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Seismic Behavior of Isolated Structures

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Abstract: ***Earthquake is one of the most dangerous hazard among the natural calamities. Due to the earthquake, many damages causes to the structure and loss of life occurs. Hence one of the most appropriate method is developed to reduce these damages is seismic base isolation. Among the variety of different isolators lead rubber bearing plays an important role. Base isolation reduces the acceleration and storey shear but at the same time it increases the time period and storey displacement which imparts the flexibility to the structure and makes the structure rigid by dissipating energy to the foundation. The study investigates seismic response of the structure after the use of lead rubber bearing as well as friction isolator. In this study, the dynamic response of multi storey RC structure shows that quantities are upto some extent which reduces the structural damages.***

I. INTRODUCTION

A new technique has introduced in earthquake engineering to prevent the structure from the damages is base isolation which does not require any additional source to work, hence it is passive system of seismic substructure or superstructure. The energy transmitted to the structure due to earthquake is dissipated by inherent damping. But for major earthquakes, inherent damping is not enough to dissipate the energy hence additional damping is required. Base isolation is a technique which reduces the effects of earthquake specially in frequency range which reduces the floor accelerations and inter storey drifts to avoid damages in cost effective manner. In recent years, base isolation is widely used for better seismic performance. Zhang et al.[1] studied seismic isolation under blast loading. Dynamic responses for multi storey building structure with fixed base and isolated base under near and far-fault ground motions is investigated by Tavokoli et al. [2]. Jamalzadeh et al. [3] explained combined effect of vertical and horizontal component of of pendulum isolator. Gheryani et al. [4] investigated the variations in dynamic response of the high-damping rubber bearings HDRBs in multi-story buildings in mechanical properties subjected to bidirectional near-fault ground motions. Cancellara et al.[5] illustrated comparative analysis of fixed base and base isolated structure with three different isolated systems. Jangid [6] studied different types of isolators for seven earthquakes. They found that variable sliding isolators performed well in comparison with conventional friction pendulum system.

From above studies, it has been observed that base isolators are one of the useful devices which helps in better seismic performance of structure. In present study, 5-storey RC building has analyzed for different earthquakes with the aid of LRB and friction pendulum system.

II. LEAD RUBBBER BEARING

LRB is basically invented in New Zealand in 1975 and is characterized by high damping capacity with horizontal stiffness. Permanent residual displacement has minimum in LRB when earthquake occurs as the rubber mobilizes sufficient restoring force which needs to re-position the building to its initial state. LRB is modelled as non-linear element by using some parameters as intial stiffness K_u, post yield stiffness K_p and yield strength Q. Post elastic stiffness is calculated as

$$K_p = \frac{GA_b}{T}$$

Where, G is shear modulus of rubber, A_b is area of rubber and T represents the thickness of the rubber. The effective stiffness is obtained as

$$K_{eff} = K_p + \frac{Q}{D}$$

Where, D is the design displacement.
Effective stiffness is designed in such a way that isolator period, T given by

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$$T = 2\pi\sqrt{\frac{M}{K_p}}$$

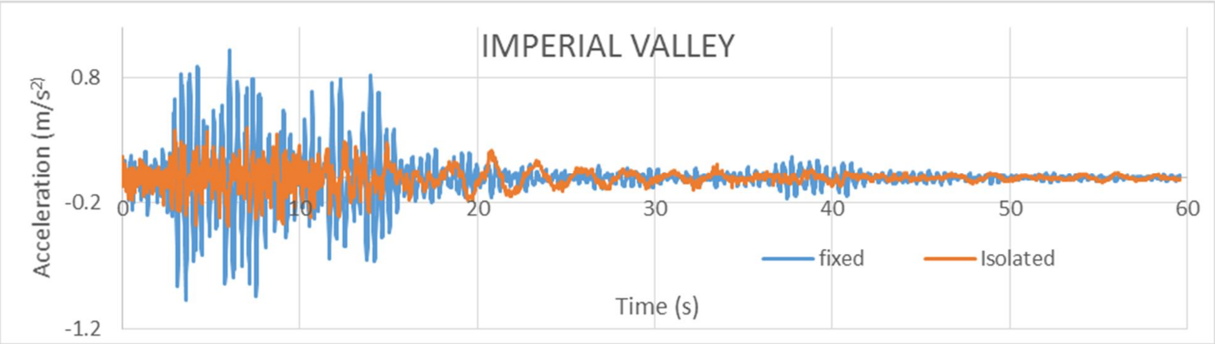
Where, M is the total mass.

