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Performance of Lead-Rubber base Isolated Building Structure in High Seismic Prone Region

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Abstract:
The enormous proportions multistory RC fixed structure is compared with LRB base isolated building under real earthquake ground motion. The structural system considered here may be a 10 story R.C.C. building (idealized as a shear type building), situated in zone IV, with hard strata & spectral acceleration as per IS1893-2016. during this work an ETABS program is employed to review the response of preset and bottom inaccessible (LRB base) structure. The optimum answer, parametric isolation properties (LRB) are studied for various damping values of LRB (ξ=0.1, 0.15, 0.20, 0.25, 0.30) with different isolation period of time as (Teff) 2.0, 2.5, 3.0 and 3.5 sec. For this analysis a actualtimehistory,namely,ImperialValley-02,havebeenextracted from "PEER GROUND MOTION DATABASE". to review the ground spectral response the variation of top floor absolute acceleration, displacement at each floor level are computed. so as to match the obtained response, SeismoMatch-2018 algorithm spectrum IS1893-2016, are used under different time domain. From the analysis it's revels that base isolated structure reduces response performance considerably in compare to the fixed structure which impart an important role in reducing the sizing of structural members and amount of designed steel requirement. A Top floor acceleration and displacement floor spectra have been developed to study the exact earthquake response.

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I. INTRODUCTION

Enormous proportions detachment mitigates quake initiated reactions bolstered the idea of decreasing the seismic interest by moving the main time of the structure as opposed to expanding the tremor opposition limit of structure [1]. The seclusion strategy are frequently received to upgrade the seismic presentation of deliberately significant structures like schools, clinic, mechanical structures, places of business and so on. The objective is to all the while decrease between story floats and floor increasing velocities to restrain or stay away from harm, not exclusively to the structure yet in addition to its establishment, during a financially savvy way. the fundamental component of the base-segregation innovation is that it present among superstructure and its establishment an appropriately picked adaptable layer in order to move the regular time of structure faraway from the prevailing time of seismic tremor ground movement and in this way to maintain a strategic distance from the ruinous impacts given by the framework reverberation [2-3]. supported the content of control to be achieved over the seismic response, the selection of the isolation

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system varies and thereupon its design is completed to suit the wants of use of the structure.

In seismically base-isolated systems, the superstructure is decoupled from the earthquake ground motion by introducing a versatile interface between the inspiration and therefore the base of the structure. Thereby, the isolation system shifts the elemental period of time of the structure to an outsized and dissipates the energy in damping, limiting the quantity of force which will be transferred to the superstructure such inter-story drift and floor acceleration and reduce drastically.It is very essential to know the varied characteristics affecting the response of fixed and base-isolated structure when used for seismic protection of the structures. Moreover, the performance of base isolated structure also reportedly depends on superstructure stiffness, damping and adaptability of the isolation system [4-5]. the extreme research activity within the field of seismic isolation has led to the event of a spread of base isolation system, which are tested and implemented in many countries with very encouraging result. Various sorts of isolation system enormously and effectively implemented everywhere the planet for seismic protection, where elastomeric rubber bearing, Lead-rubber bearing and sliding bearing are most generally used. Thus, during this paper parametric characteristics are evaluated for lead rubber bearing for various period of time , bearing damping and its performance on building structural response. Bilinear replica, wont to express the connection among the shear control and down these lines the horizontal removal, are frequently characterized by three parameters: starting firmness, post-yield solidness, and trademark quality. The trademark quality, Q, is regularly used to appraise the unfaltering quality of hysteretic conduct when the bearing encounters many stacking cycles. For this study 10 story RCC hospital building taken and modeled in ETABS program for the region IV, as per Indian code and site soil condition. The model are analyzed by Non-linear time history analysis are performed on the set of various mathematical models, with period of time T=2, 2.5, 3, 3.5sec & bearing damping value, ξ=0.10, 0.15, 0.20, 0.25, 0.30. The spectral matching procedure for real accelerograms is summarized and applied to a target earthquake response spectrum given in IS: 1893-2016, for type-I site soil. Matching technique in supported scaling of selected time history in time domain.

the precise goal of this are:

a) toward research of the consequences of increase of initial stiffness on structural response,

b) toward research of the consequence of separation phase on structural answer and,

c) toward research of the consequences of feature potency ratio of isolator on structural response.

i) To evaluate the parameters of lead rubber isolator as per the variation of effective time of isolation and damping of the isolator.

ii) To study the parametric analysis and compare the seismic response of fixed base with base isolated building.

iii) To evaluate the building floor spectra

II. MATHEMATICAL FORMULATION

A. The Building Description

For comparative parametric analysis typical plan and elevation of RCC building, having 2 basement + ground floor+10 story above ground level is taken into account as shown in Fig1 and Fig 2. The building comprises with four bays in X-direction, having 8m each length, whereas, five bays in Y-direction, having 5m for middle and 4m for both external end. The dimension of building at ground floor and basement is 40x31m. the peak of basement floors are 3.6m and 3.5m for typical floors. Total height of building from Ground floor is 35m. Concrete grade taken as M30 for beam and floor element, whereas for column M50 grade is employed .support sizing considered as mentioned as below:

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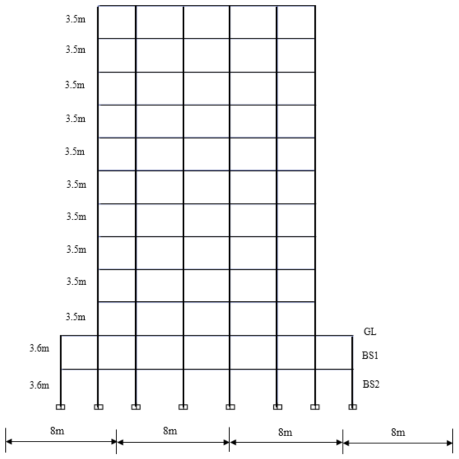
Fig 1. Typical Floor Plan



