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Integration and Performance Analysis of Hybrid Diagrid and Base Isolation Systems (HDBIS) in High-Rise Structures

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Abstract– This study delves into the realm of structural engineering, focusing on the optimization and enhancement of Hybrid Diagrid-Base Isolation Systems (HDBIS) to bolster their performance in earthquake-prone areas. Traditional construction methods for tall buildings in such regions pose significant risks due to limitations in seismic resilience. The effectiveness of using Smart Base isolation systems in diagrid and outrigger structures is examined. In response, HDBIS emerges as a promising solution, offering robust earthquake protection, design flexibility, and cost-effectiveness. To represent effectiveness of base isolation systems a fixed base model is compared with base isolated models of diagrid and outrigger structures. Through meticulous examination and fine-tuning of HDBIS components, including diagonal supports and base isolators, this research aims to tailor these systems for varying building heights and seismic intensities. Leveraging advanced computer simulations and diverse control systems, the study scrutinizes HDBIS behavior under seismic forces, focusing on movement dynamics, stress distribution, and internal forces. Employing ETABS software, representative building models are meticulously crafted to undergo comprehensive seismic response analysis, exploring critical parameters such as diagrid configurations, isolator types focusing on Rubber based Isolation, displacement, drift, stress distribution, and base shear. The findings of this research are poised to significantly advance the field of structural engineering, providing valuable insights for the selection and enhancement of HDBIS, thereby elevating seismic-resistant structural design practices.

Keywords – Hybrid Diagrid Structure, High-Rise Structures, Base Isolation, Seismic Performance, ETABS, Earthquake-Resistant.

I. INTRODUCTION

Recent earthquakes have served as valuable case studies for engineers and scientists, offering insights into the behavior of various structures under diverse seismic conditions and foundation types. These events have spurred the development of techniques aimed at safeguarding structures from earthquake effects. While conventional seismic design focuses on preventing building collapse during strong shaking, it often overlooks damage to non-structural elements, potentially rendering buildings non-functional post-event, a critical issue for vital structures such as hospitals. Two primary technologies—Base Isolation Devices and Seismic Dampers—have emerged to mitigate earthquake damage. Base isolation, also known as seismic base isolation, entails separating structures from harmful ground motions using isolators inserted between the foundation and the building. This approach provides flexibility and energy dissipation capability, crucial for minimizing structural damage. Additionally, the introduction of diagrid systems has opened avenues for achieving high efficiency and architectural innovation. Continuous form exploration, incorporating aesthetic, aerodynamic, and structural considerations, has led to experimentation with various tall building configurations, including twisted, tilted, and freeform shapes. Earthquakes, as major natural disasters, unleash stored strain energy in rock masses, resulting in significant loss of life and property damage, thereby impacting a nation's economy. Consequently, effective preventative measures are imperative to mitigate earthquake losses. Earthquake disasters pose formidable challenges due to their unpredictable nature and substantial destructive potential. Recent seismic events underscore the urgent need to assess the seismic safety of code-compliant buildings across different performance limit states. Research efforts have intensified to develop fragility relationships, essential for seismic loss assessment and mitigation strategies. Incremental dynamic analysis (IDA) has emerged as a widely adopted method for studying the performance of high-rise structures, offering accurate estimates through fragility analysis. Moreover, the adoption of performance-based or reliability-based seismic design approaches has gained traction in structural engineering. This method facilitates designing structures to specific performance objectives, particularly beneficial for innovative structural systems lacking adequate test data or in-field performance history.

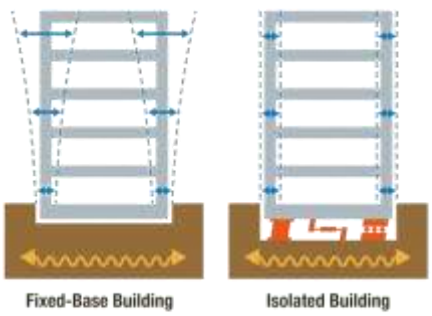

Figure 01: Behavior of Fixed base & isolated base buildings.

