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A Comparative Evaluation of Base Isolation Effectiveness in Mitigating Seismic Response for Low-Rise and Mid-Rise Buildings

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Abstract. Low-rise and mid-rise structures often possess natural periods that coincide with high-energy seismic response plateaus, rendering them susceptible to significant response amplification. This study evaluates the comparative effectiveness of High Damping Rubber Bearings (HDRB) in mitigating these risks for 4-story and 8-story office buildings under Indonesian seismic conditions. Using rigorous Non-Linear Time History Analysis (NLTHA) in the dominant X-direction, the research examines period elongation, lateral displacement, inter-story drift, peak floor acceleration, and base shear attenuation. Scientific findings reveal that HDRB transitions structural behavior into a near-rigid-body motion, reducing normalized inter-story drift to 0.26 and 0.12, and base shear by up to 71%. Furthermore, peak floor acceleration is curtailed by 51% to 59%, ensuring the protection of sensitive non-structural components. The results demonstrate that while base isolation provides superior seismic protection for both building scales, its efficacy in intercepting seismic energy and preventing operational disruptions is significantly more pronounced in mid-rise structures. This study confirms that HDRB is an increasingly vital strategy for enhancing functional resilience as building height increase.

Keywords: base isolation, high damping rubber bearing, nonlinear time history analysis, seismic performance, mid-rise buildings

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1. **Introduction**

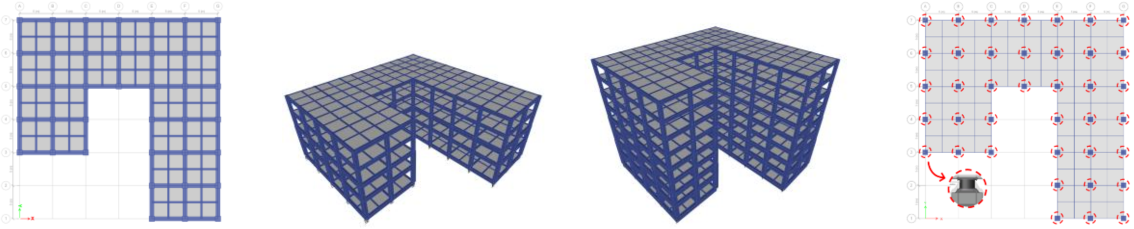
Indonesia is recognized as one of the most seismically volatile regions globally, situated at the convergence of several major active tectonic plates. This geodynamic setting results in a high frequency of high-magnitude seismic events [1]. Consequently, structural design in Indonesia strictly adheres to standards such as SNI 1726:2019, which predominantly employs a fixed-base philosophy relying on structural ductility for inelastic energy dissipation. While this approach is engineered for life safety, recent evaluations suggest that compliance with code-based elastic force demands does not inherently guarantee optimal seismic performance, particularly regarding inter-story drift control and the mitigation of non-structural damage [2]. Furthermore, Nonlinear Time History Analysis (NLTHA) studies have demonstrated that fixed-base reinforced concrete structures remain susceptible to significant deformations and excessive force demands during severe seismic excitations [3,4]. Low-rise and mid-rise structures often possess natural periods coinciding with high-energy seismic response plateaus, making them susceptible to response amplification [5,6].

While High Damping Rubber Bearings (HDRB) can mitigate this risk through period elongation and enhanced damping [7–10], this research provides a unique contribution by evaluating customized HDRB dimensions using the Bridgestone rubber compound for 4-story and 8-story buildings. It focuses on the often-overlooked low-to-mid-rise sector, where base isolation is less common but essential for effective seismic risk mitigation and structural resilience. Furthermore, the comparative analysis provides empirical evidence on how the effectiveness of base isolation scales with building height in low-to-mid-rise structures, offering a more nuanced perspective on the performance limits of high-damping systems.

2. Methods

This study employs a quantitative approach utilizing numerical simulations to compare and evaluate the seismic performance effectiveness of HDRB in 4-story low-rise and 8-story mid-rise buildings. The investigation culminates in a rigorous Non-linear Time History Analysis to comprehensively assess the dynamic structural behavior under specified seismic excitations.

2.1. *Structural Design and Specifications*



(a) (b) (c) (d)

Figure 1. Numerical modelling of existing buildings: (a) plan view of the building; (b) 4-story building; (c) 8-story building; (d) base isolation location plan

Table 1. Structural element dimensions

Frame Type	Story	Column Dimension (mm)	Main Beam Dimension (mm)	Secondary Beam Dimension (mm)	Slab Thickness (mm)
4-Story	1-2	600 x 600	400 x 600	250 x 400	120
	3-4	500 x 500	300 x 500	250 x 400	120
8-Story	1-2	800 x 800	600 x 800	250 x 400	120
	3-4	700 x 700	500 x 700	250 x 400	120
	5-6	600 x 600	400 x 600	250 x 400	120
	7-8	500 x 500	300 x 500	250 x 400	120