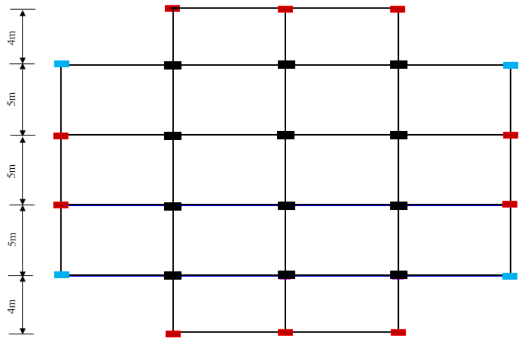


Fig 2. Longitudinal Section

TABLE I : STRUCTURAL ELEMENTS

Column	
Group-1 (black)	C 600x800 mm
Group-2 (red)	C 350x800 mm
Group-3 (blue)	C 350x600 mm
Beam	B 300x700 mm
Slab	175 mm

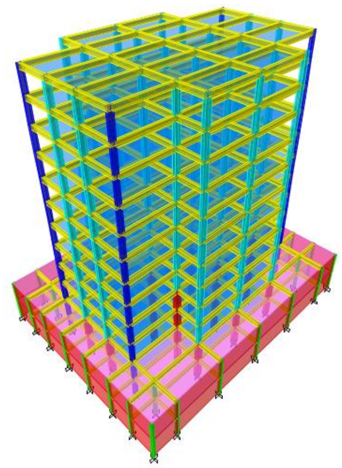


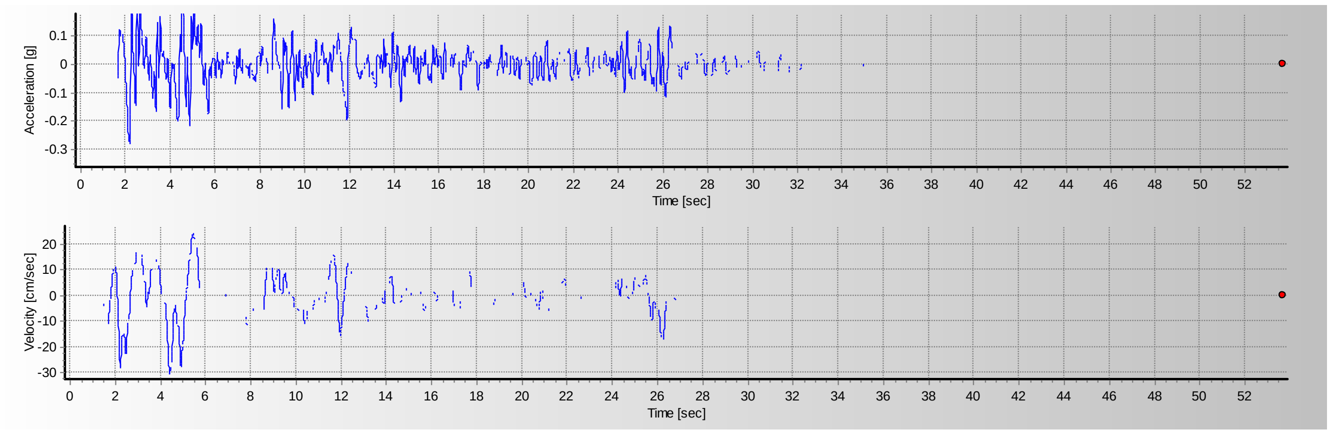
Fig 3.ETABS analysis model

Sample Earthquake used in the Analysis and Scaling

We study, ground motion record has been selected from PEER Strong Ground Motion Database [6]. The Details of Earthquake record as mentioned below:

TABLE II: Time History Record

Location	Date	Magnitide (M)	Station	Closes to fault Rupture (km)	PGA (g)	PGV (cm/sec)	PGD (cm)
Imperial Valley-02	19-May-40	6.95	El-centro Array #9	6.09	0.28	30.95	8.76



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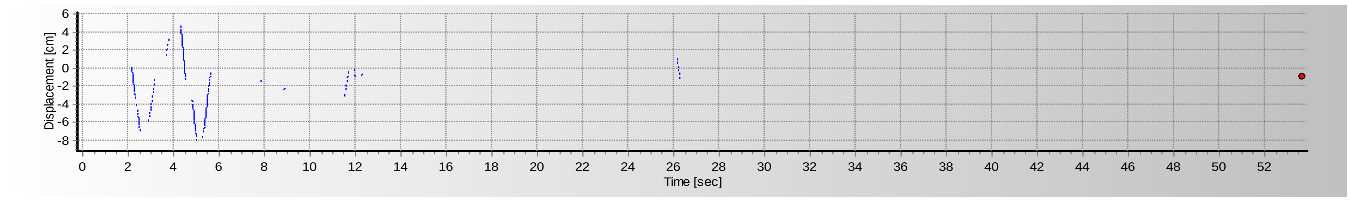

Fig 4. Imperial Valley-02-Time History Plot for Acceleration, Velocity and Displacement.

In order to obtain a design earthquake compatible with the local seismicity, an earthquake signal treatment was performed consisting baseline correction, filtering and spectral matching in time domain, using computational program "*SeismoMatch-2018*" [7].The objective of the spectral matching is to correct the actual acceleration record, compatible of standard target response spectrum properties as per IS1893-2016, for hard soil [8].The principal goal of scaling accelerograms records is to obtain a design acceleration time history that will have a response spectrum as close as desired to the predetermined codal target spectrum. After matching the time history data is examined to ensure that the acceleration, velocity and displacement time histories should be reasonably close to the target codal spectrum.

