Seismic Behaviour of High-Rise Buildings with Steel-Concrete Composite Shear Walls

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***Abstract*—The increasing construction of high-rise buildings in earthquake prone regions has created a need for efficient structural systems capable of resisting significant lateral forces. Shear walls are widely adopted to improve the lateral stiffness, strength, and stability of buildings subjected to seismic loading. However, conventional Reinforced Cement Concrete (RCC) and steel plate shear walls have certain limitations, including concrete cracking, reinforcement congestion, and steel plate buckling. Steel–concrete composite shear walls have emerged as an effective alternative by combining the compressive strength of concrete with the tensile strength and ductility of steel. The present study investigates the seismic behaviour of high-rise buildings incorporating different configurations of composite shear walls using ETABS. The analytical investigation considers buildings of 20, 25, and 30 storeys and examines four composite shear wall configurations: Double Skin Composite Shear Wall (DS-CSW), Steel Encased Composite Shear Wall (SE-CSW), Steel Encased with I-Section Composite Shear Wall (SEI-CSW), and Composite Shear Wall with I-Section (I-Section CSW). Two wall thicknesses, 200 mm and 300 mm, are considered for comparison with conventional RCC shear walls. Response spectrum analysis is adopted in accordance with Indian seismic design provisions. The structural response is evaluated in terms of storey displacement, inter-storey drift, storey shear, and lateral stiffness. The study aims to identify an efficient composite shear wall configuration that provides improved seismic performance, deformation control, and structural efficiency. The findings are intended to contribute to the application of steel–concrete composite shear walls in earthquake-resistant high-rise building design.**

***Index Terms*—Steel concrete composite shear walls, seismic behaviour, high rise buildings, response spectrum analysis, storey displacement, storey drift, lateral stiffness, RCC shear walls.**

I. INTRODUCTION

Earthquakes are among the most destructive natural hazards, frequently causing extensive damage to buildings, infrastructure, and other civil engineering structures. The seismic forces generated during an earthquake can significantly influence the strength, stiffness, stability, and overall performance of buildings. With the increasing demand for high rise construction, particularly in urban and earthquake prone regions, the development of effective structural systems to resist lateral forces has become an important consideration in modern structural engineering. Buildings subjected to earthquake loading experience horizontal forces that may result in excessive lateral displacement, inter storey drift, torsional effects, and structural damage. Therefore, appropriate lateral load resisting systems must be incorporated to ensure structural safety and satisfactory seismic performance.

Shear walls are among the most effective structural elements used to resist lateral forces generated by earthquakes and wind. They are vertical structural components designed to withstand shear forces, bending moments, and axial loads transferred from other structural members. Due to their high in plane stiffness, shear walls significantly reduce lateral displacement and inter-storey drift while improving the overall stability of buildings. They also contribute to the flexural and shear strength of structures and help dissipate seismic energy. Consequently, shear

walls are widely used in high-rise residential, commercial, and institutional buildings.

Conventional RCC shear walls provide considerable compressive strength and stiffness but may experience concrete cracking, crushing, and reinforcement congestion under severe cyclic loading. Similarly, steel plate shear walls provide excellent tensile strength and ductility but are susceptible to local and global buckling. These limitations have encouraged the development of composite shear wall systems that combine the advantages of steel and concrete.

Steel concrete composite shear walls utilize the complementary properties of both materials. Concrete provides compressive strength, stiffness, durability, and fire resistance, whereas steel contributes tensile strength, ductility, and energy dissipation capacity. The interaction between these materials improves the overall load carrying capacity and deformation behaviour of the wall system. Depending on their configuration, composite shear walls can also provide improved resistance against buckling, reduced wall thickness, and efficient utilization of construction materials.

Different composite shear wall arrangements have been developed, including double-skin composite walls, steel-encased composite walls, steel encased walls with I-section boundary elements, and walls incorporating structural I-sections. Their seismic performance depends on several parameters, such as wall thickness, steel arrangement, material properties, building height, and structural boundary conditions.

The present research investigates the seismic behaviour of high-rise buildings incorporating different steel concrete composite shear wall configurations. Analytical models are developed using ETABS, and response spectrum analysis is performed for buildings of 20, 25, and 30 storeys. The performance of composite shear walls is compared with conventional RCC shear walls to evaluate their effectiveness in controlling lateral displacement, inter storey drift, and improving structural stiffness.

II. REVIEW OF LITERATURE

Research on composite shear walls has increased considerably due to their potential to improve the seismic performance of high-rise buildings. Previous analytical and experimental investigations have examined different configurations of steel–concrete composite walls and compared their behaviour with conventional reinforced concrete and steel plate shear walls.

Experimental investigations on composite shear wall systems have indicated improvements in lateral stiffness, ultimate shear strength, ductility, and energy dissipation capacity. The interaction between steel and concrete enables the system to resist significant lateral forces while controlling deformation. Steel plates also provide confinement to concrete and help improve the stability of the composite wall.

Studies on double-skin composite shear walls have highlighted their ability to provide enhanced stiffness and strength through the interaction of concrete and external steel plates. However, fabrication and connection detailing remain important considerations.

Investigations on steel-encased composite shear walls have demonstrated the advantages of using steel plates to improve the strength and deformation characteristics of concrete walls. The steel encasement provides additional tensile resistance and helps control local instability.

Research on steel-encased composite shear walls with I-section boundary elements has indicated that structural steel sections can improve flexural resistance, stiffness, and buckling resistance. The arrangement of I-sections at suitable locations also influences the overall deformation behaviour of the wall.

Previous comparative studies have further emphasized the importance of building height, wall thickness, and shear wall positioning in determining seismic response. However, comprehensive comparisons of different composite shear wall configurations in 20 – 30 storey buildings remain an important area of investigation.