The research focuses on a comparative analysis of 4-story (low-rise) and 8-story (mid-rise) reinforced concrete buildings with their configurations shown in Figure 1(a) to (c). Regarding material specifications, the concrete is defined by a compressive strength (f'_c) of 30 MPa. The reinforcement steel utilizes yield strengths (f_y) of 420 MPa and 280 MPa for longitudinal and transverse reinforcement, respectively. For the office building functional assumption, structural loading protocols, encompassing both gravitational and lateral loads, are calculated in accordance with SNI 1727:2020 for minimum design loads [11]. Furthermore, seismic resistance criteria are established following the SNI 1726:2019 standard [12]. Detailed dimensions for each structural component are provided in Table 1 with structural element sizing established in accordance with SNI 2847:2019 requirements for Special Reinforced Concrete Moment Frames (SRCMF) [13].

2.2. Ground Motion Selection for Time History Analysis

The structural models are assumed in Denpasar, Bali, a region characterized by high seismic activity. The site is classified as Site Class D (Stiff Soil), with mapped spectral acceleration parameters at short periods (S_S) and the 1-second period (S_1) established at 0.97 g and 0.39 g, respectively. Eleven sets of ground motion records were selected from the Pacific Earthquake Engineering Research Center (PEER) [14] and the Natural Hazards Risk and Resiliency Research Center (NHR3) [15] databases.

Table 2. Selected earthquake ground motion

Label	Earthquake Event	Station	Year	Magnitude (M_w)	Distance (km)
E1	Taiwan	SMART1 C00	1985	5.8	41.7
E2	Sierra Madre	Tarzana - Cedar Hill A	1991	5.61	48.2
E3	Umbria, Italy	Citta Di Castello-Regnano	1984	5.6	41.1
E4	Molise, Italy	San Marco dei Cavoti	2002	5.7	45.5
E5	Landers	Pomona - 4th & Locust FF	1992	7.28	117.5
E6	Tabas, Iran	Ferdows	1978	7.35	91.1
E7	Kern County	LA - Hollywood Stor FF	1952	7.36	117.7
E8	El Mayor, Mexico	Mecca - CVWD Yard	2010	7.2	102.8
E9	South Peru	MOQ1	2001	8.41	89.6
E10	Tokachi	BIRATORI-E	2003	8.29	97.4
E11	Coastal, Chile	GO04	2015	8.31	87.3

The structural dynamic behavior in this study is evaluated using Nonlinear Time History Analysis (NLTHA) to capture a more realistic response to varying seismic characteristics. As shown in Table 2, eleven ground motion records were selected and scaled to ensure that the mean response spectrum matched or exceeded the target design spectrum. Utilizing the frequency-domain spectral matching method, the scale factors were calculated by determining the ratio between the target spectrum and the individual ground motion spectra at each frequency while maintaining a fixed phase [16]. In accordance with established studies, employing a suite of 7 to 11 records is recommended to achieve stable and representative response parameter estimates through mean value analysis. This ensures more reliable results by minimizing statistical uncertainties [17].

2.3. Design of Base Isolation System: High Damping Rubber Bearing (HDRB)

To accommodate different structural demands, the 4-story and 8-story buildings are equipped with HDRB D500 and HDRB D650, respectively. These isolators are modelled using Nonlinear Rubber Isolator link properties, where the nonlinear hysteretic behaviour is defined by the Wen's Model of plasticity [18]. This approach accounts for the effective stiffness (K_{eff}), yield strength (Q_d), and post-yield stiffness ratio (r) [10], enabling the simulation of equivalent damping ratios at high shear strain levels [19]. The selection of HDR material, referenced from Bridgestone catalogues, is intended to provide high inherent damping without the need for supplemental dissipation devices, thereby simplifying the isolation system configuration [20].

Unlike conventional standard sizes, the isolator dimensions were customized to provide flexibility in optimizing the structural natural period and axial load-carrying capacity specific to each story building. This customization approach aims to achieve an equilibrium between material efficiency and the maximum reduction of peak floor accelerations. In the structural model, the isolators are assumed to be positioned at the base of every column, as illustrated in Figure 1(d). The High Damping Rubber Bearings

(HDRB) for both the 4-story and 8-story buildings utilize X0.6R rubber compound material. The final design parameters and mechanical properties of the HDRB units are summarized in Table 3.