TABLE III: Ground Motion Parameter

Accelerogram	Original Accelerogram	Matched Accelerogram
Max Acceleration (g)	0.280	0.276
ax. Velocity (cm/sec)	30.939	20.867
Max Displacement (cm)	86.6	83.9

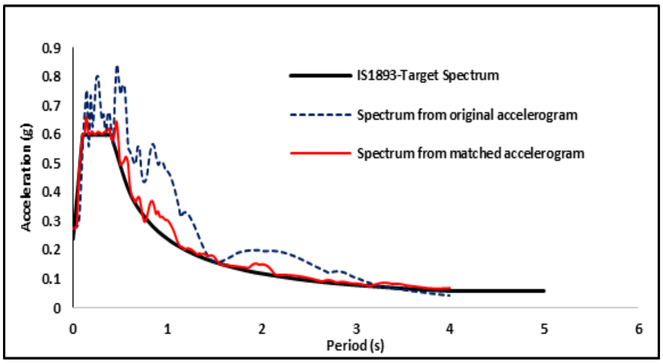

Fig 5: Scaled Spectra compatible to IS1893:2016

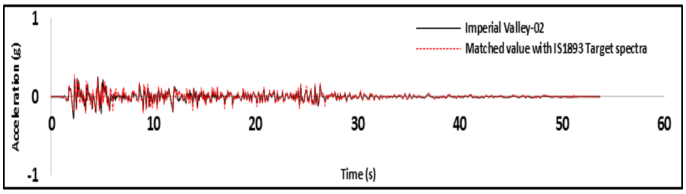

Fig 6: Scaled Time History compatible to IS1893:2016

B. Design of Isolator

Analysis model developed, analyzed and maximum vertical load on each column have been carried out. The lead-rubber isolator has been designed to mount at ground floor to decouple the superstructure from basement floors and dissipate earthquake shocks. Lead-rubber bearing were first introduced and used in New Zealand in late 1970s [9]. Since then, lead-rubber bearings were widely used all around the world for effective seismic isolation including USA and Japan.The lead-rubber bearing is similar to the elastomeric rubber bearing from construction perspective, except the additional lead-plug in central part of bearing. The lead plug has a property to deform plastically under shear deformation, thereof enhancing the energy dissipation compatibility in compare to elastomeric bearing.

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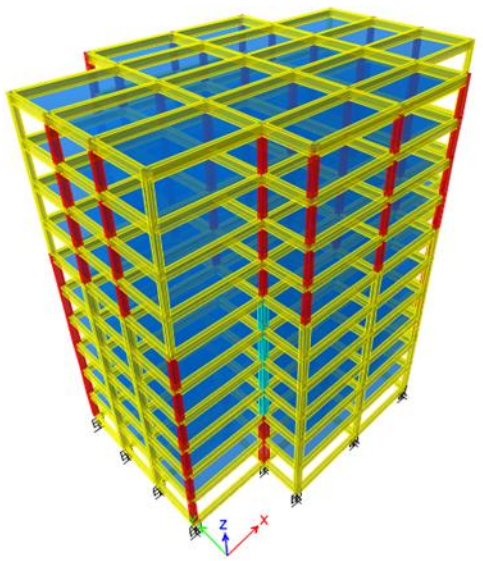


Fig 7: Building 3D model with base isolator

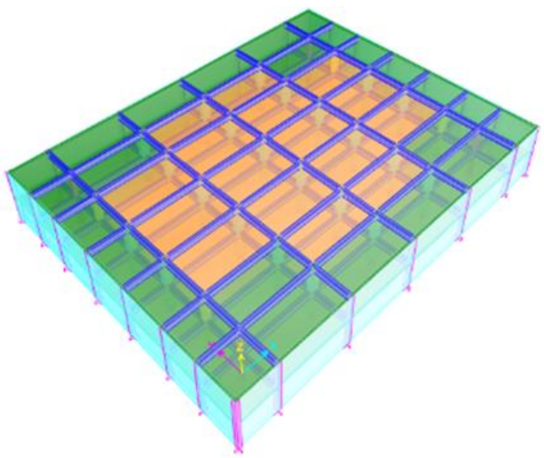


Fig 8: Building podium substructure

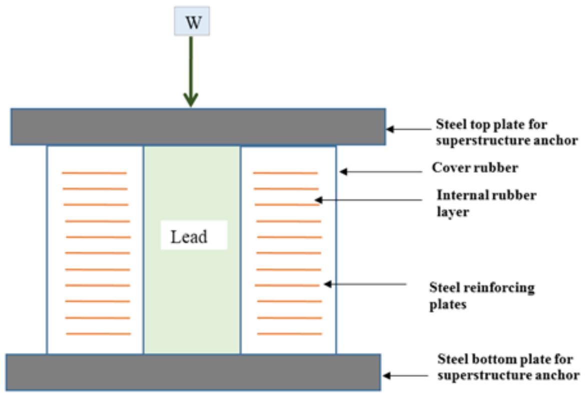
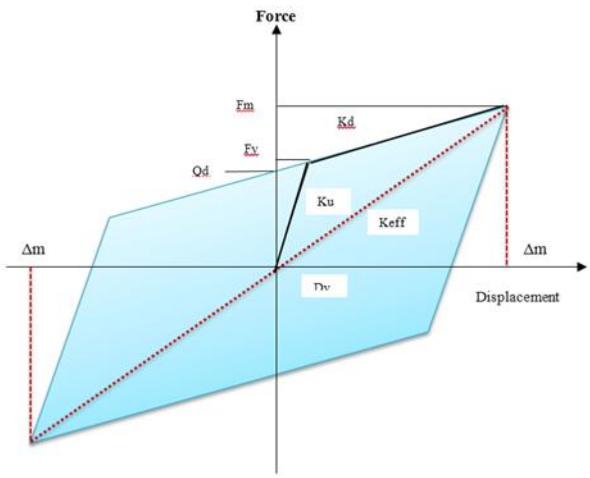


Fig 9: Bilinear Force-Deformation relationship of lead-rubber isolator.



