INVESTIGATION ON SEISMIC BEHAVIOUR OF FRAMED STRUCTURE USING BASE ISOLATORS WITH FRICTION DAMPER

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Abstract— This paper focuses on the seismic analysis of a multi-story framed structure using base isolation techniques in conjunction with friction dampers to enhance performance during seismic events. The analysis is carried out using ETABS (Extended Three-Dimensional Analysis of Building Systems) a powerful and widely accepted structural analysis and design software to facilitate accurate modeling, simulation, and interpretation of complex structural behavior under dynamic loading. In this study, a G+6 framed structure is modeled and analyzed in ETABS under seismic loading conditions as per the Indian Standard Code IS 1893 (Part 1):2016. Three models are developed: one with a base isolator, One with a friction damper and the other incorporating base isolators (lead rubber bearings) and friction dampers at strategic locations to control lateral displacement and energy dissipation.

Index Terms— Seismic Analysis, ETABS, Dynamic Response, Numerical Modelling.

I. INTRODUCTION

In recent decades, devastating earthquakes around the world have highlighted the need for resilient building design. Conventional structures often fail to withstand the lateral forces generated during seismic activity, prompting engineers to explore advanced technologies like base isolation and supplemental damping.

Base isolation acts as a flexible interface between the structure and its foundation, significantly reducing the transmission of ground motion into the superstructure. This technology is especially effective for critical buildings such as hospitals, emergency centers, and high-rise residential or commercial buildings. Friction dampers provide additional energy dissipation by converting seismic energy into heat through sliding mechanisms. Their simple design, low maintenance, and reliability make them a preferred choice for retrofitting and new constructions alike. The combined use of base isolation and friction dampers in a single structure offers a dual-layered defense mechanism where base isolators reduce displacement demands and dampers further limit internal forces and vibrations. This synergy ensures enhanced safety and performance during severe seismic events.

Modern engineering demands precision and predictive accuracy, which is made possible by advanced software like ETABS. The program allows for detailed finite element modeling, time-history analysis, and modal response spectrum studies, enabling engineers to predict structural behavior under different seismic scenarios. This study aims not only to enhance the understanding of seismic control techniques but also to demonstrate how modern tools and technologies can be harnessed to build safer and more resilient civil infrastructure.

This research investigates the seismic behavior of a G+6 reinforced concrete (RC) framed structure located in Seismic Zone V, which represents the highest level of seismic risk in the Indian seismic zoning map. The structure is analyzed using ETABS software, a widely used platform for structural modeling and dynamic analysis.

II. LITERATURE REVIEW

1) **Durgesh C. Rai (2000),** In these papers he deals with the FUTURE TRENDS IN EARTHQUAKE RESISTENT of the structures. It is well known that earthquakes will continue to occur. But for the engineer, the ultimate goal will remain same to design the structure but cost effective in manner. The

development of new structural systems and devices will continue for the base isolation, passive energy and active control systems, along with the proliferation of non-traditional civil engineering materials and techniques. The main focus on the friction damper is carried out by doing various analysis like push over analysis and response spectrum analysis. The ultimate goal will remain the same: to design the perfect, but cost effective structure, that behaves in a predictable and acceptable manner.

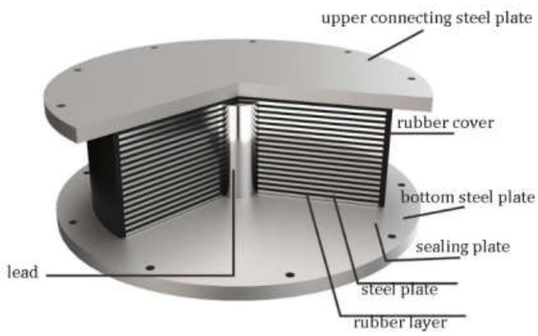
2) **Maryam Montazeri (2023):** This study suggests a new combination of seismic isolation devices for buildings consisting of FSD and PB. To investigate the eligibility of the suggested system, two types of structural systems were considered for adopting the FSD plus PB, and it was compared to the fixed-base and isolated form of the buildings including well-known seismic isolators, i.e. LRB and FPS.

