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Effect Of Shear Wall Position Variations On The Seismic Response Of Reinforced Concrete Buildings: A Case Study Of Ristia Resort

[*]Putu Didik Sulistiana[1], I Gede Premananda Putra[2], Cokorda Agung Yujana[3], Anak Agung Sagung Dewi Rahadiani[4]
[1,2,3,4]Faculty of Engineering and Planning, Warmadewa University, Denpasar, Bali 80239
[*)]Corresponding autor: didik.sulistiana@warmadewa.ac.id

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Abstract

The arrangement of shear walls plays a fundamental role in controlling the seismic behavior of reinforced concrete buildings by affecting lateral stiffness and structural deformation during earthquake loading. This study investigates the seismic performance of the Ristia Resort reinforced concrete building subjected to three alternative shear wall layouts. Three numerical structural models with identical geometry, material properties, loading conditions, and seismic design parameters were developed, with the shear wall locations defined as the only variable. Seismic performance was evaluated through response spectrum analysis based on SNI 1726:2019. The evaluation considered inter-story drift, story stiffness, and the proportion of design base shear carried by the shear wall system. Among the investigated configurations, Model 1 achieved the best structural performance by reducing the third-floor inter-story drift by 10.69% and 11.19% relative to Models 2 and 3, respectively. It also increased the average X-direction story stiffness by 6.38% and 6.48%, while the shear wall system resisted 66.74% and 71.08% of the design base shear in the X- and Y-directions, respectively. These results demonstrate that a symmetrical shear wall arrangement provides a more efficient lateral load-resisting system and improves the overall seismic performance of reinforced concrete buildings.

Keywords: *Shear Wall; Seismic Response; Reinforced Concrete; Inter-Story Drift; Story Stiffness*

INTRODUCTION

Indonesia is situated within one of the world's most active seismic regions because of the interaction between the Indo-Australian, Eurasian, and Pacific tectonic plates. Consequently, reinforced concrete (RC) buildings must be designed to sustain earthquake-induced forces while maintaining structural integrity and ensuring the safety of occupants. Among the available lateral force-resisting systems, reinforced concrete shear walls are widely recognized as one of the most efficient structural components for enhancing seismic performance, as they increase lateral stiffness, minimize inter-story drift, and reduce excessive structural deformation during earthquake events [1], [2], [3].

Previous studies have demonstrated that the seismic performance of RC buildings is governed not only by the existence of shear walls but also by their placement and configuration within the structural layout. Shear walls arranged symmetrically and positioned close to the structural core generally provide superior lateral stiffness, lower inter-story drift, and improved resistance to torsional effects compared with asymmetric layouts [1], [4], [5]. Furthermore, variations in shear wall configuration have been reported to considerably influence structural behavior, including lateral displacement, base shear capacity, vibration characteristics, and internal force distribution [6], [8]. When shear walls are positioned asymmetrically or located away from the center of stiffness, the eccentricity between the center of mass and the center of rigidity increases, leading to greater torsional responses and reduced seismic efficiency [4], [5], [9].

Recent investigations have expanded the evaluation of shear wall systems by examining the influence of wall quantity, wall-to-floor area ratio, and wall opening configuration on the seismic performance of high-rise reinforced concrete buildings. Although increasing the wall area generally enhances lateral stiffness and decreases structural displacement, excessive wall ratios often provide only limited additional structural benefit while reducing economic efficiency [6], [10]. Likewise, previous researchers have shown that strategically positioned shear walls can substantially decrease story drift and improve structural stability. However, their effectiveness is highly dependent on the relationship between the wall location and the building's center of mass as well as its center of stiffness [11], [12]. These observations confirm that optimizing shear wall placement remains an important aspect of earthquake-resistant structural design.

Although numerous investigations have examined various shear wall configurations, most have focused on comparisons between core walls, corner walls, or symmetrical and asymmetrical arrangements in regular building plans [1], [6], [11]. Comparatively fewer studies have investigated elongated reinforced concrete buildings composed of interconnected structural blocks, where the distribution of mass and stiffness is inherently non-uniform and may alter the effectiveness of different shear wall layouts. In addition, previous studies have predominantly emphasized parameters such as story drift and base shear, whereas the relationship between shear wall position and story stiffness in this type of structural configuration has received relatively limited attention [13], [14]. Therefore, further research is necessary to determine the most effective shear wall arrangement for improving the seismic behavior of elongated reinforced concrete buildings.

