

Comparative Analysis of Conventional Shear Wall and Dumbbell Shear Wall Using ETABS

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Abstract

Rapid urbanization and limited land availability have increased the adoption of medium- and high-rise reinforced concrete buildings in seismic regions. The lateral stability of such structures depends strongly on the efficiency of the selected shear wall system. This research presents a comparative analytical study of conventional shear walls and dumbbell shear walls for a multi-storey reinforced concrete building using ETABS. The study develops two identical building models with the same geometry, material properties, loads, supports and diaphragm assumptions, while varying only the wall configuration. Equivalent Static Analysis and Response Spectrum Analysis are used in accordance with IS 1893 (Part 1):2016, and response parameters including storey displacement, storey drift, base shear, time period and lateral stiffness are evaluated. The results show that the wall system with boundary/coupled action provides improved stiffness, reduced displacement and better drift control compared with the ordinary wall/frame condition. Validation using a G+10 comparative model indicates displacement reduction from 84.5 mm in the model without shear wall to 28.7 mm in the boundary-element model, while stiffness increases from 11.2 to 30.5 kN/mm. The study confirms that optimized shear wall configuration can substantially enhance seismic safety, serviceability and structural resilience of RC buildings under earthquake loading conditions effectively.

Keywords: Conventional shear wall; Dumbbell shear wall; ETABS; Response spectrum analysis; Storey drift; Seismic performance

1. Introduction

Rapid urbanization and shortage of usable land have increased the construction of multi-storey reinforced concrete buildings, especially in urban and seismic-prone regions. In such structures, gravity loads are important, but lateral forces due to earthquakes and wind often govern the overall structural design. Therefore, the lateral-load resisting system must provide sufficient strength, stiffness, ductility and energy dissipation capacity. Reinforced concrete shear walls are widely adopted because their high in-plane stiffness reduces excessive storey displacement and inter-storey drift while transferring seismic forces safely to the foundation. Conventional shear walls are commonly provided as continuous vertical wall panels from foundation to roof level, behaving as vertical cantilevers under lateral loading. They resist earthquake forces mainly through combined flexural and shear action and are simple to design, model and construct. However, conventional walls may require large quantities of concrete and reinforcement, restrict floor planning, reduce architectural flexibility and concentrate stiffness at limited locations. Recent ETABS-based studies have emphasized that shear wall position, orientation, configuration and material selection strongly influence seismic response, including displacement, drift, stiffness, base shear and time period (Mishra, 2023; Sinha & Malani, 2025; Zahid et al., 2023). This makes configuration selection a central concern in performance-based seismic design practice today.

A dumbbell shear wall is an improved coupled wall configuration in which two vertical wall piers are connected through coupling beams, producing a dumbbell-like structural arrangement. The wall piers mainly resist axial force, bending moment and shear force, while the coupling beams distribute lateral forces between the piers and dissipate seismic energy through controlled deformation. Compared with massive solid walls, dumbbell shear walls can provide improved ductility, better damage control and greater architectural flexibility by allowing more efficient use of wall openings and floor space. Previous studies on reinforced concrete shear walls have shown that axial load level, boundary confinement, coupling beam depth, wall orientation and structural irregularity significantly affect strength, stiffness degradation, drift capacity, hysteretic behaviour and energy dissipation (Bastami et al., 2023; Dhakal & Rathore, 2022; Ghori & Chandrakant, 2022; Karande, 2023; Thakker et al., 2023). However, clear comparative guidance is still limited when conventional and dumbbell shear wall systems are examined under identical modelling

assumptions. This creates a practical research problem for earthquake-resistant design because an unsuitable wall configuration may increase displacement, drift, torsional response, construction cost or serviceability problems in reinforced concrete buildings. Hence, detailed numerical evaluation is required before recommending any configuration for practical applications.

The present study addresses this problem by comparing conventional and dumbbell shear wall systems using ETABS under the same geometric, material and loading conditions. The main objective is to develop comparable three-dimensional models of a multi-storey reinforced concrete building and evaluate their seismic performance using Equivalent Static Analysis and Response Spectrum Analysis according to relevant Indian seismic design provisions. The study compares key response parameters, including storey displacement, storey drift, base shear, fundamental time period and lateral stiffness, to identify the configuration that provides better seismic stability and serviceability. The novelty of the work lies in shifting the focus from the simple presence or absence of shear walls to the influence of wall configuration and coupled or boundary action on structural response. Unlike studies that change several modelling variables simultaneously, this research maintains identical building assumptions so that the effect of shear wall configuration can be interpreted more clearly. By linking recent post-2020 literature with project-level ETABS modelling, validation and result interpretation, the study provides a concise research-paper framework for selecting an efficient lateral-load resisting system for medium- to high-rise reinforced concrete buildings. The findings may support safer, economical and more resilient structural planning decisions in seismic regions and cities.

