

# Optimization Of Variable Thickness and Distributed Shear Walls in High-Rise Residential Buildings Using ETABS For Enhanced Seismic Response

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**Abstract**—Earthquake forces are among the most critical design considerations for high-rise reinforced concrete (RC) structures, necessitating efficient lateral load-resisting systems to ensure safety and serviceability. This study investigates the seismic performance of a G+20 high-rise residential building by incorporating shear walls with varying thickness, location, and configuration using ETABS. The architectural plan of the building was prepared using AutoCAD, and the structural model was developed based on the finalized layout. Initially, the building was analyzed without shear walls to assess its inherent seismic response. The results indicated higher lateral displacement, increased storey drift, and a larger fundamental time period due to insufficient lateral stiffness. To enhance structural performance, the building height was divided into multiple zones based on seismic demand. Shear walls with variable thickness were then provided, assigning greater thickness in lower zones where seismic forces are higher and gradually reducing the thickness towards the upper levels. A comparative analysis was carried out between models with and without shear walls. The results demonstrated a significant reduction in displacement and storey drift, improved storey shear distribution, and enhanced overall lateral stiffness. The zonal arrangement of shear walls also contributed to efficient material utilization without compromising structural safety. The study concludes that the provision of distributed shear walls with variable thickness based on structural demand is an effective and economical strategy for improving the seismic buildings.

**Index Terms**—Auto CAD, ETABS, Shear walls Response Spectrum Analysis.

## I. INTRODUCTION

Rapid urbanization and population growth have led to the construction of many high-rise residential buildings in modern cities. As the height of buildings

increases, the effect of lateral loads such as wind and earthquake become more significant. These lateral forces can cause excessive displacement, storey drift, and structural instability if not properly controlled. Therefore, providing adequate lateral load resisting systems is essential in high-rise structures. Reinforced concrete shear walls are widely used as an effective structural element to resist lateral loads and improve the overall stiffness of buildings. Shear walls help in reducing storey drift, increasing strength, and improving the seismic performance of tall buildings. Structural analysis and design software such as ETABS is commonly used by engineers to evaluate the behaviour of high-rise buildings under different loading conditions. In conventional practice, shear walls are often designed with uniform thickness along the height of the building. However, the lateral load demand is not uniform throughout the structure. The lower storeys generally experience higher forces compared to the upper storeys. Providing the same thickness throughout the height may lead to unnecessary material usage and increased construction cost.

To address this issue, the present study focuses on the optimization of distributed shear walls with variable thickness in a high-rise residential building. This study presents the structural analysis and optimization of variable thickness distributed shear walls in a G+20 high-rise residential building using ETABS. The architectural plan of the building was prepared using AutoCAD, and the structural model was developed in ETABS based on the finalized layout. The building model is analysed using ETABS software, and shear wall thickness is varied based on the demand at different zones of the structure. The objective is to

improve structural performance while reducing material consumption and ensuring that storey drift and other structural parameters remain within permissible limits

## II. LITERATURE REVIEW

Hosen,2024 Optimal Shear Wall Placement for Seismic Performance. This study examines the influence of shear wall placement on the seismic performance of multi-storey buildings. The results indicate that centrally and symmetrically placed shear walls significantly reduce lateral displacement, storey drift, and torsional effects, thereby improving overall structural stability. The study also highlights that improper or asymmetrical placement of shear walls can lead to torsional irregularities and reduced performance, emphasizing the importance of proper planning in design.

R. S. Londhe, V. R. Tenagi “Seismic Performance Evaluation of RC Buildings with Distributed Shear Walls” This study focuses on the seismic behaviour of RC buildings with distributed shear walls. It concludes that proper distribution and placement of shear walls significantly increase structural stiffness and strength, while reducing storey drift. The research emphasizes that shear walls are essential structural elements for improving the seismic performance and safety of high-rise buildings.

A. B. Patil and M. R. Wakchaure (2017) in International Journal of Engineering Science and Computing conducted a comparative analysis of multi-storey buildings with and without shear walls. The study evaluates parameters such as storey displacement, drift, and base shear under seismic conditions. Results indicate that buildings without shear walls are more flexible and experience larger deformations. In contrast, structures with shear walls exhibit higher stiffness and better load resistance. The inclusion of shear walls significantly improves performance and reduces structural damage. The research emphasizes their importance in designing earthquake resistant buildings.

