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Comparative Study of Lead Rubber Bearing Base-Isolated and Fixed Base Buildings under IS 1893: 2022 Guidelines

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Abstract: Base isolation is recognized as an effective strategy in earthquake-resistant design, significantly reducing floor accelerations and inter-storey drifts. This enhances the safety of both structural and non-structural components, ensuring continued functionality of buildings even after major seismic events. The performance of base isolation systems largely depends on the linear and bilinear properties of the isolators used. This study investigates the seismic performance of a base-isolated structure in comparison to a conventional fixed-base building. A G+15 storey building model was developed and analysed using ETABS 21 software, employing Lead Rubber Bearings (LRB) for base isolation. A comparative evaluation was conducted based on key response parameters, including displacement, inter-storey drift, storey shear, and storey acceleration. The isolators were modelled using linear properties and analysed using the Response Spectrum Method in accordance with IS 1893 (Part 6): 2022. A comprehensive literature review was conducted to support the research framework, followed by model validation to align the methodology with established studies in the field. The concluding section summarizes the findings from the comparative analysis, highlighting the effectiveness of base isolation systems in enhancing seismic performance and providing insights for future research and design improvements in seismic isolation technology.
Keywords: Base Isolation, Lead Rubber Bearings (LRB), Response Spectrum Analysis, IS 1893 (Part 6): 2022

I. INTRODUCTION

In recent years, there has been a notable surge in the construction of high-rise buildings for both residential and commercial purposes. The architectural trend has shifted toward taller and more slender structures, making them increasingly susceptible to lateral forces such as wind, seismic activity, and even blast impacts. Consequently, modern structural design must prioritize resistance to these lateral loads, unlike earlier practices where buildings were primarily designed to withstand vertical loads, with lateral forces considered only in later stages of design. Today, a thorough understanding of how lateral loads affect structural behaviour is crucial for ensuring both strength and stability. The configuration of buildings to resist seismic forces primarily aims to ensure life safety during major earthquakes while also considering serviceability and the potential for economic losses. Seismic design focuses on how structures respond to significant inelastic deformations, which differ considerably from the responses under gravity or wind loads. This necessitates advanced analytical methods to assess how structures perform when subjected to earthquake-induced displacements beyond their elastic range. As a result, modern building codes allow for controlled inelastic behaviour to dissipate seismic energy, with the expectation that some level of structural damage may occur under design-level ground motions.

The idea of protecting buildings from seismic damage through isolation is not a recent development. The first patent for a seismic isolation system date back to 1909. Since then, various innovations with similar objectives have been proposed, with the technique gaining widespread attention and application globally since the 1980s. Base isolation has been successfully implemented in numerous buildings across countries such as Japan, the United States, New Zealand, and Italy. It is especially valuable for protecting critical infrastructure and heritage structures, including schools and historic buildings. To date, over a thousand buildings worldwide have adopted base isolation technology. In India, the application of base isolation began following the 1993 Killari earthquake in Maharashtra. A more prominent example is the construction of the Bhuj Civil Hospital using base isolation techniques after the devastating 2001 Bhuj earthquake in Gujarat.

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II. METHODOLOGY

The methodology adopted for this research follows a systematic approach to evaluate the seismic performance of structures with and without base isolation using Lead Rubber Bearings (LRBs). The study begins with a preliminary field investigation aimed at understanding the seismic vulnerability of existing structures and identifying the criteria for modelling. This is followed by a comprehensive literature review, which forms the foundation of the research by exploring existing studies on base isolation techniques, performance metrics, and comparative evaluations using national and international codes. Subsequently, the process involves developing identical structural drawings for both the fixed-base and isolated-base models to ensure accurate and unbiased comparison. These two structural configurations — fixed-base and isolated base using LRBs — are then modelled separately to simulate their behaviour under seismic loading.

Using ETABS 21, a well-established computer-aided structural analysis and design software, the models are generated and analysed. The software is employed for both the creation and detailed design of structural components, incorporating appropriate material properties, load combinations, and seismic zone factors. The models are analysed using response spectrum analysis as per relevant seismic codes to evaluate their performance. Once the models are analysed, the results are extracted and used for comparative analysis across several key parameters. These include the time period, where the elongation of the fundamental period due to base isolation is assessed; base shear, which helps determine the reduction in lateral seismic forces; storey displacement and storey drift, which are crucial for evaluating structural deformation and inter-storey movement under seismic excitation; and diaphragm accelerations, which are vital in understanding how seismic forces affect floor-level equipment and non-structural elements.

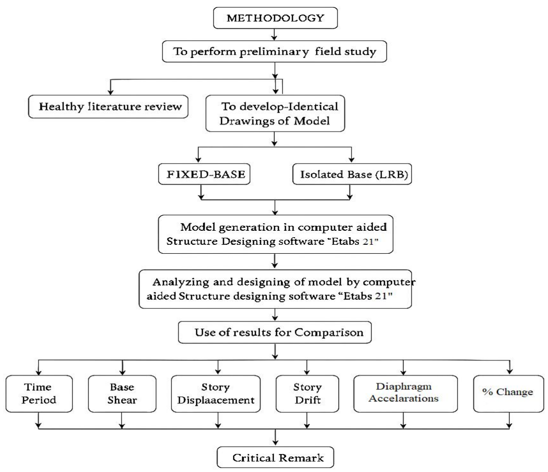

Fig. 1 Methodology

Finally, a percentage change in each parameter is calculated to quantify the benefits of using LRBs over a traditional fixed-base system. The findings culminate in a critical remark, where the implications of the results are interpreted in terms of seismic resilience, structural safety, occupant comfort, and suitability for performance-based design—particularly for critical infrastructure like hospitals and data centres. This methodological framework ensures a rigorous, replicable, and industry-relevant approach to seismic performance evaluation.