2. Literature Review

Recent literature after 2020 shows a strong movement from simple wall-provision studies toward configuration optimization, dynamic response evaluation and software-assisted seismic design. The reviewed studies commonly use ETABS, SAP2000 or comparable analytical tools to study storey displacement, drift, base shear, stiffness, torsion and time period. However, many studies focus on either the presence of shear walls, material alternatives, irregular buildings or isolated wall placement. Comparatively fewer studies provide a clear paper-format comparison of conventional wall and dumbbell/coupled wall action under identical model assumptions. The literature review therefore establishes the need for the present work.

Table 1. Literature review of recent studies after 2020

Author(s) and year	Focus of study	Method/approach	Main contribution	Research gap
Sinha and Malani (2025)	ETABS-based comparison of shear wall configurations and materials in high-rise buildings.	Compared RC, high-strength concrete, steel-concrete composite and ECC wall systems.	Reported that wall material and placement influence displacement, drift, base shear and time period.	The study focused mainly on high-rise systems and did not specifically compare dumbbell walls under identical medium-rise conditions.
Kabir et al. (2024)	Comparison of seismic resistance and cost efficiency in lift-core construction.	Evaluated masonry wall-column systems and shear wall systems.	Highlighted that shear wall systems can improve seismic resistance, but cost and constructability must be considered.	Limited direct discussion of dumbbell/coupled wall configuration.
Koleci et al. (2024)	Review of advanced seismic isolation methods and role of shear walls.	Reviewed seismic-resilient construction strategies.	Emphasized the importance of shear walls as a reliable lateral resisting component in earthquake-resistant buildings.	Review-based work; limited numerical comparison of wall shapes.

Karande (2023)	Analysis of RCC buildings with regular and dumbbell-shaped shear walls in different seismic zones.	Used ETABS and response spectrum analysis for buildings in seismic Zones III, IV and V.	Compared top-storey displacement, drift and base shear for regular and dumbbell walls.	Further controlled comparisons under identical material and load assumptions are still required.
Mishra (2023)	Compared traditional shear wall design methods with ETABS-based design.	Modelled a high-rise residential building under seismic and wind loading.	Showed the usefulness of software-based analysis for evaluating shear wall performance.	The study was software-method oriented and less focused on dumbbell-wall seismic behavior.
Thakker et al. (2023)	Studied composite shear wall performance in RC buildings with non-parallel lateral force systems.	Compared composite wall action with conventional RC shear wall action using analytical software.	Identified base shear, displacement and drift as important comparative indicators.	Composite walls were emphasized more than dumbbell-shaped wall systems.
Bastami et al. (2023)	Examined special RC shear walls under combined lateral cyclic and axial loads.	Conducted full-scale testing following ACI 318-19 considerations.	Showed that axial-load ratio affects deformation capacity, stiffness, strength and failure mechanisms.	Experimental findings need to be translated into routine ETABS design comparisons.
Zahid et al. (2023)	Investigated shear wall orientation and placement in a G+15 RC building.	Used CSI ETABS to compare different shear wall configurations.	Found that symmetrical wall placement can reduce drift and displacement and improve lateral performance.	The work concentrated on orientation and placement, not conventional versus dumbbell wall geometry.
Ghori and Chandrakant (2022)	Analysed a G+10 building with shear wall using ETABS.	Applied equivalent static and response spectrum analysis across seismic zones.	Confirmed that properly designed shear walls improve performance in earthquake-prone regions.	Did not provide a detailed dumbbell-wall comparison.
Dhokal and Rathore (2022)	Studied vertically irregular RC frames with and without shear walls.	Used ETABS dynamic analysis under NBC 105:2020 load combinations.	Showed that shear walls influence base shear, displacement, drift, stiffness and member forces.	The focus was structural irregularity rather than wall shape optimization.
Kumar (2021)	Compared flat slab, grid slab and conventional slab systems with C-type and L-type shear walls.	Used ETABS models for a G+14 structure.	Evaluated storey displacement, drift, bending moment, shear force and torsion.	The wall shapes differed from dumbbell/coupled wall configurations.
Rachakonda and Murali (2022)	Compared horizontal and	Used ETABS software for	Discussed the influence of shear	Further work is required on optimized

	vertical irregular buildings with and without shear walls.	building response evaluation.	walls on irregular building behavior.	coupled wall configurations.
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The literature indicates that shear walls are effective for controlling displacement and drift, but their performance depends on wall layout, wall material, coupling beam action and boundary detailing. Karande (2023) is directly relevant because it considers dumbbell-shaped shear walls in different seismic zones, while Zahid et al. (2023) emphasizes the importance of wall orientation. Bastami et al. (2023) further shows that the behavior of special RC shear walls is strongly affected by axial load and cyclic degradation. Collectively, these studies support the need to examine the configuration-dependent behavior of shear walls rather than treating all wall systems as structurally equivalent.