To clarify the influence of shear wall arrangement on structural behavior under seismic loading, the reinforced concrete structure of the Ristia Resort building was analyzed using three alternative shear wall configurations. Numerical simulations were performed in ETABS by applying the response spectrum procedure to each structural model. The evaluation focused on key seismic performance indicators, including inter-story drift, story stiffness, and the proportion of design base shear resisted by the shear wall system. The findings of this study are expected to support the selection of effective shear wall layouts for improving the earthquake resistance of reinforced concrete buildings, particularly those with elongated floor plans and interconnected structural systems.

METHOD

A. Research Design

This research employed a numerical simulation approach within a quantitative framework to investigate the effect of shear wall location on the seismic behavior of a reinforced concrete building. Three structural models representing different shear wall configurations were analyzed under identical structural geometry, material properties, loading conditions, and seismic design parameters. Consequently, all variables were maintained constant except for the shear wall location, allowing its influence on the structural response to be evaluated independently.

The research procedure involved several sequential stages, including the collection of structural data, development of numerical models in ETABS V21, application of gravity and seismic loading, response spectrum analysis, verification of structural performance in accordance with the Indonesian seismic design provisions, and comparison of the structural responses obtained from the three analytical models. The research design flow is illustrated in Figure 1.

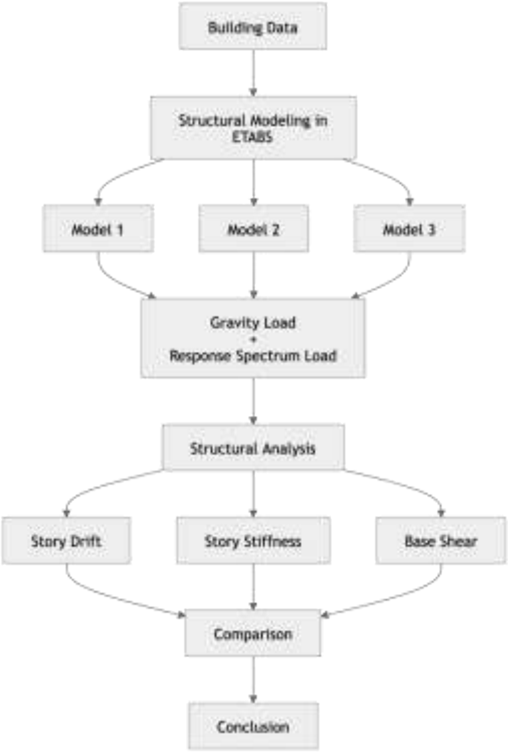


Figure 1. Research Design Flow

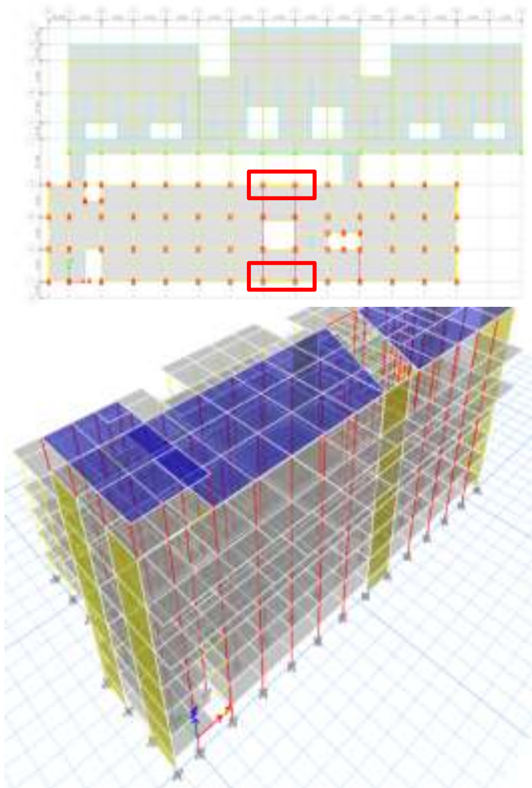
The Ristia Resort building in Blahbatuh District, Gianyar Regency, Bali, Indonesia, was selected as the case study for this research. The building is approximately 26 m in height and employs a dual lateral force-resisting system consisting of a Special Moment Resisting Frame (SMRF) together with reinforced concrete shear walls. Numerical modelling and seismic analyses were carried out in compliance with the Indonesian structural design standards [15], [16], [17].