1. Traditional RCC Shear Walls and Their Limitations

Reinforced cement concrete (RCC) shear walls have been widely used as lateral load-resisting systems in seismic regions because of their high stiffness and strength. Several studies, including Phadnis and Kulkarni (2013) and Chowdary and Pandian (2014), have demonstrated that RCC shear walls effectively reduce lateral displacement and storey drift, thereby improving the stability of buildings under seismic

loading. However, Kaushik and Dasgupta (2015) highlighted certain limitations, such as susceptibility to cracking at wall slab junctions and deterioration of energy dissipation capacity under repeated cyclic loading. Additionally, the considerable thickness and self-weight of RCC shear walls reduce usable floor space in urban high-rise buildings. These limitations create a demand for alternative structural systems offering higher strength to weight ratios and improved seismic performance.

2. Emergence and Advantages of Composite Shear Walls

The combination of steel and concrete in composite shear walls provides improved ductility, strength, and reduced weight compared with conventional RCC shear walls. Early foundational research by Wright and Gallocher (1995) demonstrated the improved behaviour of composite walls under service and construction loads, establishing their potential as an effective structural system. Yüksel and Unal (2015) investigated composite shear walls incorporating L-shaped steel sections in the boundary regions and confirmed that steel components provide effective confinement, improve load transfer, and enhance overall seismic performance. Similarly, Reslan et al. (2018) demonstrated that composite shear walls provide better energy absorption and post-yield behaviour, making them suitable for multi-storey buildings in seismic zones. The major advantages of composite shear walls include reduced wall thickness without compromising structural strength, enhanced ductility and energy dissipation capacity, lower self-weight resulting in potential savings in construction and foundation costs, and increased usable floor area, which is particularly important in urban high-rise construction.

3. Configurations and Parametric Variations of Composite Shear Walls

Various configurations of composite shear walls have been investigated to improve their structural performance under different loading conditions. Double Skin Composite Shear Walls (DS-CSWs) consist of steel plates provided on both sides of a concrete core. Research by Wenhui et al. (2021) demonstrated that DS-CSWs provide effective confinement and increased stiffness due to the larger steel area, although their fabrication and connection details may be relatively complex. Steel Plate Encased Composite Shear Walls (SE-CSWs), investigated by Wei Wang et al. (2018), demonstrated a favourable combination of strength and ductility by encasing concrete within steel plates. These walls are effective in improving shear capacity and controlling local buckling. Steel Plate Encased with I-Section Boundary Elements (SEI-CSWs) have also attracted attention because the additional I-section boundary members provide stiffness and resistance against buckling, thereby improving moment resistance and reducing lateral displacement. Studies such as Yüksel and Ünal (2015) have reported the advantages of steel boundary elements in enhancing composite wall performance. Another configuration consists of shear walls with I-section elements at their ends, which can efficiently resist bending and shear forces simultaneously. However, comparatively limited research has focused on this configuration. Milan Sitapara et al. (2016) and Patel and Bhagat (2018) conducted parametric studies demonstrating that the type of composite shear wall and the detailing of its boundary elements significantly influence seismic response parameters such as displacement, drift, and stiffness.

4. Seismic Performance: Analytical and Experimental Investigations

Considerable research has been carried out to understand the seismic behaviour of composite shear walls through experimental investigations and numerical simulations. Chen et al. (2019) investigated steel plate concrete shear walls with openings and demonstrated that composite action helps maintain seismic capacity despite geometric discontinuities. Nie et al. (2020) conducted cyclic loading tests on reinforced concrete shear walls, providing valuable insights into their failure mechanisms under combined tension, bending, and shear. Although these investigations focused on RCC shear walls, their experimental approaches provide a useful basis for evaluating the behaviour of composite shear wall systems. Dawari et al. (2021) compared RCC and composite shear wall systems using dynamic analysis. Their findings indicated that composite shear walls generally provide better seismic performance than RCC shear walls across different building heights in terms of reduced lateral displacement and storey drift, along with increased

lateral stiffness. Vijayan et al. (2020) investigated different types of shear walls in high rise buildings and emphasized the importance of shear wall location and thickness in influencing structural behaviour. These findings support the need to study multi-storey buildings with different composite shear wall configurations and thicknesses.

5. Effect of Building Height and Wall Thickness

Although several studies have investigated the seismic behaviour of buildings with shear walls, many have focused on structures with heights of up to 15 storeys. The seismic response of high-rise buildings ranging from 20 to 30 storeys incorporating composite shear walls requires further investigation. Memon and Patel (2020) reported that composite shear wall performance scales effectively with increasing building height. However, comprehensive parametric studies comparing different wall thicknesses, particularly 200 mm and 300 mm, and evaluating their influence on seismic response remain limited. This research gap is significant because wall thickness directly affects the stiffness and self-weight of the structural system, which consequently influences seismic base shear, construction cost, and usable floor space.

6. Shear Wall Placement and Torsional Irregularity

Torsional irregularity caused by the asymmetric distribution of stiffness and mass is an important consideration in the seismic design of high-rise buildings. Chittiprolu and Kumar (2014) emphasized the importance of strategically positioning shear walls in irregular buildings to minimize torsional effects and improve overall structural stability. The initial stage of the present study, which investigates H-shaped buildings with shear walls located either at the central core or at the corners, is consistent with these findings. However, limited research has specifically examined the influence of such shear wall arrangements using different composite shear wall configurations. Therefore, studying the location and arrangement of composite shear walls is important for understanding their influence on displacement, drift, stiffness, and torsional behaviour.