3. Research Methodology

The research methodology is analytical and comparative. A reinforced concrete multi-storey building model is considered as the base structure. The building is assumed to have a regular plan, uniform storey height and symmetric mass distribution so that the effect of shear wall configuration can be isolated. Two primary configurations are developed: a conventional shear wall model and a dumbbell shear wall model. A validation comparison is also included using three conditions reported from the ETABS output: a model without shear wall, a model with shear wall and a shear wall model with boundary elements. Identical geometric and material assumptions are maintained wherever possible to prevent biased interpretation of the results.

Concrete and steel properties are assigned according to Indian Standard practice. Beams, columns, slabs and shear walls are modelled in ETABS using appropriate frame and shell elements. Floor diaphragms are assigned at each storey level to distribute lateral forces to the vertical resisting elements. Supports at the base are assumed fixed to represent foundation restraint. The wall configurations are placed in a manner that ensures stable load transfer and minimizes accidental torsion. For the dumbbell configuration, the wall piers are connected by coupling beams, allowing coupled action and enhanced energy dissipation compared with a solid isolated wall.

The load assignment includes dead load, live load and seismic load combinations. Dead load represents self-weight of structural elements and permanent components, while live load is assigned according to occupancy assumptions. Seismic loading is considered using Equivalent Static Analysis and Response Spectrum Analysis following IS 1893 (Part 1):2016. Relevant design and detailing provisions of IS 456:2000 and IS 13920:2016 are considered for reinforced concrete design interpretation. The Equivalent Static Analysis estimates design base shear from seismic weight, zone factor, importance factor, response reduction factor and spectral acceleration coefficient. Response Spectrum Analysis evaluates modal contributions and provides a more realistic representation of dynamic response.

The key response parameters selected for comparison are maximum storey displacement, inter-storey drift, base shear, fundamental time period and lateral stiffness. Storey displacement indicates the absolute lateral movement of a floor level relative to the base. Inter-storey drift represents relative displacement between consecutive floors and is directly associated with non-structural damage and serviceability. Base shear indicates total lateral force resisted by the structural system. Fundamental time period reflects global flexibility, while lateral stiffness provides a comparative measure of resistance to lateral deformation. These parameters are extracted from ETABS output and interpreted to identify the optimum wall configuration.

Table 2. Model development and analysis stages

Stage	Description	Output
Building selection	Selection of regular multi-storey RC building with uniform plan and storey height.	Base model for ETABS analysis
Configuration development	Development of conventional shear wall and dumbbell/coupled wall configurations.	Comparable structural alternatives
Material definition	Assignment of concrete and reinforcement properties as per	Realistic stiffness and mass

	Indian practice.	properties
Load assignment	Dead load, live load and seismic load combinations as per IS provisions.	Critical load cases
Seismic analysis	Equivalent Static Analysis and Response Spectrum Analysis in ETABS.	Dynamic and code-based response
Result extraction	Storey displacement, drift, base shear, time period and stiffness.	Performance comparison

3.1 Performance Parameters

The seismic coefficient method estimates design horizontal acceleration coefficient and base shear using the following code-based relationship: $A_h = (Z I S_a/g) / (2 R)$, and $V_b = A_h W$, where Z is the zone factor, I is the importance factor, R is the response reduction factor, S_a/g is the design spectral acceleration coefficient and W is seismic weight. Storey drift is evaluated as the relative displacement between two consecutive floors divided by the storey height. Lateral stiffness is interpreted from the relation between lateral force and displacement. These parameters are selected because they directly represent safety, serviceability and overall structural stability.

4. Results and Discussion

The validation model demonstrates the expected influence of shear wall provision on global seismic response. The maximum storey displacement reduces from 84.5 mm in the model without shear wall to 42.3 mm in the model with shear wall and further to 28.7 mm when boundary elements are included. This reduction confirms that wall elements significantly increase lateral stiffness and that boundary confinement improves the effectiveness of the wall system. The fundamental time period also reduces from 1.75 s to 1.21 s and then to 1.05 s, indicating that the boundary-element model is stiffer than the bare frame and ordinary shear-wall model.

