

A Critical Review Study on Composite Shear Wall Systems for Seismic Stability of High-Rise Structures

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Abstract— The increasing construction of high-rise buildings in seismic regions requires efficient lateral load resisting systems to ensure structural safety and performance. Composite shear walls, which integrate reinforced concrete with steel plates or embedded steel sections, have emerged as an advanced structural system due to their improved stiffness, strength, and ductility. In this study, the seismic performance of high-rise buildings incorporating composite shear walls is evaluated through numerical modelling. A comparative assessment was carried out between buildings with composite shear walls and those with conventional reinforced concrete shear walls. Key structural parameters such as storey displacement, inter storey drift, and lateral stiffness were examined to assess the global structural behaviour. The results indicate that the incorporation of composite shear walls significantly reduces lateral displacement and storey drift while enhancing the overall stiffness of the structure. These findings demonstrate that composite shear walls provide an effective and reliable solution for improving the seismic performance and stability of high-rise buildings.

Index Terms— Composite shear wall, ETABS analysis, high-rise buildings, stiffness, displacement, storey

I. INTRODUCTION

In recent years, composite shear wall systems have attracted significant attention as an advanced alternative to conventional reinforced concrete shear walls. These systems typically consist of reinforced concrete panels combined with steel plates or embedded steel sections, allowing the two materials to act together and enhance structural performance. The composite action between steel and concrete improves load carrying capacity, ductility, stiffness, and energy dissipation during seismic events. Numerous

analytical and experimental studies have demonstrated that composite shear walls can effectively control lateral displacement and inter storey drift while improving the overall seismic behaviour of high-rise buildings. This review paper aims to examine previous research on the seismic performance, structural behaviour, and design considerations of composite shear walls, highlighting their advantages and potential applications in earthquake resistant tall building design.

II. CORRESPONDING LITERATURE

A. Comparative Analysis of RCC Wall and Composite Shear Wall.

Athira Haridas and S.A. Rasal, (2022)¹ Investigated the seismic behaviour of high-rise buildings using different types of composite shear walls. The study focused on improving the structural performance of tall buildings subjected to earthquake forces. A 20-storey H-shaped building model was analysed using ETABS software through response spectrum analysis. Four types of composite shear wall systems were considered in the study: Double Skin Composite Shear Wall (DS-CSW), Steel Plate Encased Composite Shear Wall (SE-CSW), Steel Plate Encased Composite Shear Wall with I-section (SEI-CSW), and Shear Wall with I-section (I-Sec-CSW). These models were compared with conventional reinforced cement concrete (RCC) shear wall systems. The performance of the structures was evaluated based on parameters such as storey displacement, storey drift, and storey stiffness. The results showed that composite shear walls significantly improved the seismic performance of the building by reducing displacement and drift

while increasing stiffness. Among the models studied, the SEI-CSW system demonstrated the best structural response and seismic resistance.

Mahammadasfak Memon and Ashutosh Patel. (2020)² conducted a comparative analytical study to evaluate the influence of composite shear walls on the seismic performance of reinforced concrete buildings. In their research, a G+20 storey building was modelled and analysed using ETABS software by applying the response spectrum analysis method. The study compared the structural behaviour of buildings with conventional reinforced concrete (RC) shear walls and composite shear walls under seismic loading conditions. Key performance parameters such as storey displacement, storey drift, and base shear were analysed to assess the effectiveness of the structural systems. The results indicated that composite shear walls significantly improve the lateral stiffness and overall seismic resistance of the building. It was observed that the structure with composite shear walls experienced lower storey displacement and reduced drift compared to the conventional RC shear wall system. Although the base shear increased slightly due to additional steel components, the overall structural stability and ductility of the building improved.

QiuHong Zhao's and Astaneh-Asl (2004)³ performed the cyclic behavior of traditional and innovative composite shear wall systems to evaluate their seismic performance in high-rise structures. The study focused on composite walls consisting of a steel boundary frame, steel plate shear wall, and reinforced concrete panel connected using bolts. Experimental cyclic tests were conducted on two half scale specimens representing the traditional system and an innovative system with a gap between the concrete wall and steel frame. The results indicated that both systems exhibited stable hysteretic behavior and high ductility, sustaining inter-story drift ratios exceeding 0.05 before significant strength degradation occurred. The innovative system reduced damage to the concrete panel while maintaining comparable strength and stiffness. Overall, the research demonstrated that composite shear walls provide effective lateral load resistance and improved seismic performance due to the combined action of steel and concrete components.