7. Economic and Sustainability Considerations

Although several studies have established the structural advantages of composite shear walls, their economic feasibility and sustainability aspects have not been comprehensively investigated. Tedia and Maru (2014) studied the cost and design aspects of steel concrete composite structures and concluded that composite systems can offer potential life-cycle cost benefits through reduced maintenance requirements and improved seismic performance. More recent research by Xiao Yang et al. (2021) explored the integration of engineered cementitious composites (ECC) with steel plate shear walls to improve durability and sustainability. These studies highlight the importance of considering not only structural performance but also construction efficiency, long term durability, and economic benefits when selecting suitable structural systems.

The reviewed literature indicates that composite shear walls offer considerable potential for improving the seismic performance of high-rise buildings. However, further investigation is required to understand the influence of different composite shear wall configurations, wall thicknesses, and building heights on overall structural behaviour. This motivates the present research, which systematically compares DS-CSW, SE-CSW, SEI-CSW, and I-Section CSW configurations in 20, 25, and 30 storey buildings using response spectrum analysis in ETABS 2017. The study focuses on storey displacement, inter-storey drift, storey shear, lateral stiffness, and torsional effects under seismic Zone III conditions.

III. OBJECTIVES OF THE STUDY

The primary aim of this study is to investigate the seismic behaviour of high-rise buildings incorporating steel–concrete composite shear walls and to compare their performance with conventional RCC shear wall systems using ETABS. The study evaluates the seismic response of high-rise buildings with different RCC shear wall arrangements and investigates the behaviour of composite shear walls under earthquake loading through response spectrum analysis. It compares four composite shear wall configurations, namely Double Skin Composite Shear Wall (DS-CSW), Steel Encased Composite Shear Wall (SE-CSW), Steel Encased with I-Section Composite Shear Wall (SEI-CSW), and I-Section Composite Shear Wall (I-Section CSW). The influence of two wall thicknesses, 200 mm and 300

mm, is examined for buildings of 20, 25, and 30 storeys. The seismic performance of these structural systems is assessed by comparing storey displacement, inter-storey drift, storey shear, and lateral stiffness.

IV. METHOD OF ANALYSIS

Static Analysis Method

The Static Analysis Method, also known as the Equivalent Static Method, is a simplified approach used to determine the seismic response of structures. In this method, the total seismic base shear acting on a building is calculated using parameters such as seismic zone factor, importance factor, response reduction factor, and soil type, as defined in design codes like IS 1893. This base shear is then distributed along the height of the building based on the mass and height of each floor level.

For buildings with Composite Shear Walls (CSWs), which combine reinforced concrete with steel plates, this method helps evaluate lateral displacement, storey drift, and stiffness under earthquake loading. The enhanced stiffness and strength of CSWs result in reduced deformation and improved lateral load resistance compared to conventional RCC shear walls. Static seismic analysis is most suitable for regular and low- to mid-rise structures, where higher-mode dynamic effects are minimal.

Dynamic Analysis Method

The Dynamic Analysis Method evaluates the seismic response of structures by considering their time-dependent behavior under ground motion. It accounts for mass, stiffness, damping, and vibration modes, providing a more accurate representation of structural performance during earthquakes. The analysis is typically conducted using the Response Spectrum Method or Time History Method. For Composite Shear Walls (CSWs), it helps assess storey displacement, drift, base shear, and mode shapes, reflecting the improved stiffness, ductility, and energy dissipation due to steel–concrete interaction. This method is especially suitable for tall or irregular buildings, where dynamic effects play a significant role.

V. STRUCTURAL MODELLING

Structural Modelling and Analysis

ETABS is used for the three-dimensional modelling and seismic analysis of the high-rise buildings. The software provides facilities for defining structural elements, assigning material properties, applying gravity and earthquake loads, and evaluating the dynamic response of structures.

Building Configuration

The study considers an H-shaped high-rise building with different shear wall arrangements. The building models are developed for three different heights to examine the effect of increasing storey numbers on seismic performance.

Material Properties and Structural Elements

The structural models consist of reinforced concrete slabs, beams, columns, and shear walls. For composite configurations, structural steel plates and I-sections are incorporated into the concrete wall system. The material properties are assigned according to the specifications considered in the analytical model.

The composite wall components are modelled to represent their intended structural arrangement and interaction. Particular attention is given to the positioning of steel plates and I-section elements to ensure consistency between different configurations.

Parameter	Description
Software	ETABS 2017
Building configuration	H-shaped
Building heights	20, 25 and 30 storeys
Reference system	RCC shear wall
Composite wall types	DS-CSW, SE-CSW, SEI-CSW and I-Section CSW
Wall thickness	200 mm and 300 mm
Seismic zone	Zone III
Seismic analysis	Response Spectrum Analysis
Seismic design code	IS 1893:2016

Loading Conditions

The building models are subjected to appropriate gravity and seismic loading conditions. The loading patterns considered include:

- Dead load: Self weight of structural elements, calculated automatically by ETABS.
- Live load: 3 kN/m².
- Floor finish load: 1 kN/m².
- Roof load: 1.5 kN/m².
- Wall load: 2.16 kN/m.
- Earthquake loads: EQX and EQY.
- Response spectrum loads: RSX and RSY.

Seismic Parameters

The seismic analysis is carried out considering the parameters specified in the research model in accordance with IS 1893:2016.

Seismic parameter	Value
Seismic zone	III
Zone factor	0.16
Soil type	Type II
Importance factor	1.2
Response reduction factor	5
Accidental eccentricity	5%
Seismic design code	IS 1893:2016

The response spectrum method is adopted to evaluate the dynamic characteristics and seismic response of the building models in both principal horizontal directions.