S. K. Duggal (2018) in International Journal of Civil Engineering Research studied the seismic behaviour of reinforced concrete (RC) buildings with shear walls

placed at different locations. The study mainly focuses on how the positioning of shear walls affects the response of structures under earthquake loads. It was observed that shear walls significantly enhance lateral stiffness and reduce horizontal displacement. Buildings with properly positioned shear walls showed better resistance to seismic forces and improved structural integrity. The research also highlights that improper placement may lead to inefficient load transfer and increased vulnerability. Hence, the study concludes that strategic location of shearwalls is essential for achieving stability and safety

P. Agarwal and M. Shrikhande (2015) in International Journal of Advanced Structural Engineering carried out dynamic analysis of tall buildings with different shear wall arrangements. The study focuses on the response of structures under dynamic loads such as earthquakes and wind forces. It was observed that proper arrangement of shear walls reduces vibrations and enhances overall stability. The analysis also considers time period, mode shapes, and frequency. Buildings with well-planned shear wall systems show better resistance to lateral forces. The study concludes that dynamic behaviour plays a crucial role in structural safety and performance.

M. K. Sharma and R. Gupta (2016) in Journal of Earthquake Engineering investigated the influence of shear wall position on seismic response of building structures. The study reveals that improper placement can lead to torsional irregularities and uneven stress distribution. Balanced and symmetrical positioning helps in minimizing such effects. The research also evaluates different configurations to determine the most efficient arrangement. Results show improved stability and reduced damage when shear walls are properly located. The study emphasizes the importance of careful planning in structural design.

K. S. Rao and V. V. Prasad (2021) in Materials Today: Proceedings evaluated the performance of multi-storey buildings with shear walls using ETABS software. The study analyzes key parameters such as storey displacement, storey drift, base shear, and structural stiffness. Results show that the presence of shear walls significantly reduces deformation and capacity. The use of ETABS provides accurate

simulation of structural behaviour under seismic loads. The study demonstrates that shear walls improve overall rigidity and performance. It confirms their effectiveness in modern structural design.

R. K. Raj and P. Srinivasan (2019) in Asian Journal of Civil Engineering analyzed the effect of shear wall location on high-rise buildings. Different configurations such as central core, edge placement, and asymmetric positioning were studied. The results show that centrally located shear walls provide uniform load distribution and reduce torsional effects. Asymmetrical placement can lead to uneven stress distribution and increased drift. The study also considers parameters like displacement and time period. It concludes that proper planning of shear wall location is crucial for achieving better seismic performance.

N. Subramanian (2020) in International Journal of Structural Engineering examined RCC frame structures with different shear wall configurations. The research highlights how configuration and alignment influence stiffness, strength, and load transfer mechanisms. It was observed that buildings with well-distributed shear walls show improved seismic resistance and reduced deformation. The study also compares various models to understand performance differences. Improper configuration may lead to reduced efficiency and instability. The research concludes that optimal design and arrangement of shear walls are essential for safe construction.

### III. RESEARCH METHODOLOGY

#### 1. VALIDATION

The developed structural model was validated to ensure the accuracy and reliability of the analysis results. Validation was carried out by comparing the obtained results with standard codal provisions and reference studies. Key parameters such as storey displacement, inter-storey drift, base shear, and fundamental time period were checked against permissible limits as specified in relevant design codes.

Additionally, the analysis results were compared with previously published research works to verify consistency in structural behaviour. The modelling assumptions, material properties, and loading

conditions were also carefully reviewed to ensure correctness. This validation process confirmed that the model is capable of accurately representing the seismic behaviour of the structure and that the results obtained are reliable for further evaluation and comparison.