In practice lead-rubber isolator characterized and modeled by bilinear behavior with force-deformation relationship. This relationship, termed the hysteresis loop, defines the average stiffness at a specified displacement (Effective stiffness) and hysteretic damping provided by the system. A typical hysteresis for a lead rubber bearing as shown in fig 9. For design and analysis this shape represented as bilinear behavior mainly dependupon 3 things initial/flexible limpness (Ku), post yield stiffness (Kd) and zero-displacement force intercept (Qd). The characteristic strength of lead rubber bearing is controlled by the yield strength of the lead in shear, ϭy, and the cross-sectional area of the lead-plug, AL as:

$$Q_d = 6_L A_L \quad (1)$$

Post yield stiffness, Kd, is equal to the shear stiffness of the elastomeric bearing alone:

$$K_d = \frac{G_y A_r}{T_r} \quad (2)$$

The shear modulus G_y=0.35 MPa, intended for a elevated damping rubber demeanor is a function of shear ϒ. The unloading elastic stiffness for lead-rubber bearing is defined as:

$$K_u = 6.5 K_r \left(1 + \frac{12 A_{pl}}{A_r}\right) \quad (3)$$

The second-slope stiffness, Kd, is the stiffness of elastomeric component of the bearing which can be calculated by the equation:

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$$K_{eff} = \frac{Q_d}{\Delta} + K_d \qquad (4)$$

The isolator uprooting can be determined from the powerful period, proportionate gooey damping and unearthly quickening as:

$$D_D = \left(\frac{g}{4\pi^2}\right)\frac{C_v}{B}\, T \qquad (5)$$

Where,

$C_v = \frac{S_a}{g}$ ….Spectral acceleration value for T= 1sec.

T=Target design period of isolated building

B= Damping coefficient corresponding to the effective damping ratio. The relation between B and ξ expressed in [10].

$$\frac{1}{B} = 0.25(1 - In\ \xi) \qquad (5a)$$

Effective damping ξ_{eff} is given by

$$\xi_{eff} = \frac{1}{4\pi}\frac{E_D}{E_{so}} \qquad (6)$$

Where, E_{so} = Energy stored

$$E_{so} = \frac{1}{2}K_{eff}\, D^2 \qquad (6a)$$

As we put eq. (6a) in eq (6) it becomes

$$E_D = 2\pi\xi_{eff}\, K_{eff}\, D^2 \qquad (7)$$

E_D=Energy dissipated in one cycle which is equal to the area of the hysteresis loop.

For dynamic analysis code permits, furthermore reduction of target displacement. Which can be expressed as:

$$D'_D = \frac{D}{\sqrt{1 + \left(\frac{T}{T_M}\right)^2}} \qquad (8)$$

C. NUMERICAL STUDY

A. *Mathematical Modeling of Building*

In this paper, mathematical models were defined for unchanging pedestal building and bottom inaccessible with lead rubber demeanor. structure models were analyzed by scaled actual time history analysis building was analyzed. Analysis details of the building as shown in table [11]:

TABLE IV: BUILDING ANALYSIS DETAILS

Sr. No	Description		Remark
1	No story	10 story+2 basement	
2	Type	RCC	Use as-Hospital building
3	Analysis used	Time history analysis	EQ-Imperial Valley-02
4	Scale History	Target response spectrum for hard soil	Code-IS1893-2016
5	Response reduction factor	4	
6	Seismic Zone Zone Factor	IV 0.24	Zone classified as per-IS1893-2016
6	Soil type	Hard	Type-I-IS1893-2016
7	Time Period	Tx = 0.60 Sec.	Used formula as per-IS1893-2016
		Ty = 0.72 Sec.	

B. *Seismic Isolation System*

In this study, dynamic building analysis have been performed by ETABS (Nonlinearversion 16.2.0). Dynamic axial loads under each column at calculated for calculating parametric mechanical properties of lead-rubber bearing. As the structure got decoupled from the basement podium and mounted isolator at ground level. Nonlinear dynamic history analysis have been performed, to give a more accurate picture of the contribution of thebase isolation system to the total seismic forces that are developed at the superstructure during a seismicexcitation.It must be noted here that the response of the superstructure is elastic, while the response of the seismic isolation bearings is inelastic.

i) Specification of target displacement

The target displacement of an isolator considered from the appearance given in Eq. 5. Design deflection governby spectral 5% damped acceleration, Sd1 and time period, T, shown in fig 10.

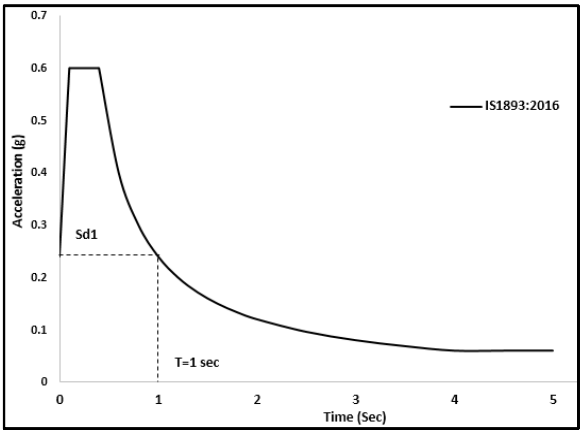

Fig.10-Codal horizontal response spectra for hard soil.