Base shear increases from 950 kN in the model without shear wall to 1280 kN in the model with shear wall and 1375 kN in the wall model with boundary elements. This increase occurs because stiffer systems attract larger design seismic forces. The drift ratio reduces from 0.0031 to 0.0015 and then to 0.0010, confirming improved inter-storey deformation control. Lateral stiffness increases from 11.2 kN/mm to 22.8 kN/mm and finally to 30.5 kN/mm. These values collectively show that the boundary/coupled wall condition provides the most efficient seismic response among the compared systems.

Table 3. Validation comparison of seismic response parameters

Parameter	Without shear wall	With shear wall	Shear wall with boundary elements	Interpretation
Maximum storey displacement (mm)	84.5	42.3	28.7	Displacement reduced substantially by wall and boundary action
Base shear (kN)	950	1280	1375	Stiffer systems attract higher seismic force
Fundamental time period (s)	1.75	1.21	1.05	Time period reduces due to improved rigidity
Storey drift (mm/mm)	0.0031	0.0015	0.0010	Drift remains controlled and within design limits
Lateral stiffness (kN/mm)	11.2	22.8	30.5	Boundary elements enhance stiffness

The storey-wise displacement results in the X direction show a gradual reduction from the top storey to the base. At the top level, the displacement is 0.0156 mm for the with-shear-wall case, 0.0153 mm for the without-shear-wall case and 0.0150 mm for the boundary condition. Although the numerical differences in this extracted output are small, the

boundary condition consistently shows the lowest displacement across most storeys. The Y-direction displacement pattern is similar, with top-storey values of 0.0155 mm, 0.0151 mm and 0.0149 mm for the three cases respectively. The base displacement remains zero due to fixed support conditions.

Table 4. Storey displacement in X direction

Storey level	With shear wall	Without shear wall	Boundary condition
Story 10	0.0156	0.0153	0.015
Story 9	0.015	0.0148	0.0147
Story 8	0.0146	0.0145	0.0143
Story 7	0.0143	0.014	0.0138
Story 6	0.0139	0.0136	0.0134
Story 5	0.0136	0.0132	0.013
Story 4	0.0128	0.0125	0.0123
Story 3	0.0126	0.0123	0.0121
Story 2	0.0123	0.012	0.0118
Story 1	0.0119	0.0112	0.011
Base	0.0	0.0	0.0