Table 3. Design characteristics and mechanical properties of HDRB

Specification	**Notation**	**4-Story**	**8-Story**
Elastomer diameter	(D_B)	500 mm	650 mm
Total rubber thickness	(T_r)	140 mm	210 mm
Equivalent shear modulus	(G_{eq})	0.62 MPa	0.62 MPa
Equivalent damping ratio	(H_{eq})	24%	24%
Maximum shear strain	(γ_{maks})	2.2	1.7

2.4. *Analysis Procedure and Evaluation Criteria*

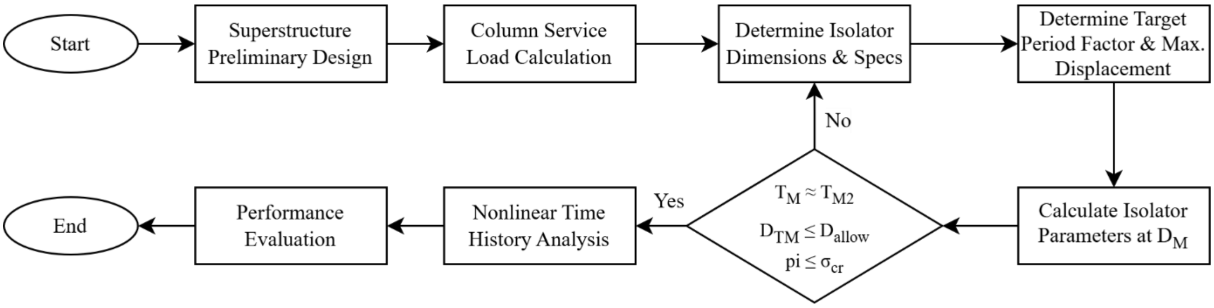


Figure 2. Research workflow

The systematic research framework is illustrated in Figure 3. The initial phase involves the preliminary design of the superstructure and the calculation of column service axial loads, which serve as the basis for determining isolator dimensions and target seismic parameters. Once the isolator properties at the design displacement (D_M) are established, a rigorous verification procedure is implemented.

The design verification encompasses three primary criteria: the consistency of the effective period ($T_M \approx T_{M2}$), compliance with the allowable displacement limit ($D_{TM} \leq D_{allow}$), and stability assessment against critical compressive stress ($p_i \leq \sigma_{cr}$). Failure to satisfy any of these criteria triggers a design iteration process until an optimal isolator configuration is achieved. Following the validation of the design, the final phase focuses on Nonlinear Time History Analysis (NLTHA) to comprehensively evaluate the system's effectiveness in seismic response reduction.

3. **Results and Discussion**

The numerical simulations provide a comprehensive overview of the divergent dynamic behaviors between the conventional fixed-base and base-isolated systems. While the analysis evaluates structural responses in both the X and Y directions, this study focuses on the X-direction for comparative assessment, as the modal analysis indicates a dominant first mode in this direction.

3.1. *Fundamental Period Elongation*

The implementation of a base isolation system is proven to significantly elongate the natural period of the structure. As illustrated in Figure 4, the first-mode fundamental period of the 4-story building increased from 0.645 s in the fixed-base (FB) configuration to 2.223 s in the isolated-base (IB) model. Similarly, the 8-story building showed an increase from 0.916 s (FB) to 2.963 s (IB). This reflects the period elongation effect resulting from the additional lateral flexibility of the isolators at the structural base. This shift enables the isolated structure to move away from the high-acceleration plateau of the response spectrum, thereby reducing dynamic responses to seismic loads and enhancing the overall seismic performance of the system [21,22].

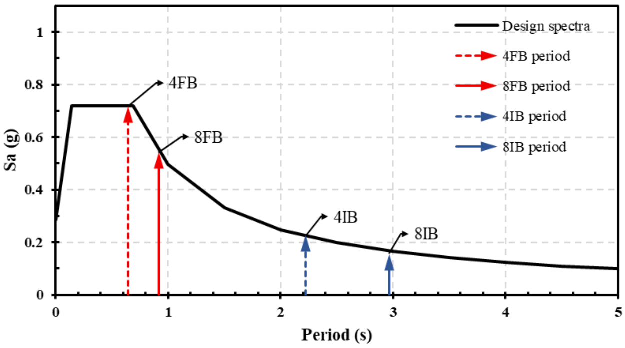


Figure 3. Comparison of natural vibration periods against the design response spectrum

Table 4. Comparison of fixed base and isolated base structure performance in x-direction

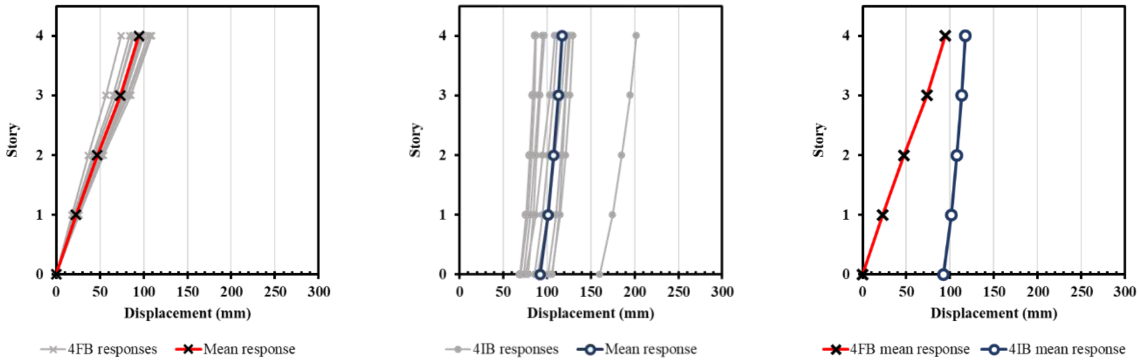
Type	4-Story				8-Story			
	LD (mm)	ISD (%)	FA (mm/s^2)	BS (kN)	LD (mm)	ISD (%)	FA (mm/s^2)	BS (kN)
Fixed	94.59	0.88%	9489	12937	203.76	1.07%	10975	23555
Isolated	25.11	0.23%	4651	4334	29.25	0.13%	4446	6840
Ratio	0.27	0.26	0.49	0.34	0.14	0.12	0.41	0.29