ii) Parametric study for mechanical properties of LRB

In this paper, iterative LRB properties have been evaluate for different vertical loading on the column. As per the maximum vertical seismic loads on each column three column grouping are made for the building shown in (Table:1). For these column groups, different LRB properties have been worked out to make economical design and thereby reduce the cost of the isolation. Parametric study carried out for target time period Tb=2.0, 2.5, 3.0, and 3 sec. corresponding effective damping, ξb=0.10, 0.15, 0.20, 0.25, 0.30.For each loading group, parametric iteration of LRB properties have been evaluated which are mentioned in tables as:

TABLE V: PARAMETRIC PROPERTIES OF LRB FOR GROUP 1 COLUMN LOADING

11Sr no	Tb Sec	ξeff	S_{d1}	B	D_D (m)	$D_{D'}$ (m)	Dy (mm)	K_U (kN/mm)	K_{eff} (kN/mm)	K_V (kN/mm)	Q_D (kN)	Fy (kN)
1	2	0.1	0.24	1.21	0.099	0.094	5.57	6.45	0.863	1301	30.79	35.92
2	2	0.15	0.24	1.38	0.086	0.083	7.52	5.9	0.845	1067	38.23	44.4
3	2	0.2	0.24	1.53	0.078	0.074	8.52	5.47	0.828	880	40.21	46.67
4	2	0.25	0.24	1.67	0.071	0.068	12.13	5.73	1.167	874	60.34	69.48
5	2	0.3	0.24	1.814	0.066	0.063	15.77	6.02	1.594	867	83.1	94.92
6	2.5	0.1	0.24	1.21	0.123	0.12	5.67	6.33	0.754	1309	30.79	35.92
7	2.5	0.15	0.24	1.38	0.108	0.105	7.52	5.9	0.749	1067	38.23	44.4
8	2.5	0.2	0.24	1.53	0.097	0.095	10.62	6.16	0.977	1061	40.21	46.67
9	2.5	0.25	0.24	1.67	0.089	0.087	14.56	6.52	1.329	1052	60.34	69.48
10	2.5	0.3	0.24	1.814	0.082	0.08	15.77	6.02	1.313	867	83.1	94.92
11	3	0.1	0.24	1.21	0.148	0.145	5.67	6.33	0.71	1309	30.79	35.87
12	3	0.15	0.24	1.38	0.13	0.127	8.53	6.6	0.876	1302	48.66	56.28
13	3	0.2	0.24	1.53	0.117	0.115	10.62	6.16	0.873	1061	56.71	65.38
14	3	0.25	0.24	1.67	0.107	0.105	13.95	6.46	1.126	1053	78.82	90.16
15	3	0.3	0.24	1.814	0.099	0.097	15.77	6.02	1.131	867	83.1	94.92
16	3.5	0.1	0.24	1.21	0.173	0.17	5.67	6.33	0.679	1309	30.79	35.87
17	3.5	0.15	0.24	1.38	0.151	0.149	7.52	5.9	0.641	1067	38.23	44.4
18	3.5	0.2	0.24	1.53	0.136	0.134	10.62	6.16	0.803	1061	56.71	65.38
19	3.5	0.25	0.24	1.67	0.125	0.123	13.95	6.46	1.016	1053	78.82	90.16
20	3.5	0.3	0.24	1.814	0.155	0.113	15.77	6.02	1.01	867	83.1	94.92

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III. RESULT AND DISCUSSION

A. Comparison between design and time history analysis procedure

To investigate the effectiveness of base isolated building, time history analysis have perform on both the model. The isolator performance parameter are the shear force coefficient, C, (the maximum isolator force normalized by the weight of structure) and the isolator displacement, DD. The ratios of the displacements and shear coefficient from the time history analysis to the values predicted by the design procedure are plotted in Table VI. In this study all twenty cases analyzed to work out the optimum case in each assumed time period.

TABLE VI: LRB ISOLATION SYSTEM PERFORMANCE

							Design Procedure			Time History Analysis			
No	System	Seismic Weight (W)	Qd (kN)	Variation	Tb (Sec)	ξeff	DD	Vs=K.Δ	C=Vs/W	DD	BS	C=BS/W	Accel
1	LRB	75399	30.79	0.04	2	0.10	94	832.2	0.011	69	1298	0.017	0.830
		75399	38.23	0.05	2	0.15	83	734.8	0.010	72	1310	0.017	0.940
		75399	40.21	0.05	2	0.20	74	655.1	0.009	82	983	0.013	0.750
		75399	60.34	0.08	2	0.25	68	602.0	0.008	87	786	0.010	0.720
		75399	83.1	0.11	2	0.30	63	557.7	0.007	85	764	0.010	0.680
2	LRB	75399	30.79	0.04	2.5	0.10	120	679.2	0.009	62	1686	0.022	1.100
		75399	38.23	0.05	2.5	0.15	105	594.3	0.008	64	1438	0.019	1.030
		75399	40.21	0.05	2.5	0.20	95	1273.5	0.017	73	1012	0.013	0.870
		75399	60.34	0.08	2.5	0.25	87	492.4	0.007	82	830	0.011	0.740
		75399	83.1	0.11	2.5	0.30	80	452.8	0.006	88	726	0.010	0.690
3	LRB	75399	30.79	0.04	3.0	0.10	145	517.7	0.007	67	1329	0.018	1.050
		75399	48.66	0.06	3.0	0.15	127	453.4	0.006	65	1293	0.017	1.020
		75399	56.71	0.08	3.0	0.20	115	410.6	0.005	76	894	0.012	0.840
		75399	78.82	0.10	3.0	0.25	105	374.9	0.005	75	825	0.011	0.770
		75399	83.1	0.11	3.0	0.30	97	346.3	0.005	88	698	0.009	0.690
4	LRB	75399	24.15	30.79	3.5	0.10	170	491.3	0.007	62	1435	0.019	1.120
		75399	30.79	38.23	3.5	0.15	149	430.6	0.006	65	1220	0.016	1.030
		75399	35.34	56.71	3.5	0.20	134	387.3	0.005	71	977	0.013	0.900
		75399	50.89	78.82	3.5	0.25	123	355.5	0.005	84	716	0.009	0.730
		75399	69.27	83.10	3.5	0.30	113	326.6	0.004	88	679	0.009	0.690

