the structure and reduce the damage to the structural and non structural member.

Types of base isolation:

(1) Elastomeric Bearings - Low damping natural rubber bearings

- High damping natural rubber bearings

- Lead rubber bearings

(2) Sliding Bearings - Flat slider bearing

- Concave slider bearing

Lead rubber bearing isolator: Lead rubber bearings (LRB) are usually made of alternating layers of steel plates and natural rubber with a central hole into which the lead core is press-fitted. LRB include central lead plug that is use to increase additional stiffness and increase energy dissipation capacity of bearing. The high vertical stiffness is achieved by having thin layers of rubber reinforced by steel covers. In LRB isolators since damping comes from the lead core, usually there is no need to use high damping rubber and therefore ordinary rubber is generally used.

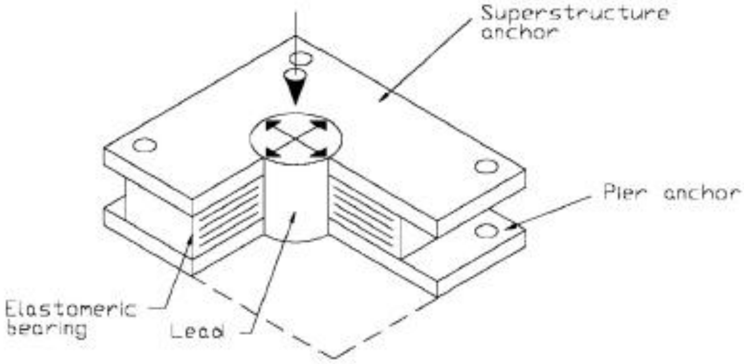


Fig.1 Lead rubber bearing isolator

Friction pendulum system: The approach for increasing flexibility in a structure is to provide a sliding or friction surface between the foundation and the base of the structure. The coefficient of friction is must be sufficiently high to provide a friction force that can sustain strong winds and minor earthquakes without sliding. Main problem with a sliding structure is the residual displacements that occur after major earthquakes. To solve this problem, the sliding surface is often made concave so as to provide a re-centering force. This is the idea behind the most popular friction pendulum system (FPS).

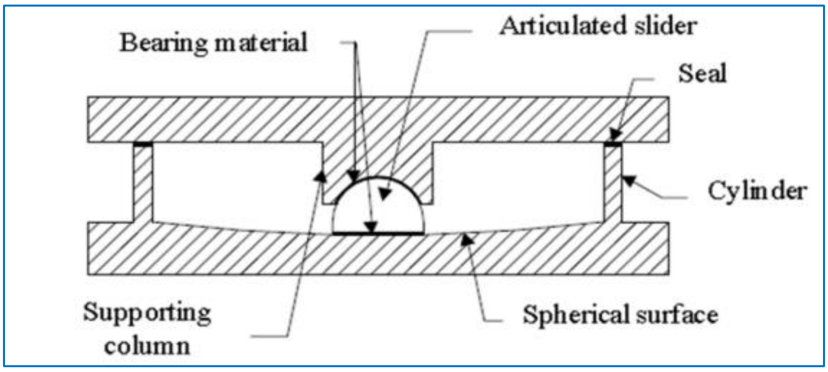


Fig.2 Friction pendulum system

IRREGULRITIES

Irregular buildings comprise a huge portion of the present urban infrastructure. Many times, there may be possible irregular distributions in their mass, stiffness and strength along the height of building. Asymmetry may arise due to uneven distribution of stiffness of lateral load resisting elements as well as non-uniform distribution of dead and live load mass on the plan of the building. Besides is non-coincidence of centre of mass (CM) and centre of rigidity (CR) and the resulting torsional response due to earthquake ground shaking.

TYPES OF IRREGULARITIES

Plan irregularities -Torsion irregularity

- Re-entrant corners

- Out of plane irregularity

- Floor slab having excessive cut outs

Vertical irregularities - Stiffness irregularity

- Mass irregularity
- Vertical geometrical irregularity
- Weak storey
- Floating Columns

II. RELATED WORKS

Victor A. Zayas, Stanley S. Low, Stephen A. Mahin This paper summarizes the results of a comprehensive research and testing program to assess the technical performance of the friction pendulum system. In addition, the example building design using the FPS is given. the shake table test of building models demonstrated that the use of gravity and geometry to provide the restoring force achieves an effective and versatile seismic isolation system. Components test of individual FPS isolators demonstrated that the isolators retain full strength and stability throughout their displacement range. The FPS isolated structure demonstrated excellent seismic response when subjected to severe earthquake ground motions, near fault event, long period motion and severe vertical motion.