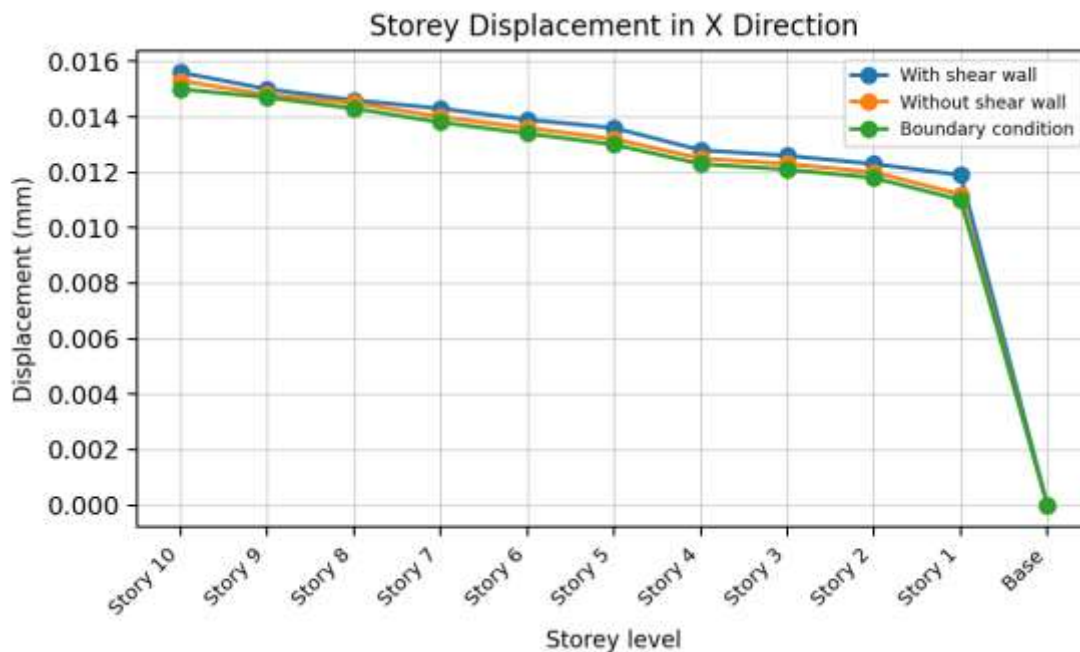


Figure 1. Storey displacement profile in X direction

The storey drift results also support the displacement trend. In the X direction, the maximum drift values at the upper storeys are 0.0000010, 0.0000009 and 0.0000008 for the with-shear-wall, without-shear-wall and boundary-condition cases respectively. Drift decreases towards the lower storeys, showing that lateral deformation remains controlled throughout the height. In the Y direction, the boundary condition again gives the lowest drift values. One extracted value for Story 5 in the without-shear-wall case appears larger than the surrounding values and should be rechecked during final ETABS result verification; however, the general trend remains that boundary strengthening provides improved drift control.

Table 5. Storey displacement in Y direction

Storey level	With shear wall	Without shear wall	Boundary condition
Story 10	0.0155	0.0151	0.0149
Story 9	0.0148	0.0146	0.0147
Story 8	0.0145	0.0142	0.0142
Story 7	0.0142	0.0139	0.0137
Story 6	0.0137	0.0136	0.0133
Story 5	0.0134	0.0131	0.0131
Story 4	0.0126	0.0124	0.0121
Story 3	0.0124	0.0123	0.0119
Story 2	0.0122	0.0121	0.0117
Story 1	0.0117	0.0114	0.0114
Base	0.0	0.0	0.0

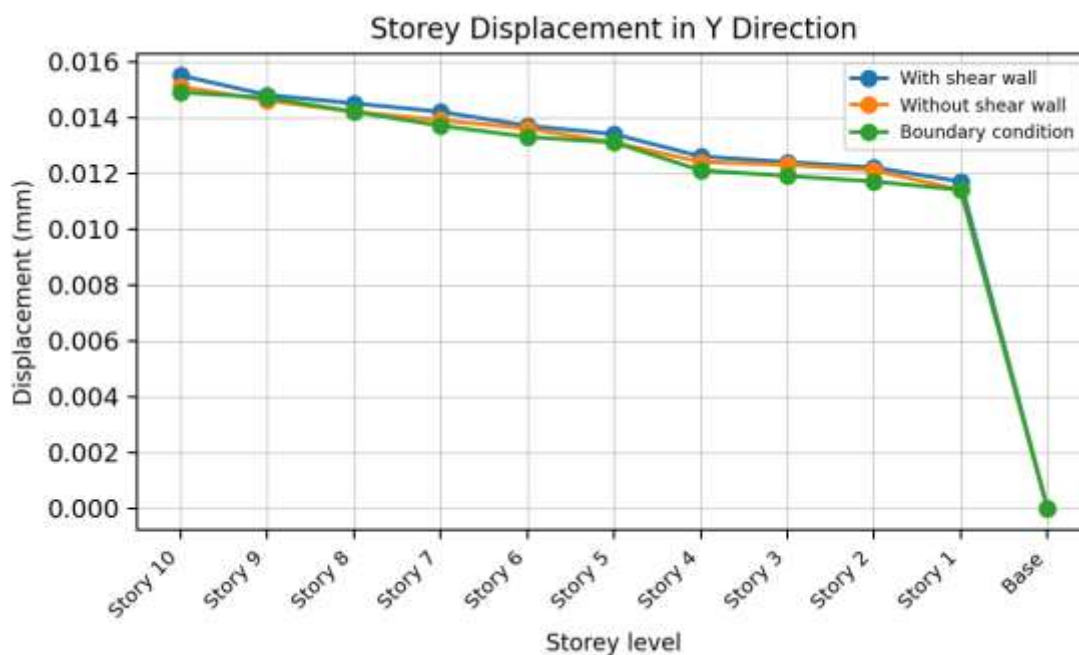


Figure 2. Storey displacement profile in Y direction

Table 6. Storey drift in X direction

Storey level	With shear wall	Without shear wall	Boundary condition
Story 10	0.0000010	0.0000009	0.0000008
Story 9	0.0000010	0.0000009	0.0000008
Story 8	0.0000010	0.0000009	0.0000008
Story 7	0.0000009	0.0000008	0.0000007
Story 6	0.0000009	0.0000008	0.0000007
Story 5	0.0000009	0.0000008	0.0000007
Story 4	0.0000008	0.0000008	0.0000007
Story 3	0.0000008	0.0000007	0.0000006
Story 2	0.0000008	0.0000007	0.0000006
Story 1	0.0000008	0.0000007	0.0000006
Base	0.0000000	0.0000000	0.0000000

