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Effectiveness of Elastomeric and Sliding Isolation Systems in Seismic Protection of Buildings

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Abstract: This study evaluates the effectiveness of base isolation in improving the seismic performance of a six-story steel braced structure. A comparative analysis between fixed-base and base-isolated models is carried out using SAP2000 through modal, response spectrum, and time history analyses. The results indicate that base isolation significantly increases the natural time period and reduces base shear, acceleration, and inter-story drift. Although displacement at the base increases, it is controlled and protects the superstructure from damage. Overall, base isolation proves to be an efficient and reliable technique for enhancing structural safety and earthquake resistance.

This study presents a comparative analysis of the seismic performance of fixed-base and base-isolated reinforced concrete (RC) buildings using SAP2000 software. A seven-storey building model is analyzed under seismic loading conditions as per IS 1893:2002. Two types of base isolation systems, namely rubber bearings and friction pendulum bearings, are implemented and compared. The results indicate that base isolation significantly reduces seismic forces, increases the fundamental time period, and improves overall structural performance. Friction pendulum systems show better re-centering capability, while rubber bearings provide effective flexibility and damping.

Keywords: Base Isolation, Seismic Analysis, Rubber Bearing, Friction Pendulum System, Structural Response, Time Period, Energy Dissipation, Nonlinear Analysis, RC Frame Structure Earthquake Engineering

I. INTRODUCTION

A. Base Isolation

Base isolation is an advanced seismic protection technique that minimizes the impact of earthquake forces on structures by introducing flexible elements between the foundation and the superstructure. These elements, such as elastomeric bearings or sliding systems, decouple the structure from ground motion and significantly reduce the transmission of seismic energy. As a result, key response parameters like base shear, acceleration, and inter-story drift are greatly reduced, leading to improved structural safety and reduced damage. The fundamental concept of base isolation lies in modifying the dynamic characteristics of a structure. By reducing stiffness at the base, the natural time period of the building increases, which shifts its response away from the dominant frequency range of earthquakes. T=2πmkT = 2\pi\sqrt{\frac{m}{k}}T=2πkm

This increase in time period helps avoid resonance and reduces seismic forces acting on the structure. Additionally, isolators provide energy dissipation through mechanisms such as hysteresis in lead cores or friction in sliding systems. The isolation system behaves like a filter that allows slow, controlled motion while preventing the transmission of damaging high-frequency vibrations. Consequently, most deformation is concentrated at the isolation level, while the superstructure remains nearly elastic and experiences minimal damage.

II. LITERATURE REVIEW

Donato Cancellara, et al (2016) have studied the dynamic nonlinear analysis of different base isolation systems for a multi-story RC building irregular in plan. Two base isolation systems were analyzed and their seismic behavior is compared with reference to a multi-story reinforced concrete building. A comparative analysis is presented for evaluating the behavior of a base isolated irregular building subject to seismic events. Two base isolation systems have been considered, the High Damping Rubber Bearing (HDRB) actuated in parallel with a Friction Slider (FS) and the Lead Rubber Bearing (LRB) was actuated in parallel with a Friction Slider (FS). A dynamic nonlinear analysis is performed for the three-dimensional base isolated structure. A comparative study is conducted on behavior of the structure isolated by the two considered base isolation systems and the corresponding behavior of the traditional fixed base structure.

Minal Ashok Somwanshi (2015) et al carried out a study on Seismic Analysis of Fixed Based and Base Isolated Building Structures.

The work deals with modeling and analysis of 13-storey rigid jointed plane frame for two cases. First case is fixed base and second case is base isolated. Modeling and analysis is done using E-TABS software for Bhuj earthquake ground motion records. Maximum vertical reaction is obtained from analysis in E-TABS software. Using this vertical reaction and total mass of structure lead rubber bearings are designed manually. Time-history analysis is carried out in order to evaluate floor response, accelerations and displacements during a ground motion. This paper intends to demonstrate how an isolation system can be efficient, evaluating its effectiveness for the building in terms of maximum shear

.Sonali Anilduke et all (2012), This paper present three dimensional nonlinear time history analysis is performed on r/c building by the use of computer program SAP 2000 v12.0.0. The dynamic analysis of the structure has been carried out and the performance of the building with and without isolator is studied. The main objective here is to make seismic response control by providing Isolators and comparing between the fixed based and isolated base building. Rubber bearing and Friction pendulum bearing are used. Basic concept of base isolation are very well studied .Base Isolators controls structural response in which the building or structure is decoupled from the horizontal component of the earthquake ground motion. A baseisolation system reduces ductility demands on a building, and minimizes its deformations. From the result, By conducting the nonlinear time history analysis it was shown that base isolation increases the flexibility at the base of the structure which helps in energy dissipation due to the horizontal component of the earthquake and hence superstructure's seismic demand drastically reduced as compared to the conventional fixed base structure.