M.K. Sharbatdar, S.R. Hoseini Vaez, G. Ghodrati Amiri and H. Naderpour in this paper estimation of seismic response of base-isolated structures for site close to an active fault should account for these aspects of near fault ground motions. For these structural models prepared for analysis include 15-story buildings. The models prepared using FPS isolators (Friction Pendulum System) and LRB (Lead Rubber Bearing). In this Nonlinear analytical modelling techniques were used for dynamic analysis of structural models. There are two Californian earthquake events selected as near-source ground motions: the 1966 Parkfield and the 1979 Imperial Valley earthquake. After the analysis result is as conclude under 4 records of Imperial Valley earthquake and it shows that the value of maximum base displacement can be differed as far as 66% in a zone restricted within a distance of about 4km from the ruptured fault. In addition to, in this zone maximum top floor acceleration can be differed up to 35% for the records of Imperial Valley.

ABM Saiful Islam, Mohammed Jameel, Syed Ishtiaq Ahmad, and MohdZamin Jumaat in this paper examine the effect of incorporation of isolator on the seismic behaviour of buildings subjected to the appropriate earthquake for medium risk seismicity region. It makes certain the incorporating isolator with all relevant properties as per respective isolators along with its time period and damping ratio. In this build up a relationship for increasing floor height and therefor the changes for incorporating isolator with same time period and damping ratio for each lead rubber bearing (LRB) and high damping rubber bearing (HDRB). Dynamic analyses achieved using response spectrum and time history analysis. Behavioural changes of structural parameters are reviewed. The study gives that the values of structural parameters reduce a large amount while using isolator. However, LRB is found beneficial than HDRB. The structure meets huge storey drift at the soft storey level that may be severe and cause immature failure.

Md Arman Chowdhury, and Wahid Hassan in this paper Multi-storey irregular structure of twenty stories with and without isolator has been modelled using software SAP2000 v15 for seismic zone of Bangladesh. Dynamic response of building under actual earthquakes, Chi-Chi, Taiwan, 1999 and Northridge have been studied. Lead rubber bearing (LRB) is applied which were connected to all column and foundation of the building. This paper focus on the comparison of isolated and non-isolated building performances with Time History Analysis and Response Spectrum Analysis. Results of comparison between isolated and non-isolated building under different earthquake reveal that the displacement obtained by non-isolated building is much higher than isolated structure.

Petti, Luigi, Fabrizio Polichetti, Alessio Lodato, and Bruno Palazzo this paper shows a seismic behaviour structures with base isolation with friction pendulum bearings subjected to near fault events. And these are characterized by significant vertical ground motion components which is evaluated. In specific, in order to judge the effects of vertical components on seismic response, non-linear dynamic analysis has carried out by using several numerical models, have been fulfilled by viewing two near-fault events, L'Aquila 2009 and Emilia Romagna 2012. The acquired results show that increasing vertical seismic motion base shear significantly increases while relative displacements increase very little.

Radmila B. Salic, Mihail A. Garevski, and Zoran V. Milutinovic this paper shows, A GF+7 storey, orthogonally almost symmetric, shear wall residential tower building has been studied in all details in order to clarify the influence of lead-rubber bearings (LRB) seismic isolation upon its seismic performance. The existing building's mode shapes, natural frequencies and damping ratios are obtained by ARTeMIS (Ambient Response Testing and Modal Identification Software). This system consisting of 32 LR bearings has been designed for maximum expected earthquake in accordance with USB-97 code provisions. In these four totally different real-earthquake time history records were accustomed to quantitatively define and compare nonlinear responses of fixed-base and LRB isolated structures. Two mathematical models prepare for study of the response of building using Etabs software. LRB designed as per axial forces and designed in 3 different groups. After analytical and experimental results, time period and displacement increase, storey drift, acceleration and base shear decrease.