3) **Kumar and Jain (2020)** conducted comparative analyses on high-rise buildings equipped with friction dampers and base isolators. Their findings confirmed that integrating friction dampers with base isolation systems effectively reduces peak structural response parameters such as displacement, acceleration, and inter-storey drift under seismic loading. This combined approach leverages the advantages of base isolators in lengthening the natural period of the structure and friction dampers in dissipating seismic energy, leading to improved overall seismic resilience. The study underscores the importance of hybrid seismic control systems in mitigating earthquake-induced damages in high-rise buildings, especially in regions of high seismicity. These findings align with the objective of this research, which analysis a G+6 framed structure incorporating Lead Rubber Bearing base isolators and steel friction dampers to evaluate their combined effectiveness in seismic zones with severe earthquake risk.

III. BASE ISOLATORS

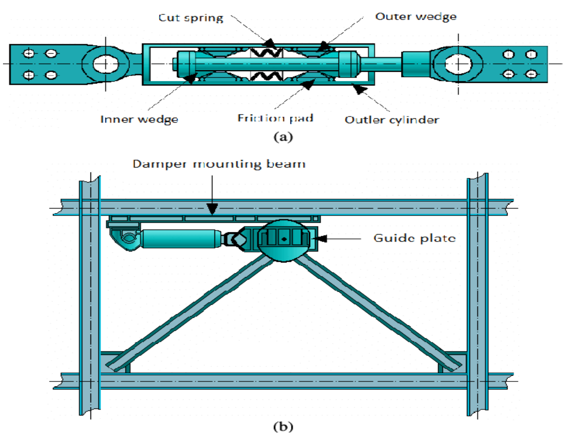
Base Isolation is an advanced seismic protection technique used to reduce the impact of earthquake ground motions on a structure. It involves placing flexible bearing elements known as isolators between the building's foundation and superstructure. These isolators allow controlled movement during an earthquake, effectively decoupling the structure from the shaking ground. By absorbing and deflecting seismic energy, base isolation minimizes the amount of force transferred to the superstructure, thereby reducing structural damage and enhancing the safety of occupants.

By decoupling the superstructure from the shaking ground, base isolation significantly reduces building acceleration, inter-storey drift, and overall structural damage, enhancing the safety and performance of the structure during seismic events.

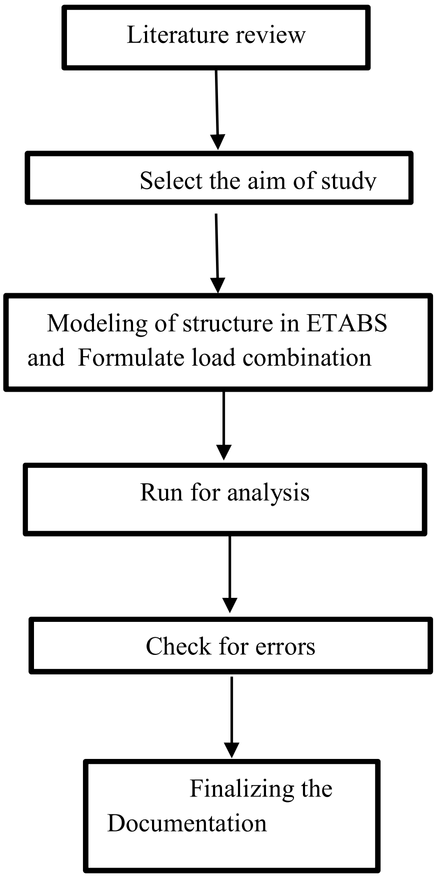


IV. FRICTION DAMPER

A **Friction Damper** is a type of energy dissipation device used in structures to reduce vibrations and absorb seismic energy through the controlled sliding of two or more surfaces in contact under pressure. These dampers operate by converting kinetic energy from structural motion during an earthquake into heat energy through friction, thereby limiting the amplitude of vibration and protecting the structure from damage.