Response Spectrum Analysis

Response spectrum analysis is a dynamic analysis method used to estimate the maximum response of structures subjected to earthquake ground motion. It considers the natural vibration characteristics of the building and evaluates the corresponding modal responses using a design response spectrum.

In the present study, response spectrum analysis is performed in the X and Y directions. The resulting structural responses are used to assess the influence of composite shear wall configurations on lateral displacement, storey drift, storey shear, and stiffness.

Seismic Response Parameters

The seismic performance of the different structural models is evaluated using the following parameters.

Storey Displacement

Storey displacement represents the horizontal movement of a particular floor relative to its original position. It is an important parameter for evaluating the lateral deformation of high-rise buildings under earthquake loading. Excessive displacement may cause structural and non-structural damage.

Inter Storey Drift

Inter-storey drift is defined as the relative horizontal displacement between two consecutive floors. It is generally expressed as the ratio of relative displacement to storey height. Controlling inter-storey drift is essential to prevent excessive deformation and damage to structural and non-structural components.

Storey Shear

Storey shear is the total horizontal seismic force transferred through a particular storey. It represents the lateral force-resisting demand on the structural system and is influenced by building mass, stiffness, and dynamic characteristics.

Storey Stiffness

Storey stiffness represents the resistance offered by a storey against lateral deformation. Higher lateral stiffness generally results in lower displacement and improved deformation control, although excessive stiffness must also be considered in relation to seismic force demand.

Effect of Building Height

Building height significantly influences the dynamic characteristics and seismic response of a structure. As the number of storeys increases, the fundamental time period and lateral deformation generally increase. Therefore, comparing 20, 25, and 30 storey buildings helps establish the influence of structural height on the effectiveness of different composite shear wall systems.

Numerical Input Details for RCC Shear Wall Models

Table 3.1: Numerical input for modelling details of building with shear wall model and building with core wall model

Model	RCC Core wall model	RCC Shear wall model
Plan area	37 × 31.5 m	37 × 31.5 m
Shape of building	H shape	H shape
Model name	Model 1	Model 2
No of storey	G+25	G+25
Storey height	3m	3m

Shear wall location	Only at core	At corners and at core
Column size and grade	900 × 900 mm M50	300 × 900 M50 (15th floor) M40 from 16 to 25th floor
Beam size and grade	300 × 750 mm M40	300 × 750 mm M40
Slab thickness and grade	150 mm; M40	150 mm; M40
Shear wall thickness and grade	300 mm -M50	300 mm -M50 Till 15th floor and M40 from 16 to 25th floor;

- Geometry

a) Heights: 20, 25, and 30 storeys to represent typical high rise building scenarios.

b) Shear wall thicknesses: 200 mm and 300 mm to evaluate the influence of wall thickness on seismic performance.

- Material Properties

a) Concrete Grade and Steel reinforcement specifications follow IS 456:2000.

b) Elastic modulus, density, and damping properties are input based on typical RCC values.

- Load Cases

a) Dead load, live load, floor finish, and wall load as per IS 456:2000.

b) Earthquake loads in X and Y directions generated automatically by ETABS using IS 1893:2016 parameters.

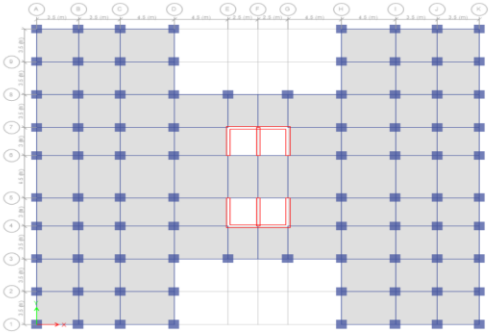
- Analysis Type

a) Linear static analysis for gravity and basic lateral load cases.

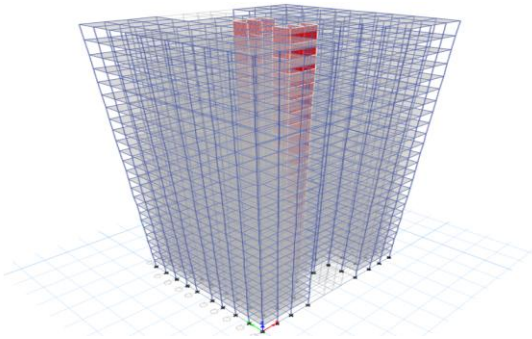
b) Response spectrum analysis for seismic response to simulate realistic earthquake ground motions considering multiple frequencies.

This approach enables comparison of the structural response such as displacement, storey drift, stiffness, and torsional behavior between buildings with different shear wall layouts and thicknesses, providing insights into optimized design for seismic resistance.

Building Model with RCC Shear Walls

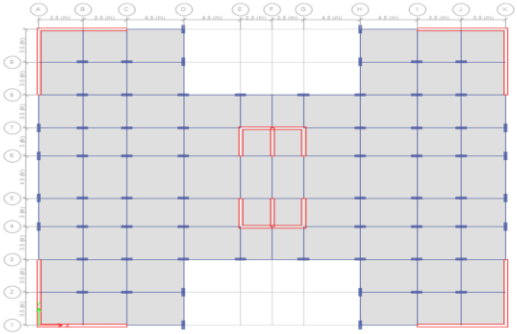


(a) Plan

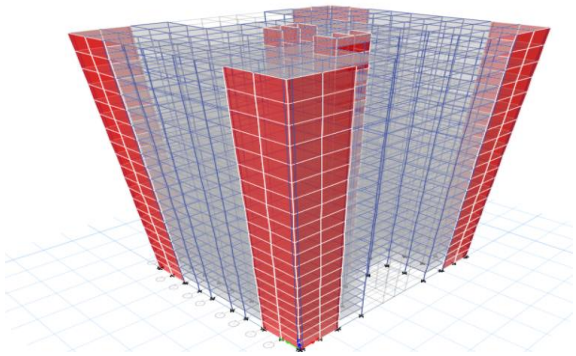


(b) 3-D view

Model 1: With Only Shear Walls at Core/Lift Area



(a) Plan



(b) 3-D view

Model 2: Model with Shear Walls at Corners along with Core Walls

VI. RESULT AND DISCUSSION

Effect on Lateral Displacement

Analysis of Lateral Displacement:

Model 1 vs. Model 2

- Comparison Basis: The lateral displacements of two building models are compared:

a) Model 1: Building with shear wall only at the core area.

b) Model 2: Building with RCC shear walls both at the corners and core.