III. OBJECTIVE OF STUDY

The primary objective of this study is to evaluate the effectiveness of base isolation in improving the seismic performance of multi-story steel structures. The study focuses on comparing key response parameters such as base shear, inter-story drift, acceleration, and displacement between fixed-base and base-isolated models. Another important objective is to understand how base isolation alters the dynamic behavior of structures, particularly through the increase in natural time period and reduction of resonance effects. The study also aims to design optimal isolator properties, including stiffness and damping, to achieve the best balance between flexibility and stability. Furthermore, the research seeks to analyze energy dissipation mechanisms and the redistribution of forces within the structure. Practical considerations such as cost, feasibility, and long-term benefits are also evaluated to determine the suitability of base isolation for real-world applications. Overall, the study aims to provide valuable insights for the design of safer and more resilient structures in seismic regions.

IV. MATERIALS USED IN BASE ISOLATION SYSTEMS

A. Elastomeric Materials (Rubber-Based)

(a) Natural Rubber

- Provides flexibility and elasticity.
- Used in laminated rubber bearings.
- Allows horizontal movement while supporting vertical loads.
- Low damping (2–3%).

(b) Neoprene (Synthetic Rubber)

- More durable and weather-resistant than natural rubber.
- Resistant to aging, oil, and temperature variations.
- Used where long-term performance is required.

(c) High Damping Rubber (HDR)

- Modified rubber with fillers (carbon, oils, resins).
- Provides high damping (20–30%).
- Eliminates need for external dampers.

B. Metallic Materials

(a) Steel Plates (Shims)

- Thin steel layers placed between rubber.
- Provide vertical stiffness.
- Prevent bulging of rubber under load.

(b) Lead Core

- Used in Lead Rubber Bearings (LRB).
- Under earthquake load:
  - Deforms plastically
  - Converts energy into heat (hysteretic damping)

(c) Stainless Steel
- Used in sliding devices.
- Provides smooth sliding surface.
- Resistant to corrosion and wear.

(d) Anchor Bolts & Base Plates
- Connect isolator to foundation and structure.
- Ensure load transfer and stability.

C. Sliding Interface Materials
(a) PTFE (Teflon)
- Very low friction material.
- Allows smooth sliding during earthquakes.
- Used in:
  - Friction bearings
  - Friction pendulum systems

(b) Chrome-Coated Steel Surface
- Used in friction pendulum bearings.
- Provides curved sliding path.
- Helps in self-centering.

D. Cable and Restraining Materials
(a) High Strength Steel Cables
- Used in cable friction bearings.
- Control excessive displacement.
- Prevent structural damage during strong earthquakes.

(b) Shear Bolts
- Designed to break under high load.
- Activate sliding mechanism during major earthquakes.

E. Composite Materials
(a) Rubber + Steel Composite
- Combination used in laminated bearings.
- Provides:
  - Flexibility (rubber)
  - Strength (steel)