Identical material and site conditions were adopted for all analytical models. Concrete was defined with a compressive strength (f'_c) of 25 MPa, whereas the reinforcing steel had a yield strength (f_y) of 420 MPa. The structural analysis assumed a medium soil site classification based on SNI 1726:2019 [17]. The geometry of the columns, beams, slabs, and shear walls was generated directly from the structural design drawings of the Ristia Resort building.

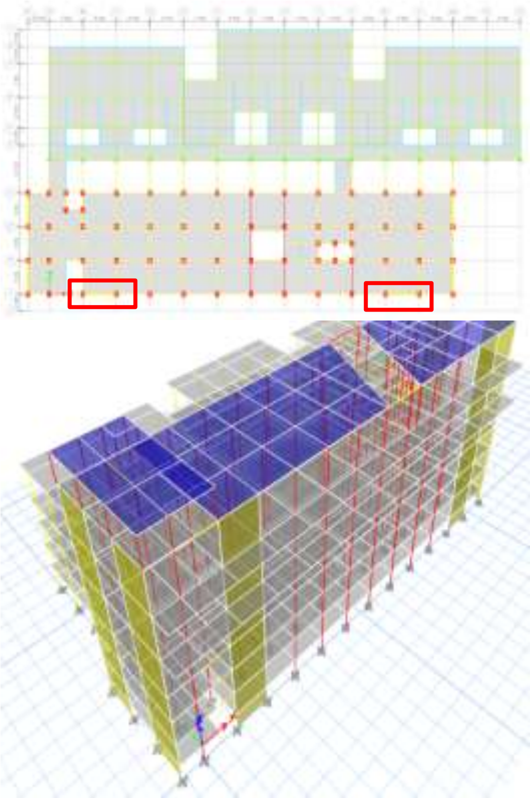
B. Shear Wall Configurations

Three analytical models with different shear wall layouts were developed by varying only the shear wall location, while all other structural properties and analysis parameters remained unchanged. The configurations of the models are shown in Figure 2.

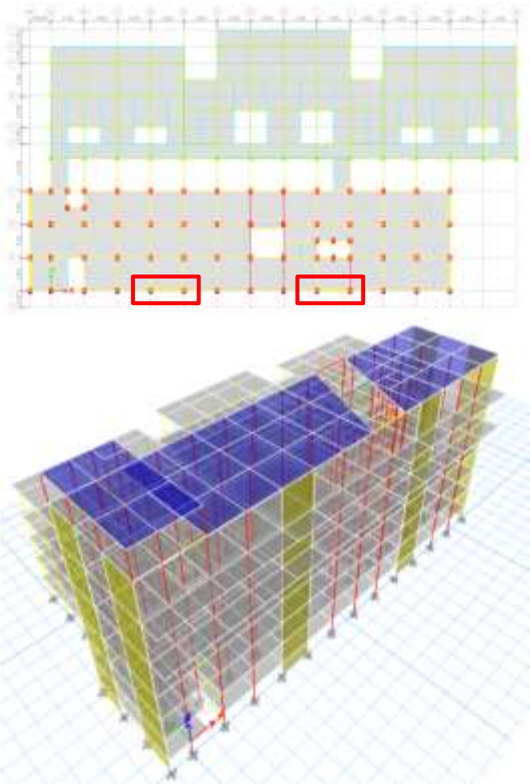
- Model 1: The shear walls were arranged around the central core of the building, resulting in a relatively symmetrical distribution of lateral stiffness.
- Model 2: The shear walls were shifted toward one side of the building while maintaining the same wall dimensions and structural properties as those adopted in Model 1.
- Model 3: The shear walls were placed at an alternative location to examine how a different lateral stiffness distribution influences the overall seismic response of the structure.



a. Floor Plan and 3D Model 1



b. Floor Plan and 3D Model 2



c. Floor Plan and 3D Model 3

Figure 2. Shear wall configurations for all model

C. Dimensions of Structural Members

To ensure that the effect of shear wall placement could be evaluated objectively, all analytical models employed identical dimensions for the primary structural members. The dimensions of the columns, beams, slabs, and shear walls used in this study are summarized in Table 1.