A. A. Kale and S. A. Rasal, (2017)⁴ presented a comprehensive review on seismic and wind analysis of multistory buildings, emphasizing the importance

of evaluating structural performance under dynamic loading conditions. The study highlights the increasing construction of tall buildings in seismic-prone and coastal regions of India, which makes the assessment of wind and earthquake effects essential. The authors reviewed various analytical studies where multistory buildings of different plan shapes and heights were modeled and analyzed using advanced structural software such as ETABS and STAAD.Pro. Key structural parameters including story displacement, story drift, base shear, overturning moment, acceleration, and time period were examined using response spectrum and static analysis methods. The review concludes that building configuration, height, and structural irregularities significantly influence seismic response, and wind effects become more critical for very tall buildings.

Reslan N, Masri A and Machaka M, (2018)⁵ have presented an analytical investigation on the seismic efficiency of composite shear walls (CSW) for multistory buildings. The study compared the structural performance of buildings equipped with conventional reinforced concrete shear walls (RCSW) and composite shear walls using three-dimensional numerical models developed in ETABS. Buildings of different heights (8, 14, and 20 storeys) were analyzed under seismic loading through equivalent static analysis, response spectrum analysis, and time-history analysis using the Izmit earthquake record. Key response parameters such as base shear, storey drift, and structural stiffness were evaluated to assess the lateral load-resisting capacity. The results indicated that composite shear walls reduce structural dead load and base shear while enhancing stiffness and ductility compared to conventional systems. The study concluded that CSW systems provide improved seismic resistance and structural efficiency for medium and high-rise buildings.

Nancy Kashyap and Swati Choudary, et al. (2022)⁶ conducted a comparative analytical study on the effectiveness of different shear wall configurations in irregular multistory structures subjected to seismic loading. The research focused on evaluating the influence of shear wall placement on the overall structural performance of reinforced concrete buildings. Several numerical models of irregular buildings with different shear wall arrangements were developed and analyzed using ETABS software in accordance with seismic design provisions. Key

response parameters such as storey displacement, storey drift, base shear, and lateral stiffness were examined to assess the seismic behavior of the structures. The results indicated that the strategic placement of shear walls significantly enhances structural stiffness and reduces lateral displacement and inter-storey drift. The study concluded that proper configuration and positioning of shear walls play a crucial role in improving the seismic stability and overall performance of irregular high-rise buildings.

Xiang Sun, et al. (2023)⁷ investigated the structural behavior and design methodology of a plug-in type prefabricated composite shear wall using detailed finite element analysis. The proposed system consists of prefabricated wall units connected through bolted plug-in joints to facilitate rapid on-site assembly. The numerical results indicated that the prefabricated composite shear wall exhibited damage patterns, initial stiffness, and ultimate load carrying capacity comparable to those of conventional composite shear walls with identical geometrical configurations. Under cyclic loading conditions, the wall demonstrated stable and full hysteretic loops, indicating significant energy dissipation capacity and favorable seismic performance. A parametric study further evaluated the influence of aspect ratio, axial compression ratio, and end column dimensions on hysteretic behavior. The results revealed that an aspect ratio of approximately 1.5 provides optimal seismic performance, while axial compression ratios between 0.3 and 0.7 enhance structural response. Enlargement of end column sections improved load-bearing capacity but resulted in a slight reduction in structural ductility.

Devendra R. Hargunani and S. A. Rasal (2023)⁸ conducted a comprehensive review focusing on recent developments in composite walling systems and shear wall design for improving the seismic resilience of high-rise structures. The study evaluated the structural characteristics and performance of composite shear walls composed of profiled light gauge steel sheets filled with concrete, which act together to resist lateral and seismic loads. The authors reported that steel-concrete composite wall systems provide enhanced stiffness, strength, ductility, and energy dissipation when compared with conventional reinforced concrete shear walls. The review also discussed the influence of key parameters such as wall aspect ratio, steel plate thickness, structural configuration, and openings on the overall seismic response of buildings. In addition,

the application of fiber reinforced composites was highlighted for improving confinement and mechanical performance of concrete elements. The study concluded that composite shear wall systems are an effective and reliable structural solution for improving the seismic safety of modern high-rise buildings.

