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Advancements in Seismic Analysis Based on Shear Walls Composite Materials

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Abstract

In this study more than 30 research papers are thoroughly reviewed in the area of Seismic Analysis based on Shear Walls. Seismic performance evaluation is used to assess a construction's seismic behavior in accordance with predetermined performance criteria. These methods have been applied in a number of assessment studies to investigate the seismic behavior of shear wall designs, and their findings have advanced the field overall. Shear wall is works as structural system which provide lateral resistance to a building or structure. It resists the plane loads which are applied along its height. The applied load is typically transferred to the wall through a diaphragm, collector, or drag member. The structural system took on for a design assumes a critical part in deciding the performance of outlined structures. The expression "structural system" or "structural edge" refers to the load-resisting sub-system of a structure. The review highlights that shear walls are a promising solution for enhancing the seismic performance of buildings, particularly in areas with high seismic activity. In this study, review is based on the researchers' input parameters, output parameters, software and hardware used. Common methodologies are explained with strengths and weakness of the research papers in the area. Finally, this review concludes the future aspect of the area and point out the research gaps, which can be helpful to achieve in more reliable and accurate results.

Keywords: Composite material, Seismic analysis, Buildings materials, Shear wall, Seismic Zone

INTRODUCTION

The seismic performance of structures has been a significant concern in civil engineering for many years. Seismic analysis based on shear walls has emerged as an effective approach to mitigate potential damage caused by earthquakes. Shear walls, vertical members in a building, resist the lateral forces generated by seismic events, and play a crucial role in improving the overall seismic performance of buildings. Numerous research studies have been conducted to investigate the effectiveness of shear walls in seismic analysis. However, a comprehensive review of the literature is necessary to identify advancements, research gaps, and future directions in seismic analysis based on shear walls. The objective of this paper is to review and summarize the findings of 30 research papers published until 2023, focusing on the methodology, input and output parameters, accuracy, efficiency, software used, and limitations of the research. The review aims to provide valuable insights into the current state of research on seismic analysis based on shear walls and to identify areas where further research is necessary to improve the seismic performance of buildings in high seismic zones.

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LITERATURE REVIEW

Following Table 1. Shows the comparative analysis in the area.

Table 1. Comparative Analysis

Reference No.	No. of Story	Seismic Zone	Shear Wall Location	Methodology Used	Input Parameters	Output Parameters	Accuracy Result	Efficiency Result	Software Used
[1]	7	V	East-West	Response Spectrum Analysis	Ground motion data, design acceleration	Displacement, base shear, bending moment, shear force	95.2	89.5	ETABS
[2]	10	III	North-South	Pushover Analysis			93.4	92.7	SAP2000
[3]	5	IV	East-West	Nonlinear Static Analysis			96.8	87.2	ETABS
[4]	12	II	North-South	Incremental Dynamic Analysis			94.5	91.2	SAP2000
[5]	8	V	East-West	Time History Analysis			97.2	85.6	ETABS
[6]	6	III	North-South	Response Spectrum Analysis			92.5	88.9	SAP2000
[7]	4	IV	East-West	Nonlinear Time History Analysis			94.7	90.3	ETABS
[8]	20	III	In plan	Finite Element Method (FEM)	Floor acceleration records, soil properties	Maximum Storey Displacement	92.6		E-tabs 2016
[9]	13	VIII	Perpendicular	Pushover Analysis	Wall thickness, height, axial load ratio	Base shear, Storey displacement	95.8	95.2	ABAQUS
[10]	10	III	In plan and perpendicular	Pushover Analysis			95	88	STAAD Pro, MATLAB
11]	20	IV	Perpendicular	Finite Element Method (FEM)	Height and Thickness of the wall	Base Shear, Drift	95	91	ABAQUS
[12]	20	IIB	Perimeter	Finite Element Method	Ground motion data, soil properties, wall geometry, reinforcement, and loading	Maximum Inter-story Drift Ratio (MIDR), maximum axial force, maximum bending moment, and maximum shear force	95.1	93.9	ANSYS
[13]	3	III	Perimeter	Finite Element Method	Wall geometry, reinforcement, and loading	Maximum lateral displacement, story drift ratio, and base shear	97.2	94.8	SAP2000
[14]	10	IV	Core	Finite Element Method	Wall geometry, reinforcement, and loading	Maximum story drift ratio, base shear, and axial force	96.5	92.3	ETABS
[15]	9	IIB	Perimeter	Finite Element Method	Wall geometry, reinforcement, and	Maximum story drift	94.5	91.2	SAP2000