Table 1. Dimensions of the structural members

Structural Component	Member ID	Dimension (mm)
Columns	K1	400 × 600
	K2	250 × 400
	K3	350 × 350
	K4	200 × 200
Beams	B1	500 × 600
	B2	250 × 400
	B3	200 × 300
Slabs	P1	100 (thickness)
	P2	120 (thickness)
	P3	150 (thickness)
Shear Wall	SW	200 (thickness)

D. Loading and Load Combinations

1. Dead Loads

a. Dead load on the roof slab

Mortar layer 2cm = 42 kg/m^2
Ceramic floor = 24 kg/m^2
M.E.P Instalation = 40 kg/m^2
Planfond = 11 kg/m^2
= 124 kg/m^2

b. Additional dead load on floor slabs

Mortar layer 2cm = 42 kg/m^2
Ceramic floor = 24 kg/m^2
M.E.P Instalation = 40 kg/m^2
Planfond = 11 kg/m^2
= 124 kg/m^2

c. Additional dead load applied to the staircase

Mortar layer 2cm = 42 kg/m^2
Ceramic floor = 24 kg/m^2
= 66 kg/m^2

d. The additional dead load acting on the beams was calculated based on the weight of brick masonry walls with finishing. The wall load was determined as 1.278 kg/m.

E. Live Loads

The live loads were assigned according to the functional use of each structural component in accordance with SNI 1727:2020 [16]. A roof live load of 1.33 kN/m² was adopted based on Table 4.1 of SNI 1727:2020 [16]. The balcony live load was specified as 4.92 kN/m², while the live load for the occupied rooms was taken as 1.92 kN/m², both in accordance with Table 4.3-1 of SNI 1727:2020 [16]. In addition, a staircase live load of 1.33 kN/m² was assigned based on Clause 4.5.4 of the same standard.

F. Seismic Load

The seismic analysis was carried out using the response spectrum method in accordance with the requirements of SNI 1726:2019 [17]. The site-specific design response spectrum was obtained from the Indonesian Design Response Spectrum Program [18]. The generated response spectrum together with its spectral acceleration curve for the Blahbatuh site is presented in Figures 3 and 4, respectively.

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Program Respons Spektra Peta Gempa Indonesia 2021
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  Nama Kota             :
  Bujur   / Longitude : 115.2963636 Degrees
  Lintang / Latitude  : -8.5364147 Degrees

  Kelas Situs           : SD - Tanah Sedang

   PGA  = 0.435103 g
   PGAm = 0.506850 g
   CRs  = 0.000000
   CR1  = 0.000000
   Ss   = 0.976352 g
   S1   = 0.394229 g
   TL   = 12.000000 detik
   Fa   = 1.109459
   Fv   = 1.905771
   Sms  = 1.083223 g
   Sm1  = 0.751310 g
   Sds  = 0.722149 g
   Sd1  = 0.500873 g
   T0   = 0.138718 detik
   Ts   = 0.693588 detik
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Figure 3. Output program response spectrum

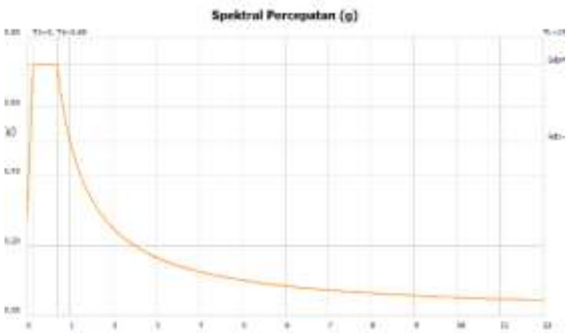

Figure 4. Spectral acceleration curve

G. Load Combinations

Strength design load combinations were assigned in accordance with SNI 1726:2019 [17]. The combinations considered in the numerical analysis are listed in Table 2.