Pratham Singh et al. (2023)⁹ conducted a comparative analytical study to evaluate the influence of structural plan configuration and shear wall placement on the wind response of high-rise reinforced concrete buildings using ETABS. A G+25 multi-storey building was numerically modeled with three different plan geometries rectangular, square, and C-shaped to assess their lateral load-resisting behavior under wind loading conditions. The structural performance was evaluated based on critical response parameters including storey displacement, inter-storey drift, and base shear for models with and without shear wall systems. The analysis demonstrated that the incorporation of shear walls significantly enhances the global stiffness and lateral load resistance of the structure, thereby reducing lateral displacements and drift. Among the considered configurations, the rectangular plan exhibited superior aerodynamic stability and structural efficiency by producing comparatively lower displacement and drift values. The study concluded that optimized building geometry combined with strategically placed shear walls significantly improves the wind-resistant performance of high-rise RCC structures.

Akansha Dwivedi and B.S Tyagi, (2020)¹⁰ presented a technical study on Seismic Analysis of Building with and Without Shear Wall for Building with RCC and Composite Column. The research evaluated the seismic behavior of a multi-storey building by comparing four analytical models: an RCC building without shear walls, an RCC building with shear walls, a building with composite columns without shear walls, and a composite column building with shear walls. The analysis was performed for a G+19 structure located in seismic Zone IV using equivalent static analysis and response spectrum analysis. Key structural parameters such as storey displacement, storey drift, stiffness, base shear, and lateral forces were examined to assess the seismic response of the models. The results indicated that the introduction of shear walls significantly enhances lateral stiffness and reduces storey displacement and drift. Furthermore,

buildings with composite columns exhibited improved structural performance compared to conventional RCC framed structures, demonstrating better resistance improved overall stability.

B. Seismic Analysis of RCC Wall And Composite Shear wall.

V. B. Dawari, B. M. Dawari, and H. A. Chaphekar (2021)¹¹ conducted a detailed analytical investigation on the seismic performance of multi-storey buildings incorporating reinforced concrete (RC) shear walls and composite shear wall systems. The study focused on evaluating the effectiveness of shear walls as primary lateral load resisting elements when integrated with moment resisting frames in medium- and high-rise structures. Conventional RC shear walls often suffer from reinforcement congestion near boundary elements, which limits their practical application in taller buildings. To overcome this limitation, the authors examined composite shear wall systems consisting of reinforced concrete walls with encased structural steel sections such as I-sections and hollow box profiles placed at different locations within the wall. The seismic response of buildings with RC shear walls and composite shear wall panels was comparatively analyzed by evaluating parameters such as storey displacement, inter-storey drift, base shear, and structural stiffness. The results indicated that the inclusion of encased steel profiles significantly enhances the lateral stiffness, load carrying capacity, and ductility of the structure. Furthermore, composite shear wall systems demonstrated improved energy dissipation capacity and better overall seismic performance compared to conventional RC shear walls, making them a more efficient structural system for mid-rise and high-rise buildings subjected to earthquake loading.

Athira Haridas and S. A. Rasal (2021)¹² presented a comprehensive overview of the seismic behavior of high-rise buildings incorporating composite shear wall systems. The study critically reviewed previous experimental and analytical investigations on different types of shear walls used as lateral load resisting elements in multi-storey structures. The authors highlighted that conventional reinforced concrete and steel plate shear walls have been widely adopted to resist wind and seismic loads; however, composite shear walls provide improved structural efficiency due to the combined action of steel and concrete. The

review indicated that composite shear wall systems exhibit enhanced lateral stiffness, higher ductility, and superior energy dissipation capacity under cyclic loading conditions. Furthermore, these systems contribute to reduced wall thickness, lower dead load, and improved construction efficiency. The study also reported improved seismic performance in terms of reduced storey displacement, storey drift, and storey shear. However, the authors emphasized that limited research is available on the application and design criteria of composite shear walls in high-rise buildings according to Indian seismic design standards, highlighting the need for further analytical and experimental investigations.