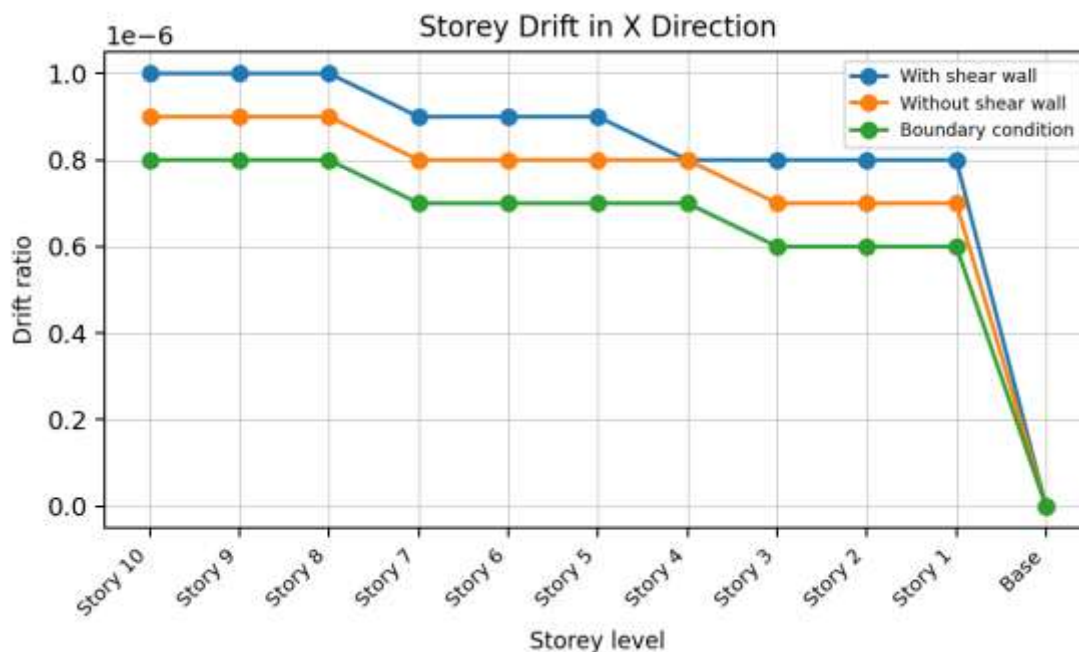


Figure 3. Storey drift profile in X direction

Table 7. Storey drift in Y direction

Storey level	With shear wall	Without shear wall	Boundary condition
Story 10	0.0000010	0.0000009	0.0000008
Story 9	0.0000010	0.0000009	0.0000008
Story 8	0.0000010	0.0000009	0.0000008
Story 7	0.0000001	0.0000009	0.0000007
Story 6	0.0000009	0.0000008	0.0000007
Story 5	0.0000009	0.0000008	0.0000007
Story 4	0.0000009	0.0000008	0.0000007
Story 3	0.0000008	0.0000008	0.0000006
Story 2	0.0000008	0.0000007	0.0000006
Story 1	0.0000008	0.0000007	0.0000006
Base	0.0000000	0.0000000	0.0000000



Figure 4. Storey drift profile in Y direction

The base shear profiles in both X and Y directions are almost identical among the compared storey-wise output cases because the mass and design seismic force distribution remain nearly the same. At the top level, the base shear values in X direction are 1.1165 kN, 1.1161 kN and 1.1163 kN, while the Y-direction values are 1.1164 kN, 1.1162 kN and 1.1163 kN. The base reaction is reported as -1.53 kN, indicating reaction force direction opposite to the applied lateral force. These results imply that changes in wall configuration have greater influence on deformation control than on storey-wise base shear magnitude when mass and loading are unchanged.

The overall discussion indicates that wall configuration should not be evaluated only by base shear. A stiffer structure may attract greater lateral force, but its serviceability performance can improve substantially because of lower displacement and drift. The dumbbell or boundary-element wall system provides a favourable balance by improving ductility and energy dissipation through coupled action. For practical design, the optimum wall configuration should satisfy code drift limits, maintain architectural usability, reduce torsional irregularity and ensure sufficient detailing of boundary regions and coupling beams.