Note: LD: Lateral Displacement; ISD: Inter-story Drift; FA: Floor Acceleration; BS: Base Shear.

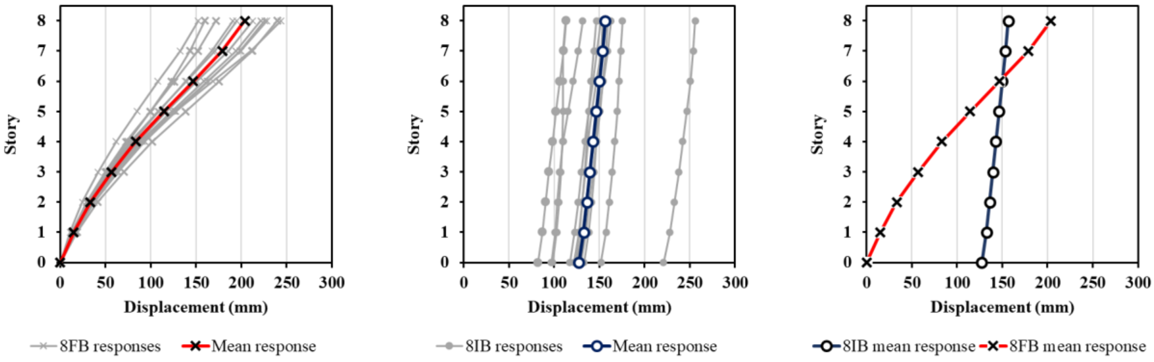
Furthermore, base isolation significantly concentrates cumulative mass participation within the primary fundamental modes. This indicates that the structural dynamic response is significantly dominated by the first and second modes, while the contribution of higher vibration modes becomes negligible. This characteristic signifies a more focused and stable system response in the primary horizontal directions, which is a hallmark of effective isolated building dynamics in reducing seismic demands compared to conventional structures [23,24].

3.2. Structural Lateral Displacement

As shown in Figure 5, the fixed-base (FB) structure exhibits a steep diagonal displacement profile, indicating significant flexural deformation across all stories. In contrast, the isolated-base (IB) structure concentrates deformation at the isolation level. The nearly vertical displacement profile of the IB model demonstrates a rigid body motion behavior [25], which is technically advantageous in significantly minimizing inter-story drift.



(a)



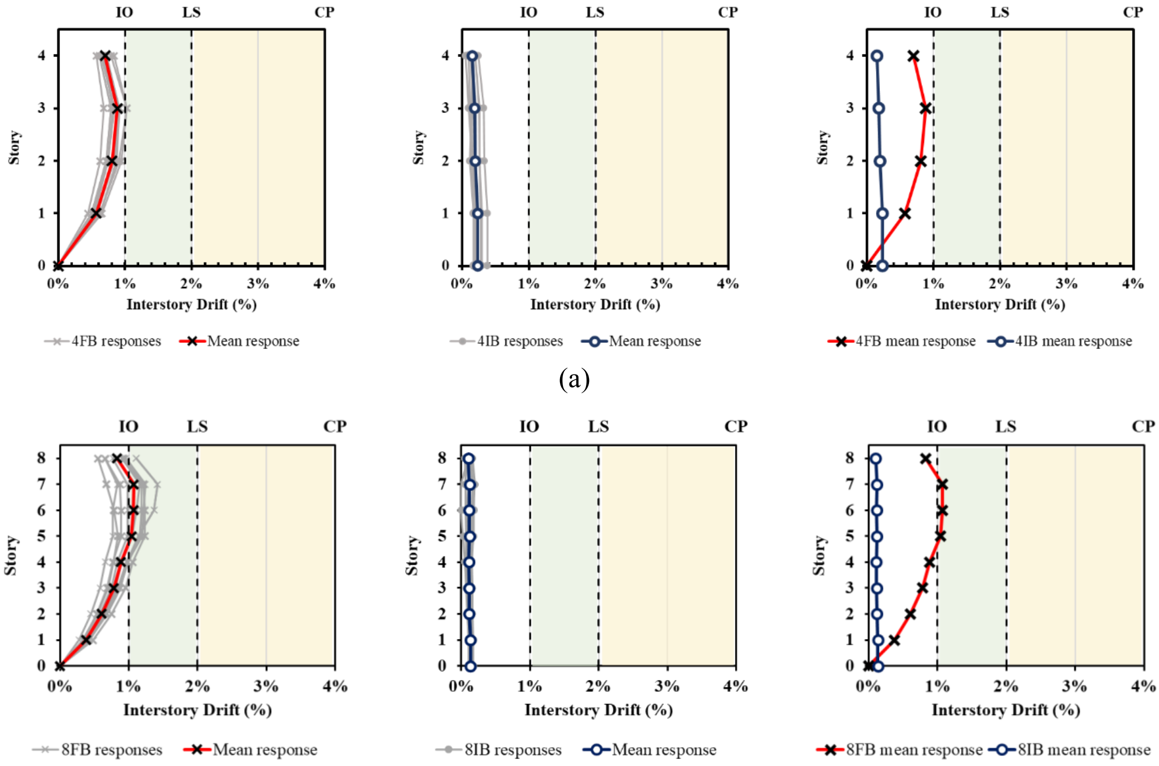
(b)