Wei Wang et al. (2017)¹³ conducted an extensive experimental investigation on the seismic performance of steel plate reinforced concrete composite shear walls (SPRW). In this study, a total of sixteen SPRW specimens along with three conventional reinforced concrete shear wall specimens were tested under quasi-static cyclic loading to evaluate their structural response. The research focused on critical seismic performance parameters such as failure mode, lateral load-carrying capacity, ductility, stiffness degradation, and energy dissipation characteristics. The composite wall system consisted of a steel plate embedded within the reinforced concrete panel, allowing efficient composite interaction between steel and concrete. The results demonstrated that the inclusion of an internal steel plate significantly enhanced the hysteretic behavior, ductility, and shear resistance compared with traditional RC shear walls. Furthermore, a parametric investigation was carried out to examine the influence of aspect ratio, steel plate thickness, wall thickness, and detailing configuration on seismic response. Based on the experimental observations, the authors proposed a hysteretic model and a shear capacity design equation to support the structural design of steel plate reinforced composite shear wall systems for earthquake-resistant high-rise buildings.

Anjana R. K. Unnithan and S. Karthiyaini. (2017)¹⁴ investigated the structural performance of high-rise buildings incorporating steel plate shear wall (SPSW) systems as an effective lateral load-resisting mechanism. The study focused on the design and analytical evaluation of a G+9 storey composite building subjected to seismic loading conditions. Numerical modelling and structural analysis were

carried out using ETABS, while the seismic response of the structure was evaluated through response spectrum analysis in accordance with IS 1893. Structural members were designed based on the provisions of IS 800. The research examined the influence of steel plate thickness on key structural performance parameters such as storey displacement, inter storey drift, overturning moment, and storey shear. The results indicated that the incorporation of steel plate shear walls significantly improves the lateral stiffness, ductility, and energy dissipation capacity of the structure. Furthermore, optimization of steel plate thickness contributed to enhanced seismic resistance and reduced lateral deformation, demonstrating the effectiveness of SPSW systems in improving the seismic stability of high-rise composite buildings.

Sanjivan Mahadik, et al. (2020)¹⁵ have studied the effectiveness of incorporating steel fiber reinforced concrete (SFRC) in reinforced concrete shear walls to enhance structural performance under lateral loading. The study addressed the issue of reinforcement congestion in conventional RC shear walls, particularly in boundary elements where dense transverse reinforcement is required to resist high lateral forces. To overcome this limitation, the researchers introduced steel fibers as a composite material within the concrete matrix to improve ductility, stiffness, and energy dissipation capacity while reducing the requirement for excessive reinforcement. A finite element analysis was carried out using ETABS to evaluate the behavior of shear wall models with and without openings under lateral loads. The results indicated that the addition of approximately 1.5% steel fibers improved compressive strength, modulus of elasticity, and crack resistance, while also enhancing the overall ductility and load-carrying capacity of the shear wall system. The study concluded that SFRC shear walls provide improved seismic performance and structural efficiency compared to conventional RC shear walls.

G. Sijwala, et al. (2022)¹⁶ proposed and experimentally investigated an innovative composite structural system known as the concrete filled cold-formed steel shear wall (CFCSW). The proposed wall system consists of cold formed steel channel sections welded together and subsequently filled with concrete to enhance composite interaction between steel and

concrete components. Three CFCSW specimens with an aspect ratio of 1.0 were experimentally tested under monotonic lateral loading to evaluate structural parameters such as stiffness, ultimate load-carrying capacity, ductility, and failure mechanisms. In addition, three-dimensional nonlinear finite element models were developed and validated against experimental results to accurately simulate the structural response. A comprehensive parametric study was also conducted to examine the influence of critical design parameters including wall height, steel plate thickness, weld spacing, and concrete thickness. The results indicated that increasing weld spacing and incorporating openings within the wall improved stiffness, ductility, and peak load capacity. The study concluded that the CFCSW system exhibits superior lateral load resistance and structural efficiency, making it a promising alternative for seismic-resistant composite shear wall systems in modern high-rise construction.

K. Sai Lakshmi, P. Prabha, B. Ajitha, and G. S. Palani et al. (2015)¹⁷ investigated the in-plane shear behavior of steel-foam concrete composite wall panels developed as an efficient lateral load-resisting system. The composite wall consisted of two cold-formed profiled steel sheets with a lightweight foamed concrete core connected through intermediate mild steel fasteners to ensure effective composite interaction. Experimental investigations were carried out under monotonic in plane shear loading to evaluate parameters such as ultimate shear strength, stiffness, load-deformation response, stress-strain characteristics, and failure modes. The results indicated that the intermediate fasteners effectively enhanced the steel-concrete interaction and prevented premature elastic buckling of the steel sheets. The composite panels exhibited improved shear stiffness, load-carrying capacity, and ductility due to the combined action of steel skins and foamed concrete infill, demonstrating their suitability for lateral load resistance in structural wall systems.