III. ANALYSIS OF 5 STOREY VERTICAL GEOMETRIC IRREGULAR BUILDING

Section properties: Beam (m): 0.250x0.350, column(m): 0.500x0.500, slab(m): 0.125

Material properties: Concrete grade: M25, Elasticity of concrete: 2.5×10^{10} N/mm^2, Poisson's ratio of concrete: 0.2, Unit weight of concrete: 25 KN/m^3

Table:1 Time History for analysis

Time History	Earthquake Magnitude	No of Time Step	Scale Factor	Step Size
Elcentro	6.9	1700	0.01	0.02
Kobe	6.9	1981	0.01	0.02
Loma Prieta	7.0	5000	0.01	0.005

Plan of 5 storey irregular building:

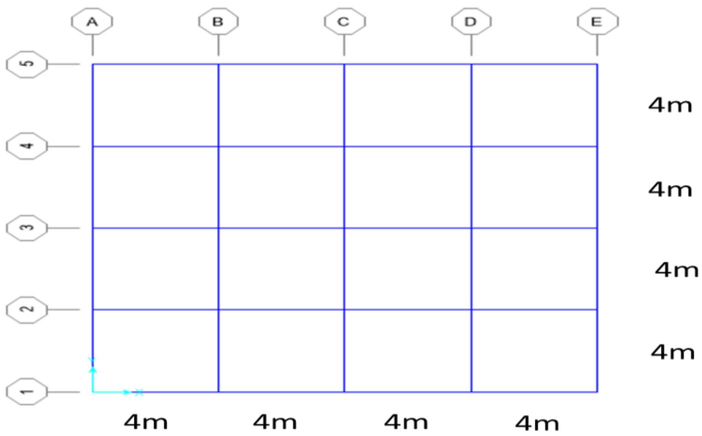


Fig.3 Plan of Irregular Building (IR)

Elevation of 5 storey irregular building:

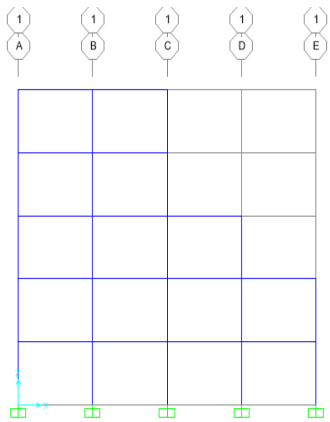


Fig.4 Elevation of IR-1

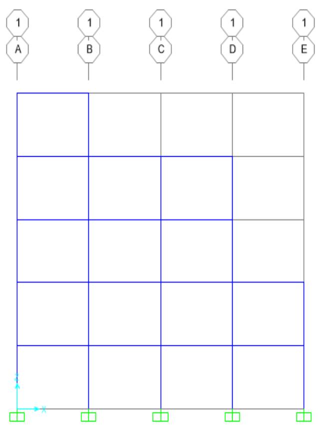


Fig.5 Elevation of IR-2

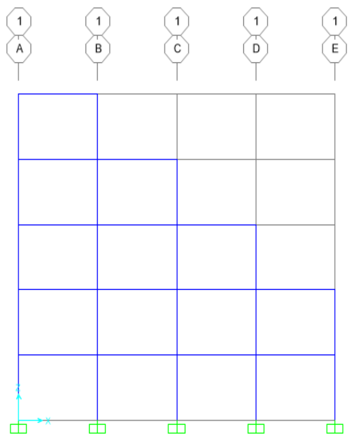
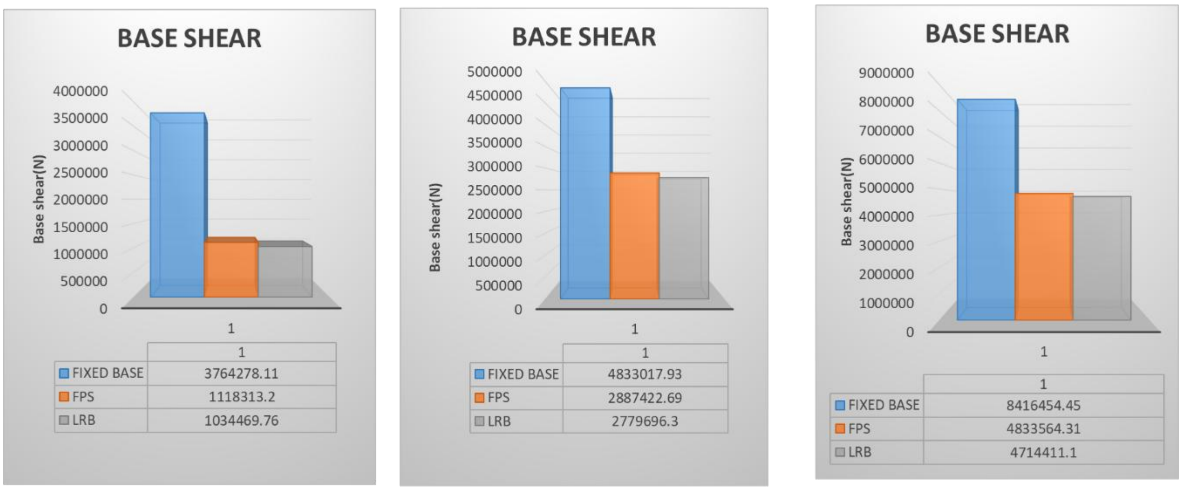