Figure 4. Comparison of mean lateral displacement profiles in x-direction: (a) 4-story responses; (b) 8-story responses

The analytical data from Table 4 reveals that the 4-story fixed-base (FB) configuration generates a maximum deformation of 94.59 mm, which is curtailed to 25.11 mm in the isolated-base (IB) structure, reflecting a response ratio of 0.27, or approximately a 73% reduction. Even greater performance is observed in the 8-story model, where the isolation system suppresses lateral deformation from 203.76 mm to just 29.25 mm, achieving a response ratio of 0.14. This indicates that the isolation effectiveness improves as the building height increases, resulting in an 86% reduction for the taller structure.

3.3. Inter-story Drift Reduction

The seismic performance of the structure is evaluated by examining the maximum inter-story drift during the earthquake response, which serves as a primary indicator of the building's damage level. According to the FEMA 356 guidelines [26], the seismic performance levels for reinforced concrete frame systems are defined based on maximum inter-story drift limits: 1% for Immediate Occupancy (IO), 2% for Life Safety (LS), and 4% for Collapse Prevention (CP), as illustrated in Figure 5.



(a)

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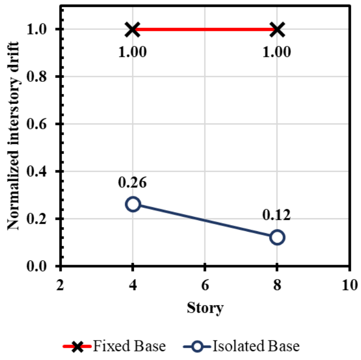


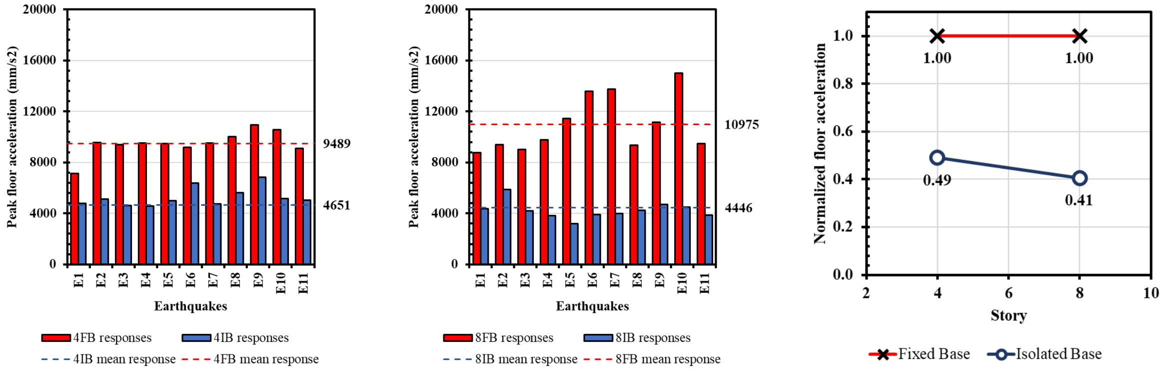
(c)

Figure 5. Inter-story drift profiles in x-direction: (a) 4-story responses; (b) 8-story responses; (c) comparison of mean peak responses between fixed-base and isolated-base configurations

The integration of HDRB significantly enhances seismic resilience by decoupling the superstructure from ground motions, ensuring structural integrity through balanced elastic stiffness and efficient energy dissipation [27]. As illustrated in Figure 5(c) and Table 4, the maximum inter-story drift for the 4-story structure is significantly curtailed from 0.88% to 0.23%. This performance demonstrates that the isolated response ratio is merely 0.26, representing a 74% reduction. A more substantial improvement is observed in the 8-story model, where the drift decreases from 1.07% to 0.13%, yielding a response ratio of only 0.12 or an 88% reduction of the seismic demand. This drastic reduction, particularly pronounced as building height increases, minimizes the risk of architectural damage and post-earthquake functional loss [28], ensuring that both models remain well within the Immediate Occupancy (IO) performance threshold as defined by FEMA 356 [26].