S. Bahadır Yuksel and Alptuğ Unal (2015)¹⁸ has presented an experimental investigation on the seismic behavior of composite shear walls incorporating L-shaped steel sections in the boundary regions. The study proposed the use of folded L-section steel plates as longitudinal reinforcement in boundary elements to

address the issue of reinforcement congestion commonly observed in conventional reinforced concrete shear walls. A one-third scaled composite shear wall specimen with an aspect ratio of 3.2 was experimentally tested under simulated cyclic lateral loading to evaluate its structural performance. The seismic response of the specimen was assessed by analyzing hysteresis curves, envelope curves, stiffness degradation, and energy dissipation characteristics. In addition, cracking patterns and deformation behavior were examined to understand the failure mechanism. The results indicated that the incorporation of L-shaped steel boundary elements significantly improved stiffness, ductility, and energy absorption capacity, demonstrating the effectiveness of composite shear wall systems for earthquake-resistant structural applications.

Ashitha V Kalam and Reshma C et al. (2019)¹⁹ has conducted a vulnerability assessment of tube-in-tube structural systems subjected to severe wind loads using dynamic wind analysis. The study evaluated the structural behavior of bundled tubular configurations by applying the Gust Factor Method to determine wind loads and the corresponding structural response. Important performance parameters such as storey displacement, storey drift, base shear, and overall stiffness were analyzed to assess the efficiency of the system. The results indicated that bundled tube structures exhibit high lateral stiffness and improved load distribution, making them highly effective for tall and super-tall buildings subjected to heavy lateral loads. The study also concluded that providing a central shear core within each tube significantly enhances the overall structural stability and lateral load resisting capacity while facilitating the accommodation of vertical transportation systems in high-rise buildings.

Khan Shaima Khan et al. (2023)²⁰ conducted an analytical study to evaluate the influence of wind loads on reinforced concrete buildings constructed on flat and sloping terrains. In this research, buildings of different heights (G+5, G+10, and G+15) were analyzed on terrain slopes of 0°, 10°, 20°, and 30°, resulting in a total of 36 structural models. The analysis was performed using ETABS software to assess wind-induced structural response for different wind zones. Key parameters such as storey displacement, storey drift, base shear, and modal time period were evaluated. The results indicated that

lateral displacement and drift increased with building height and terrain slope. It was also observed that the modal time period increased in Zones III and IV but decreased in Zone V due to higher wind intensity requiring greater structural stiffness.

Maza Mohmad Sahil et al. (2021)²¹ studied an analytical investigation on the effect of wind loads on multi-storey buildings of varying heights. The study examined G+15, G+25, and G+35 storey structures with square and rectangular plan configurations, considering different terrain categories. Wind load calculations were performed using the Gust Factor Method to evaluate the dynamic response of the structures. The analysis focused on key structural parameters such as storey displacement and storey drift under wind loading conditions. The results revealed that lateral displacement increases progressively with the increase in building height, reaching its maximum value at the top storey and gradually reducing towards the base where it becomes negligible. Furthermore, buildings located in terrain category I exhibited higher displacement and storey drift compared to those situated in terrain categories II, III, and IV due to reduced surface roughness and higher wind exposure.

III. CONCLUSION

The review clearly indicate that the inclusion of composite shear walls significantly improves the lateral load-resisting efficiency of the structural system. A substantial reduction in peak lateral displacement and inter-storey drift was observed across all building configurations, ensuring compliance with permissible drift limits and enhanced serviceability performance. The increased stiffness of composite systems contributes to better control of deformation demands and redistribution of lateral forces, thereby improving overall structural stability. Furthermore, Double Steel Plate Shear Wall (DSPW) systems exhibited superior behavior due to the confinement effect of concrete infill and the prevention of local buckling of steel plates. This results in enhanced ductility, higher energy dissipation capacity, and improved hysteretic performance under cyclic loading. The study also highlights that an increase in wall thickness from 200 mm to 300 mm leads to a proportional increase in stiffness and

corresponding reduction in displacement response, although with implications on structural weight.

In conclusion, composite shear walls, particularly DSPW configurations, demonstrate superior seismic performance over conventional RC shear walls, making them highly suitable for high-rise structures in seismic zones. Their ability to combine strength, stiffness, and ductility ensures improved structural resilience, optimized performance, and efficient material utilization in modern tall building design.

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