- Permissible Displacement Limit: According to IS 456:2000, the maximum allowable lateral displacement (inter storey drift) for buildings is limited to H/500, where H is the building height. For the 25 storey building analyzed, this limit corresponds to a maximum permissible displacement of 150 mm.
- Response Spectrum Analysis Results: The results from response spectrum analysis indicate:

a) The maximum lateral displacement occurs at the top storey in both models, which is typical due to cumulative drift effects.

b) Model 2 (with 300 mm thick RCC shear walls at corners and core) shows a significant reduction in lateral displacement compared to Model 1:

- Approximately 19% reduction in the X-direction displacement.
- Approximately 12% reduction in the Y-direction displacement.
- Displacement Profile Observation: It is observed that lateral displacement increases progressively from the lower storeys up to the top, reflecting expected behavior under seismic loading as deformation accumulates along the height of the structure.
- Implications:

  The addition of corner shear walls alongside the core shear wall (Model 2) enhances lateral stiffness, effectively controlling building sway and drift under seismic forces. This leads to better structural performance and increased safety margins with displacements well within code limits.

Storey Drift

Storey Drift Analysis and Comparison

a) Definition and Allowable Limits: According to IS 1893:2016, storey drift is defined as the relative lateral displacement between two consecutive floors. The code limits this drift to a maximum of 0.004 times the storey height to ensure structural and nonstructural safety.

Given a storey height of 3 meters, the maximum permissible storey drift is:

0.004×3 m = 0.012 m =12mm

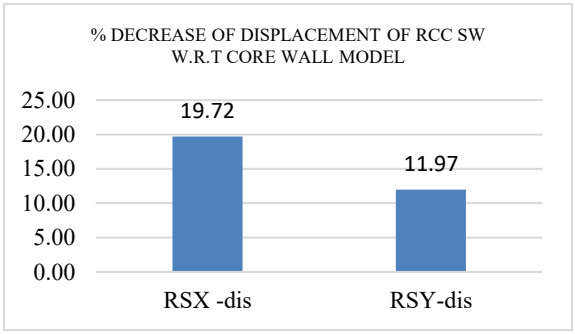


Fig. 4.1: % Decrease in Displacement (X and Y) of Model 2 vs Model 1

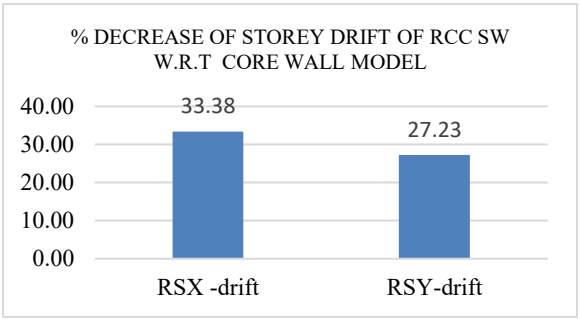


Fig. 4.2: % Decrease in Storey Drift (X & Y) of Model 2 vs Model 1 at 8th Storey

b) Observed Maximum Drift: In Model 1 (shear wall only at the core), the maximum storey drift is observed at the 8th storey. For a consistent comparison, the corresponding 8th storey in Model 2 (shear walls at corners and core) is considered.

c) Comparative Results:

Model 2 shows a significant reduction in maximum storey drift values at the 8th storey:

1) Approximately 33% decrease in the X-direction.
2) Approximately 27% decrease in the Y-direction.

d) Behavior at Upper Storeys: It is noted that, beyond the 8th storey, the storey drift in Model 2 becomes slightly higher than in Model 1, though still within the allowable limit (12 mm). This increase is minor and does not pose any safety concerns.

e) Justification for Neglecting Increased Drift at Top Storey: Since design and safety assessments

generally consider the maximum drift value in the entire building, the lower maximum drift at the 8th storey is taken as the critical value. The slightly higher drift at the top storey in Model 2 is therefore considered negligible in the overall performance evaluation.

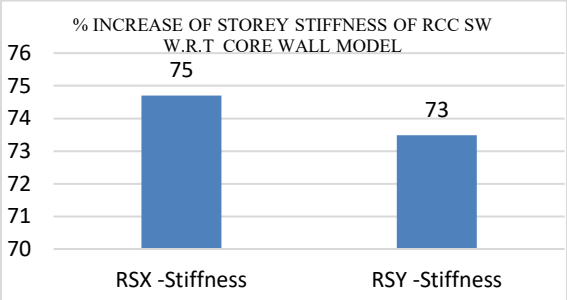


Fig. 4.3: Graphical representation of percentage decrease of storey stiffness along X and Ydirection of model 2 w.r.t model