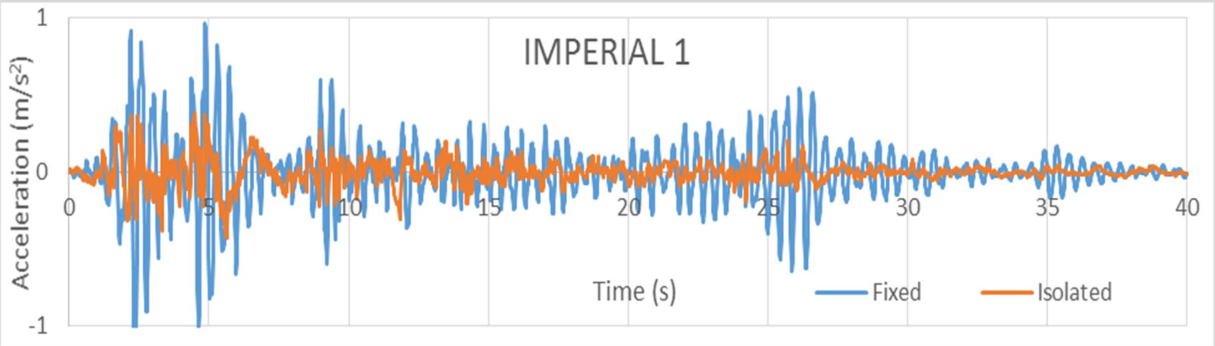
$$Q = \frac{\pi\beta_{eff}K_pD^2}{(2-\pi\beta_{eff})D-2Dy}$$

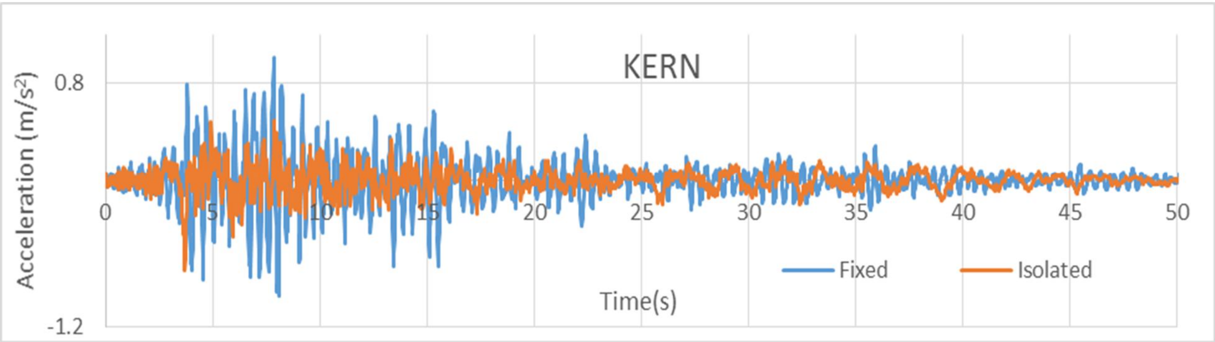
Where, D_y is the yield displacement.
For this study, β_{eff} is taken as 0.05.
Yield force of bearing can be found as:

$$Q = \frac{\pi\beta_{eff}K_pD^2}{(2-\pi\beta_{eff})D-2Dy}$$

$$K_u = \frac{F_y}{D_y}$$







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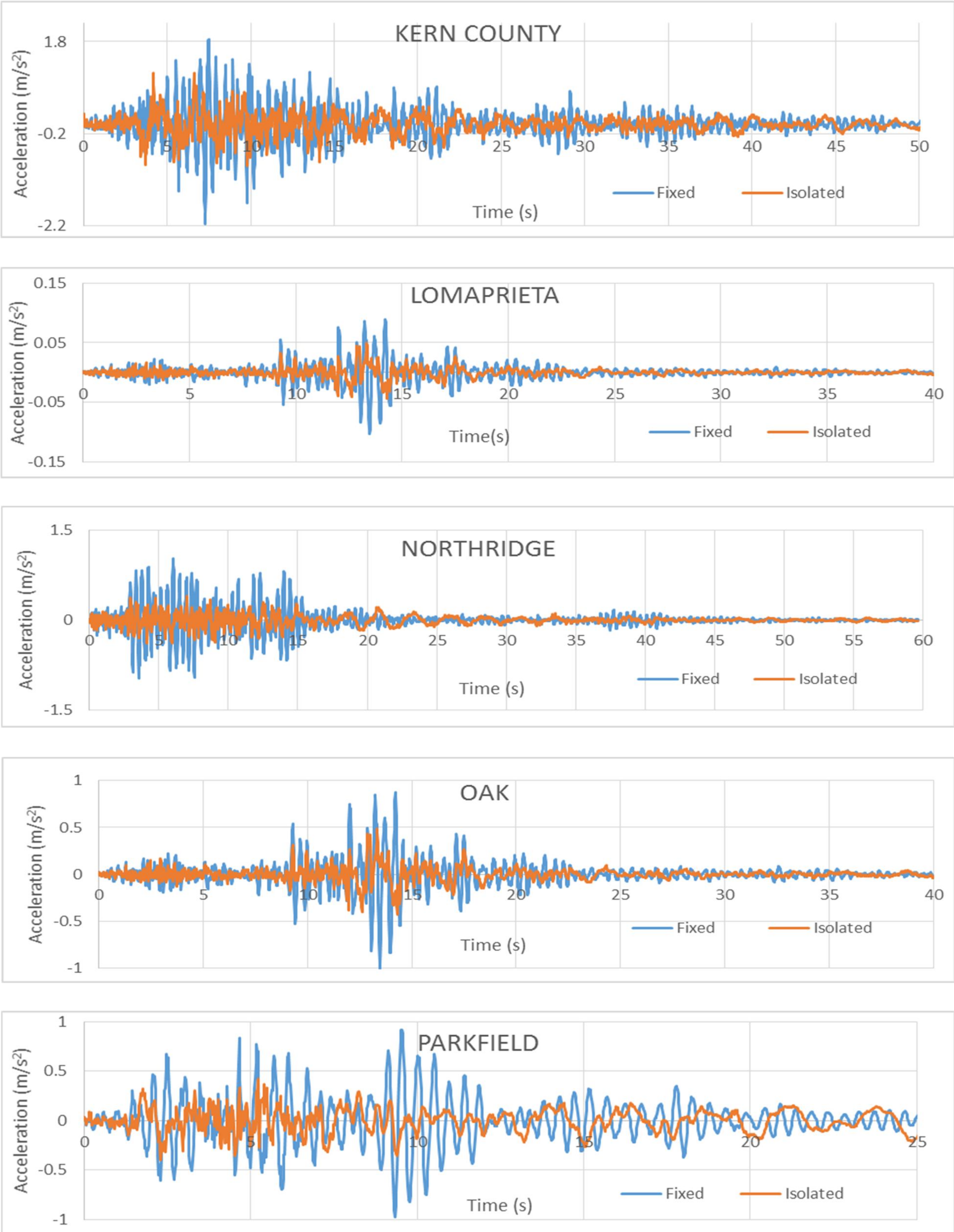

Figure. Top floor accelerations for eight earthquakes

Above figure shows the variation of top floor accelerations with respect to time period. The top floor acceleration is reduced in the structure with LRB and it shows the energy is dissipated by the use of LRB.

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III. FRICTION ISOLATOR

The standard and effective techniques for seismic isolation is friction isolation devices. These isolators are insensitive to the frequency content of ground motion as they have tendency of sliding system which spreads and reduces the earthquake energy over a wide range of frequencies. These bearings slides on global concave surface and made up of cylindrical surfaces.

The resisting force of an isolator F is given as

$F = \frac{W}{R} D + \mu\, W(\text{sign}\dot{D})$

Where, R is the radius of curvature of dish

Restoring force due to rise of mass which provides horizontal stiffness as, $K_H = \frac{W}{R}$

Horizontal stiffness produces an isolated structures period,

$$T = 2\pi \sqrt{R/g}$$

The second term in above equation of restoring force shows the friction force between slider and concave surface. The coefficient of friction μ depends upon the sliding velocity $\dot{D}$ and pressure *p*.