#### 2. ARCHITECTURAL PLAN OF G+20 STOREY BUILDING

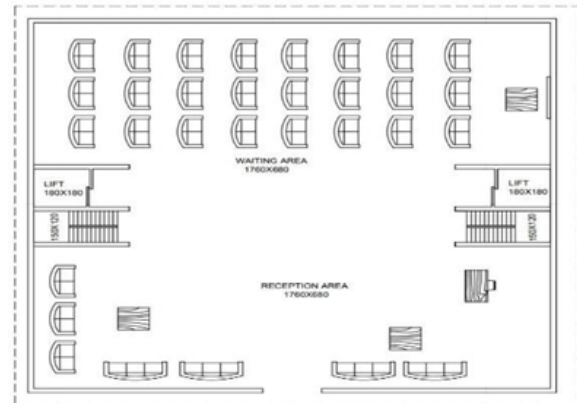


Figure 1 Ground Floor Plan

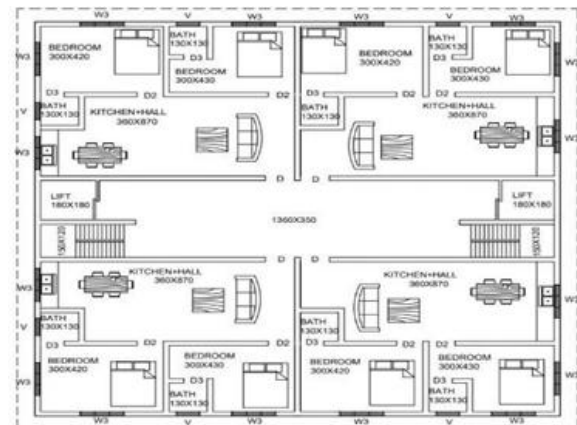


Figure 2. 20 Storey Plan

#### 3. MODELLING OF BUILDING BY USING ETABS

The building was modelled using ETABS based on the finalized architectural plan. A three-dimensional model of the G+20 reinforced concrete structure was created by defining structural elements such as beams, columns, slabs, and shear walls along with material properties. Loads including dead load, live load, and seismic load were applied as per relevant codes, and suitable load combinations were considered. The model was then analyzed to evaluate structural behavior in terms of displacement, storey drift, and overall stability under seismic loading.

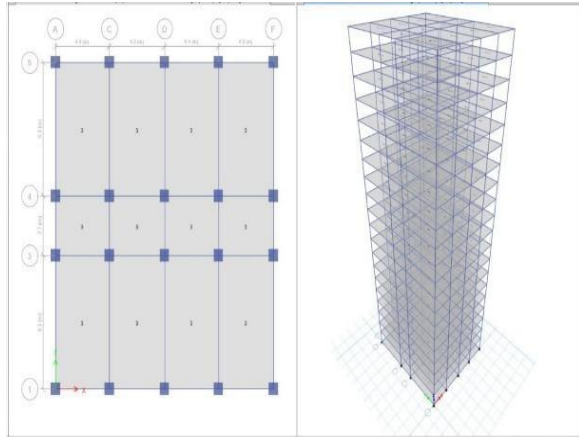


Figure 3 Load assessment view

#### 4. CREATING DEMAND ZONES

In this study, the building height was divided into five demand zones based on the variation of seismic forces along the height. The lower storeys experience higher seismic demand due to greater load accumulation, while the upper storeys are subjected to comparatively lower forces. Accordingly, the structure was segmented into five zones, and shear wall thickness was varied in each zone. Thicker shear walls were provided in the lower zones to resist higher forces, and the thickness was gradually reduced towards the upper zones.

This zonal approach ensures efficient utilization of materials while maintaining structural safety and improved seismic performance

#### 5. DISTRIBUTED SHEARWALLS AND VARIABLE THICKNESS OF SHEARWALLS

Table 1 Shearwall thickness distribution

FLOORS	THICKNESS (mm)
0-4	400
5-8	350
9-12	300
13-16	250
17-20	200

The shear wall is placed at the centre of the building to ensure uniform distribution of lateral forces and to reduce torsional effects. This improves overall stability and reduces displacement and storey drift. The figure 4 shows the central placement of the shear wall in the building plan.

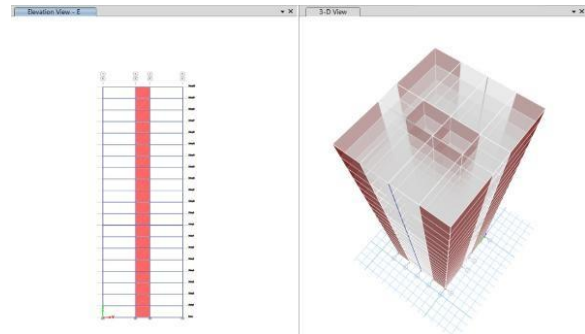


Figure 4 Centre placement of shearwalls

The shear wall is placed at the corners of the building to increase lateral stiffness and improve structural strength. This arrangement helps in resisting seismic forces effectively, but improper or unsymmetrical placement may lead to torsional effects. The figure 5 shows the corner placement of shear walls in the building plan.