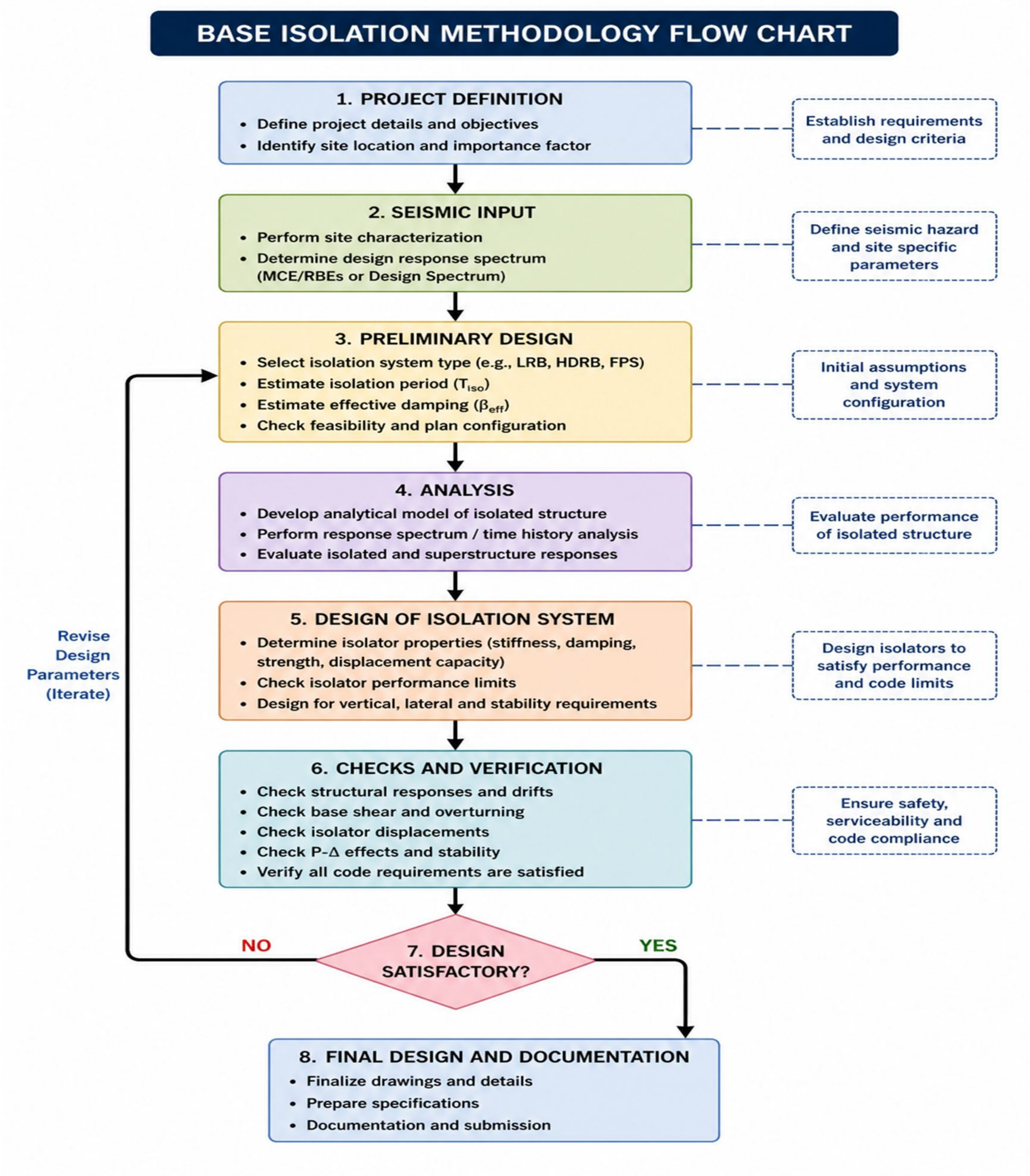
F. Protective Materials
(a) Rubber Covering
- Protects internal components.
- Prevents:
  - Dust entry
  - Corrosion

V. METHODOLOGY

The methodology of this study involves evaluating the seismic performance of a six-story steel braced moment-resisting frame by comparing two analytical models: a fixed-base structure and a base-isolated structure. Both models are developed using SAP2000 software and are subjected to identical loading and seismic conditions to ensure a fair comparison.

The analysis begins with modal analysis to determine the dynamic characteristics of the structure, followed by response spectrum analysis and nonlinear time history analysis using the El Centro 1940 earthquake record. The structural model includes realistic assumptions such as proper mass distribution, diaphragm constraints, and material properties based on standard design codes like IBC and AISC.

After analyzing the fixed-base structure, a base isolation system is introduced by incorporating isolators with appropriate stiffness and damping properties. The same analyses are then repeated for the isolated model. The results from both models are compared to evaluate the effectiveness of base isolation in reducing seismic response and improving structural performance. This approach ensures a comprehensive assessment of both structural behavior and practical feasibility.



