Proceedings of the 8th International Conference on Civil Engineering for Sustainable Development (ICCESD 2026), 5~7 February 2026, KUET, Khulna, Bangladesh

SEISMIC PERFORMANCE ANALYSIS OF SHEAR WALL PLACEMENT IN RC BUILDINGS WITH VARYING ASPECT RATIOS

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ABSTRACT

This study examines the impact of shear wall positioning and the aspect ratio of the building's plan on the seismic performance of reinforced concrete (RC) structures. The goal is to determine the most effective configuration of shear walls to improve earthquake resilience in RC structures. Twenty models of RC buildings were developed in ETABS 2022, each featuring 11 stories (G + 10), with each story measuring 10 feet in height. Four different plan aspect ratios, viz. 1:1, 1:1.25, 1:1.5, and 1:1.75 were considered. For each aspect ratio, five model buildings were developed, one is a bare frame model and the remaining four are models with different placements of shear walls. Analysis procedures and building considerations are used according to BNBC 2020. Equivalent static analysis was performed to evaluate the lateral displacement, story drift, story stiffness and story shear. Findings indicate that the arrangement of shear walls considerably enhances lateral performance. Shear walls that are positioned in a core configuration yield the highest stiffness and the least displacement, whereas a configuration with edge walls provides optimal resistance to story shear. Asymmetric placement of walls results in torsional irregularities, causing an uneven distribution of stiffness. When the aspect ratio of the plan increases, displacement and drift increase, but stiffness and base shear decrease. In conclusion, this paper recommends good advice on how to create earthquake-resistant reinforced concrete buildings with a variety of plan shapes.

Keywords: *Plan Aspect Ratio, Story Drift, Lateral Displacement, Story Shear and Seismic Performance.*

1. INTRODUCTION

Earthquakes generate strong ground motions capable of causing severe structural damage and loss of life. Recent events, including the 7.7-magnitude Mandalay earthquake (2025) and the 5.4-magnitude Narsingdi earthquake (2025), which damaged buildings across Dhaka, highlight the increasing seismic threat in South and Southeast Asia. Bangladesh's location near the Dauki Fault, Tripura Fold Belt, and Arakan Subduction Zone, combined with dense population and inadequate construction practices, makes cities like Gazipur highly vulnerable. The seismic performance of reinforced concrete (RC) buildings is strongly influenced by their geometry and lateral-resisting system. Shear walls effectively enhance stiffness and reduce drift, but their efficiency depends on proper placement, as asymmetric layouts can induce torsional irregularities. The aspect ratio of a building's plan also affects lateral deformation (Domadzra and Hasan, 2024).

Previous studies have emphasized these configuration-dependent behaviors. Haque et al. (2016) showed that regular (square) RC buildings experience lower displacement and drift compared to W-, L-, and rectangular shapes. Farhan and Bommisetty (2019) also found that irregular C-, T-, and I-shaped buildings had more drift and displacement, with T-shaped buildings being the worst. Vertical irregularities also play a critical role in seismic response. Shelke and Ansari (2017) found that mass, stiffness, and geometric irregularities notably increase base shear and inter-story drift, especially in upper floors. Investigations on shear-wall positioning further highlight the influence of layout. Domadzra and Hasan (2024) demonstrated that a central-core shear wall reduced displacement by 36.6% and drift by 47% in a G+15 building. Krishnan and Sivakumar (2023) showed that central and inner-core wall placements significantly improved stiffness and reduced drift up to 46.6% across different story heights. While these studies provide valuable insights, most examine either plan irregularity or shear-wall location independently, leaving limited understanding of how shear-wall placement interacts with varying plan aspect ratios.

To address this gap, the present study investigated the seismic performance of twenty G+10 RC buildings integrating four plan aspect ratios (1:1, 1:1.25, 1:1.5, and 1:1.75) with five shear-wall configurations. Using ETABS 22 and the Equivalent Static Analysis procedure prescribed in BNBC 2020, the models were evaluated based on lateral displacement, story drift, stiffness distribution, and story shear. The findings offer performance-based guidance on optimal shear-wall placement for different building geometries, contributing to improved seismic design strategies for RC structures in earthquake-prone regions such as Bangladesh.

2. METHODOLOGY

This study adopts a numerical modeling approach to assess how shear-wall placement and plan aspect ratio influence the seismic behavior of mid-rise RC buildings. A total of twenty analytical models were developed in ETABS 22 and evaluated using the Equivalent Static Analysis procedure prescribed in BNBC 2020. All geometric, material, and loading parameters were kept consistent across the model set to ensure that observed differences in seismic response resulted solely from variations in wall layout and plan proportion.

2.1 Material Properties and Structural Components

All models were developed using reinforced concrete with a compressive strength of 4000 psi. and reinforcing steel having a yield strength of 60000 psi. A constant story height of 10′ and slab thickness of 5″ were used. Structural members were assigned consistent dimensions, with 20″×20″ columns and beams sized as 10″×20″ and 10″×24″. Shear walls were modeled as vertical shell elements with a constant thickness of 10″ and a constant length. Rigid diaphragms and fully rigid beam-column joints were assumed at each floor, and fixed-base boundary conditions were applied to isolate the effects of plan aspect ratio and wall layout on seismic response.