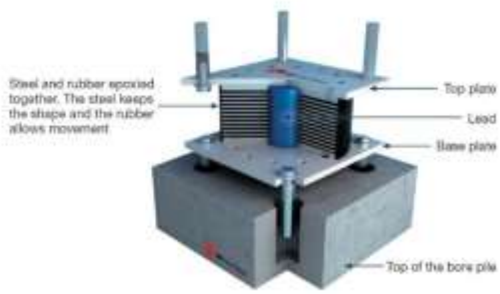

Figure 02: Base isolator and its composition

II. RESEARCH GAP

Hybrid diagrid-base isolation systems (HDBIS) designed for one building height may not be suitable for different heights. Buildings of different heights show different behavior when subjected to lateral forces such as seismic load and wind. Therefore, the one-size-fits-all approach does not apply to all types of buildings of different heights. Tailoring techniques based on specific construction characteristics are essential for effective structural solutions. The current research landscape lacks a thorough investigation into the combined seismic performance of Hybrid Diagrid-Base Isolation Systems in high-rise buildings. While Diagrid structures and Base Isolation Systems have been studied separately, there's a noticeable gap in understanding how these technologies work together. Key areas of neglect include exploring the impact of building height, addressing practical implementation challenges, and conducting comprehensive comparisons with traditional systems. Filling this research void is essential to gain a complete understanding of the potential, challenges, and practicality of implementing this hybrid solution in earthquake-prone areas.

III. AIM AND OBJECTIVES

- Investigate and quantify the seismic performance of Hybrid Diagrid-Base Isolation Systems (HDBIS) in high-rise structures.
- Utilize a comprehensive approach, integrating analysis and experimentation, to examine four critical aspects: diagrid configurations, stress distribution, Storey Drift, Srorey Stiffness and base shear.
- Focus exclusively on Rubber based Isolation applied to diagrid structures to provide detailed insights into their performance across varying building heights (15, 30, and 50 storey).
- Contribute to the optimization of seismic resilience in high-rise buildings by informing practical design considerations based on understanding of diagrid Structures and base isolation performance.

IV. MATERIAL AND METHOD

Modeling Procedure in ETABS

The modeling procedure of fixed base and base isolated building in ETAB and design steps of isolators and linear static analysis using UBC 97 for isolated building has been carried out and seismic design procedure has been done using IS 1893:2002 (Part 1), for that the following data is used.

Building details and plan

Grade of Concrete – M30, Steel Grade – Fe500
Floor to Floor height is 3m, Plinth height above GL is 0.9
Depth of Foundation is 0.6m below GL, Parapet height is 1m, Slab thickness is 180mm,
External wall thickness = 230mm, Internal wall thickness = 195mm,
Size of Columns = 250*750mm, Size of Beams = 250*450mm, Size of Diagrid = 400*400mm
Live load on floor = 3 KN/m², Live load on Roof = 1.5 KN/m²
Site located in Seismic zone 4, i.e. Z= 0.24
Building is resting on medium soil, Take importance factor as 1.
Building frame type – SMRF, Density of Concrete = 25 KN/m³
Density of Masonry wall = 20 KN/m³
Using the above plan in (G+15, G+30, G+50) RCC frame, the RCC G+15, G+30, G+50 frame has been analyzed & Designed for a fixed base & isolated base with Rubber based Bearing for Earthquake forces by ETABS software.