3.4. Peak Floor Acceleration (PFA) Reduction

Peak floor acceleration is a critical determinant of structural resilience, directly influencing occupant comfort and the seismic protection of internal assets [29,30]. In this research, minimizing PFA is prioritized to safeguard sensitive electronic equipment and ensure the stability of unanchored non-structural components.



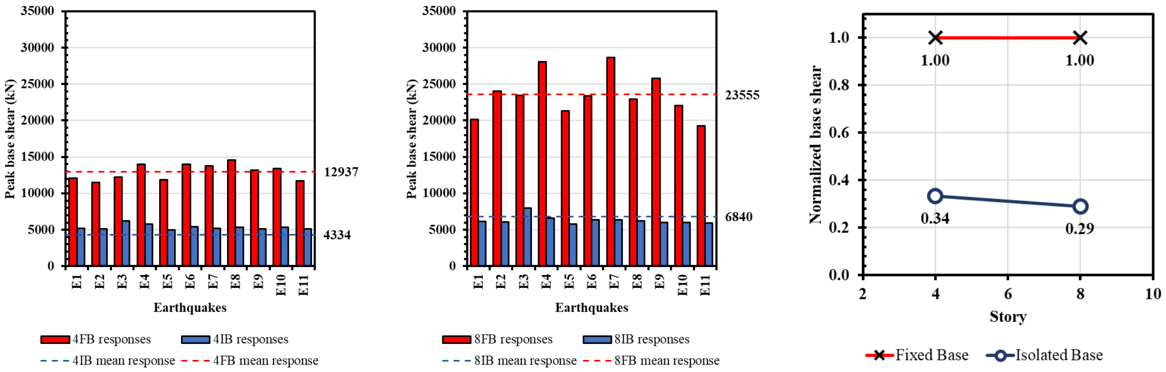
(a) (b) (c)

Figure 6. Peak floor acceleration profiles in x-direction: (a) 4-story responses; (b) 8-story responses; (c) comparison of mean responses between fixed-base and isolated-base configurations

The analytical results in Figure 6 and Table 4 demonstrate that the HDRB system significantly attenuates peak accelerations by acting as a low-pass filter that blocks high-frequency ground motion components. Specifically, the mean peak floor acceleration for the 4-story fixed-base structure of 9489 mm/s^2 is curtailed to 4651 mm/s^2, yielding a response ratio of only 0.49. A more pronounced reduction is observed in the 8-story model, where the acceleration decreases from 10975 mm/s² to 4446 mm/s², resulting in a superior response ratio of 0.41. The greater reduction observed in the 8-story model suggests that the synergistic effect between the base isolation's flexibility and the building's inherent natural period further enhances the seismic demand attenuation. These findings are consistent with previous benchmarking studies [9], which reported acceleration reductions ranging from 28% to 45% depending on seismic intensity levels. The slightly higher attenuation observed in this study further validates the effectiveness of the customized HDRB properties in filtering floor accelerations.

3.5. *Base Shear Reduction*

Base shear is a fundamental parameter in evaluating structural seismic performance, as it directly represents the resultant inertial forces transferred from ground motion to the superstructure during an earthquake. In conventional structures, the magnitude of this shear force is heavily influenced by the structural stiffness and the ground acceleration induced at relatively short natural periods.



(a) (b) (c)

Figure 7. Base shear profiles in x-direction: (a) 4-story responses; (b) 8-story responses; (c) comparison of mean responses between fixed-base and isolated-base configurations

The analytical results in Figure 7 and Table 4 highlight a significant reduction in base shear forces, a direct consequence of the isolation system's ability to modify the structural impedance. Mean base shear data indicates that the 4-story structure experiences a reduction from 12937 kN to 4334 kN, decreasing the response ratio to 0.34. Similarly, the 8-story model shows a more substantial decline from 23555 kN to 6840 kN, resulting in a response ratio of only 0.29. The observed attenuation in base shear aligns with the trends reported in previous studies, which noted reductions of 33% to 44% under various seismic intensities [9]. However, the higher efficiency achieved in this study highlights the effectiveness of the customized HDRB configuration in further decoupling the superstructure from seismic demands compared to standardized isolation applications.

This attenuation is driven by the synergistic effect of period elongation and enhanced hysteretic damping. By shifting the fundamental period into the lower-energy region of the design spectrum, the HDRB system effectively limits the pseudo-acceleration demand on the superstructure. Furthermore, the nonlinear hysteretic behavior [31] of the rubber compound facilitates significant energy dissipation at the isolation interface, effectively acting as a 'fuse' that prevents the transmission of damaging inertial forces.