Table 2. Strength Design Load Combinations

Load Case	Load Combination
LC1	U = 1.4D
LC2	U = 1.2D + 1.6L
LC3	U = 1.2D ± 1.0E + 0.5L
LC4	U = 0.9D ± 1.0E

RESULTS AND DISCUSSION

A. Inter-Story Drift

Inter-story drift is widely used as a key indicator for assessing the seismic performance of building structures because it represents the lateral deformation experienced by each story and reflects the potential impact on both structural stability and non-structural components. The inter-story drift responses of the three analytical models in the X-direction are presented in Figure 5.

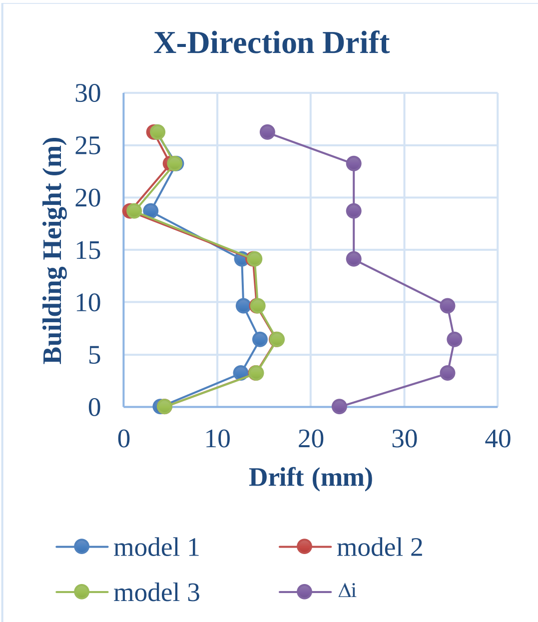

Figure 5. Inter-story drift responses X-direction

Based on the analysis results, Model 1 produced the lowest drift response from the first to the fourth floor compared with Models 2 and 3. The largest difference occurred at the third floor, where the drift of Model 1 was 14.58 mm, while Models 2 and 3 produced drift values of 16.325 mm and 16.4175 mm, respectively. This indicates that Model 1 reduced the drift by approximately 10.69% compared with Model 2 and 11.19% compared with Model 3. The lower drift response in Model 1 indicates that placing shear walls on both sides of the building provides a more balanced stiffness distribution in the lower stories.

However, at the fifth floor, Model 1 showed a higher drift value than the other two models. The drift values at this level were 2.88 mm for Model 1, 0.693 mm for Model 2, and 1.16 mm for Model 3. This condition suggests that the interaction between the structural block located at grid 0–2 and the adjacent building block at grid 3–7 influences the drift distribution along the building height. Therefore, although Model 1 performs better in the lower stories, the stiffness transition between connected building blocks should also be considered in evaluating the overall seismic response.

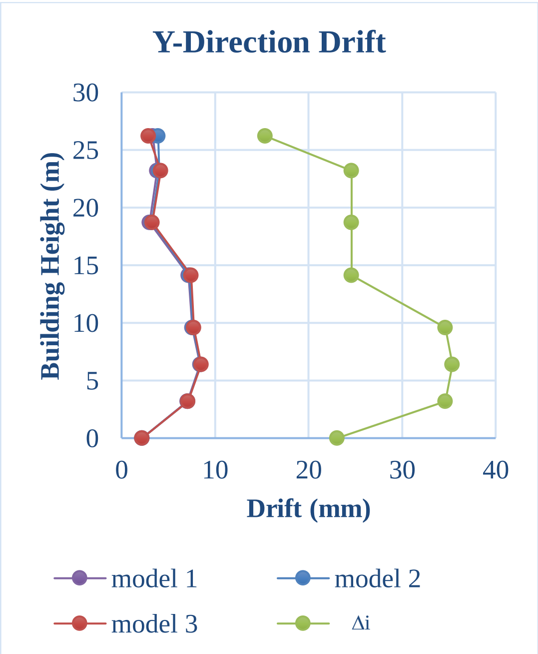

Figure 6. Inter-story drift responses Y-direction

In the Y-direction, the drift responses of the three models showed relatively small differences, as shown in Figure 6. At the eighth floor, the drift values were 3.322 mm for Model 1, 3.9215 mm for Model 2, and 2.904 mm for Model 3. These results indicate that the variation of shear wall position had a less significant influence on the Y-direction response. This is reasonable because the main variation of shear wall placement was more dominant in the X-direction. All drift values in both principal directions remained within the allowable drift limit specified by SNI 1726:2019 [17].