The equivalent (peak to peak) stiffness is,

$$K_{eff} = \frac{W}{R} + \frac{\mu W}{D}$$

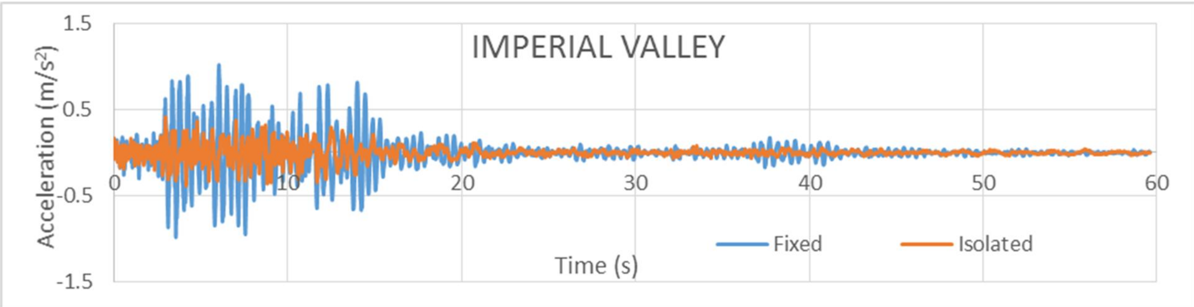
Damping produced by friction at sliding surface is given by the code formula

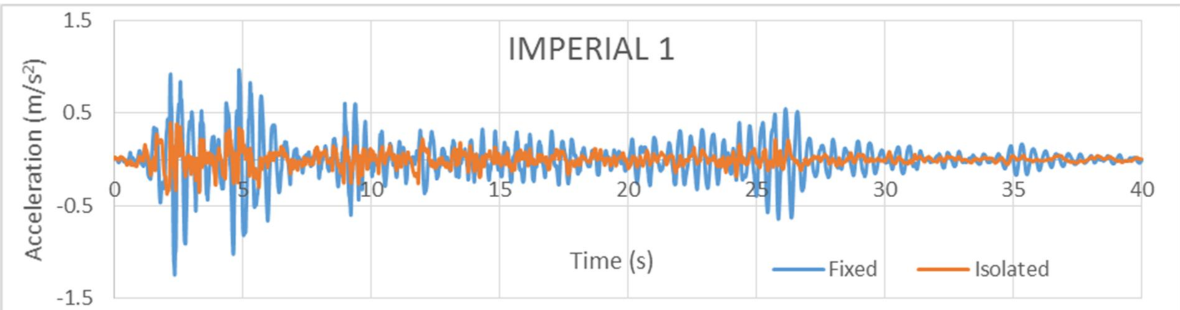
$$\beta_{eff} = \frac{\text{area of hysteresis loop}}{4\pi K_{eff} D^2}$$

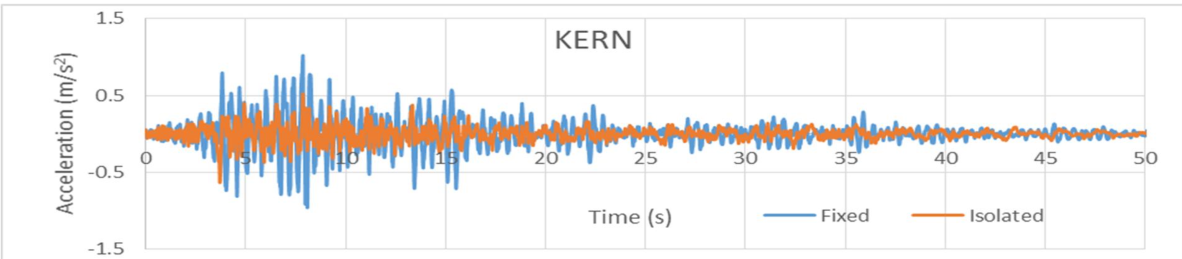
The area of the hysteresis loop is 4μWD.