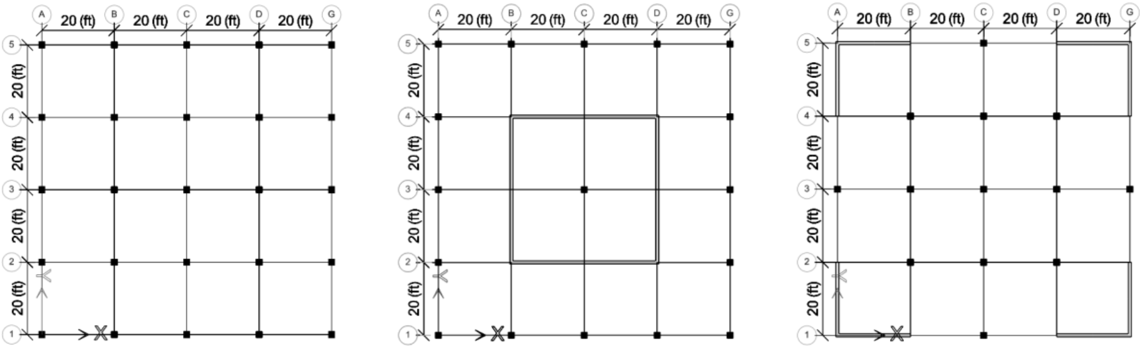
2.2 Model Geometry and Layout

Reinforced concrete building models were developed with four different plan aspect ratios to evaluate the influence of geometric proportion and shear-wall configuration on seismic performance. A uniform grid system was used for all models, consisting of 20′ bay spacing in both directions. The base (reference) plan measured 80′×80′, corresponding to an aspect ratio of 1:1. Modified plan dimensions were then generated to achieve aspect ratios of 1:1.25, 1:1.5, and 1:1.75 by elongating the plan in the X-direction while keeping the Y-dimension constant. For each aspect ratio, five shear-wall configurations were modeled, and corresponding aspect-ratio categories were assigned as follows:

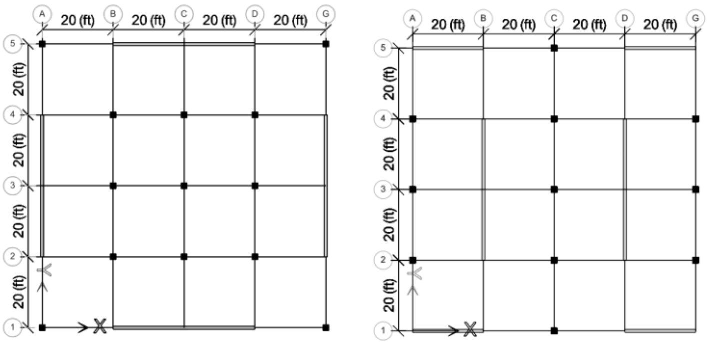
(a) SWP0: Bare frame (no shear walls);
(b) SWP1: Shear Wall Placement 1 (central core);
(c) SWP2: Shear Wall Placement 2 (corner walls);
(d) SWP3: Shear Wall Placement 3 (mid-side walls);
(e) SWP4: Shear Wall Placement 4 (Monaxial symmetric walls).

(a) AR1: Plan aspect ratio 1:1 (80′×80′);
(b) AR2: Plan aspect ratio 1:1.25 (100′×80′);
(c) AR3: Plan aspect ratio 1:1.50 (120′×80′);
(d) AR4: Plan aspect ratio 1:1.75 (140′×80′).

Model IDs were assigned based on aspect ratio and shear-wall configurations (e.g., AR1SWP0 for aspect ratio 1.0 with no shear walls). This systematic layout allowed consistent evaluation of how plan geometry and wall placement influence structural behavior under seismic loading. For the aspect ratios of 1:1, 1:1.25, 1:1.5, and 1:1.75, the corresponding shear-wall layout plans are presented in Figures 1, 2, 3, and 4, respectively, each illustrating all five shear-wall configurations considered for that particular plan geometry.