III.MODEL BUILDING

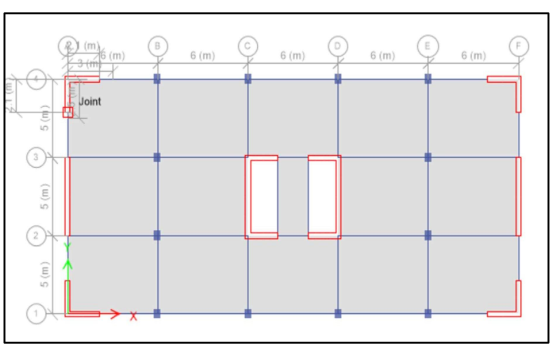

Fig 2 Plan View of Building

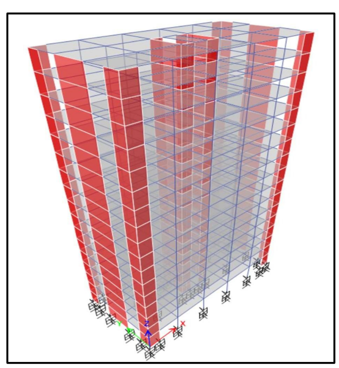

Fig 3 3D view of G+15 BUILDING

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A comprehensive overview of the structural models employed in this study, detailing the geometry, plan configuration, material specifications, sectional dimensions of structural elements, and the applied loading conditions. The selection of these parameters has been made judiciously, incorporating advancements in construction materials, computational modelling, and structural analysis. Recent amendments and updates in design standards—namely IS 1893 (Part 1): 2016, IS 875 (Part 3): 2015, and IS 16700: 2017—have been strictly adhered to throughout the modelling and analysis processes to ensure compliance with current engineering practices.

A variety of structural analysis and design software packages are available for simulating building behaviour, including STAAD Pro., SAP2000, MIDAS, RCDC, and ETABS. In the present study, ETABS 2021 has been selected as the primary analytical tool due to its robust capabilities in integrated structural modelling, analysis, and design. ETABS is built on a finite element (FE) framework and is specifically optimized for multi-storeyed building systems. Its intuitive user interface and comprehensive feature set make it particularly suitable for both linear and nonlinear static and dynamic analyses. Additionally, ETABS facilitates the easy generation and export of graphical outputs and result tables, enhancing interpretability and documentation of analytical findings.

TABLE I
INPUT DATA PARAMETERS

Parameter	Value
Number of Stories	16
Storey Height	3 meters
Plan Dimensions	30mts. X 15mts.
Grade of concrete	M 30 for beams ans slabs
	M 40 for columns and shear walls
Longitudinal Reinforcement	Fe 550
Confinement Reinforcement	Fe 415
Seismic zone	Zone V
Importance Factor	1
Response Reduction Factor	Fix Base = 5
	Isolated Structure = 2
Damping Ratio	5%
Soil Type	Type II (Medium)
Structural System	Dual System: Ductile RC structural walls with RC SMRFs
Location of Isolation Layer	At the base of structure
Wind Coefficient	
Wind Speed Vb (m/s)	50
Risk Coefficient (k1 factor)	1
Terrain category (k2)	2
Topography (k3 factor)	1
Importance factor (k4)	1

TABLE III
TYPES OF LOADS

Type of Load	**Location**	***Intensity (kN/m²)***
Dead Load (FF)	Typical Floor	*1.5*
	Roof	*1.5*
Live Load	Typical Floor	*3*
	Roof	*3*
Seismic Load	*As per IS 1893:2016*	-

Structural Element	Parameter	*Size*
Shear Wall	Thickness	*350 mm*
	Length	*As per Plan*
Beam	Width	*300 mm*
	Depth	*600 mm*
Slab	Thickness	*150 mm*
Column	Width	*450 mm*
	Depth	*600 mm*

Base isolation technology has been predominantly effective for low- to mid-rise buildings, generally ranging up to 10 to 15 stories or approximately 40 to 50 meters in height. In this research, a 15-storey building was modelled with base isolation, placing it at the upper boundary of the recommended range. Despite being at the limit, this makes the structure a suitable candidate for implementing base isolation, allowing for a meaningful assessment of the technique's effectiveness in reducing seismic demands on mid-rise buildings.

IV. DESIGN OF LINEAR ISOLATION SYSTEM

The linear isolation system operates based on linear mechanical properties that govern the behaviour of the isolators under dynamic loading conditions. The primary characteristics of such a system include:

- Effective Stiffness: This parameter defines the isolator's resistance to deformation under dynamic forces and directly influences the natural period of the isolated structure. Accurate estimation of effective stiffness is essential for achieving the desired shift in the fundamental frequency of the structure.
- Hysteretic Damping: This denotes the energy dissipation capacity of the isolator resulting from cyclic loading and unloading. Hysteretic damping plays a vital role in attenuating seismic vibrations and thereby enhances the system's overall energy dissipation capability.

The design of the isolation system is carried out in accordance with *IS 1893 (Part 6):2022*. The design procedure involves the following steps

A. Establish Dynamic Parameters

- ❖ Determine seismic zone and zone factor:
  - ➢ Seismic Zone: V
  - ➢ Zone Factor(Z): 0.36
  - ➢ Seismic Weight on Isolation System(W): 79918 kN from ETABS
- ❖ Identify soil type:
  - ➢ Type II – Medium Soil
- ❖ Select the response reduction factor:
  - ➢ For Fixed Base Building: R = 5
  - ➢ For Isolated Building: R = 2
- ❖ Choose the type of isolator:

Lead Rubber Bearings:

Lead Rubber Bearings (LRB) are rubber bearings made up of alternate layers of steel laminates and hot vulcanized rubber with a cylindrical central lead core.