B. Comparison between LRB and fixed structure

Table. VI shows the performance result of all LRB parameter for Tb=2.0, 2.5, 3, 3.5 sec with respect to the LRB damping 0.10,

TABLE VI: LRB ISOLATION SYSTEM PERFORMANCE

Sr. No	Tb (Sec)	ξ	BI		Fixed	
			Db	Ac	Db	Ac
			(mm)	(m/sec^2)	(mm)	(m/sec^2)
1	3.5	10	62	1.12	5.7	2.48
2	2.5	15	64	1.03		
3	2.5	20	73	0.87		
4	2	25	87	0.72		
5	2	30	65	0.68		

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0.15, 0.20, 0.25, 0.30. All four LRB system time history analysis, optimum performance of isolator have been worked out for these damping values.

C. Floor spectra plot variation

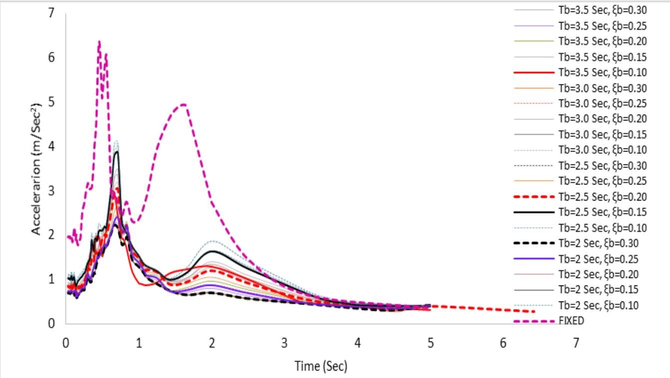

Fig.11-Floor acceleration response spectra at top floor.

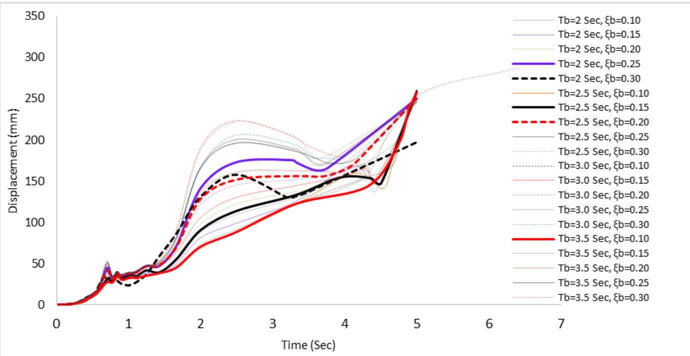

Fig.12-Displacement spectra at ground floor (Top of LRB)

Response spectrum is the curve showing the maximum response versus the structural frequency relationship [11]. A study of floor response spectra for a base-isolated multi-story structure under seismic ground excitations is carried out. All the LRB systems studied in Table.VI have been considered An El-Centro earthquake accelerograms is used to evaluate the floor response spectra.The characteristics of the spectra generated by different base isolation systems are studied, and the variation of all twenty LRB system plotted on a single graph [13]. The results are compared with those for the fixed-base structure. Fig.11, shows the plotting of floor acceleration spectra at top floor of the building. All optimum design cases shown in dark line. For all the cases (ξ=0.10, Tb= 3.5 S, ξ=0.15, Tb=2.5 S,ξ=0.20, Tb= 2.5 S, ξ=0.25, Tb=2.0 Sξ=0.30, Tb= 2.0 S)maximum peak ordinate occur at the time period of 0.8 second and gradually lower down further.

Similarly, Fig. 12, shows the floor displacement spectra at ground floor (Top of the isolator & column interface). Displacement spectra depict the LRB performance for all studied systems. From all the cases studied system ξ=0.25, Tb= 2.0 S and ξ=0.30, Tb= 2.0 S evaluate the better response than other governing optimum cases of LRB performance.

D.Floor time history plot

In time history analysis of building lead rubber bearings designed are linked at bottom of the respective column at ground level to ensure all the properties of spring. Table-VI, shows the performance of all the LRB system considered in this study. The time history for base shear of the BI building (ξ=0.30, Tb=2.0 Sec) and fixed building comparisons are illustrated in Fig. 13. The maximum base shear in fixed building occur 4900 kN at T-4.9 Sec and for base isolated building, the base shear reduces 1140 kN drastically.