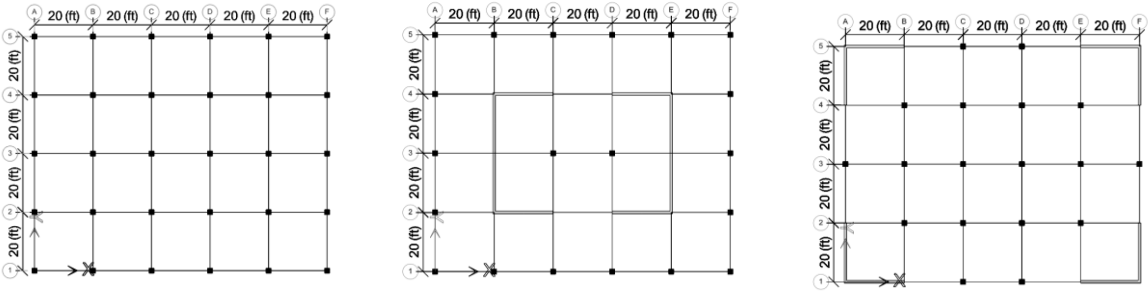


(a) Model AR1SWP0 (b) Model AR1SWP1 (c) Model AR1SWP2

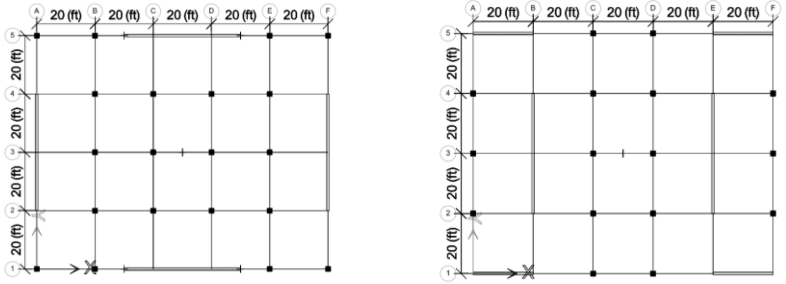


(d) Model AR1SWP3 (e) Model AR1SWP4

Figure 1: Shear-wall layout plans for aspect ratio 1:1

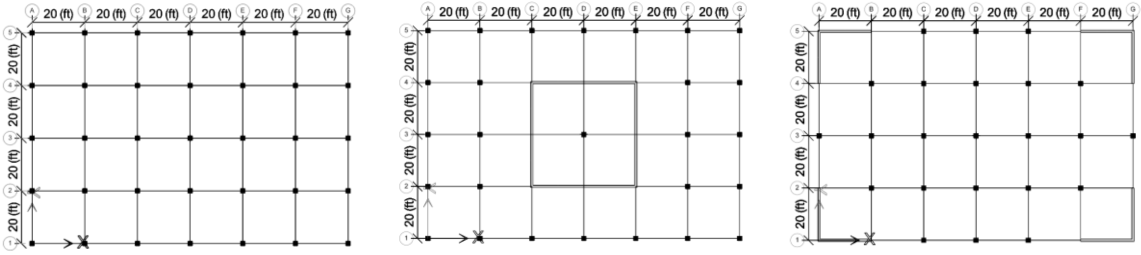


(a) Model AR2SWP0 (b) Model AR2SWP1 (c) Model AR2SWP2

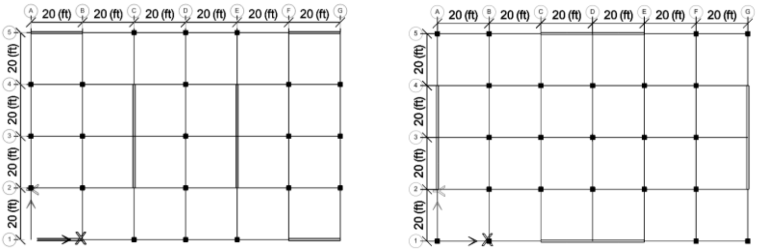


(d) Model AR2SWP3 (e) Model AR2SWP4

Figure 2: Shear-wall layout plans for aspect ratio 1:1.25

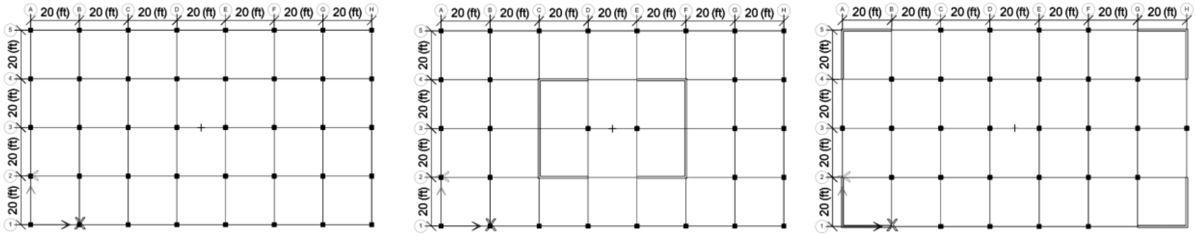


(a) Model AR3SWP0 (b) Model AR3SWP1 (c) Model AR3SWP2

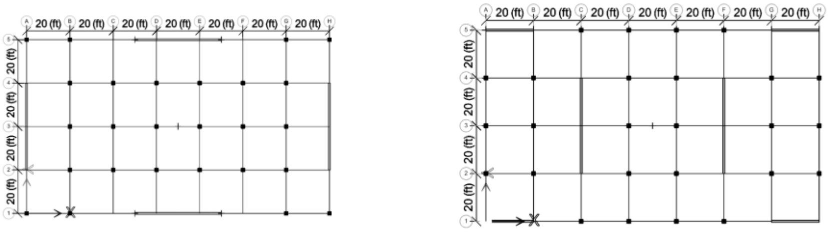


(d) Model AR3SWP3 (e) Model AR3SWP4

Figure 3: Shear-wall layout plans for aspect ratio 1:1.5



(a) Model AR4SWP0 (b) Model AR4SWP1 (c) Model AR4SWP2



(d) Model AR4SWP3 (e) Model AR4SWP4

Figure 4: Shear-wall layout plans for aspect ratio 1:1.75

2.3 Seismic Analysis and Evaluation Criteria

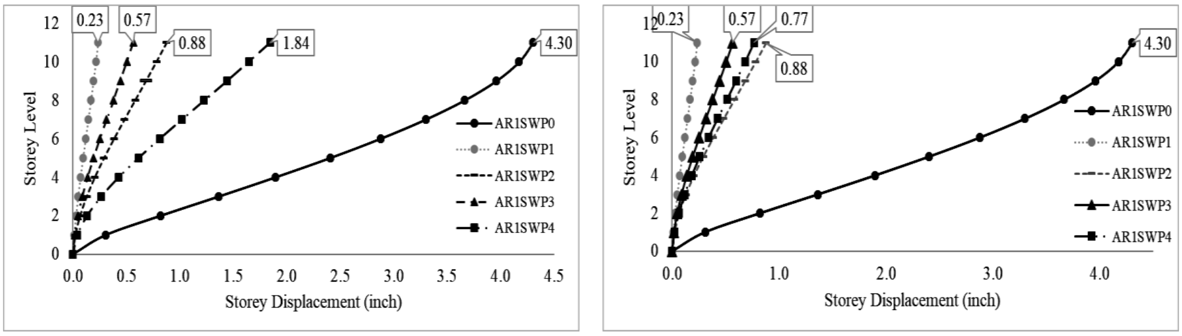
Seismic analysis was performed using the Equivalent Static Procedure specified in BNBC 2020. As the building falls under Seismic Design Category D, BNBC 2020 mandates consideration of orthogonal load effects; therefore, thirty percent of the perpendicular seismic action was included in all relevant load cases. ETABS was used to obtain key seismic response parameters for each model, including lateral displacement, story drift, story stiffness, and story shear. These parameters enabled a systematic evaluation of deformation control, stiffness distribution, and lateral force transfer, allowing a clear comparison of how plan aspect ratio and shear-wall placement influence overall seismic performance.

3. RESULT AND DISCUSSION

This section presents the seismic performance results of reinforced concrete buildings with four plan aspect ratios (1:1, 1:1.25, 1:1.5, and 1:1.75) and five shear-wall configurations, including a bare frame. The analysis examines how shear-wall placement and increasing plan elongation influence key response parameters, such