B. Base Shear Distribution

The distribution of base shear was examined to evaluate the contribution of the shear wall system in resisting earthquake-induced lateral loads. According to SNI 1726:2019 [17], for a dual structural system, the shear walls are permitted to resist a maximum of 75% of the design base shear, whereas the moment-resisting frame is required to carry at least the remaining 25%.

The results presented in Table 3 indicate that all three analytical models complied with the dual structural system requirements. In the X-direction, the proportion of design base shear resisted by the shear walls reached 66.74% for Model 1, 65.02% for Model 2, and 65.00% for Model 3. Compared with the other configurations, Model 1 exhibited an increase of 1.72 and 1.74 percentage points relative to Models 2 and 3, respectively. Expressed as a relative improvement, the shear wall contribution in Model 1 was approximately 2.65% greater than Model 2 and 2.68% greater than Model 3.

Table 3. Base shear results

Model	Percentage of Base Shear Resisted by Shear Walls (%)		Control Base Shear < 75%
	Arah X	Arah Y	
1	66.74	71.08	**OK**
2	65.02	70.57	**OK**
3	65.00	70.67	**OK**

In the Y-direction, the shear wall contribution was 71.08% for Model 1, 70.57% for Model 2, and 70.67% for Model 3. Although the differences were relatively small, Model 1 still produced the highest percentage of base shear resisted by the shear walls. These findings indicate that the shear wall configuration in Model 1 provides a slightly more effective lateral load-resisting mechanism while still satisfying the maximum allowable shear wall contribution for a dual structural system.

C. Story Stiffness

Story stiffness was analyzed to examine the effect of shear wall placement on the lateral stiffness characteristics of the structure. As shown in Figure 7, Model 1 exhibited the highest average story stiffness in the X-direction among the three analytical models. Compared with Models 2 and 3, the average stiffness of Model 1 increased by approximately 6.38% and 6.48%, respectively. These results suggest that the shear wall arrangement adopted in Model 1 provides a more efficient lateral stiffness distribution in the direction where the wall location was varied.

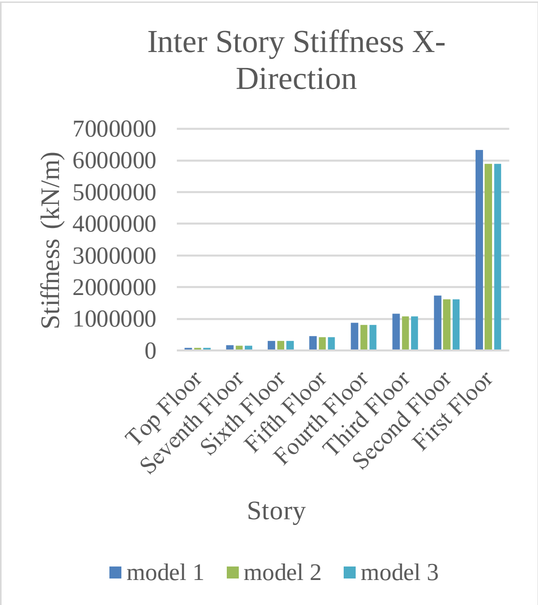

Figure 7. Inter Story stiffness X-direction

The higher stiffness achieved by Model 1 can be attributed to the placement of shear walls on both sides of the building, resulting in a more effective lateral load-resisting system and lower deformation demand in the lower stories. In contrast, Models 2 and 3, in which the shear walls were concentrated on one side of the structure, produced a less uniform stiffness distribution, leading to greater lateral drift in the X-direction.

In the Y-direction, the stiffness values of the three analytical models were nearly identical, as illustrated in Figure 8. At the first floor, the stiffness values were 11,150,441.989 kN/m, 11,144,557.275 kN/m, and 11,146,857.708 kN/m for Models 1, 2, and 3, respectively. At the fourth floor, the corresponding values were 1,385,371.353 kN/m, 1,384,287.369 kN/m, and 1,384,923.791 kN/m, whereas the eighth-floor stiffness values were 64,044.970 kN/m, 64,347.511 kN/m, and 64,120.150 kN/m, respectively.