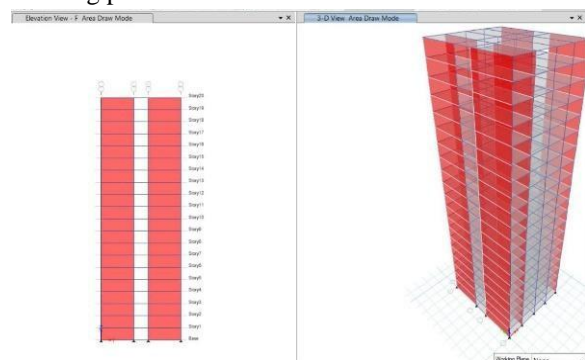


Figure 5 Corner placement of shearwalls

The shear walls are provided at the corners along with the central core to improve lateral stiffness and structural performance. The corner walls increase rigidity, while the central wall ensures uniform force distribution and reduces torsion. This arrangement improves stability and reduces displacement and storey drift. The figure shows the placement of shear walls at the corners along with the central core of the building plan.

#### 6. RESPONSE SPECTRUM ANALYSIS

Shear wall thickness was varied based on demand zones, and shear walls were provided at both the central core and corner regions of the building. Response Spectrum Analysis was then performed to evaluate the seismic behaviour of the structure. The analysis helped in assessing parameters such as displacement, storey drift, and overall stability.

7. RESULTS

The results were obtained from Response Spectrum Analysis carried out on the structural model. Key parameters such as displacement, storey drift, base shear, and time period were evaluated for both models with and without shear walls. These values were compared using graphical representations to clearly understand the variation in structural behaviour. The comparison helps in identifying the effectiveness of shear walls in improving the seismic performance of the building.

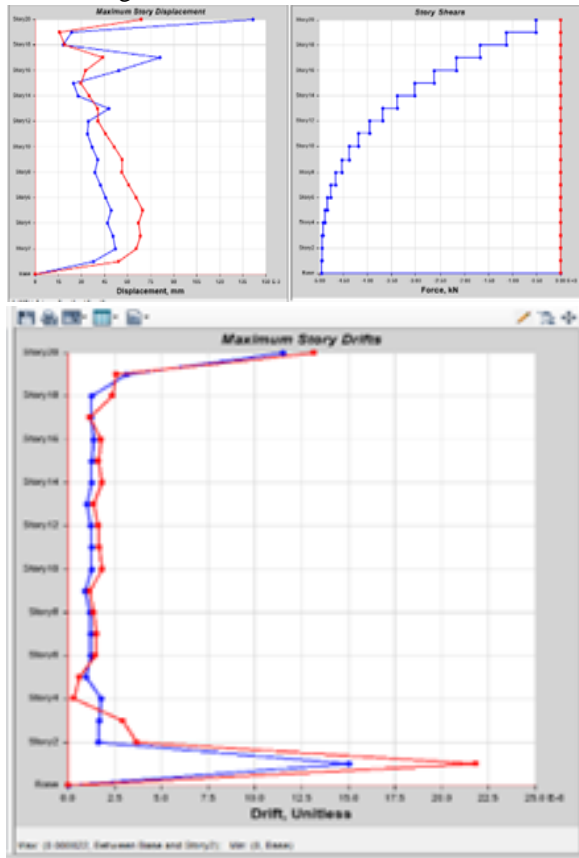


Figure 6 Displacement drift and shear graph of without shearwall model

Table 2 Storey wise displacement, drift and shear values of without shearwall model

STOREY	DISPLACEMENT	DRIFT	SHEAR
0	0	0	-4.99
1	55	22	-4.93
2	67	3.5	-4.93
3	70	2.7	-4.8
4	66	0.1	-4.76

5	73	0.6	-4.74
6	67	1.5	-4.7
7	60	1.5	-4.6
8	67	1	-4.6
9	58	0.9	-4.51
10	55	2.3	-4.45
11	45	2.2	-4.3
12	43	2	-3.98
13	43	0.9	-3.8
14	33	2.3	-3.3
15	30	0.8	-2.6
16	31	2.3	-2.2
17	44	1.3	-2.2
18	16	2.4	-1.3
19	15	2.5	-0.50
20	67	13	-0.50