4. **Conclusion**

This study confirms that High Damping Rubber Bearings (HDRB) effectively transition structural behavior from a shear-dominant deformation to a near-rigid-body motion, successfully addressing the inherent vulnerability of structures whose natural periods coincide with high-energy seismic plateaus. The findings demonstrate that while base isolation provides a substantial safety margin for both scales, its efficacy in intercepting seismic energy and mitigating response amplification is significantly more pronounced in mid-rise buildings compared to low-rise configurations. By shifting the structural demand to the isolation interface, the system not only ensures structural integrity but also maintains the operational continuity of acceleration-sensitive environments, proving to be an increasingly vital strategy as building height increase.

Declaration of AI and AI assisted technologies in the writing process

During the preparation of this work, the author(s) used ChatGPT and Gemini in order to support editorial tasks, refine wording, and format sections for clarity. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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References

[1] H. Rakuasa and Y. Pakniany, “Assessing the Probability of Megathrust Earthquakes in Indonesia: A Review of Seismic Hazard Assessment and Mitigation Strategies,” *Scientia Naturalis Journal of Loomingulisus ja Innovatsioon*, vol. 1, no. 3, pp. 98–116, 2024, doi: https://doi.org/10.70177/innovatsioon.v1i3.1275.

[2] Dwi Yanto, Tavio, and A. H. Jusuf, “Engineering Assessment of Earthquake Resistant Building Code Based on Seismic Load Responses,” *Advance Sustainable Science Engineering and Technology*, vol. 8, no. 1, p. 0260102, Dec. 2025, doi: https://doi.org/10.26877/asset.v8i1.2400.

[3] S. Liu, Z. Chen, and Y. Liu, “Seismic Isolation Layout Optimized of Mid-Rise Reinforced Concrete Building Frame Structure,” *Buildings*, vol. 14, no. 7, Jul. 2024, doi: https://doi.org/10.3390/buildings14072172.

[4] A. Naiel, N. Hanna, and I. Lotfy, “Assessing seismic performance of mid-rise reinforced concrete buildings using fragility curves,” *Innovative Infrastructure Solutions*, vol. 10, no. 1, Jan. 2025, doi: https://doi.org/10.1007/s41062-024-01750-9.

[5] G. D. Hatzigeorgiou and G. Kanapitsas, “Evaluation of fundamental period of low-rise and mid-rise reinforced concrete buildings,” *Earthq. Eng. Struct. Dyn.*, vol. 42, no. 11, pp. 1599–1616, 2013, doi: https://doi.org/10.1002/eqe.2289.

[6] I. Nurhuda, P. Sabdono, M. R. Afrizal, L. A. P. Pratama, and S. A. Faishal, “Empirical Formula for the Fundamental Period of Reinforced Concrete Moment Resisting Frames in Indonesia,” *Jurnal Teknik Sipil*, vol. 32, no. 1, pp. 1–8, Apr. 2025, doi: https://doi.org/10.5614/jts.2025.32.1.1.

[7] R. Adiastuti, D. Wibowo, and M. Kartikasari, “Performance evaluation of seismic base isolation systems in multi-storey structures located in high seismic zones,” *International Journal of Structural Design and Engineering*, vol. 6, no. 2, pp. 24–9, 2025, doi: https://doi.org/10.22271/27078280.

[8] M. Misdi and A. Hamzah, “Time History Analysis pada Struktur Bangunan yang Menggunakan Base Isolator,” *Jurnal Al Ulum LPPM Universitas Al Washliyah Medan*, vol. 13, no. 1, pp. 82–88, Jan. 2025, doi: https://doi.org/10.47662/alulum.v13i1.874.

[9] M. F. Firmansyah, A. B. Habieb, and F. Faimun, “A Study on the Effects of Implementing Base Isolation System for Existing RC Buildings on Soft Soil,” *Journal of Civil Engineering*, vol. 40, no. 1, pp. 12–9, Feb. 2025, doi: http://dx.doi.org/10.12962%2Fj20861206.v40i1.19925.

[10] N. Khofifah and A. B. Habieb, “Seismic Performance Enhancement of a Reinforced Concrete Building Using an RB-HDRC Base Isolation System,” *G-Tech: Jurnal Teknologi Terapan*, vol. 10, no. 2, pp. 753–763, Apr. 2026, doi: https://doi.org/10.70609/g-tech.v10i2.9398.

[11] Badan Standarisasi Nasional, “SNI 1727:2020 Beban desain minimum dan kriteria terkait untuk bangunan gedung dan struktur lain,” 2020.

[12] Badan Standarisasi Nasional, “SNI 1726:2019 Tata cara perencanaan ketahanan gempa untuk struktur bangunan gedung dan nongedung,” 2019.

[13] Badan Standarisasi Nasional, “SNI 2847:2019 Persyaratan beton struktural untuk bangunan gedung dan penjelasan,” 2019.

[14] PEER, “Pacific Earthquake Engineering Research Center,” https://peer.berkeley.edu/

[15] NHR3, “Natural Hazards Risk and Resiliency Research Center (NHR3),” https://www.risksciences.ucla.edu/nhr3.