V. METHODOLOGY



VI DIMENSIONS

Grade of concrete : M30

Grade of steel : Fe500

Live load : 3 KN/m^2

Floor finish : 1 KN/m^2

Wall load : 14 KN/m^2

Live load on all floors : 4 KN/m^2

Zone factor :0.36

Importance factor :1

Soil type :Medium

Link (Friction damper) Properties

Mass :80 kg

Weight :0.78 kN

Effective Stiffness :108855 kN/m

Slip load :250 kN

LRB link properties

Linear Property

For U2 Direction

Effective Stiffness of Bearing, Ke : 800 kN/m

For U3 Direction

Effective Stiffness of Bearing, Ke :1500000 kN/m

Non Linear Property

For U2 Direction

Initial Stiffness of Bearing, Ke : 250 kN/m

Yield strength of Bearing, Fy :100 kN

Post yield stiffness ratio : 0.1

For U3 Direction

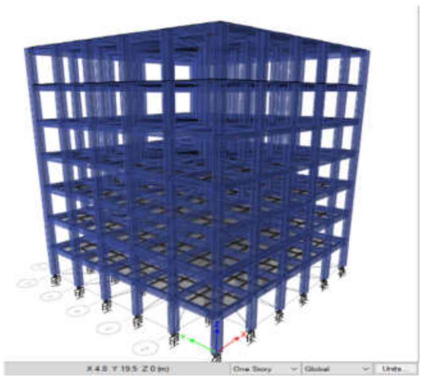
Initial Stiffness of Bearing, Ke : 250 kN/m

Yield strength of Bearing, Fy :100 kN

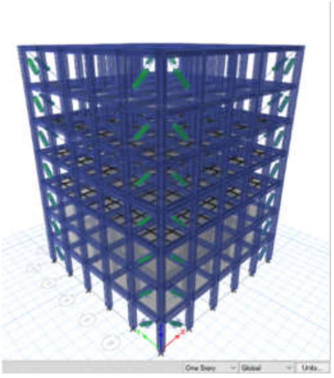
Post yield stiffness ratio : 0.1

VII MODELLING

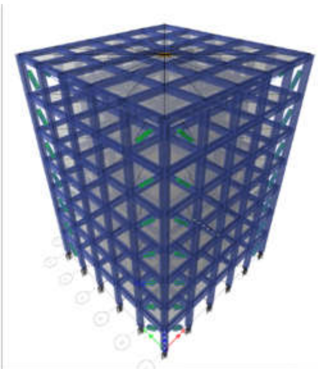
1. A STRUCTURE WITH LRB



2. A STRUCTURE WITH FRICTION DAMPER



3. A STRUCTURE WITH LRB AND FD

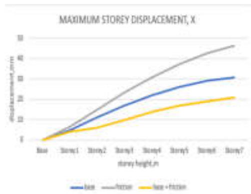


VIII.RESULTS

1.MAXIMUM STOREY DISPLACEMENT

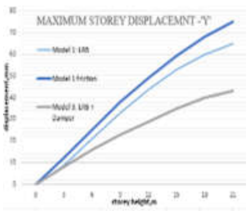
In ETABS and seismic analysis software, it's calculated from the dynamic or response spectrum analysis under earthquake load cases.

Story	base	friction	base + friction
Base	0	0	0
Storey1	4.855	6.465	3.855
Storey2	11.096	15.006	6.096
Storey3	16.838	23.219	9.838
Storey4	21.823	30.74	13.823
Storey5	25.898	37.265	16.898
Storey6	28.901	42.497	18.901
Storey7	30.704	46.127	20.704



storey displacement in X direction

Storey Level	Model 1: LRB	Model 2 friction	Model 3: LRB + Damper
Roof (7th)	64.743	76.977	43.101 mm
6th	59.82	65.892	39 .909mm
5th	52.695	52.321	34.998 mm
4th	43.645	47.428	28.678 mm
3rd	32.994	31.397	22.567mm
2nd	21.116	20.387	15.789 mm
1st	8.701	9.612	7.987 mm
Ground	0	0	0 mm

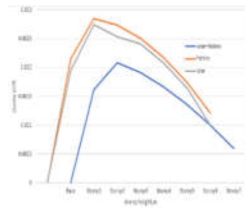


storey displacement in Y direction

2. MAXIMUM STOREY DRIFT

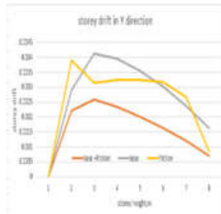
Storey drift is defined as the lateral displacement difference between two consecutive storeys due to lateral loads (e.g., earthquake or wind), divided by the storey height. It represents the relative horizontal movement of one floor with respect to the floor below.