Table 8. Base shear in X direction

Storey level	With shear wall	Without shear wall	Boundary condition
Story 10	1.1165	1.1161	1.1163
Story 9	1.1161	1.1159	1.1161
Story 8	1.1155	1.1155	1.1155
Story 7	1.1151	1.1151	1.1151
Story 6	1.1149	1.1149	1.1149
Story 5	1.1135	1.1135	1.1135
Story 4	1.1123	1.1123	1.1123
Story 3	1.1001	1.1001	1.1001
Story 2	1.0199	1.0199	1.0199
Story 1	1.0065	1.0065	1.0065
Base	-1.53	-1.53	-1.53

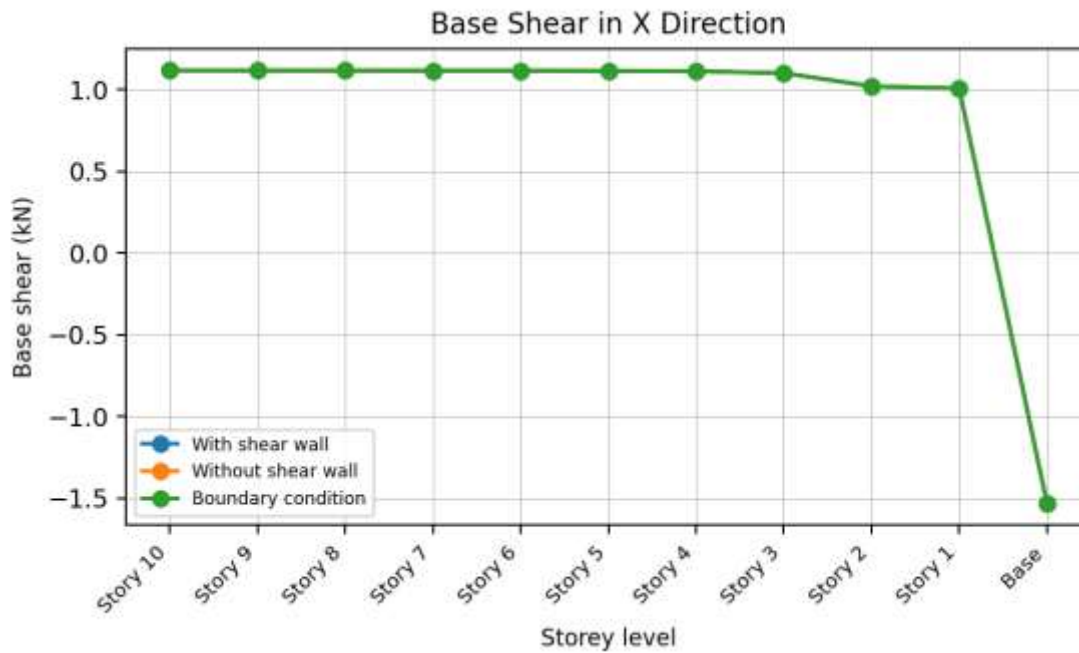


Figure 5. Base shear profile in X direction

Table 9. Base shear in Y direction

Storey level	With shear wall	Without shear wall	Boundary condition
Story 10	1.1164	1.1162	1.1163
Story 9	1.1161	1.1159	1.1161
Story 8	1.1155	1.1155	1.1155
Story 7	1.1151	1.1153	1.1151
Story 6	1.1149	1.1149	1.1149
Story 5	1.1135	1.1135	1.1135
Story 4	1.1123	1.1122	1.1123
Story 3	1.1001	1.1001	1.1001
Story 2	1.0199	1.0199	1.0199
Story 1	1.0065	1.0065	1.0065
Base	-1.53	-1.53	-1.53