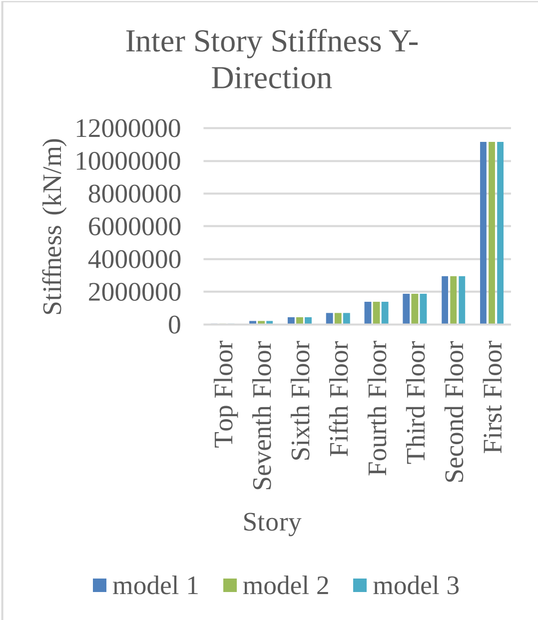

Figure 8. Inter Story stiffness Y-direction

The similarity of the stiffness values in the Y-direction indicates that variations in shear wall placement had only a limited influence on lateral stiffness in this direction. This observation is consistent with the inter-story drift results, which also showed only minor differences among the three models. Therefore, the effect of shear wall configuration in this study was considerably more pronounced in the X-direction than in the Y-direction.

CONCLUSION

The numerical results indicate that shear wall arrangement plays a major role in the seismic response of the reinforced concrete building, particularly along the X-direction. Model 1, which adopted a balanced shear wall layout on both sides of the structure, demonstrated superior performance compared with the other configurations.

Compared with Models 2 and 3, Model 1 reduced the third-floor inter-story drift by 10.69% and 11.19%, respectively. In addition, the average story stiffness in the X-direction increased by 6.38% relative to Model 2 and 6.48% relative to Model 3. The contribution of the shear wall system to the design base shear was also the highest in Model 1, while remaining within the dual structural system requirements specified in SNI 1726:2019.

Overall, a balanced distribution of shear walls was found to improve lateral stiffness and reduce inter-story drift, resulting in better seismic performance. In contrast, variations in shear wall placement had only a minor influence on the structural response in the Y-direction, indicating that the effectiveness of the investigated configurations was more evident in the X-direction. Therefore, placing shear walls on both sides of the building is recommended as the most suitable configuration for enhancing the seismic performance of the Ristia Resort building.

BIBLIOGRAPHY

[1] S. Mahmoud, "In-Plane Shear-Wall Configuration Effects on the Seismic Performance of Symmetrical Multistory Reinforced-Concrete Buildings," *International Journal of Civil Engineering*, vol. 19, no. 10, pp. 1195–1208, Oct. 2021, doi: 10.1007/s40999-021-00634-8.

[2] S. Anuda, N. A. Abdulrahman, and N. Z. N. Azizan, "A Review of Shear Wall Location Response in High-Rise RCC Structures as a Result of Earthquake Effect," in *Structural Integrity Cases in Mechanical and Civil Engineering*, S. , K. S. S. S. , M. N. N. Abdullah, Ed., Springer, Cham, Jan. 2022, pp. 1–12. doi: 10.1007/978-3-030-85646-5_1.

[3] A. Uma, K. Ullas, R. Shruthi, and B. J. Amith, "Seismic Analysis of a High-Rise RC Building with Varying Shear Wall Configurations using ETABS," in *16th International Conference on Advances in Computing, Control, and Telecommunication Technologies, ACT 2025*, Mandya, India: Adichunchanagiri University, BGS Institute of Technology /Civil Engineering, 2025.

[4] K. Pranava, A. R. Avinash, M. Chaithra, S. Anil, and K. Kamath, "Seismic Performance of Torsionally Irregular Multistorey RC Buildings with Optimised Shear Wall Configurations," *Infrastructures (Basel).*, vol. 10, no. 11, Nov. 2025, doi: 10.3390/infrastructures10110296.