as lateral displacement, story drift, story stiffness, and story shear in both directions. All models were analyzed in ETABS 22 following BNBC 2020 provisions, and serviceability checks were performed to ensure compliance with drift and displacement limits. Results are presented in graphs, followed by a comparison of the best-performing configurations for each aspect ratio to evaluate overall seismic efficiency.

3.1 Evaluation of Lateral Displacement Behaviour

Lateral displacement is a key indicator of seismic performance, as excessive displacement reflects inadequate lateral stiffness and may lead to structural and non-structural damage. The results presented in Figure 5 and Table 1 show that the bare frame models (SWP0) exhibit the highest lateral displacement for all plan aspect ratios, confirming the limited lateral resistance of moment-resisting frames without shear walls. Similar observations have been reported by Haque et al. (2016) and Farhan and Bommisetty (2019), who found that RC buildings without shear walls experience significantly higher displacement due to lower lateral stiffness, particularly in elongated and irregular plans. The introduction of shear walls substantially reduces lateral displacement by increasing the global stiffness of the structural system. Among the configurations studied, the central core shear-wall arrangement (SWP1) demonstrates the maximum reduction in displacement for the square plan (aspect ratio 1:1), achieving nearly a 95% reduction compared to the bare frame. This behavior aligns with the findings of Domadzra and Hasan (2024) and Krishnan and Sivakumar (2023), who reported that centrally located shear walls provide uniform stiffness distribution, minimize translational deformation, and effectively control lateral displacement under seismic loading.



(a) X-Direction

(b) Y- Direction

Figure 5: Lateral Displacement for Aspect Ratio 1:1

Table 1: Maximum Lateral Displacement of Model Buildings with varying Aspect Ratios