The energy dissipation provided by the lead core, through its yielding, allows to achieve an equivalent viscous damping coefficient up to about 40. Usually, they are circular in shape but can also be fabricated in square sections; they can also be fabricated with more than one lead core,

B. Set Target Period and Target Displacement:

- ❖ For most base-isolated systems, set the building's period to 2-3 seconds.
- ❖ Defining the Maximum Effective Natural Period ($T_{eff,\,max}$) and Minimum Effective Natural Period ($T_{eff,\,min}$) at 2.5 and 3. seconds, respectively.

C. Obtain Effective Stiffness, Effective Damping, and Estimate Base Shear:

- ❖ Calculate the effective stiffness of the isolator, as per CL. 6.1.4 of IS-1893: Part 6.

$$T_{eff,\max} = 2\pi\sqrt{\frac{W_e}{gK_{eff,\min}}}. \qquad T_{eff,\max} = 2\pi\sqrt{\frac{W_e}{gK_{eff,\max}}}$$

K_{eff_max} = (79918/9.81)*(2π/2.5)^2 $\qquad$ K_{eff_min} = (79918/9.81)*(2π/3)^2

K_{eff_max} = 51.458 kN/mm $\qquad$ K_{eff_min} = 35.735 kN/mm

- ❖ Determine the effective damping required.
  - ➢ Assume Damping Ratio for the system, ζ = 10% (Generally considered between 10-20)
  - ➢ Hence the effective damping can be estimated as below,

$$C = 2 \cdot \frac{\varsigma}{100} \cdot \sqrt{W \cdot \frac{K_{eff\ max}}{g}}$$

$$C = 2 * 0.1 * \sqrt{((79918 * 51.458/9.81)} = 40.95\ K_{n-s/m}$$

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❖ Determine the effective damping required,

The Base-Isolation System shall be designed and constructed to withstand at least a minimum lateral earthquake displacement of Δ_{SD} as per **CL. 6.1.2** of IS-1893: Part-6, along each of its principal plan direction, and estimated by:

$$\Delta_{SD} = \left[Z \left(\frac{S_a}{g} \right)_{T_{eff,\max}} \beta \right] g \frac{T_{eff,\max}^2}{4\pi^2}$$

Where,

(S_a/g) = Design horizontal spectral acceleration coefficient (corresponding to 5 percent damping) at a natural period of Teff,maxT_{\text{eff,max}}Teff,max, as obtained from Fig. 2 of IS 1893 (Part 1)

β = damping multiplier, is given by:

$$\beta \frac{S_a}{g} = 0.242$$

$$\beta = \sqrt{(0.1)/(0.05+0.1)} = 0.816$$

Hence, Design Displacement:

$$\Delta_{sd} = (0.36 * 0.242 * 0.816 * 9.81) * 3^2/4\pi^2 = 0.159\ m$$

❖ Estimate the base shear based on the effective stiffness and damping.

➢ Design Earthquake Lateral Force for Design of the Components of Isolation System and of the Structural Elements below the base as per CL. 6.1.5 of IS-1893: Part 6:

$$V_B = K_{eff.\max} \Delta_{SD}$$

$$V_b = 51.458 * 1000 * 0.159 = 8186.14 \text{ Kn}$$

➢ Design Earthquake Base Shear Force for the Superstructure as per CL. 6.1.6 of IS-1893: Part 6:

$$V_S = \frac{V_B}{R_1}$$

Where,

R1 = Response Reduction Factor of a base-isolated building given by:

$$R_1 = Min\left[\frac{3}{4} R : 2\right] \qquad R_1 = \text{Min } [(3/4)*5:2] = 2$$

Hence,

$$V_s = 8186.14/2 = 4091 \text{ Kn}$$

If the base shear in ETABS is coming less than the Vs calculated as above then scale up the RSA Function match to to the value.

D. Finalize Number, Location, and Properties of Dampers:

- Location of Dampers:
  - ➢ The Isolators are located at the bottom of story GF.
  - ➢ One Isolator is placed below each column and each shear wall.

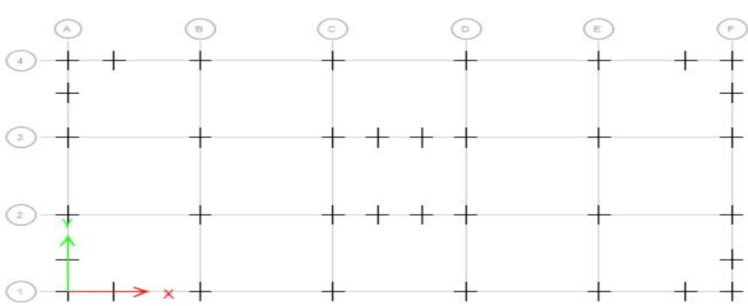

Fig 4 Location of Isolators

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- Define the properties of each damper to meet the requirements calculated in Step 4:
  The stiffness and damping of each isolator are proportionate to the relative vertical force i.e Seismic mass on the group. This ensures that the distribution of forces is balanced and the isolation system performs effectively under seismic loads. Following is calculation of same and results are summarized in Table.
- Known Parameters:
  i. Total Seismic Weight on Isolation System: W_{Total} =79918 kN
  ii. Total Stuffiness Required in Isolation System: $K_{Total\,=}$ 51.458 kN/mm
  iii. Number of Isolators present in Total: n=36