[5] G. S. Sandeep, K. Y. M. Arun, V. Sundareshan, P. Pandit, and P. Sarkate, "Torsional Behavior of Reinforced Concrete High-Rise Structure with Diverse Shear Wall Resisting Systems under Seismic Loading," *Civil Engineering and Architecture*, vol. 13, no. 6, pp. 4559–4569, Nov. 2025, doi: 10.13189/cea.2025.130631.

[6] A. Khelaifia, R. Chebili, and A. Zine, "Impact of the position and quantity of shear walls in buildings on the seismic performance," *Asian Journal of Civil Engineering*, vol. 25, no. 1, pp. 953–964, Jan. 2024, doi: 10.1007/s42107-023-00824-w.

[7] S. Erden and B. Doran, "Effect of Location in Plan of Reinforced Concrete Shear Walls on Nonlinear Behavior," in *Proceedings of the 7th International Conference on Earthquake Engineering and Seismology. ICEES 2023.*, E. , A. H. , G. E. , Y. C. Uckan, Ed., Springer, Cham, Sep. 2024, pp. 467–479. doi: 10.1007/978-3-031-57659-1_34.

[8] J. Tarigan, J. Manggala, and T. Sitorus, "The effect of shear wall location in resisting earthquake," in *IOP Conference Series: Materials Science and Engineering*, Institute of Physics Publishing, Mar. 2018. doi: 10.1088/1757-899X/309/1/012077.

[9] Z. D. Shinwari, E. Yousufi, M. R. Haqbani, and N. Safi, "Pertinent Emplacement of Shear Walls to Diminish the Torsional Effects in Asymmetric-RC Framed Buildings," in *E3S Web of Conferences*, EDP Sciences, Mar. 2024. doi: 10.1051/e3sconf/202449702004.

[10] J. Yuzbasi *et al.*, "Influence of Shear Wall Area-to-Floor Area Ratios and Configurations on the Seismic Response of Tall RC Building Structures: An Overview of Adana After the 2023 Kahramanmaraş Earthquakes," *Buildings*, vol. 16, no. 9, May 2026, doi: 10.3390/buildings16091658.

[11] A. Khelaifia, S. Guettala, N. D. Henni, and R. Chebili, "Strategic Shear Wall Placement for Enhanced Seismic Resilience," in *International Conference on Civil, Structural and Transportation Engineering*, Avestia Publishing, 2024. doi: 10.11159/iccste24.203.

[12] A. R. Simon, F. K. Hridoy, M. Fahim Siddique, and S. A. Safat, "Orientation and location of shear walls in RC buildings to control deflection and drifts," in *Procedia Structural Integrity*, Elsevier B.V., 2023, pp. 162–168. doi: 10.1016/j.prostr.2023.06.028.

[13] A. Khelaifia, A. Zine, S. Guettala, and R. Chebili, "Assessment of the position and quantity of shear walls their correlation with building height on the seismic nonlinear performance," *Asian Journal of Civil Engineering*, vol. 25, no. 8, pp. 5925–5937, Dec. 2024, doi: 10.1007/s42107-024-01154-1.

[14] C. R. K. Reddy, D. P. Ravella, P. S. Reddy, and S. M. Kumar, "Study of effective location of shear wall in multi-storeyed buildings for optimum seismic response," *ARPN Journal of Engineering and Applied Sciences*, pp. 740–746, Sep. 2024, doi: 10.59018/062496.

[15] Badan Standardisasi Nasional, *SNI 2847:2019: Persyaratan Beton Struktural untuk Bangunan Gedung*. Jakarta, Indonesia: BSN, 2019.

[16] Badan Standardisasi Nasional, *SNI 1727:2020: Beban Desain Minimum dan Kriteria Terkait untuk Bangunan Gedung dan Struktur Lain*. Jakarta, Indonesia: BSN, 2020.

[17] Badan Standardisasi Nasional, *SNI 1726:2019: Tata Cara Perencanaan Ketahanan Gempa untuk Struktur Bangunan Gedung dan Non Gedung*. Jakarta, Indonesia: BSN, 2019.

[18] Pusat Penelitian dan Pengembangan Perumahan dan Permukiman (Puskim), Kementerian Pekerjaan Umum dan Perumahan Rakyat, Design Response Spectrum Application, 2021. [Online]. Available: https://rsa.ciptakarya.pu.go.id/2021/