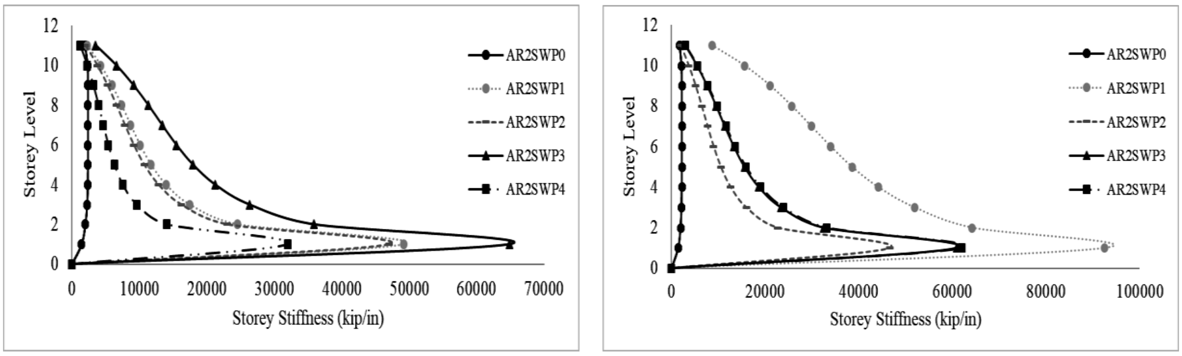
Model Type	Aspect Ratio							
	1:1		1:1.25		1:1.5		1:1.75	
	EX	EY	EX	EY	EX	EY	EX	EY
SWP0	4.30	4.30	6.55	6.68	4.15	4.83	4.09	5.03
SWP1	0.23	0.23	0.92	0.31	0.32	0.35	1.12	0.47
SWP2	0.88	0.88	1.01	1.04	1.12	1.20	1.23	1.34
SWP3	0.57	0.57	0.61	0.72	0.80	0.85	0.94	0.97
SWP4	1.84	0.77	1.75	0.71	2.41	1.23	2.03	1.10

However, as the plan aspect ratio increases, the effectiveness of SWP1 gradually decreases. This reduction can be attributed to the increased plan elongation, which amplifies flexural deformation and uneven stiffness distribution along the longer direction. Previous studies have noted that elongated building plans are more susceptible to higher lateral deformation due to increased overturning effects and reduced torsional rigidity (Haque et al., 2016; Farhan and Bommisetty, 2019). In contrast, the corner-wall (SWP2) and mid-side wall (SWP3) configurations show relatively stable displacement control across all aspect ratios, with reductions typically ranging from 70% to 90%. This consistent behavior suggests that distributing shear walls along the building perimeter or mid-sides enhances resistance against both translational and torsional deformation. Similar conclusions were drawn by Krishnan and Sivakumar (2023), who observed that multiple wall locations along the building perimeter lead to balanced stiffness and improved displacement control across different building geometries.

The monaxial symmetric wall configuration (SWP4) exhibits pronounced directional behavior, performing better in the Y-direction while showing reduced efficiency in the X-direction for elongated plans. This directional response indicates the presence of stiffness asymmetry, which can induce torsional effects and increase displacement in the weaker direction. Such behavior has also been highlighted by Shelke and Ansari (2017), who reported that asymmetric stiffness distribution leads to uneven lateral deformation and increased torsional demand. Overall, the lateral displacement results confirm that shear-wall placement plays a crucial role in seismic response. While central-core walls are most effective for compact and square plans, distributed wall configurations such as SWP2 and SWP3 provide more reliable displacement control for buildings with higher plan aspect ratios. These findings are consistent with previous research and reinforce the importance of considering both plan geometry and shear-wall layout in seismic design.

3.2 Evaluation of Story Stiffness Behaviour

Story stiffness is a critical parameter governing seismic response, as it directly influences lateral displacement, inter-story drift, and force distribution along the building height. Higher stiffness generally results in reduced deformation demand, while non-uniform stiffness distribution may lead to soft-story behavior and increased seismic vulnerability. The story stiffness profiles presented in Figure 6 and the maximum values summarized in Table 2 illustrate the influence of shear-wall placement and plan aspect ratio on the overall rigidity of the RC buildings. The bare frame models (SWP0) exhibit the lowest stiffness values across all aspect ratios, confirming that moment-resisting frames alone provide limited lateral rigidity under seismic loading. Similar findings were reported by Shelke and Ansari (2017), who observed that RC frames without shear walls are more flexible and prone to excessive deformation, particularly in mid- and upper-story levels.



(a) X- Direction (b) Y- Direction

Figure 6: Story Stiffness for Aspect Ratio 1:1.25

The introduction of shear walls leads to noticeable improvements in story stiffness by increasing the lateral load–resisting capacity of the structural system. The central-core shear-wall configuration (SWP1) shows modest stiffness enhancement for square (1:1) and moderately elongated (1:1.5) plans; however, a reduction in stiffness is observed for the intermediate aspect ratio of 1:1.25. This sensitivity to plan geometry can be attributed to changes in stiffness distribution and torsional characteristics, as also noted by Haque et al. (2016), who reported that irregular or elongated plans may reduce the effectiveness of centrally located lateral elements. The corner-wall (SWP2) and mid-side wall (SWP3) configurations demonstrate relatively consistent stiffness behavior across most aspect ratios, with small but stable gains compared to the bare frame. This trend suggests that distributing shear walls along the building perimeter contributes to a more uniform stiffness distribution and improved torsional resistance. Similar conclusions were drawn by Krishnan and Sivakumar (2023), who found that shear walls placed away from the core, particularly along the perimeter, help balance stiffness and enhance overall structural stability under seismic actions.