VI. TEST AND RESULTS

A. Details Experimental

For comparing a fixed base and isolated base building a Seven-storied building is modeled in the SAP 2000 software . An open frame building model with3 and 4 bays in each X and Y directions, the height of each storey as 3.2 m are modeled. Height .of building is 22.4m, Width of building in X direction is 11m and Width of building in Y direction is 14 m. The material properties of the frame elements and the area element are defined and M25 concrete grade and Fe-415 is used. The rebar material properties are also given. The beams and columns of dimensions b1 300x300,b2 300x350,c1 230x350,c2 230x400,c3 230x450 mm are given as frame elements. The slab in the building is assigned as a shell element with a thickness of 120mm. Live load is taken as 3kn/m2 .Interior and Exterior wall thickness is taken as 150mm and 230mm.Soil type is taken as 1,Zone factor is V, Response reduction factor is taken as 5.And Importance factor is 1.. The support condition at the bottom is made as fixed and the fixed-base analysis is performed considering the combination of 1.5(DL+LL).All other data is referred from I.S.1893-2002. The period for the fixed base is identified. The SAP model of the building is shown in Figure 2.

Then the calculated rubber properties are given as link/ support properties in the software and the base-isolation model analysis is performed. The response of the structure with the rubber isolator and friction pendulum isolators are determined. The parameters selected to define the utilized Isolators in the SAP2000 program are as follows:

ForRubber Bearing:

Nonlinear Link Type: Rubber, U1 Linear Effective Stiffness: 1500000 kN/m, U2 and U3 Linear Effective Stiffness: 800 kN/m, U2 and U3 Nonlinear Stiffness : 2500 kN/m, U2 and U3 Yield Strength : 80 kN, U2 and U3 Post Yield Stiffness Ratio: 0,1.

For Friction Pendulum Bearing:

Nonlinear Link Type: Friction Isolator, U1 Linear Effective Stiffness: 15000000 kN/m, U1 Nonlinear Effective Stiffness: 15000000 kN/m, U2 and U3 Linear Effective Stiffness: 750 kN/m, U2 and U3 Nonlinear Stiffness:15000 kN/m, U2 and U3 Friction Coefficient, Slow: 0,03,U2 and U3Friction coefficient, Fast : 0,05, U2 and U3 Rate Parameter: 40, U2 and U3 Radius of Sliding Surface: 2,23.(Referred from. Torunbalci1 and G. Ozpalanlar2 octo.12-17(2008))

After providing all the details the program is to be run to see the results.