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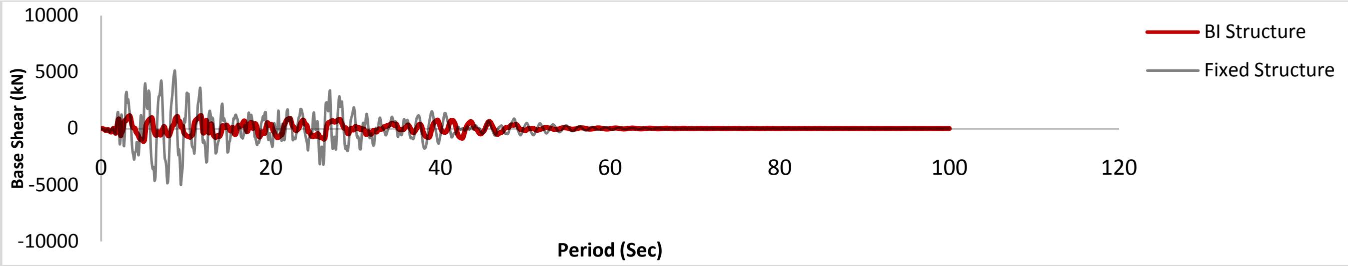


Fig.13-Plots the time history at ground floor (Top of LRB)

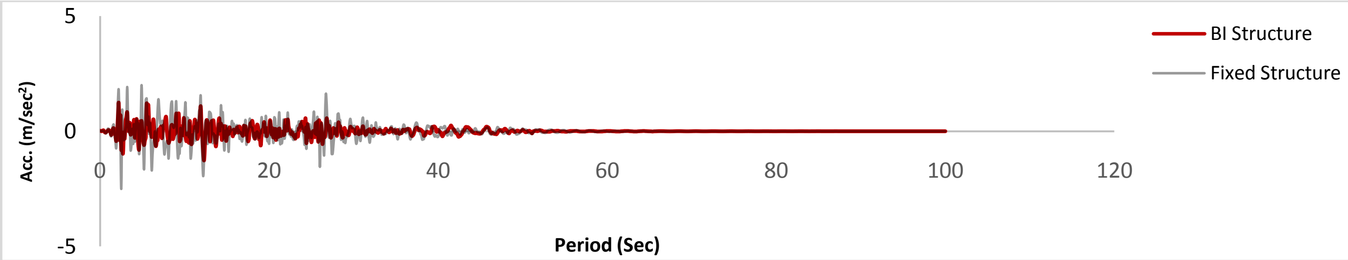
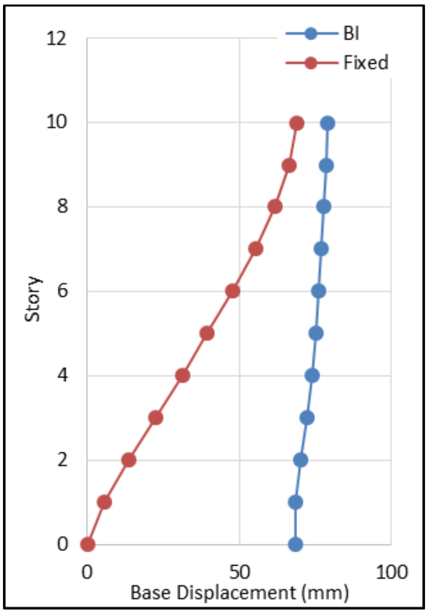


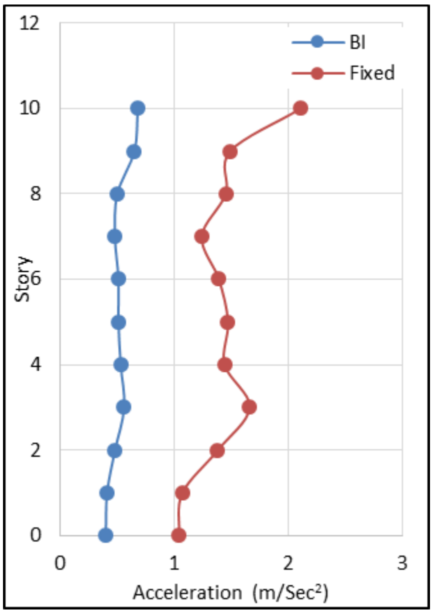
Fig.14-Plots the time history at top floor

Similarly, Fig. 14-dipict floor acceleration time history for fixed and base isolated building at the top level of the building.. The maximum top floor acceleration in fixed building occur 2.48 m/sec^2 and for base isolated building, the base shear reduces 0.68 m/sec^2.

E. Displacement and acceleration plot



(a)



(b)

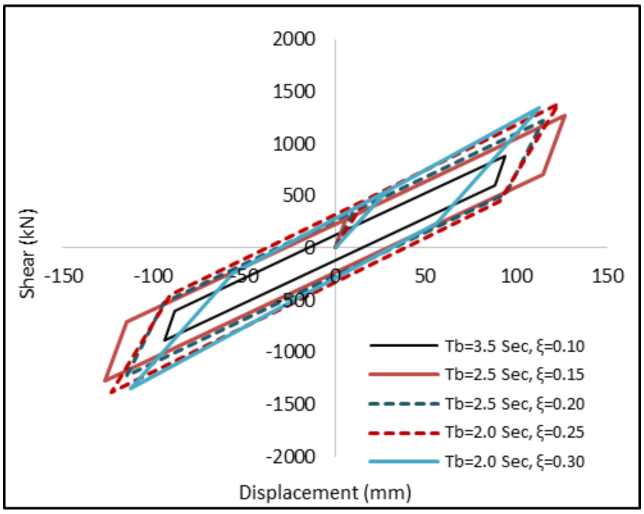
Fig.15-Story plot for Fixed and BI base(a) Displacement & (b) Acceleration

In base isolation technique of building, seismic forces are dissipated by flexible bearing with high damping material. Fig. 15-shows story forces variation for both fixed and BI building structure. In fixed structure dynamic forces absorbed by the structural itself caused heavy forces and moments induced in structural element. Fig. 15(a) shows the 67mm base displacement at ground level (Top of LRB interface). Fig. 15 (b) shows the maximum story acceleration comparison for both the systems. Thus, Acceleration of BI building successively lowered in each story of the building in compare to the fixed structure, due to flexibility dissipation of earthquake forces at the base of the building.