Table 2: Maximum Story Stiffness of Model Building with varying Aspect Ratios

Model	Aspect Ratio

Type	1:1		1:1.25		1:1.5		1:1.75	
	EX	EY	EX	EY	EX	EY	EX	EY
SWP0	931.86	931.86	1677.57	1677.57	1368.53	1368.53	1586.87	1586.87
SWP1	968.86	968.86	1182.41	1182.41	1451.48	1451.48	1625.11	1625.11
SWP2	953.151	953.151	1171.49	1171.49	1389.82	1389.82	1608.16	1608.16
SWP3	953.65	953.65	1176.86	1176.86	1390.32	1390.32	1603.78	1603.78
SWP4	1152.72	1152.72	1258.76	1258.76	1719.00	1719.00	1606.13	1606.13

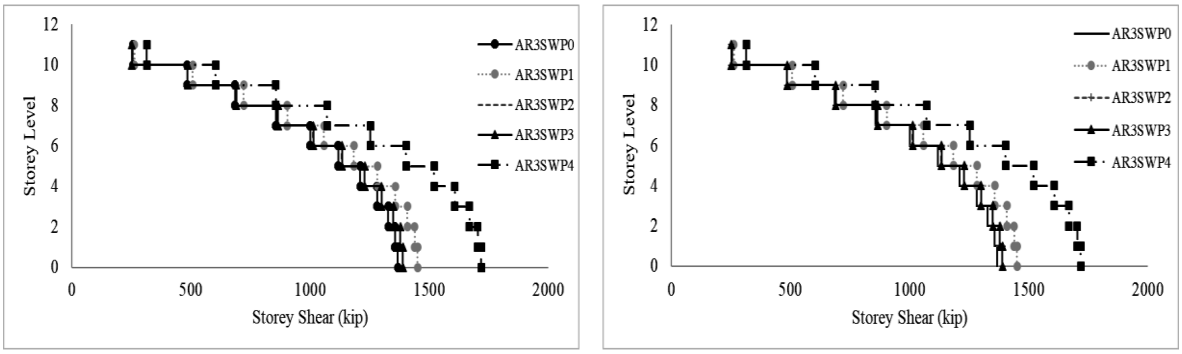
Among all configurations, the monaxial symmetric wall arrangement (SWP4) provides the most significant stiffness enhancement for square and moderately elongated plans, achieving stiffness increases exceeding 20% in some cases. This improved performance can be attributed to the alignment of shear walls with the principal direction of seismic forces, which effectively increases flexural and shear rigidity. Domadzra and Hasan (2024) reported comparable findings, noting that strategically aligned shear walls significantly enhance stiffness and improve seismic performance. However, the observed reduction in stiffness for the 1:1.25 aspect ratio highlights the influence of plan geometry on stiffness efficiency and the potential onset of torsional effects when stiffness is not symmetrically distributed. Overall, the story stiffness results confirm that shear-wall placement and plan aspect ratio jointly govern the rigidity of RC buildings. While centrally located walls are effective for compact geometries, perimeter and mid-side wall configurations offer more stable stiffness performance across varying plan aspect ratios. These findings are consistent with previous research and emphasize the importance of achieving a balanced stiffness distribution to ensure reliable seismic behavior.

3.3 Evaluation of Story Shear Behaviour

Story shear represents the cumulative lateral force that a structure must resist at each floor level during seismic excitation. It is a direct indicator of how seismic forces are distributed and transferred through the vertical lateral force–resisting system. The magnitude and distribution of story shear are strongly influenced by structural stiffness, shear-wall configuration, and plan geometry. The results presented in Table 3 and Figure 7 show that all shear-wall configurations significantly increase story shear compared to the bare frame (SWP0). This behavior is consistent with fundamental seismic theory: as lateral stiffness increases, the structure attracts higher seismic forces. According to equivalent static analysis principles adopted in BNBC 2020, base shear is proportional to the effective stiffness and mass participation of the structure.

Among the studied configurations, SWP1 (central core shear walls) consistently produces the highest story shear values—approximately 25–30 times greater than the bare frame. This is supported by previous studies which demonstrate that centrally located shear walls provide a direct and continuous load path for seismic forces, resulting in maximum force attraction and transfer capacity. Domadzra and Hasan (2024) reported that core shear-wall systems significantly increase base and story shear due to enhanced global stiffness and reduced flexibility. However, while higher story shear capacity reflects improved strength and stiffness, it also implies greater force demand on the wall elements, requiring careful detailing to avoid brittle failure. Krishnan and Sivakumar (2023) emphasized that central-core systems concentrate seismic forces and therefore must be designed with adequate ductility and confinement.