Fig.6 Elevation of IR-3

Base shear:

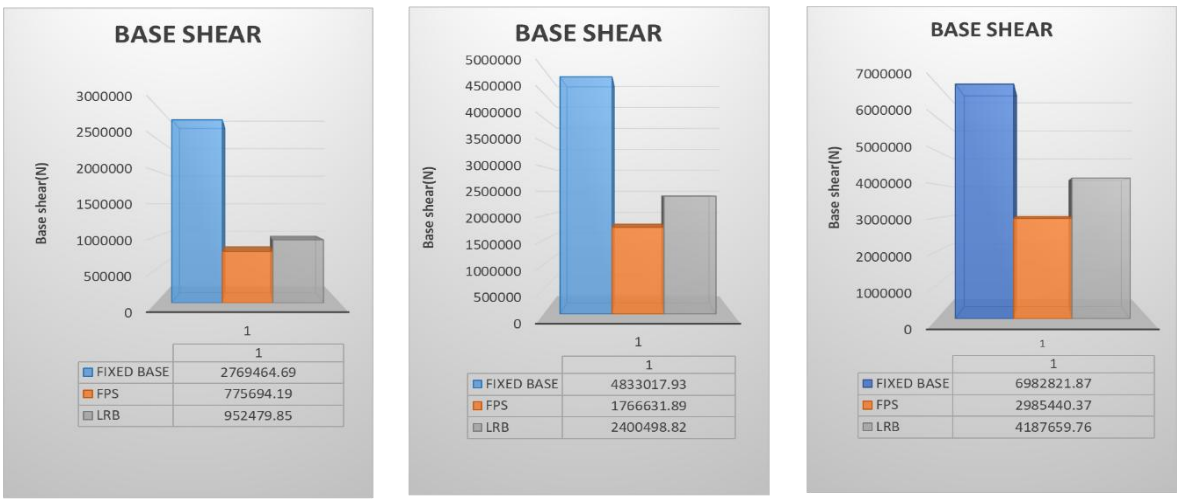
ELCENTRO KOBE LOMA PRIETA

Fig.7 Base shear for IR -1



ELCENTRO KOBE LOMA PRIETA

Fig.8 Base shear for IR -2



ELCENTRO KOBE LOMA PRIETA

Fig.9 Base shear for IR -3

Storey drift:

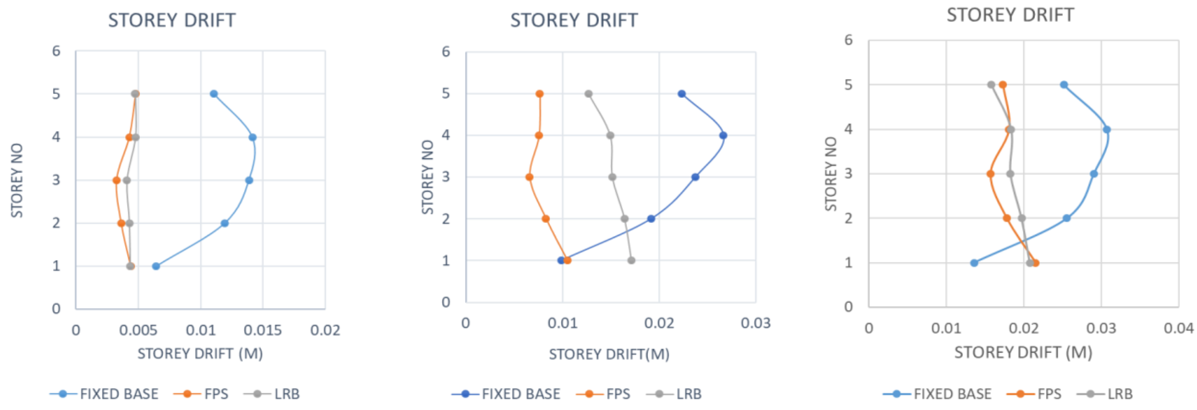


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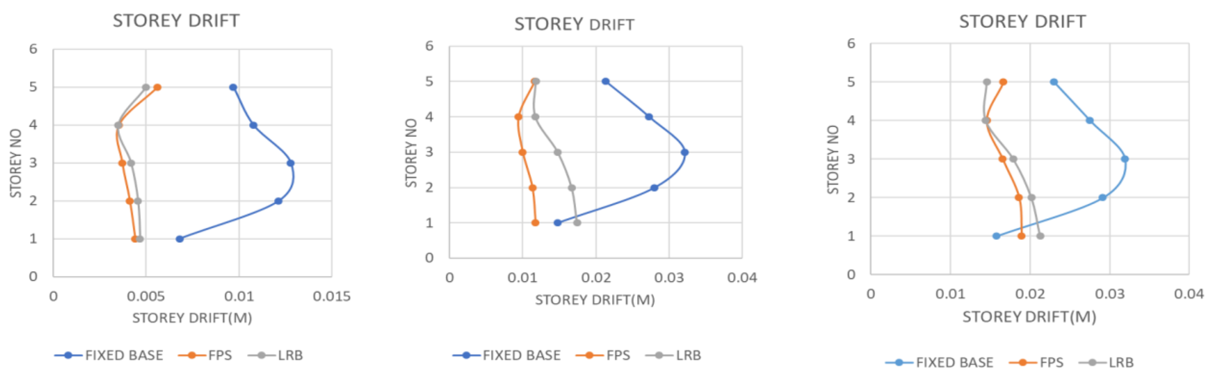
Fig.10 Storey drift for IR -1



ELCENTRO KOBE LOMA PRIETA

Fig.11 Storey drift for IR -2

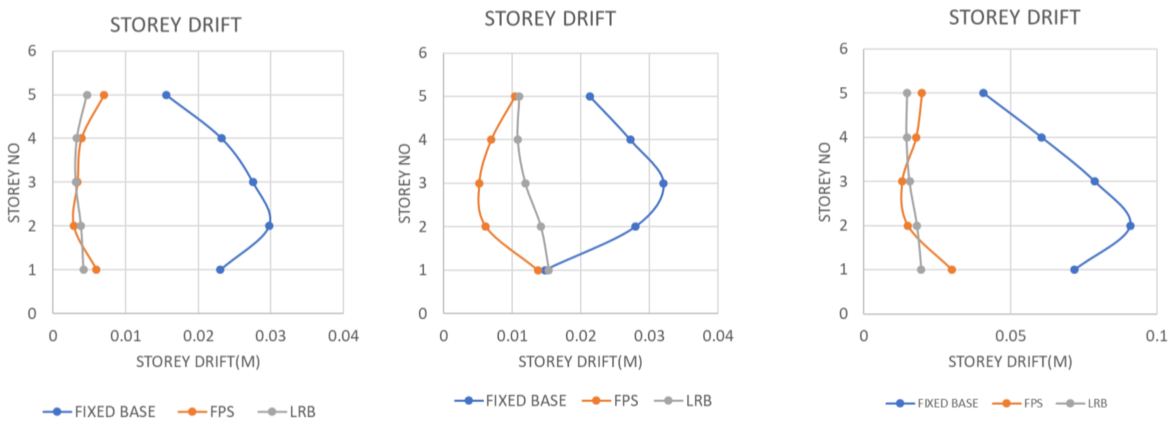


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Fig.12 Storey drift for IR -3

Absolute acceleration:

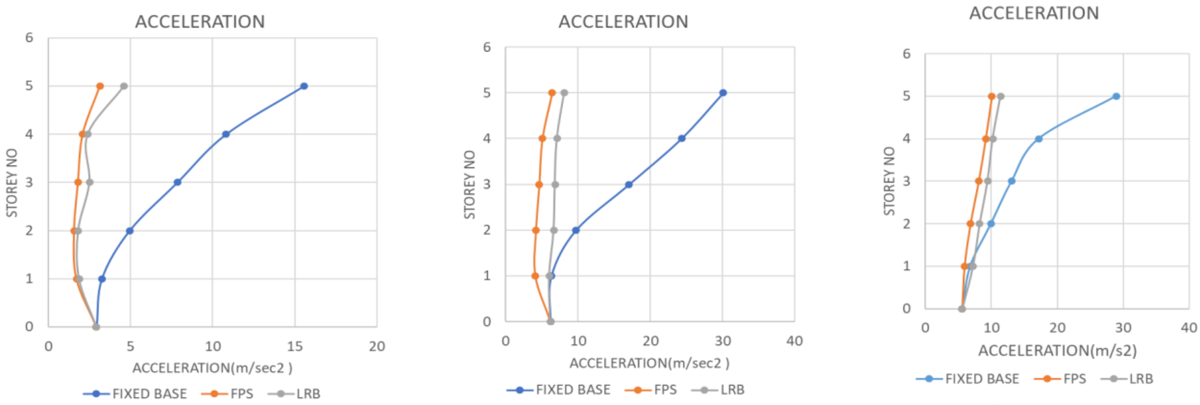

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Fig.13 Absolute acceleration for IR -1

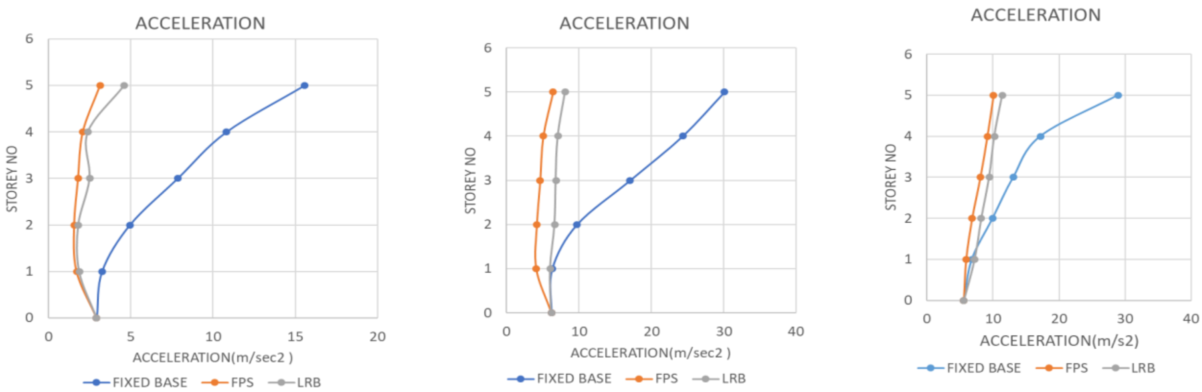

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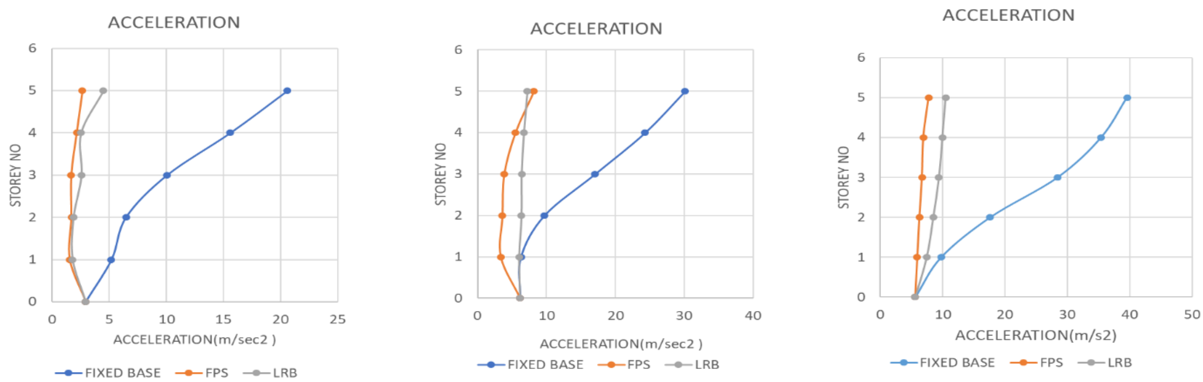
Fig.14 Absolute acceleration for IR -2



ELCENTRO KOBE LOMA PRIETA

Fig.15 Absolute acceleration for IR -3

IV. CONCLUSIONS

From the above result, it is seen that the reduction in base shear for FPS and LRB isolated models are almost same in comparison with the fixed base model using three different time history. It is seen that the reduction in storey drift for LRB isolated model is more than the FPS isolated model in comparison with the fixed base model using three different time history. It is seen that reduction in top floor acceleration for FPS isolated model is more than the LRB isolated model in comparion with fixed base model using three different time history.

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