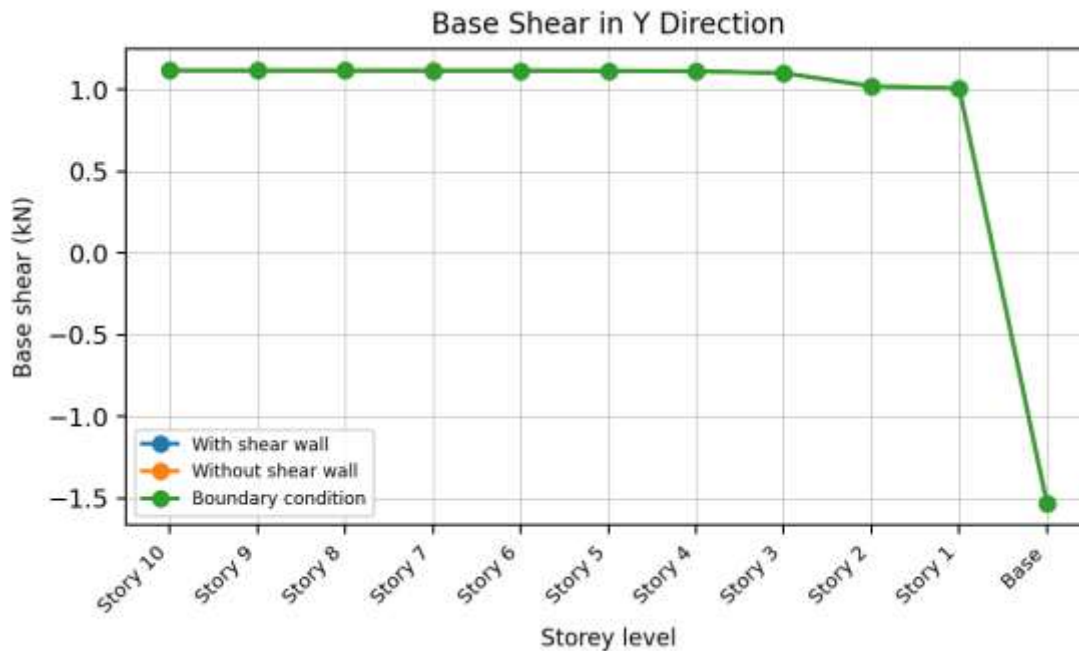


Figure 6. Base shear profile in Y direction

5. Conclusion

The comparative research confirms that shear wall configuration strongly influences the seismic response of reinforced concrete multi-storey buildings. Conventional shear walls improve lateral resistance and displacement control compared with an ordinary frame system, but the boundary-element or dumbbell/coupled wall configuration provides better overall seismic performance due to enhanced stiffness, ductility and energy dissipation capacity.

The validation results show a reduction in maximum displacement from 84.5 mm in the model without shear wall to 28.7 mm in the boundary-element shear wall model. The fundamental time period reduces from 1.75 s to 1.05 s, while lateral stiffness increases from 11.2 kN/mm to 30.5 kN/mm. These findings demonstrate that the inclusion of properly detailed wall elements improves global rigidity and reduces seismic deformation demand.

Storey displacement and storey drift results in both X and Y directions show that the boundary condition consistently produces the lowest response values across the building height. Although base shear values remain close in the storey-wise output tables, the displacement and drift results demonstrate the practical benefit of optimized wall configuration. This confirms that performance-based comparison should consider deformation parameters in addition to force parameters.

The study recommends the use of optimized dumbbell or boundary-element shear wall systems for medium-rise reinforced concrete buildings in seismic regions where both structural safety and architectural flexibility are important. Future work may include nonlinear pushover analysis, time-history analysis using multiple ground motions, cost comparison, reinforcement detailing checks and experimental validation of coupling beam behavior.

6. Limitations and Future Scope

The present study is limited to analytical modelling and interpretation of available ETABS output. The results are suitable for comparing global seismic response; however, detailed member-level reinforcement design, construction sequence effects, soil-structure interaction and nonlinear material degradation are outside the scope of the present paper. The reported storey-wise displacement and drift values should also be verified against the final ETABS model before journal submission because one Y-direction drift entry in the extracted table appears inconsistent with the surrounding values.

Future work can extend the research by performing nonlinear static pushover analysis and nonlinear time-history analysis using multiple earthquake records. Such analysis would help identify plastic hinge formation, coupling beam

yielding sequence, damage distribution and collapse prevention performance. A parametric study may also be conducted by varying coupling beam depth, wall pier thickness, boundary-element dimensions, concrete grade, reinforcement ratio and wall location in plan.

A cost and constructability comparison should be added to determine whether the improved performance of the dumbbell or boundary-element wall system justifies additional reinforcement detailing and formwork complexity. Experimental validation using scaled wall specimens or comparison with published cyclic wall tests would further strengthen the reliability of the numerical conclusions. Finally, the research can be expanded to irregular buildings, soft-storey buildings and buildings located in higher seismic zones to evaluate the robustness of the proposed configuration under more demanding structural conditions.

Recent data-driven and resilient-wall studies also indicate that future seismic assessment can incorporate machine-learning backbone models, explainable deformation-capacity prediction and modular rocking wall concepts (Aghagholizadeh, 2024; Deger & Kaya, 2021; Deger et al., 2023). These methods can be used along with ETABS-based linear analysis to develop more comprehensive performance-based design recommendations for conventional, coupled and dumbbell shear wall systems.

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