Configurations SWP2 (corner walls) and SWP3 (mid-side walls) exhibit moderate but stable increases in story shear, generally 14–20 times that of the bare frame across all aspect ratios. This balanced response suggests efficient lateral force distribution through multiple vertical elements, reducing excessive force concentration. This observation aligns with the findings of Farhan and Bommisetty (2019), who reported that perimeter and symmetrically distributed shear walls enhance seismic resistance by improving torsional stability and distributing shear demand more uniformly across the structure. Similarly, Haque et al. (2016) noted that buildings with regular wall distribution experience smoother shear variation along height and reduced vulnerability to localized damage. SWP3, in particular, demonstrates consistent story shear behavior across varying plan aspect ratios, indicating its suitability for both compact and elongated building plans where architectural constraints may limit core wall placement.



(a) X- Direction

(b) Y- Direction

Figure 7: Story Shear for Aspect Ratio 1:1.5

Table 3: Maximum Story Shear of Model Building with varying Aspect Ratios

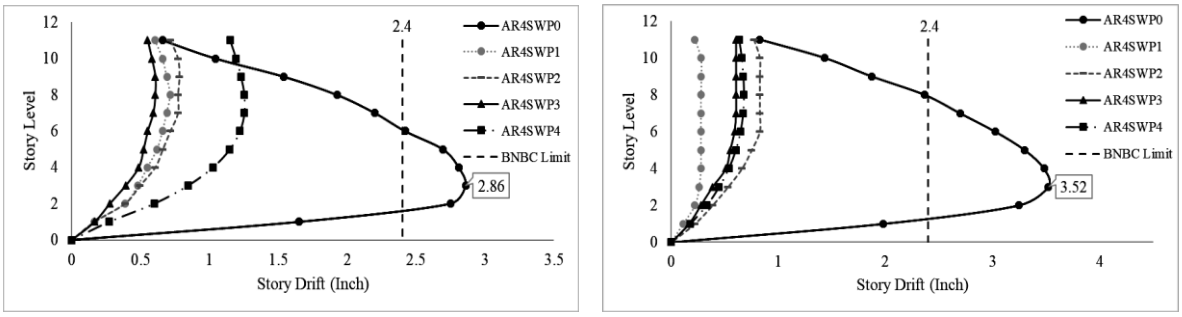
Model Type	Aspect Ratio							
	1:1		1:1.25		1:1.5		1:1.75	
	EX	EY	EX	EY	EX	EY	EX	EY
SWP0	3307	3307	1431	1429	4799	4534	5544	5148
SWP1	92023	92027	49181	92429	101859	101575	52134	93870
SWP2	45569	45569	47029	46646	48426	47699	49774	48729
SWP3	60986	60986	64803	60910	62161	61581	61588	62161
SWP4	30564	61286	31969	61978	32470	62165	34075	63096

The SWP4 configuration shows pronounced directional dependence, with significantly higher story shear in the Y-direction compared to the X-direction. This behavior is attributed to the monaxial and asymmetric stiffness contribution of the wall layout, which results in uneven force attraction. Shelke and Ansari (2017) highlighted that asymmetric stiffness distribution leads to directional amplification of seismic forces and increased torsional effects, especially in elongated or irregular plans. Your results confirm this behavior, emphasizing that while SWP4 may be effective in one principal direction, it is less reliable as a globally balanced lateral system. Across all configurations, increasing plan aspect ratio alters story shear demand. Elongated plans (higher aspect ratios) generally show redistribution rather than uniform increase of story shear, reflecting reduced global stiffness and increased flexibility. This trend is well documented in seismic performance studies, where elongated buildings exhibit lower base shear coefficients but higher displacement and torsional sensitivity (Haque et al., 2016; Farhan & Bommisetty, 2019)

3.4 Evaluation of Story Drift Behaviour

Story drift is one of the most critical seismic performance indicators, as it directly reflects structural deformation demand and potential damage to both structural and non-structural components. Excessive inter-story drift can lead to cracking, failure of infill walls, malfunction of services, and in severe cases, structural instability. For this reason, BNBC 2020 prescribes strict drift limits to ensure serviceability and life safety. The drift profiles obtained in this study (Figure 8) exhibit a characteristic trend commonly observed in mid-rise RC buildings subjected to seismic loading: story drift increases from the base, reaches a maximum at mid-height stories, and then decreases toward the roof. This behavior occurs due to the combined effects of cumulative lateral deformation, stiffness variation along height, and higher-mode participation.

This trend is well documented in seismic literature. Shelke and Ansari (2017) reported that maximum drift typically occurs at intermediate stories in RC frames due to reduced stiffness concentration and increased lateral flexibility at those levels. Similar observations were also noted by Farhan and Bommisetty (2019), particularly for buildings with plan irregularities and varying stiffness distribution. The results in Table 4 clearly demonstrate that the inclusion of shear walls substantially reduces story drift across all plan aspect ratios when compared to the bare frame (SWP0). The bare frame consistently shows the highest drift values, in some cases exceeding BNBC 2020 recommended limits, confirming its vulnerability under seismic excitation.