Responses of Composite Shear Wall Models

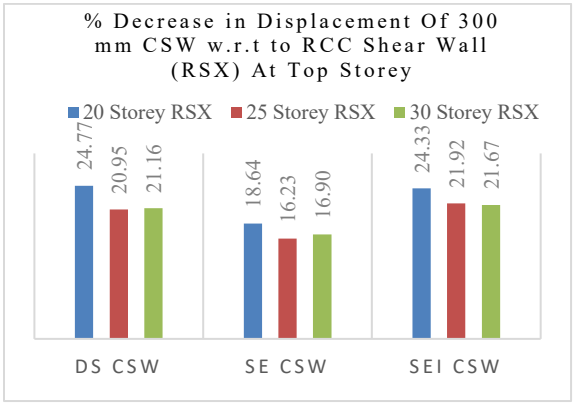
Lateral Displacement

The seismic response of structures incorporating composite shear walls was analyzed in terms of lateral displacement using response spectrum analysis. The results indicate that the introduction of composite shear walls significantly reduces lateral displacement compared to traditional RCC shear wall models. To quantify this improvement, the percentage difference in displacement between the composite shear wall models and RCC shear wall models is presented.

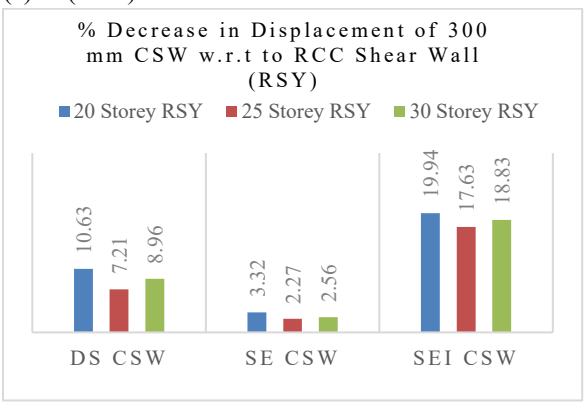
Figures compares the lateral displacement reductions for 300 mm thick composite shear walls, including Double Skin Composite Shear Wall (DS CSW), Steel Plate Encased Composite Shear Wall (SE CSW), and Steel Plate Encased Composite Shear Wall with I-Section (SEI CSW), across buildings of 20, 25, and 30 storeys in both X and Y directions. Since the maximum displacement occurs at the top storey, the percentage reduction is calculated based on the displacement at this level.

Figure follows the same comparison methodology but focuses on 200 mm thick composite shear walls. In both figures, the percentage decrease reflects the effectiveness of different composite shear wall types in reducing lateral displacement compared to conventional RCC shear walls.

The graphical results clearly demonstrate that composite shear walls effectively reduce lateral displacements. For 300 mm thick shear walls, the maximum reduction in top storey displacement is observed to be 24% in the X direction and 19% in the Y direction. In comparison, for 200 mm thick shear walls, the maximum displacement reduction at the top storey increases to 26% in the X direction and 21% in the Y direction.



(a) in (RSX) directions

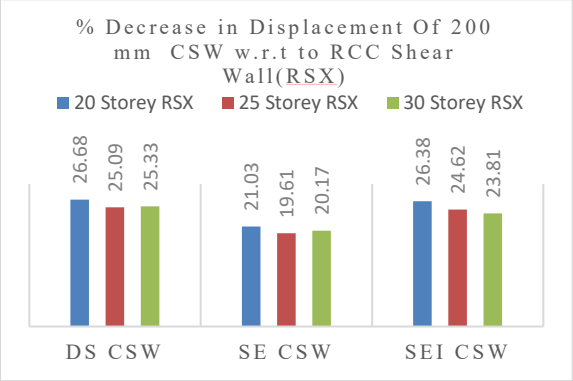


(b) in (RSY) directions

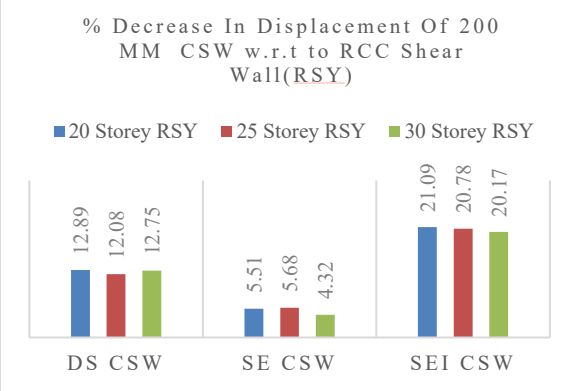
Fig. 4.4: % Decrease in Displacement of 300 mm CSW w.r.t to RCC shear wall at top storey

Among the different types of composite shear walls, the Double Skin CSW (DS CSW) and Steel Encased with I-section CSW (SEI CSW) exhibit nearly identical performance in the X direction. However, in the Y direction, the percentage decrease in displacement is lower for DS CSW than for SEI CSW. Specifically, in both X and Y directions, the SEI CSW models show displacement reductions ranging from 17% to 24% for 300 mm walls and 20% to 26% for 200 mm walls. The Steel Encased CSW (SE CSW) shows the least reduction, with displacement decreases in the Y direction as low as 2% to 5%. Additionally, it is noted that reducing the wall thickness improves performance in terms of displacement reduction for all composite shear wall

types. Lastly, the percentage decrease in displacement remains almost consistent across the different building heights (20, 25, and 30 storeys), with a slightly higher reduction observed in the 20 storey models



(a) in (RSX) direction



(b) in (RSY) direction

Fig. 4.5: % Decrease in Displacement of 200 mm CSW w.r.t to RCC shear wall at top storey

Storey Drift

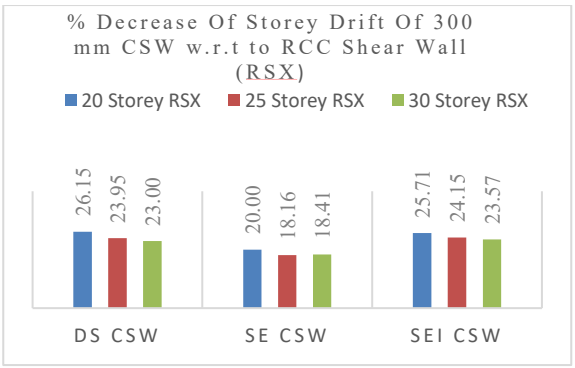
Story drift, defined as the relative lateral displacement between two consecutive storeys, should ideally be limited to less than 0.004 times the storey height to ensure structural safety and serviceability. The story drift of structures incorporating composite shear walls was evaluated through response spectrum analysis. The results indicate a noticeable reduction in storey drift with the introduction of composite shear walls.