[16] I. P. Ellsa Sarassantika and H. L. Hsu, “Upgrading framed structure seismic performance using steel Lever-Armed dampers in the Braces,” *Eng. Struct.*, vol. 280, Apr. 2023, doi: https://doi.org/10.1016/j.engstruct.2023.115683.

[17] D. Caicedo, S. Karimzadeh, V. Bernardo, and P. B. Lourenço, “Selection and Scaling Approaches of Earthquake Time-Series for Structural Engineering Applications: A State-of-the-Art Review,” Apr. 01, 2024, *Springer Science and Business Media B.V.* doi: https://doi.org/10.1007/s11831-023-10025-y.

[18] S. J. Lee and J. H. Kim, “Effect of Nonlinear Hysteresis Details of Isolation System on In-Structure Response Spectra,” *Applied Sciences (Switzerland)*, vol. 15, no. 1, Jan. 2025, doi: https://doi.org/10.3390/app15010062.

[19] B. Chen, J. Dai, T. Song, and Q. Guan, “Research and Development of High-Performance High-Damping Rubber Materials for High-Damping Rubber Isolation Bearings: A Review,” Jun. 01, 2022, *MDPI*. doi: https://doi.org/10.3390/polym14122427.

[20] M. Leblouba, “Selection of seismic isolation system parameters for the near-optimal design of structures,” *Sci. Rep.*, vol. 12, no. 1, Dec. 2022, doi: https://doi.org/10.1038/s41598-022-19114-7.

[21] D. S. Du, S. G. Wang, W. Q. Liu, S. Shi, C. P. Lee, and J. Xu, “Modal property of base-isolated high-rise structure considering soil–structure interaction effect,” *Advances in Mechanical Engineering*, vol. 10, no. 12, Dec. 2018, doi: https://doi.org/10.1177/1687814018803808.

[22] G. Zhao, L. Zhang, D. Liu, and K. Shen, “Seismic Response Analysis of Double-Layer Isolation Structures in High-Rise Buildings,” *Buildings*, vol. 15, no. 8, Apr. 2025, doi: https://doi.org/10.3390/buildings15081292.

[23] F. Naeim and J. M. Kelly, *Design of Seismic Isolated Structures: From Theory to Practice*. John Wiley & Sons, 1999.

[24] A. G. Wahab, Z. Tao, H. Li, A. Y. Rasa, T. Huma, and Y. Liang, “Dynamic Simulation and Seismic Analysis of Hillside RC Buildings Isolated by High-Damping Rubber Bearings,” *Infrastructures (Basel).*, vol. 10, no. 9, Sep. 2025, doi: https://doi.org/10.3390/infrastructures10090239.

[25] P. Usta, “Investigation of a base-isolator system’s effects on the seismic behavior of a historical structure,” *Buildings*, vol. 11, no. 5, May 2021, doi: 10.3390/buildings11050217.

[26] FEMA 356, “Prestandard and Commentary for the Seismic Rehabilitation of Buildings,” Washington, D.C., Nov. 2000.

[27] I. P. E. Sarassantika and H. L. Hsu, “Improving brace member seismic performance with amplified-deformation lever-armed dampers,” *J. Constr. Steel Res.*, vol. 192, May 2022, doi: https://doi.org/10.1016/j.jcsr.2022.107221.

[28] A. Zarkasi, H. Hariyadi, N. Hidayati, A. Fitrayudha, and M. Heru, “The Influence of Base Isolator on The Reinforced Concrete Structures at Sapadia Mataram Hotel Earthquake-Induced,” *Reka Buana : Jurnal Ilmiah Teknik Sipil dan Teknik Kimia*, vol. 9, no. 1, pp. 95–108, Apr. 2024, doi: https://doi.org/10.33366/rekabuana.v9i1.5562.

[29] H. D. Setio, D. Kusumastuti, S. Setio, P. H. R. Siregar, and A. Hartanto, “Pengembangan Sistem Isolasi Seismik pada Struktur Bangunan yang Dikenai Beban Gempa sebagai Solusi untuk Membatasi Respon Struktur,” *Jurnal Teknik Sipil*, vol. 19, no. 1, p. 1, Apr. 2012, doi: https://doi.org/10.5614/jts.2012.19.1.1.

[30] V. Vukobratović and S. Ruggieri, “Floor acceleration demands in a twelve-storey RC shear wall building,” *Buildings*, vol. 11, no. 2, pp. 1–20, Feb. 2021, doi: https://doi.org/10.3390/buildings11020038.

[31] W. A. Ghafar, T. Zhong, Z. Lai, Z. Pingle, Y. Yang, and M. M. Hasan, “Seismic isolation for existing structures: a review of retrofitting techniques, case studies, and trends,” *Discover Civil Engineering*, vol. 2, no. 1, Jul. 2025, doi: https://doi.org/10.1007/s44290-025-00300-1