(a) X- Direction

(b) Y- Direction

Figure 8: Story Drift for Aspect Ratio 1:1.75

Among the configurations, SWP1 (central core shear walls) provides the most effective drift control, achieving reductions of up to 96% for square plans and maintaining superior performance even as the plan becomes elongated. This behavior can be attributed to the uniform stiffness distribution and minimized torsional effects provided by centrally located walls. Domadzra and Hasan (2024) similarly observed that core shear walls significantly reduce inter-story drift by enhancing global stiffness and ensuring symmetric force transfer. SWP3 (mid-side walls) also demonstrates strong and consistent drift reduction across all aspect ratios, typically ranging between 79% and 88%. Its effectiveness arises from balanced stiffness placement along both principal directions, which limits differential deformation between adjacent stories. Krishnan and Sivakumar (2023) found comparable reductions in drift when shear walls were placed symmetrically along the building perimeter or mid-sides, emphasizing their suitability for drift control in regular and moderately elongated plans. SWP2 (corner walls) provides moderate but stable drift reduction across all configurations. While corner walls enhance torsional resistance, they may not be as effective as central or mid-side walls in limiting translational deformation, especially in elongated plans. This observation is consistent with Haque et al. (2016), who reported that perimeter-only stiffening improves overall performance but may still allow higher inter-story drift compared to centrally stiffened systems.

The SWP4 configuration exhibits pronounced directional behavior, with significantly better drift reduction in the Y-direction than in the X-direction, particularly for higher aspect ratios. This indicates stiffness imbalance and torsional sensitivity caused by monaxial wall placement. Such directional dependency has been widely reported in seismic studies of asymmetric buildings. Farhan and Bommisetty (2019) emphasized that asymmetric wall layouts can result in uneven drift demand and increased torsional response, especially in elongated plan geometries.

Table 4: Maximum Story Drift of Model Building with varying Aspect Ratios

Model Type	Aspect Ratio							
	1:1		1:1.25		1:1.5		1:1.75	
	EX	EY	EX	EY	EX	EY	EX	EY
SWP0	2.99	2.99	3.72	3.95	2.89	3.36	2.86	3.52
SWP1	0.12	0.12	0.57	0.18	0.19	0.2	0.72	0.28
SWP2	0.67	0.67	0.63	0.65	0.7	0.74	0.78	0.82
SWP3	0.35	0.35	0.37	0.45	0.49	0.53	0.61	0.61
SWP4	1.16	1.16	0.37	0.44	1.5	0.75	1.25	0.68

An increase in plan aspect ratio generally leads to higher story drift values across all shear-wall configurations. Elongated buildings exhibit reduced lateral stiffness along the longer direction, resulting in increased deformation demand. This trend is consistent with previous findings, where rectangular and elongated plans were shown to be more drift-sensitive than square configurations under seismic loading (Haque et al., 2016). Despite this, the presence of well-distributed shear walls, particularly in SWP1 and SWP3 successfully keeps drift within allowable BNBC limits even for the highest aspect ratio (1:1.75), highlighting the effectiveness of proper wall placement in mitigating geometric disadvantages.

4. CONCLUSIONS

This study assessed how plan aspect ratio and shear-wall placement influence the seismic behavior of RC buildings. The incorporation of shear walls significantly improved seismic performance by reducing lateral displacement and story drift while enhancing stiffness and base shear capacity compared to the bare frame configuration.

(a) Across all aspect ratios, the bare frame (SWP0) exhibited the highest displacement and lowest stiffness, confirming its poor lateral resistance under seismic loading;
(b) The configuration SWP1 demonstrated the best overall seismic performance, providing the highest stiffness, the lowest displacement, and the most uniform behavior in both directions;
(c) The configuration SWP3 also performed strongly, especially for aspect ratios 1:1 and 1:1.25, offering effective displacement control and balanced stiffness distribution;
(d) The configuration SWP2 performed well in terms of base shear, particularly for lower aspect ratios, due to efficient lateral force transfer along the building perimeter;
(e) The configuration SWP4, although sensitive to torsional effects in elongated plans, still provided acceptable stiffness and resistance for compact geometries, demonstrating its viability where architectural constraints limit symmetrical wall placement;
(f) Overall, the different shear-wall configurations each showed strengths: SWP3 offered good stiffness and displacement control, SWP2 excelled in base-shear capacity, and SWP4 contributed acceptable performance in smaller plan ratios despite torsional tendencies;
(g) Increasing plan aspect ratios led to higher displacement and reduced stiffness and base shear, indicating lower seismic rigidity in elongated structures.

ACKNOWLEDGEMENTS

The authors are grateful for the cooperation and advice they got while doing this research. An enormous thank to the academic supervisors and partners whose helpful comments and support made this study possible. The authors also want to thank the people who assisted them with technology and facilities, which were very important for doing the numerical analyses and finishing the work efficiently.

DECLARATION OF USE OF AI

The authors used artificial intelligence (AI) only to improve the language, grammar, clarity, and structure of the written content. The research concepts, methodology, data analysis, result interpretation, and technology findings were developed independently and without the use of AI technologies. The authors meticulously reviewed and confirmed every aspect of the work to ensure accuracy, originality, and compliance with academic and ethical standards.

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