The effectiveness of different composite shear wall (CSW) types was quantified by calculating the percentage difference in storey drift compared to traditional RCC shear wall models. These percentage differences are graphically presented in Figures.

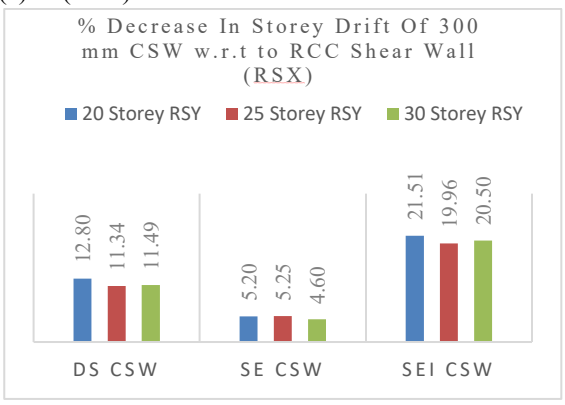
Figure illustrates the comparison for 300 mm thick shear walls in both X and Y directions, covering the Double Skin Composite Shear Wall (DS CSW), Steel Plate Encased Composite Shear Wall (SE CSW), and Steel Plate Encased Composite Shear Wall with I-Section (SEI CSW) across 20, 25, and 30 storey buildings. Figure 18 presents a similar comparison for 200 mm thick shear walls.

The maximum drift in RCC shear wall models for the 20 storey buildings was observed at the 11th storey for 300 mm walls and the 10th storey for 200 mm walls. For 25 storey buildings, the maximum drift shifted to the 13th and 12th storeys for 300 mm and 200 mm walls, respectively. In 30-storey buildings, the peak drift occurred at the 16th storey for both thicknesses.

To assess the performance of composite shear walls, the percentage reduction in storey drift was calculated at these respective storeys where the maximum drift occurred in the RCC models. This approach enables a clear understanding of the effectiveness of CSWs in controlling story drift at critical levels.

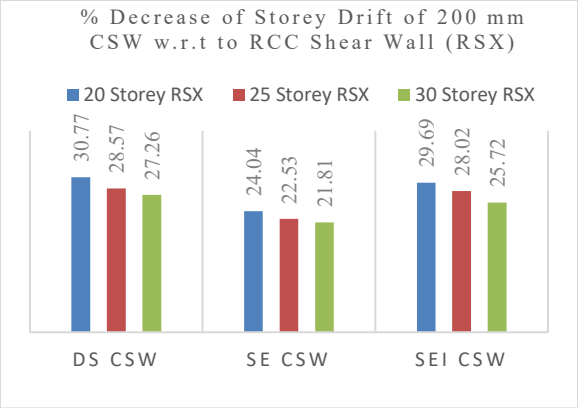


(a) in (RSX) direction

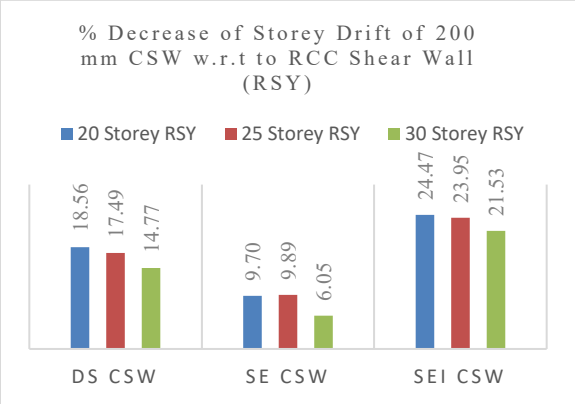


(b) in (RSY) direction

Fig. 4.6: % decrease of storey drift of 300 mm CSW w.r.t to RCC shear wall



(a) in (RSX) direction

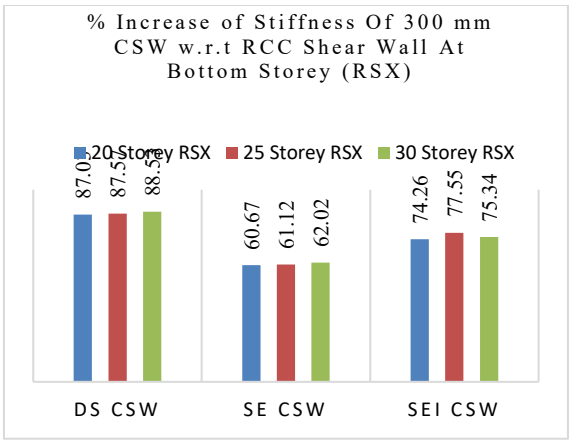


(b) in (RSY) direction

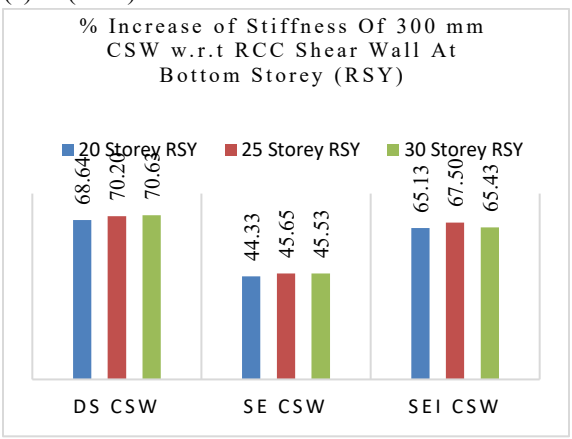
Fig. 4.7: % decrease of storey drift of 200 mm CSW w.r.t to RCC shear wall