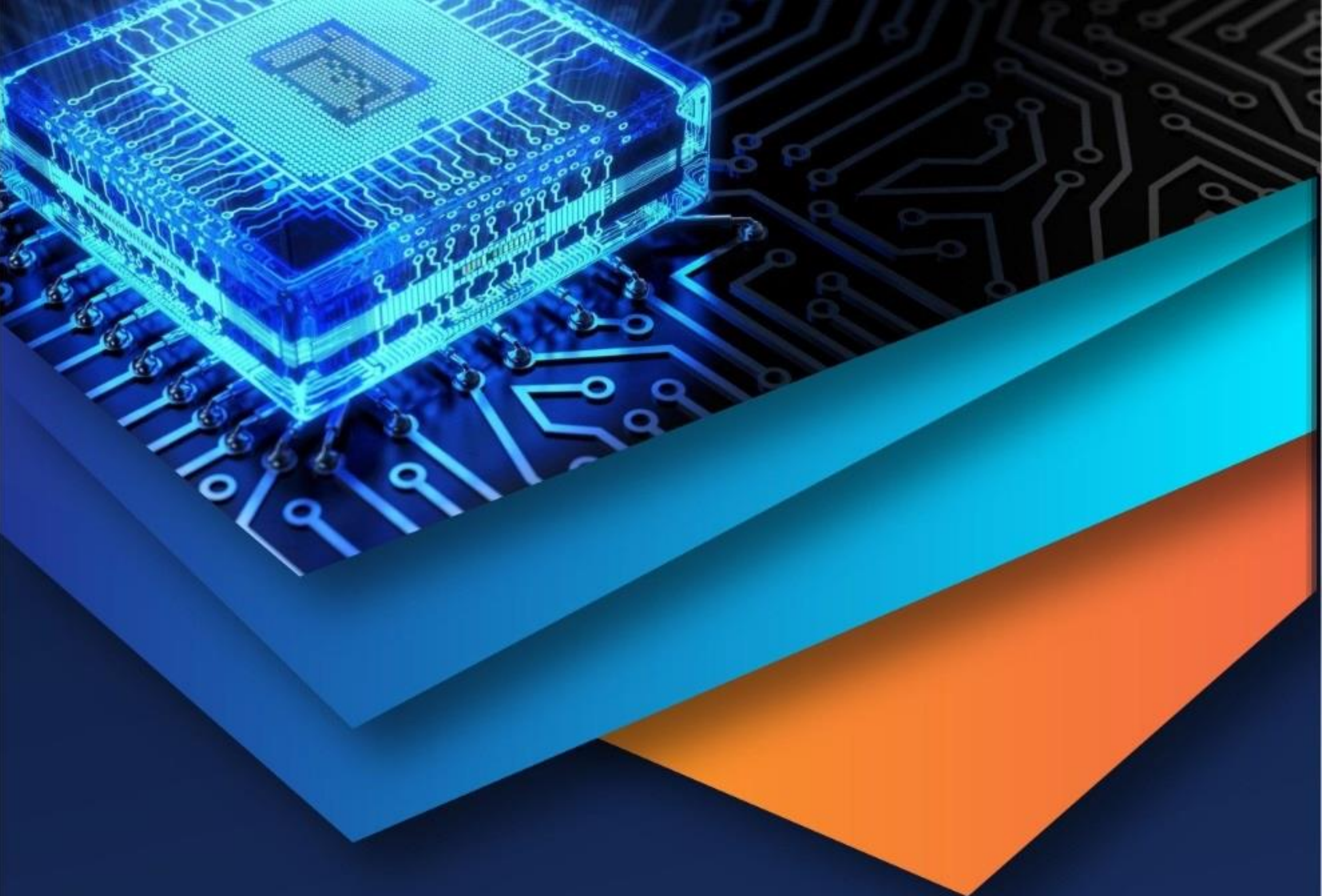
VII. CONCLUSION

The study concludes that base isolation is a highly effective technique for enhancing the seismic performance of structures. By increasing flexibility and energy dissipation capacity, it significantly reduces base shear, acceleration, and structural damage. Although the displacement at the base increases, it is controlled and confined to the isolation layer, thereby protecting the superstructure.

Different types of isolators offer varying benefits, with friction pendulum systems providing excellent reduction in forces and rubber bearings offering better control of acceleration. Overall, base isolation ensures improved safety, reduced damage, and better post-earthquake functionality, making it a reliable solution for earthquake-resistant design.

REFERENCES

[1] G. A. Eiby, "A History of Anti-Seismic Measures in New Zealand", Bull. N.Z. Nat. Soc. Earthq. Engng, Vol. 8, No. 4, pp. 255-259 (December 1975).
[2] G. W. Housner, "Analysis of Structural Response and Instruments", Summary Report, Proc. 3rd Wld. Confr. Earthq. Engng, Vol. II, (1965).
[3] "Earthquake Resistant Regulations of the World", Compiled by the Organising Committee of the 2nd Wld Confr. on Earthq. Engng, (i9 60).
[4] "New Zealand Standard 4203 (1976), Part 3: Earthquake Provisions, 3.4.6, Distribution of Horizontal Seismic Forces.
[5] A. B. M. Saiful Islam*, Mohammed Jameel and Mohd Zamin Jumaat "Seismic isolation in buildings to be a practical reality: Behavior of structure and installation technique." Journal of Engineering and Technology Research Vol. 3(4), pp. 99-117, (April 2011)
[6] Milne J, Etheridge R, Gray T (1886): Experiments on a Building to resist Earthquake motion. Report of the British Association for the Advancement of Science. 55th meeting 1885, 371, London.
[7] Piazzi Smith C (1885). An Earthquake Invention. Nature.32 (818), 213.
[8] Milne J (1885). An Earthquake Invention. Nature.32 (833), 573-574.
[9] Stevenson DA (1885). An Earthquake Invention. Nature.33 (836), 7.
[10] Stevenson DA (1886). An Earthquake Invention. Nature.33 (858), 534.



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