Following below are the Calculation of isolator Properties
i. Total Seismic Weight: W =79918 kN
ii. Total Number of Isolators present in group n=36

∴ Stiffness Required for group, $K_{req}=K_{total}*W_{G1}/W_{TOTAL}$ =51.458*79918/79918 = 51.458 kN/m
∴ Stiffness Required per isolator, $K_{G1}=K_{req}/n$ =51.458/36=1.430 kN/mm
∴ Damping Required per isolator,

$$C_{G1}:=2\cdot\zeta\cdot\sqrt{\left(W_{G1}\cdot\frac{K_{G1}}{g}\cdot\frac{1}{n}\right)}$$

C_{G1}=2*0.1*√(79918*51.458*1000/9.81*36) = 683 kN-s/m

V. RESULT OF COMPARATIVE STUDY

A detailed comparison of the seismic responses for response spectrum analysis of fixed-base versus isolated building is provided. This includes evaluating factors such as displacement, storey drift, acceleration, and force distribution:

A. Storey Displacements

Storey displacement refers to the horizontal movement or displacement of each floor (storey) of a building relative to its original position. This displacement is typically measured during seismic events or other dynamic loading conditions. Results are represented in tabular format as below,

TABLE IIIII
STOREY DISPLACEMENT SUMMARY

STOREY DISPLACEMENTS								
			BASE ISOLATION		FIXED BASE		% CHANGE	
STOREY	ELEVATION	LOCATION	BASE X-DIRECTION mm	BASE Y DIRECTION mm	FIXED X-DIRECTION mm	FIXED Y DIRECTION mm	X- DIRECTION	Y DIRECTION
ROOF	51	TOP	115.731	103.264	74.831	33.486	-35.340574	-67.572436
15TH FLOOR	48	TOP	114.443	102.257	71.066	31.144	-37.902711	-69.543405
14TH FLOOR	45	TOP	113.089	101.232	67.137	28.766	-40.633483	-71.584084
13TH LOOR	42	TOP	111.639	100.185	62.995	26.357	-43.572587	-73.69167
12TH FLOOR	39	TOP	110.071	99.115	58.647	23.92	-46.718936	-75.866418
11TH FOOR	36	TOP	108.355	98.019	53.892	21.463	-50.263486	-78.103225
10TH FLOOR	33	TOP	106.503	96.902	48.941	19	-54.047304	-80.392562
9TH FLOOR	30	TOP	104.515	95.766	43.776	16.551	-58.115103	-82.717248
8TH FLOOR	27	TOP	102.397	94.621	38.439	14.139	-62.460814	-85.057228
7TH FLOOR	24	TOP	100.163	93.474	32.983	11.791	-67.070675	-87.385797
6TH FLOOR	21	TOP	97.835	92.34	27.483	9.539	-71.908826	-89.669699
5TH FLOOR	18	TOP	95.441	91.233	22.03	7.418	-76.917677	-91.86917
4TH FLOOR	15	TOP	93.024	90.173	16.746	5.469	-81.998194	-93.934992
3RD FLOOR	12	TOP	90.642	89.181	11.785	3.734	-86.998301	-95.813009
2ND FLOOR	9	TOP	88.368	88.284	7.343	2.262	-91.690431	-97.437814
1ST FLOOR	6	TOP	86.311	87.511	3.671	1.107	-95.746776	-98.735016
GF	3	TOP	84.596	86.888	1.082	0.328	-98.72098	-99.622503
Base	0	TOP	83.706	86.646	0	0	-	-

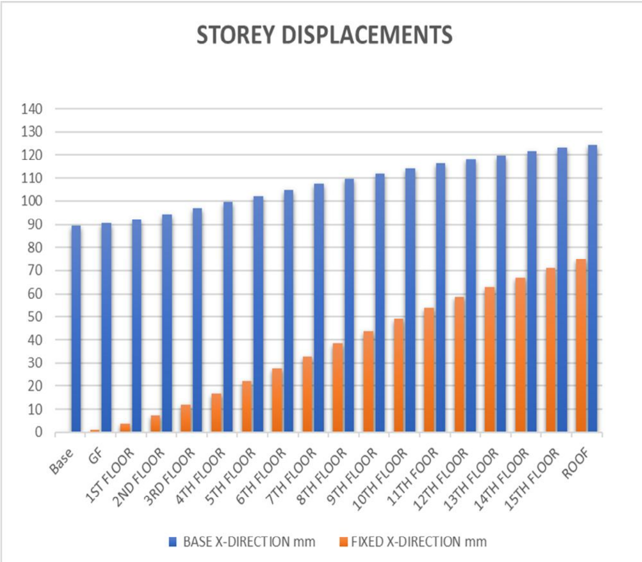

Fig. 5 Storey Displacements X Direction.

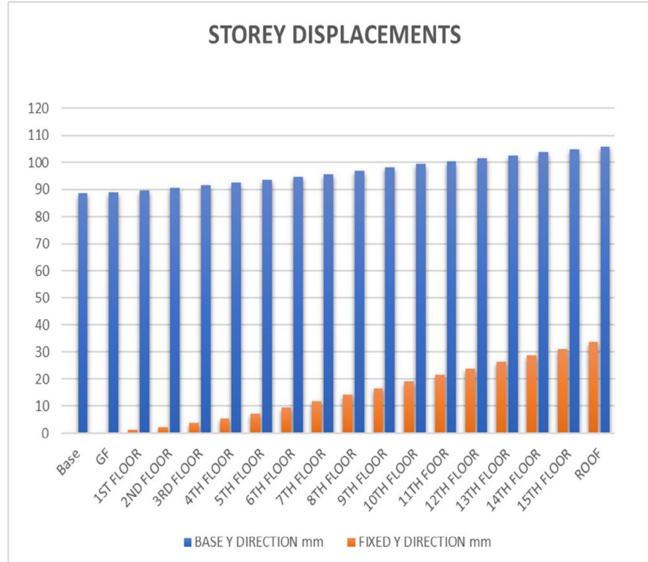

Fig. 6 Storey Displacements Y Direction.