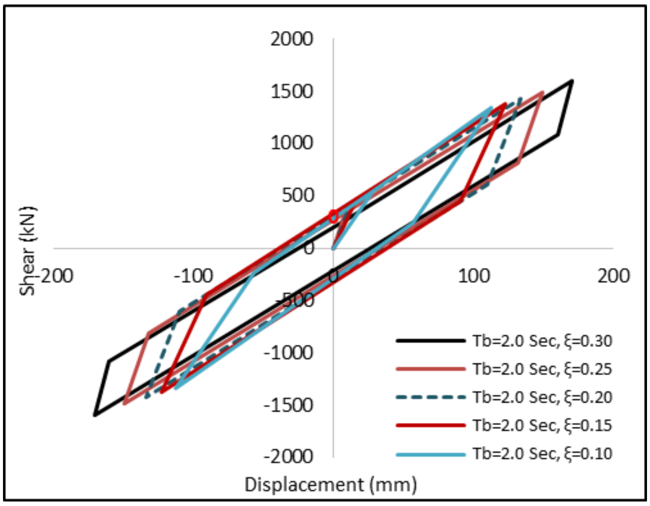
F. Force-deformation of LRB

Lead rubber bearings constructed of high damping rubber, have a nonlinear force deflection relationship. This relationship, termed the hysteresis loop, defines the effective stiffness (average stiffness at specified displacements) and the hysteretic dampingprovided by the system [12]. Fig. 16(a)-depicts the bi-linear hysteresis curve for each optimum case shown in Table-VI. Each case show different shear resisted by the bearing with corresponding to the bearing displacement. Maximum force resisted by the case 1. Tb=2.0 Sec, ξ=0.25 and lower force dissipated by the case 2.Tb=3.5 Sec, ξ=0.10.

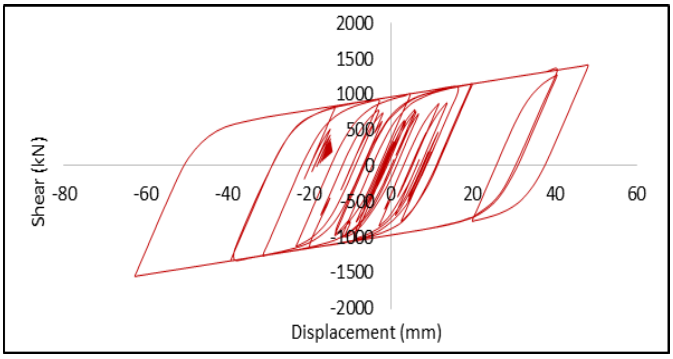
Fig. 16(b)-depicts the cases for Tb=2.0 Sec. with ξ=0.10, 0.15, 0.20, 0.25, 0.30. As the damping of the demeanor increases,



(a)



(b)



(c)

Fig.16-Hysteresis curve (a) Optimum cases as per Table VI, (b) Optimum design case ξ=0.30 & Tb=2.0 Sec.
(c) Time history analysis - case ξ=0.30 & Tb=2.0 Sec.

the displacement of the bearing get increase and vice versa. Fig. 16(c)-depicts the actual hysteresis of optimum isolator.

IV. CONCLUSIONS

The investigation of permanent bottom and LRB bottom inaccessible 3-D ten story RCC structure are executed during this paper. A comprehensive examination are performed on the exhibition of base segregated structures. The conduct of building structure laying on LRB isolator is contrasted and fixed base structure under most extreme proficient seismic tremor. a whole rundown of execution of isolator is exhibited in Table VI.

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Seismic base segregation can lessen the seismic impacts and along these lines floor increasing velocities, between story floats, and base shear by extending the characteristic time of vibration of a structure by means of utilization of elastic disconnection cushions between the sections and in this manner the establishment. Notwithstanding, just on the off chance that the misshapening limit of the isolators surpassed, isolators may burst or clasp. In this way, it's imperatively critical to precisely appraise the tallness base relocations just in the event of serious seismic tremors, especially if the base disconnected structure is most likely going to be struck by close issue quakes. Close issue quakes may contain significant stretch speed beats which can correspond with the measure of the base separated structures. In such a case, the isolators may distort unnecessarily. The analysis comparison revels that base isolated structure reduces response performance considerably in compare to the fixed structure which impart an important role in reducing the sizing of structural members and amount of designed steel requirement also . Top floor acceleration and displacement floor spectra are developed to review the precise earthquake response and checking out the optimum design parametric properties of LRB and corresponding cost comparison just in case of Indian site area in highly seismic zone IV.

1. Increase of your time period of building- As results of the increased flexibility of the system, natural period of the structure increased from T=0.6sec to T=4.2sec, distancing natural period of the system from the predominant periods of the expected earthquake actions.
2. Reduction of base-shear- Reduction of the base-shear force is clear within the model with implemented seismic isolation. For the optimum case of LRB isolator, the base-shear force under the El-Centro earthquake excitation has been reduced 3.2 times in compare to fixed base structure.
3. Increase of displacements-Increased flexibility of the system led to extend of the entire displacements thanks to the elasticity of the prevailing isolation. Displacements of the system are concentrated at the isolation top planlevel. Total displacement at isolation top level is 68 mm under the El-Centro earthquake excitation.
4. Optimum LRB system- After analyzing all cases of various Tb and ξ values of the isolator system optimum design cases found as a) ξ=10, Tb=3.5 S, b)) ξ=15, Tb=2.5 S, c) ξ=20, Tb=2.5 S, d) ξ=25, Tb=2 S, e) ξ=30, Tb=2.0 S.
5. Reduction of story acceleration-Due to increased flexibility and damping of isolator, it predominantly dissipate most of the earthquake energy. Analysis has been shown significant reduction of floor acceleration. For fixed structure top floor acceleration under earthquake excitation has found 2.48 m/sec2, where as in base isolated structure for same floor it's found 0.68m/sec2.

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