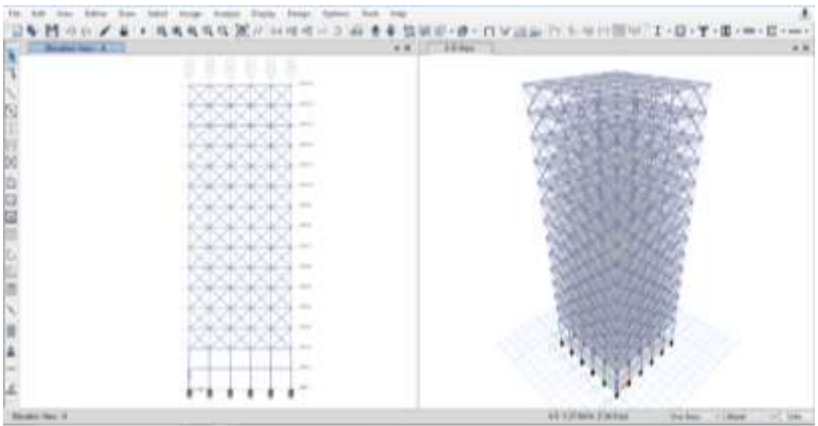

Figure 3. Elevation & 3-D model of diagrid structure having Base-Isolation

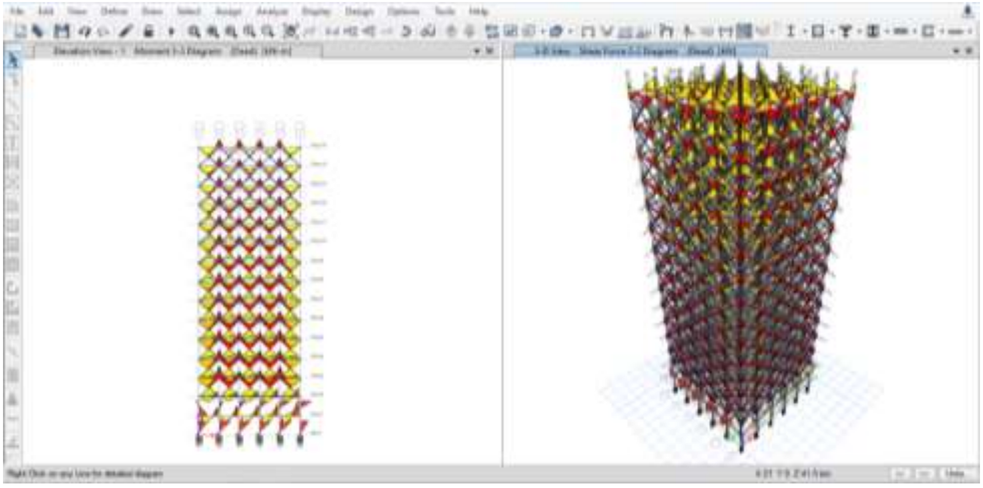

Figure 4. Shear Force 2-2 Diagram

Detailed Procedure

- Open ETABS and create a new project.
- In the 3D view, create the geometry of your structure by adding nodes and members. You can use the "Create" menu or the "Quick Create" toolbar to create nodes and members.
- Assign properties to the members, such as section properties, material properties, and cross-section shape. You can do this by selecting the member and using the "Properties" menu or the "Properties" toolbar.
- Assign joints, restraints and provide fixed and rubber based isolation.
- Define the loading conditions for your structure. This includes applying loads, such as gravity loads, wind loads, or earthquake loads, as well as defining the load cases and load combinations.
- Run the analysis to calculate the internal forces and displacements in the structure.
- Check the results to ensure that the structure meets the design criteria and make any necessary adjustments.

V. RESULTS

Comparasion of Story Drift

Table 1 represents the story drift

Table 01. Showing values of Story Drift

Story	Drift	Drift
	Rubber Based Isolation	Fixed Based Isolation
Story1	0.00062	0.000426
Story2	0.000218	0.000556
Story3	0.000148	0.000225
Story4	0.000162	0.000287
Story5	0.000139	0.000344
Story6	0.000159	0.000391
Story7	0.000239	0.00043
Story8	0.000256	0.00046
Story9	0.000269	0.000482
Story10	0.000278	0.000497
Story11	0.000283	0.000504
Story12	0.000285	0.000505
Story13	0.000283	0.0005
Story14	0.000279	0.00035
Story15	0.000273	0.000477

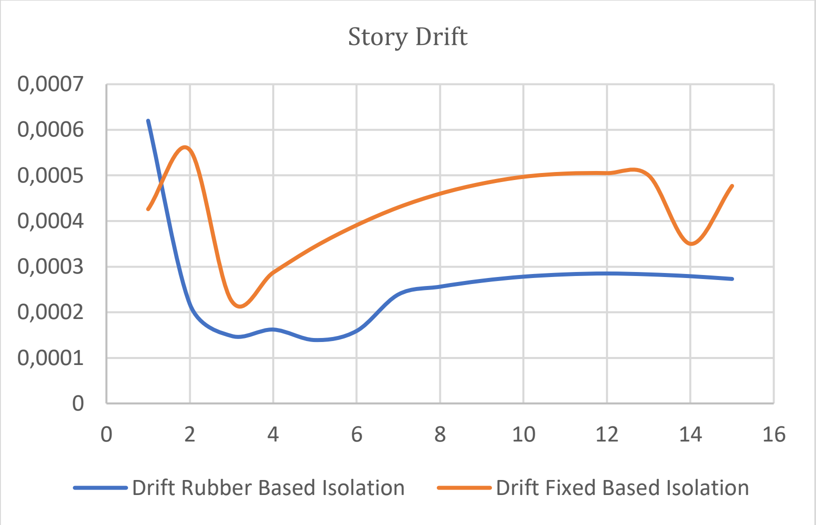

Figure 05. Showing values of Story Drift

Comparasion of Story Stiffness

Table 2 represents the story Stiffness

Table 02. Showing values of Story Stiffness

Story	Stiffness (kN/m)	Stiffness (kN/m)
	Rubber Based Isolation	Fixed Based Isolation
Story1	563167.606	1987809.85
Story2	1243416.761	1521223.942
Story3	1243416.761	3754359.891
Story4	2772274.069	2911319.139
Story5	2265980.743	2400674.806
Story6	1932281.797	2065323.679
Story7	1692747.011	1821430.963
Story8	1502579.549	1626756.898
Story9	1340554.524	1458462.783
Story10	1191292.422	1300903.564
Story11	1042568.668	1142188.92
Story12	884235.844	971695.82
Story13	706437.172	778692.244
Story14	498996.33	551727.269
Story15	250625.932	277846.544