B. Storey Drifts

Storey drift is the relative displacement or movement between adjacent storeys of a building. It's usually expressed as the ratio of the displacement between two storeys to the height of the storey under consideration. Results are represented in tabular format as below,

TABLE IVV

STOREY DRIFTS SUMMARY

STOREY DRIFTS								
			BASE ISOLATION		FIXED BASE		% CHANGE	
STOREY	ELEVATION	LOCATION	BASE X-DIRECTION mm	BASE Y DIRECTION mm	FIXED X-DIRECTION mm	FIXED Y DIRECTION mm	X-DIRECTION	Y DIRECTION
ROOF	51	TOP	0.000451	0.000345	0.001326	0.000787	194.0133	128.115942
15^{TH} FLOOR	48	TOP	0.000476	0.000351	0.00139	0.000799	192.01681	127.635328
14^{TH} FLOOR	45	TOP	0.000509	0.000359	0.001469	0.000811	188.60511	125.905292
13^{TH} LOOR	42	TOP	0.00055	0.000367	0.001554	0.000822	182.54545	123.978202
12^{TH} FLOOR	39	TOP	0.000601	0.000375	0.001651	0.000827	174.70882	120.533333
11^{TH} FOOR	36	TOP	0.000647	0.000382	0.001725	0.000828	166.61515	116.753927
10^{TH} FLOOR	33	TOP	0.000692	0.000388	0.001785	0.000823	157.94798	112.113402
9^{TH} FLOOR	30	TOP	0.000734	0.000391	0.001831	0.000809	149.45504	106.905371
8^{TH} FLOOR	27	TOP	0.00077	0.000391	0.001858	0.000787	141.2987	101.278772
7^{TH} FLOOR	24	TOP	0.0008	0.000386	0.001862	0.000754	132.75	95.3367876
6^{TH} FLOOR	21	TOP	0.000818	0.000376	0.001836	0.000709	124.44988	88.5638298
5^{TH} FLOOR	18	TOP	0.000823	0.000359	0.001773	0.000651	115.43135	81.3370474
4^{TH} FLOOR	15	TOP	0.000808	0.000335	0.00166	0.000579	105.44554	72.8358209
3^{RD} FLOOR	12	TOP	0.000768	0.000303	0.001483	0.000491	93.098958	62.0462046
2^{ND} FLOOR	9	TOP	0.000693	0.00026	0.001225	0.000385	76.767677	48.0769231
1^{ST} FLOOR	6	TOP	0.000576	0.000209	0.000863	0.00026	49.826389	24.4019139
GF	3	TOP	0.001736	0.000578	0.000361	1.09E-04	-79.205069	-81.141869
Base	0	TOP	0	0	0	0	-	-

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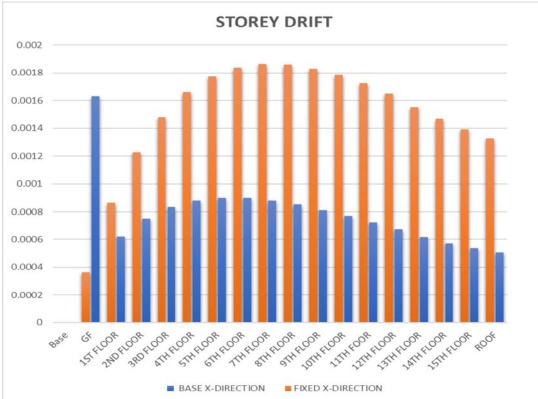

Fig. 7 Storey Drift X Direction.

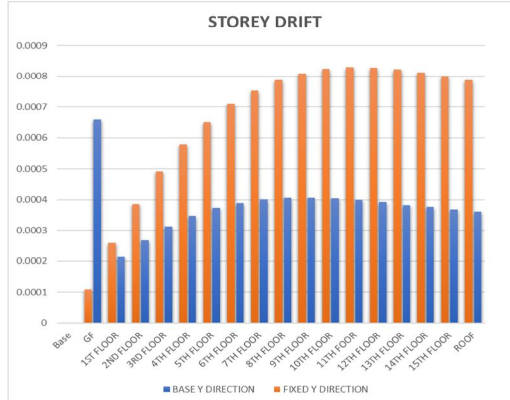

Fig. 8 Storey Drift Y Direction.