Table 3 Time period

MODE	PERIOD (Sec)
1	1.064
2	0.992
3	0.904
4	0.494
5	0.467
6	0.462
7	0.443
8	0.419
9	0.402
10	0.267
11	0.257
12	0.232

The model without shear walls showed higher displacement and inter-storey drift due to low lateral stiffness, making the structure more flexible and vulnerable under seismic loads. It also had a higher time period and inefficient base shear distribution, leading to increased deformation and instability. Overall, the absence of shear walls results in poor

seismic performance and reduced structural safety.

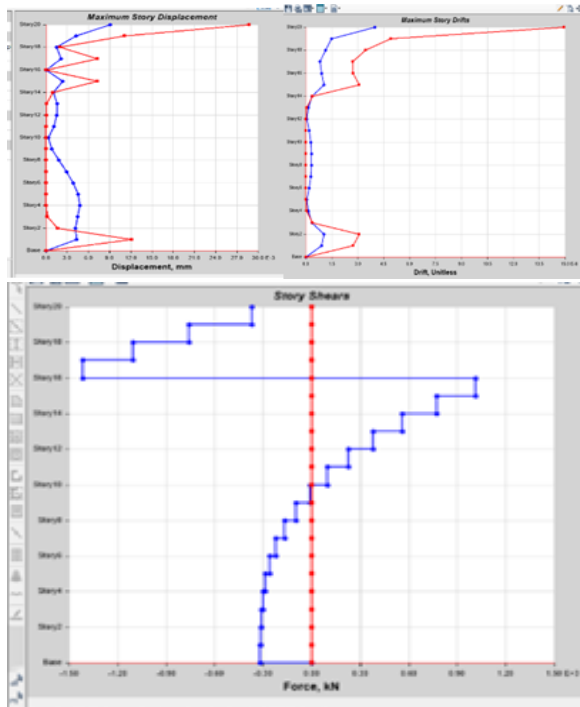


Figure 7 Displacement drift and shear graph of with shear wall model

Table 4 Storey wise displacement, drift and shear values of with shear wall model

Storey	Displacement (Mm)	Drift	Shear
0	0	0	-0.31
1	4	0.9	-0.31
2	3.9	1	-0.31
3	4.5	0.5	-0.30
4	5	0.2	-0.30
5	4.5	0.1	-0.29
6	3.3	0.2	-0.28
7	3	0.3	-0.2
8	2	0.32	-0.19
9	1.2	0.32	-0.19
10	0.1	0.3	0
11	1.23	0.2	0.1
12	1.8	0.1	0.4
13	2.3	0.2	0.55
14	2	0.5	0.8
15	2.6	1	1
16	0	0.9	1
17	2.6	0.6	-1.3
18	2	1	-1
19	4.3	1.4	-0.88
20	8.9	3.5	-0.28

Table 5 Time period

MODE	PERIOD (Sec)
1	0.95
2	0.8
3	0.513
4	0.21
5	0.181
6	0.133
7	0.093
8	0.083
9	0.063
10	0.057
11	0.053
12	0.041

From the analysis results, it is observed that the storey displacement gradually increases from the base to the top storey, with the maximum displacement of 8.9 mm occurring at the top level. The maximum storey drift obtained is 3.5 mm, which is within the permissible limit specified by IS 1893. The storey shear values vary along the height of the structure and are comparatively higher at the lower storeys. The modal analysis shows that the fundamental time period of the structure is 0.95 seconds. The distribution of shear walls with various thicknesses improves the lateral stiffness of the structure and helps in controlling displacement and drift. Overall, the building exhibits satisfactory seismic response under lateral loading conditions.

#### IV CONCLUSION

This study focuses on optimizing the location and thickness of shear walls in a G+20 high-rise building. Analysis of different placements showed that centre and corner configurations provide better overall performance. Based on this, the building was modeled in ETABS and analyzed under relevant loads. Shear wall thickness was optimized by providing higher thickness in high-demand zones and reducing it in low-demand zones. This results in a safe, efficient, and economical structural system, with improved displacement, storey drift, shear, and time period characteristics

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