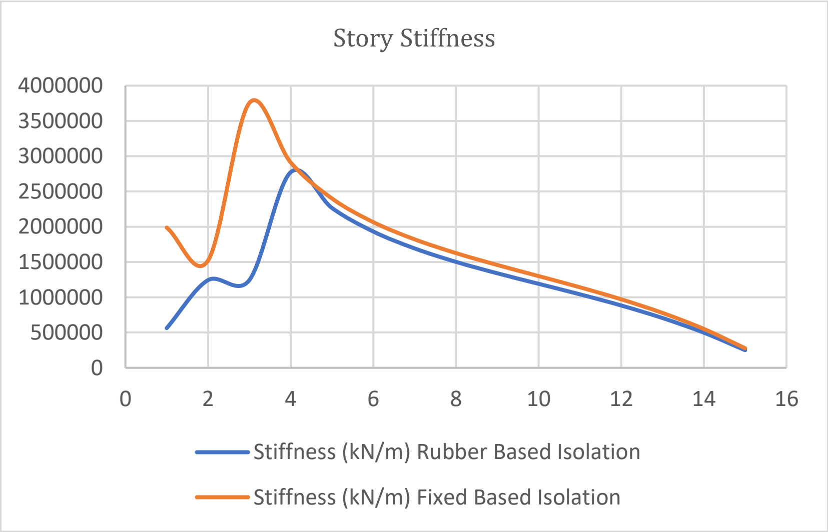

Figure 06. Showing values of Story Stiffness

VI. CONCLUSION

- Base isolation represents a monumental breakthrough in structural engineering, achieved through collaborative efforts of engineers worldwide.
- Through meticulous examination of building collapse phenomena, engineers have developed a powerful strategy to mitigate seismic risks.
- Utilization of materials such as rubber, steel, and advanced damping systems enables base isolation to effectively transform formidable earthquakes into manageable threats.
- Structures equipped with base isolation have demonstrated remarkable resilience, enduring even the most severe seismic events like the Northridge earthquake.
- As earthquakes continue to pose a persistent threat, the significance of base isolation as a 20th-century innovation remains unparalleled.
- The potential of base isolation to safeguard lives and preserve infrastructure underscores its status as a historic and life-saving advancement in structural design.

REFERENCES

1. J.J. Connor. An introduction to structural motion control. IT University Press, 2001
2. Vasant A. Matsagar and R. S. Jangid-Analysis response of structures retrofitted using base isolation devices are investigated and the retro fit schemes are illustrated
3. BrunoBriseghellaet.al- The base isolation system(BIS) has been suggested as an innovative retrofit strategy and adopted for the seismic upgrading of some major buildings 9
4. S.J. Patil, G.R. Reddy, 'State Of Art Review-Base Isolation Systems For Structures', International Journal of Emerging Technology and Advanced Engineering, Volume 2, Issue 7, ISSN 2250-2459, July 2012.
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), 99-117, April 2011. [3] Y. Ribakvo and I. Iskhakov, 'Experimental Methods for Selecting Base Isolation Parameters for Public Buildings', The open construction and building technology Journal, 2,1-6,2008.
6. Tustomu Hanai, Shinji Nakata, Shin-ichi Kiriyama, and Nobuo Fukuwa, 'Coparison of seismic performance of base-isolated house with various decvices', 13th World Conference on Earthquake Engineering, Vancouver, B.C., Canada, August 1-6, 2004, Paper No. 1203.
7. Farzad Naeim and James M. Kelly, Design of seismic isolated structures from theory to practice, JOHN WILEY & SONS, INC., Canada 1999.
8. Seismic Base Isolation Technique for Building Earthquake Resistance on WWW.URLhttp://articles.architectjaved.com/earthquake_resistance_structure/sei smic-base-isolation-technique-for-building-earthquake-resistance/
9. R. Ivon Skinner, Trevor E. Kelly and Bill (W.H.) Robinson, Seismic Isolation for Designers and structural Engineers, Holmes Consulting group, New York, 1993.
10. Pankaj Agrawal and Manish Shrikhande, Earthquake and vibration effect on Structure: Basic element of Earthquake Resistant Design, 'Earthquake resistant design of structures, PHI Learning private limited, New Delhi, 200- 201, 2012.
11. Peng Hsiang Charng, 'Base Isolation for Multistory Building Structures', Ph.D Thesis, Dept.of Civil Engineering, University of Cantebury, Newzealand Dec 1998.