C. Storey Force

Storey shear forces are the lateral forces acting on each storey of a building due to horizontal loads such as wind or earthquakes. These forces are responsible for causing lateral movement or deformation in the structure. Results are represented in tabular format as,

TABLE V
STOREY SHEAR FORCE

STOREY SHEAR FORCE								
			BASE ISOLATION		FIXED BASE		% CHANGE	
STOREY	ELEVATION	LOCATION	BASE X-DIRECTION mm	BASE Y DIRECTION mm	FIXED X-DIRECTION mm	FIXED Y DIRECTION mm	X-DIRECTION	Y DIRECTION
ROOF	51	TOP	236.7401	235.6556	1120.7333	813.6792	373.40239	245.283201
15^{TH} FLOOR	48	TOP	505.9764	505.1311	2127.2399	1599.3218	320.42275	216.615192
14^{TH} FLOOR	45	TOP	766.0263	766.9483	2874.6641	2223.9585	275.26963	189.975022
13^{TH} LOOR	42	TOP	1017.5585	1021.7982	3448.7102	2721.9719	238.92009	166.39036
12^{TH} FLOOR	39	TOP	1267.1699	1276.4034	3912.0525	3130.815	208.7236	145.284132
11^{TH} FOOR	36	TOP	1509.7174	1525.646	4297.8132	3482.4573	184.67667	128.261163
10^{TH} FLOOR	33	TOP	1746.255	1770.5619	4632.7374	3798.9842	165.29558	114.563761
9^{TH} FLOOR	30	TOP	1977.9814	2012.2824	4946.113	4093.7734	150.05862	103.439309
8^{TH} FLOOR	27	TOP	2206.2368	2252.0286	5257.703	4374.7676	138.31091	94.2589717
7^{TH} FLOOR	24	TOP	2432.5158	2491.1169	5577.0151	4645.1492	129.26943	86.4685355
6^{TH} FLOOR	21	TOP	2658.5058	2730.9891	5906.1898	4903.6715	122.16201	79.5566119
5^{TH} FLOOR	18	TOP	2886.1631	2973.2929	6236.083	5145.877	116.06828	73.0699656
4^{TH} FLOOR	15	TOP	3117.8805	3220.0719	6550.0546	5364.8051	110.08036	66.6051339
3^{RD} FLOOR	12	TOP	3356.9123	3474.2333	6833.1407	5550.3586	103.55434	59.7577975
2^{ND} FLOOR	9	TOP	3608.5864	3740.8429	7066.1966	5689.9847	95.816196	52.1043479
1^{ST} FLOOR	6	TOP	3884.6988	4031.7175	7219.1149	5774.061	85.834611	43.2159123
GF	3	TOP	4230.0291	4392.9867	7275.7389	5804.8961	72.0021	32.1400791
Base	0	TOP	0	0	0	0	-	-

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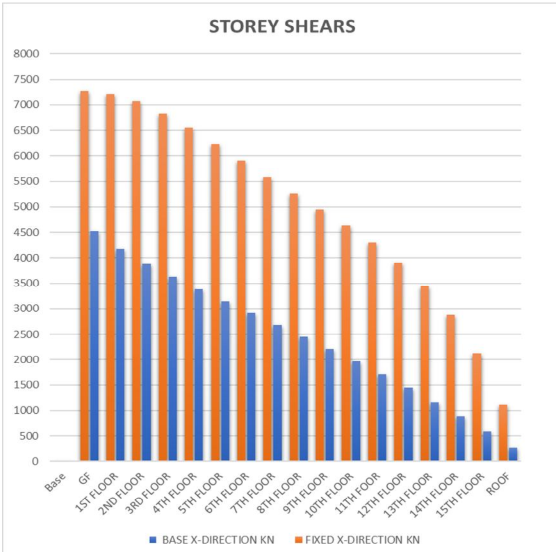

Fig. 9 Storey Shears X Direction.

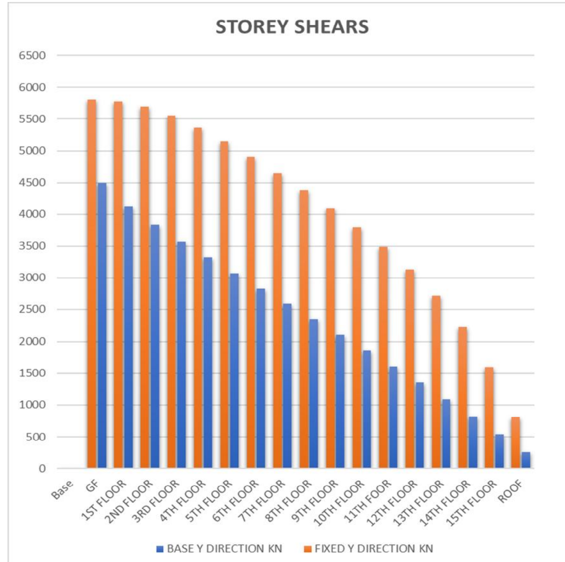

Fig. 10 Storey Shears Y Direction.

D. Modal Time Periods

Modal time periods represent the natural periods of vibration of a structure in various modes. Each structure has multiple modes of vibration, and each mode has an associated time period and mode shape. These time periods are crucial in seismic analysis because they help predict how a structure will respond to different frequencies of earthquake ground motions. Modal time periods directly influence the spectral acceleration values derived from the response spectrum. Shorter periods (higher frequencies) typically lead to higher spectral accelerations, indicating higher forces that the structure needs to withstand. Conversely, longer periods (lower frequencies) often correspond to lower spectral accelerations. The Time periods of Fixed and Isolated structure are represented in following

TABLE VI

MODAL TIME PERIODS

MODAL TIME PERIODS			
Case	**Mode**	ISOLATED **Period sec**	FIXED **Period sec**
Modal	1	2.973	1.362
Modal	2	2.801	0.947
Modal	3	2.484	0.838
Modal	4	0.694	0.366
Modal	5	0.525	0.205
Modal	6	0.44	0.204
Modal	7	0.265	0.167
Modal	8	0.148	0.096
Modal	9	0.147	0.086
Modal	10	0.138	0.084
Modal	11	0.083	0.063
Modal	12	0.071	0.049