The graphical analysis indicates that the percentage reduction in storey drift for Double Skin CSW (DS CSW) and Steel Plate Encased with I-Section CSW (SEI CSW) are nearly identical in the X direction. However, in the Y direction, the DS CSW exhibits a lower reduction in drift compared to the SEI CSW. Although the Steel Encased CSW (SE CSW) demonstrates lower performance than the other two composite shear wall types in the Y direction, its reduction in storey drift in the X direction ranges from 18% to 24% for both 200 mm and 300 mm thick walls, which falls within the range observed for the DS CSW and SEI CSW. Regarding the influence of building height, the percentage reduction in storey drift remains largely consistent, with a slight decrease as the number of storeys increases.

The maximum percentage reduction in storey drift observed is 30% for 200 mm walls and 26% for 300 mm walls in the X direction, while in the Y direction, the maximum reductions are 24% for 200 mm walls and 21% for 300 mm walls.



(a) in (RSX) direction

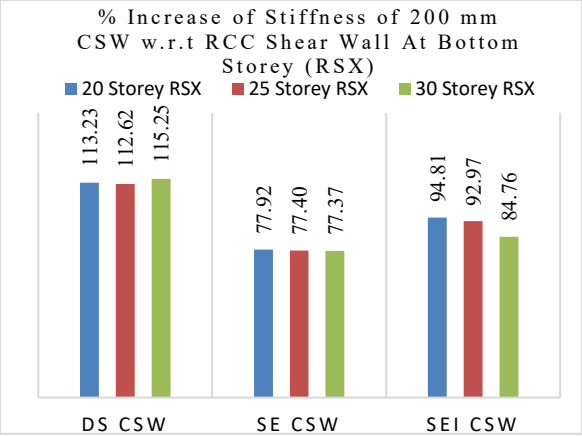


(b) in (RSY) direction

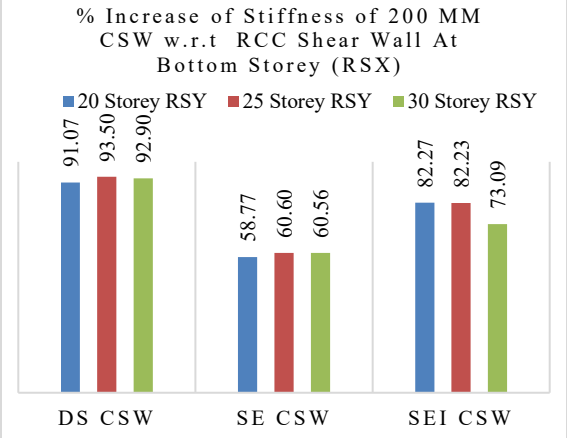
Fig. 4.8: % increase of storey stiffness of 300 mm CSW w.r.t to RCC shear wall

The percentage increase in storey stiffness is consistent across all building heights. For 300 mm thick shear walls, the highest percentage increase is observed in Double Skin Composite Shear Walls (DS CSW), attributed to the larger steel area. The percentage increase in storey stiffness ranges from 60% to 88% in the X direction and slightly lower, from 44% to 70% in the Y direction. This indicates that regardless of the composite shear wall type, a significant improvement in storey stiffness is achieved.

Similarly, for 200 mm thick shear walls, the maximum increase in stiffness is observed in DS CSW, exceeding 100% improvement. Overall, for 200 mm walls, the percentage increase in storey stiffness falls within the range of 60% to 110%. For both thicknesses, the order of maximum stiffness gain is consistent: DS CSW shows the highest increase, followed by SEI CSW, and then SE CSW



(a) in (RSX) direction



(b) in (RSY) direction

Fig. 4.9: % increase of storey stiffness of 200 mm CSW w.r.t to RCC shear wall

VII. CONCLUSION

Based on the structural analysis carried out using ETABS, the seismic performance of high-rise buildings incorporating RCC and steel concrete composite shear walls was evaluated for 20, 25, and 30 storey structures. The results demonstrate that shear walls play a significant role in improving the seismic resistance of buildings by reducing lateral displacement and inter-storey drift while increasing lateral stiffness

The seismic analysis conducted using ETABS demonstrates that steel concrete composite shear walls provide better seismic performance than conventional RCC shear walls in 20, 25, and 30 storey buildings.

- Among the configurations studied, SEI-CSW exhibited the best overall performance, reducing storey displacement by 17–24% (300 mm) and 20–26% (200 mm), and inter-storey drift by 19–25% and 21–30%, respectively.
- Its lateral stiffness increased by 65–77% and 73–94%, respectively. DS-CSW achieved the maximum stiffness improvement of 87% for 300 mm walls and 110% for 200 mm walls, while SE-CSW showed comparatively moderate improvements.
- The results indicate that 200 mm composite shear walls can provide effective seismic performance with reduced wall thickness and improved space utilization.

Overall, SEI-CSW offers the most balanced performance in terms of displacement reduction, drift control, and stiffness enhancement, making it a promising alternative to conventional RCC shear walls in high-rise buildings

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