For fixed period T,

$$R = \frac{gT^2}{(2\pi)^2}$$







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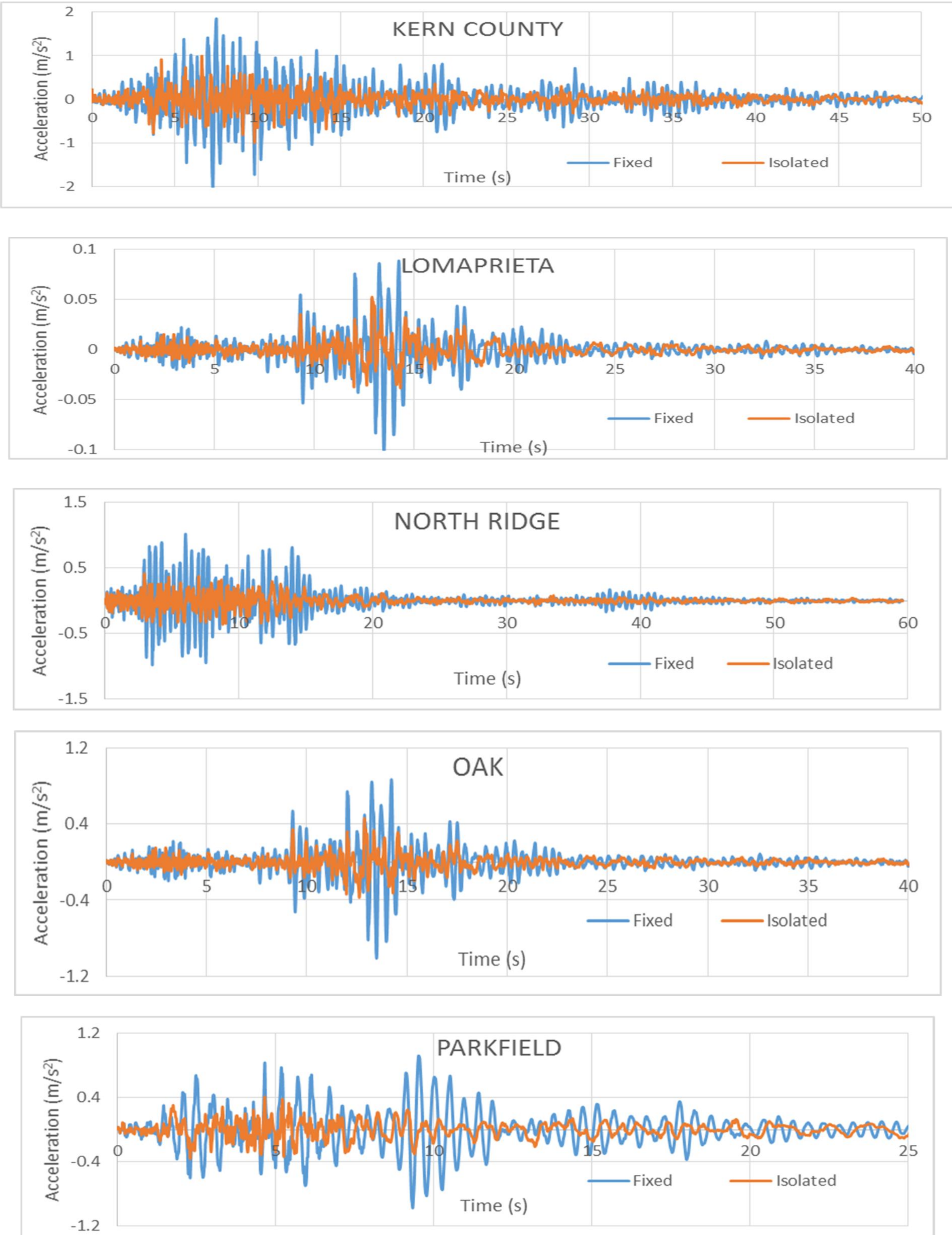

Figure. Top floor accelerations for eight earthquakes

In above figure, there is considerable amount of storey acceleration in the structure provided with isolator. Due to the use of isolator storey drift and acceleration is reduced when compared to structure with fixed base as isolator deformed itself, hence amount of energy transmitted to the structure is less.

IV. CONCLUSION

The results of the present study shows the variation in response of isolated structure and fixed base structure. The use of friction isolator and LRB has proved to be effect in reduction of acceleration with response of ground motions. Due to this reason, the analytical study has been carried out and following observations are made:

A. While comparing the two isolators, the top floor acceleration of structure is reduced as compared to fixed base structure for all earthquakes.
B. The energy dissipation capacity is more in friction isolator as compared to LRB.
C. In the case of friction isolator, reduction in top floor acceleration of superstructure is similar to the LRB.

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