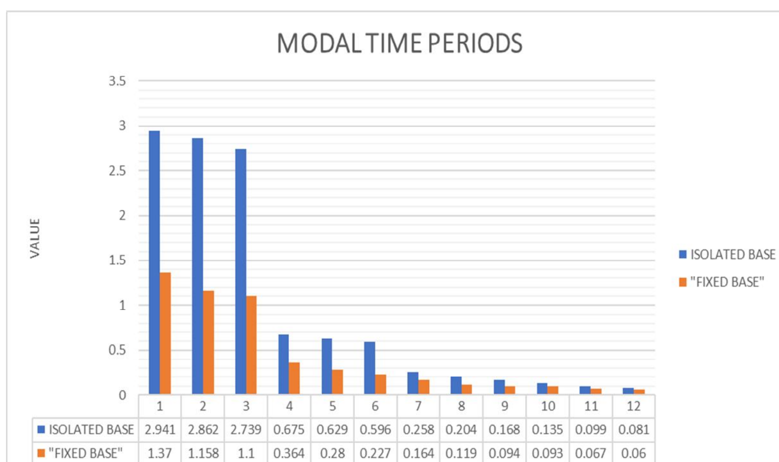

Fig. 11 Modal Time Periods Comparison

E. Diaphragm Accelerations

Diaphragm accelerations refer to the horizontal accelerations experienced by floor or roof diaphragms during an earthquake. Following table and figure summarize the results of diaphragm accelerations for Fixed and Isolated structure.

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TABLE VII
DIAPHRAGM ACCELERATIONS SUMMARY

DIAPHRAGM ACCELERATIONS								
			BASE ISOLATION		FIXED BASE		% CHANGE	
STOREY	ELEVATION	LOCATION	BASE MAX UX mm/sec^2	BASE MAX UY mm/sec^2	FIXED MAX UX mm/sec^2	FIXED MAX UY mm/sec^2	X-DIRECTION	Y DIRECTION
ROOF	51	TOP	566.26	564.82	2791.89	2058.2	393.0403	264.399278
15TH FLOOR	48	TOP	544.84	546.57	2148.73	1671.28	294.37817	205.776021
14TH FLOOR	45	TOP	525.38	530	1755.49	1387.88	234.1372	161.864151
13TH LOOR	42	TOP	508.34	515.42	1621.69	1242.66	219.0168	141.096581
12TH FLOOR	39	TOP	494	503.11	1587.99	1189.22	221.45547	136.373755
11TH FOOR	36	TOP	482.35	493.3	1555.53	1160.15	222.48989	135.181431
10TH FLOOR	33	TOP	473.99	486.09	1594.17	1152.9	236.32988	137.1783
9TH FLOOR	30	TOP	469.07	481.46	1660.04	1175.37	253.90027	144.126199
8TH FLOOR	27	TOP	467.58	479.27	1706.45	1201.39	264.95359	150.670812
7TH FLOOR	24	TOP	469.42	479.25	1739.73	1192.14	270.61267	148.751174
6TH FLOOR	21	TOP	474.32	481.04	1742.57	1141.46	267.38278	137.290038
5TH FLOOR	18	TOP	481.81	484.19	1687.8	1077.5	250.30406	122.536608
4TH FLOOR	15	TOP	491.22	488.18	1601.56	1015.62	226.03721	108.042116
3RD FLOOR	12	TOP	501.68	492.45	1499.85	922.68	198.96548	87.3652147
2ND FLOOR	9	TOP	512.12	496.46	1285.92	749.88	151.0974	51.0454014
1ST FLOOR	6	TOP	521.21	499.71	870.32	489.83	66.98068	-1.9771467
GF	3	TOP	527.45	501.81	341.51	199.41	-35.252631	-60.261852
Base	0	TOP	528.85	500.75	0	0	-	-

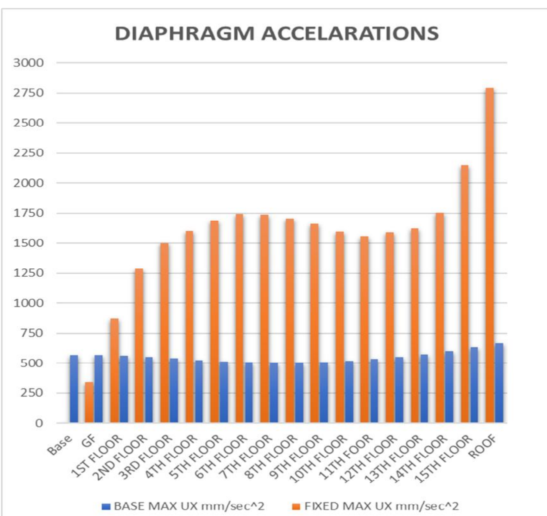

Fig. 12 Diaphragm Accelerations X Direction.

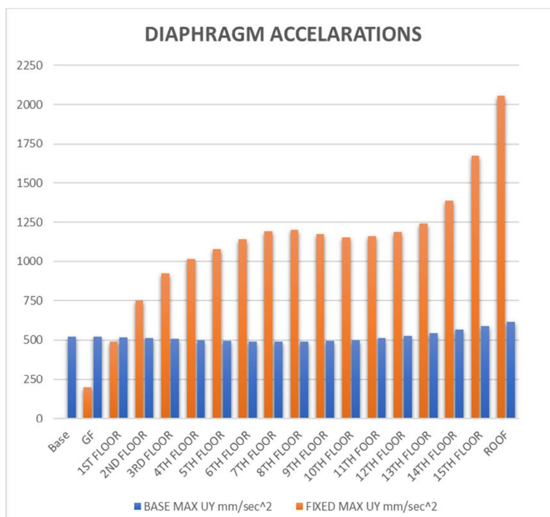

Fig. 13 Diaphragm Accelerations Y Direction.