Storey	base	friction	base+friction
Base	0	0	0
Storey1	0.001618	0.002155	0.001618
Storey2	0.00208	0.002847	0.00208
Storey3	0.001914	0.002738	0.001914
Storey4	0.001661	0.002507	0.001661
Storey5	0.001358	0.002175	0.001358
Storey6	0.001001	0.001744	0.001001
Storey7	0.000601	0.00121	0.000601



storey drift in X direction

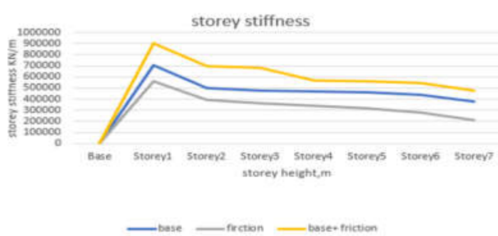
Storey	base	friction	base+friction
Base	0	0	0
Storey1	0.0029	0.0039	0.002204
Storey2	0.004138	0.003138	0.002592
Storey3	0.003959	0.003259	0.002337
Storey4	0.003551	0.003251	0.00201
Storey5	0.003017	0.00317	0.001631
Storey6	0.002375	0.002675	0.001191
Storey7	0.001641	0.000841	0.000695



storey drift in Y direction

3. STOREY STIFFNESS

In seismic engineering, storey stiffness refers to the ability of a particular storey (or floor level) of a building to resist lateral deformation when subjected to lateral forces such as earthquakes or wind. LRBs make the structure more flexible → lower stiffness. Dampers reduce motion without



Storey	base	friction	base+friction
Base	0	0	0
Storey1	702099.552	563333.771	902099.552
Storey2	499973.002	392204.163	699973.002
Storey3	480052.469	363309.569	680052.469
Storey4	470228.062	340838.936	570228.062
Storey5	459501.662	316699.174	559501.662
Storey6	441452.986	281529.838	541452.986
Storey7	378449.085	210709.492	478449.085

reducing stiffness much. LRB + Damper system provides controlled stiffness with energy dissipation.

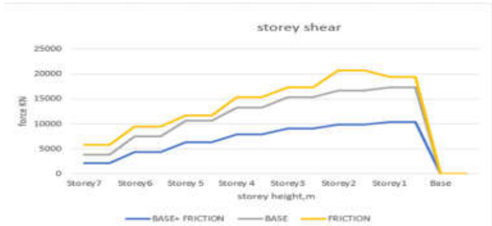
4.STOREY SHEAR

Storey shear refers to the total horizontal (lateral) force acting at the base of a storey due to lateral loads such as earthquakes or wind.

Model 1: LRB only → reduces base shear by allowing flexible base movement

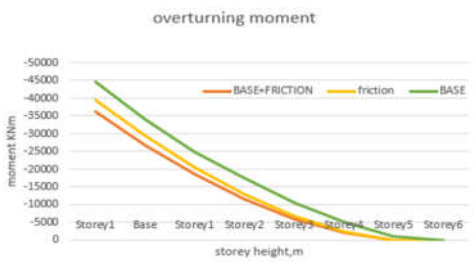
Model 2: Friction Dampers → controls motion via energy dissipation but higher shear

Model 3: LRB + Dampers → reduces both motion and base shear effectively.



Storey	BASE	FRICTION	BASE+ FRICTION
Storey7	3835.5444	5835.5444	2191.1987
	3835.5444	5835.5444	2191.1987
Storey6	7535.2548	9535.2548	4385.1607
	7535.2548	9535.2548	4385.1607
Storey 5	10718.696	11718.696	6278.8378
	10718.696	11718.696	6278.8378
Storey 4	13326.732	15326.732	7852.992
	13326.732	15326.732	7852.992
Storey3	15330.953	17330.953	9084.6086
	15330.953	17330.953	9084.6086
Storey2	16706.701	20706.701	9926.7806
	16706.701	20706.701	9926.7806
Storey1	17387.439	19387.439	10323.209
	17387.439	19387.439	10323.209
Base	0	0	0
	0	0	0

5. OVERTURNING MOMENT



The Overturning Moment is the rotational effect (moment) generated at the base of a structure due to lateral forces like earthquakes or wind.

IX.CONCLUSION

This study presents a comprehensive seismic performance assessment of a G+7 reinforced concrete (RC) framed structure using advanced passive control techniques: base isolation and energy dissipation. The building is located in Seismic Zone V and rests on medium soil, following provisions of IS 1893:2016 and relevant codes. The integration of Lead Rubber Bearings with Steel Friction Dampers provides the most balanced and effective solution. This combined system offers: Minimal storey drift, Lowest base shear and overturning moment, Optimal storey stiffness, Enhanced performance under severe seismic shaking. Hence, for critical and tall buildings located in high seismic zones like Zone V, the combined use of base isolators and energy dissipation devices is highly recommended. This approach improves not only life safety but also serviceability and cost-effectiveness in the long run, by minimizing structural and non-structural damage during major earthquakes.

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