VI. CONCLUSIONS

This study presents a comparative seismic performance evaluation of a fixed-base and a base-isolated (Lead Rubber Bearing) multi-storey building as per IS 1893 (Part 6)-2022 using linear isolation modeling and response spectrum analysis in ETAB21. The findings highlight the substantial advantages offered by base isolation systems across various critical structural parameters, affirming their effectiveness in seismic mitigation.

The results demonstrate a remarkable reduction in displacement, storey drift, storey shear, and storey acceleration when linear base isolation is implemented. Specifically, the top-storey displacements were reduced by approximately 56–61% in both X and Y directions. Similarly, storey drifts were lowered by 55–60%, reinforcing the role of base isolators in limiting inter-storey deformation and enhancing structural and non-structural safety. In terms of storey shear, a consistent reduction of 50–65% was observed across all levels, significantly reducing the lateral force demands on structural members. Furthermore, the modal time periods of the isolated structure increased by an average of 110%, effectively shifting the building's dynamic response out of the range of dominant ground motion frequencies, which contributes to a substantial reduction in seismic forces. A key finding is the reduction in storey accelerations above the isolation layer, where values decreased by 38–41% in both directions. This drop plays a critical role in safeguarding internal contents, sensitive equipment, and ensuring post-earthquake functionality—vital for hospitals, heritage buildings, and other critical infrastructure. Overall, the linear base isolation system, particularly using Lead Rubber Bearings, exhibits enhanced seismic performance by reducing structural responses, increasing energy dissipation, and improving occupant safety. The significant improvements observed across all seismic response parameters strongly support the adoption of base isolation as a reliable and effective strategy in performance-based seismic design, especially for buildings located in high seismic zones.

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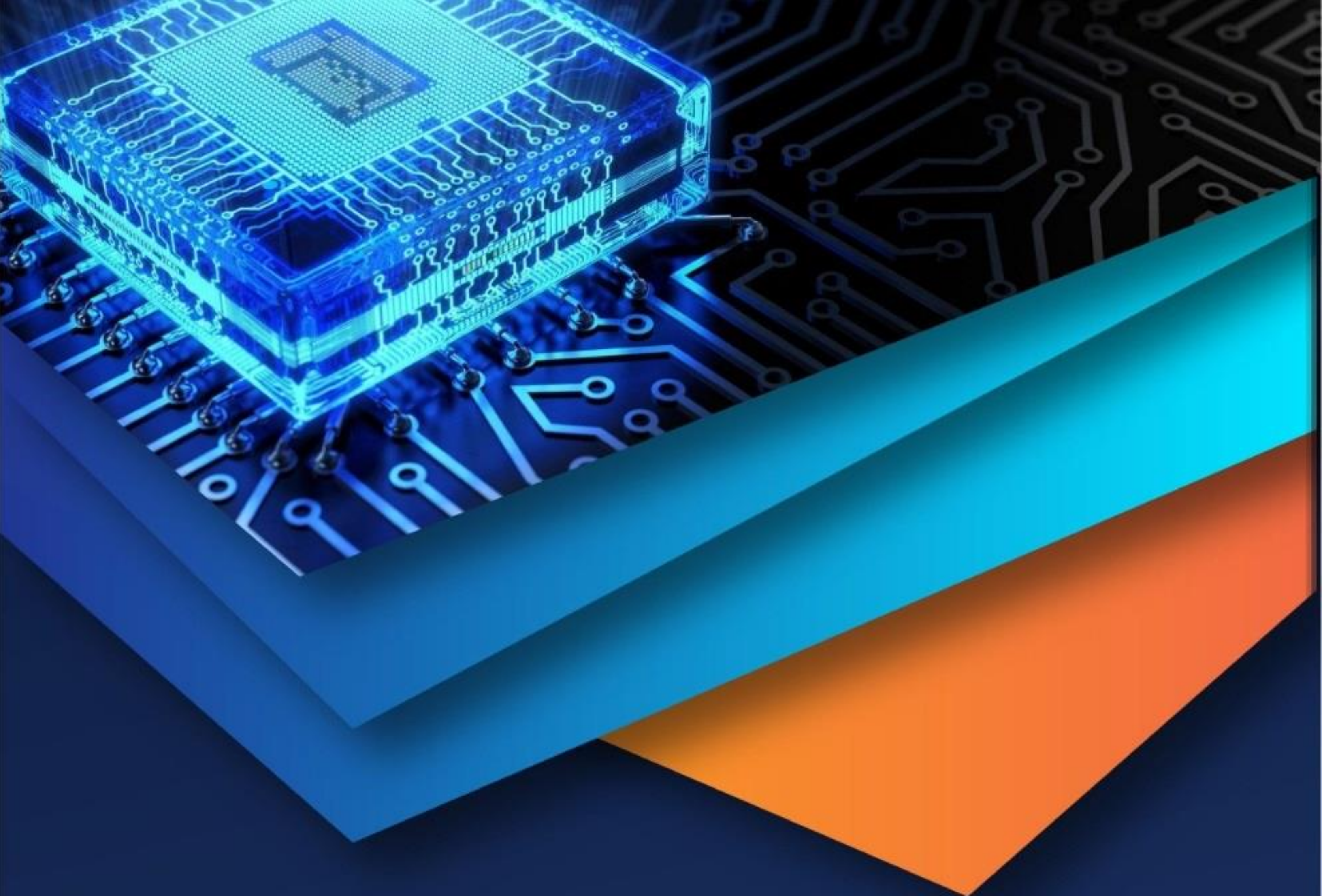

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