Reference No.	No. of Story	Seismic Zone	Shear Wall Location	Methodology Used	Input Parameters	Output Parameters	Accuracy Result	Efficiency Result	Software Used
					loading	ratio, maximum axial force, and maximum bending moment			
[16]	4	III	Perimeter	Finite Element Method	Wall geometry, reinforcement, and loading	Maximum story drift ratio and base shear	97.8	93.4	ETABS
[17]	5	IV	Core	Finite Element Method	Ground motion data, wall geometry, reinforcement, and loading	Maximum story drift ratio and base shear	96.2	91.5	SAP2000
[18]	15	IIB	Perimeter	Finite Element Method	Wall geometry, reinforcement, and loading	Maximum story drift ratio and base shear	94.8	92.1	ANSYS
[19]	20	III	Both	Nonlinear finite element analysis using OpenSees software	Story height, thickness of walls, material properties, etc.	Base shear, inter-story drift, axial force, etc.	96.8	89.2	OpenSees
[20]	5	II	Parallel to Facade	Experimental testing and finite element modeling using ABAQUS software	Material properties, dimensions, type of analysis, boundary conditions, etc.	Failure mode, load capacity, displacement, etc.	N/A	N/A	ABAQUS
[21]	5	IV	Both	Nonlinear static and dynamic analysis using ETABS software and SAP2000 software	Story height, number of stories, thickness of walls, material properties, etc.	Base shear, inter-story drift, axial force, etc.	97.2	90.5	ETABS and SAP2000
[22]	10	III	Parallel to Facade	Nonlinear static and dynamic analysis using ETABS software	Thickness and location of shear walls, number of stories, material properties, etc.	Base shear, inter-story drift, axial force, etc.	95.7	92.3	ETABS
[23]	7	IV	East-West direction	Pseudo dynamic method	Ground motion records, stiffness of shear walls, and the in-plane dimensions	Maximum inter-story drifts, maximum floor accelerations, and maximum forces	98.3	95.3	ABAQUS/Explicit
[24]	10	III	East-West	Nonlinear dynamic	Building geometry and material	Inter-story drift ratios,	92.4	93.2	OpenSees

Reference No.	No. of Story	Seismic Zone	Shear Wall Location	Methodology Used	Input Parameters	Output Parameters	Accuracy Result	Efficiency Result	Software Used
			direction		properties, lateral force distributions	maximum floor accelerations, and shear forces			
[25]	15	II	North-South direction	Linear static	Building geometry and material properties, lateral force distributions	Inter-story drift ratios, maximum floor accelerations, and shear forces	94.1	96.8	ETABS
[26]	10	IV	East-West direction	Nonlinear static	Building geometry and material properties, lateral force distributions	Maximum inter-story drifts and shear forces	98.7	97.2	SAP2000
[27]	20	IV	North-South direction	Nonlinear static		Inter-story drift ratios, maximum floor accelerations, and shear forces	96.3	94.8	OpenSees
[28]	8	III	North-south	--	Dimensions of the structure, type of material, and properties	Base shear, displacement, storey drift, and moment	97.3	89.1	SAP 2000
[29]	6	V	East-west	--	Storey height, dimensions of columns, beams, and walls	Maximum lateral displacement and base shear	92.3	88.1	ETABS
[30]	10	IV	North-south	--	Properties of structural elements and seismic loading	Storey drift, base shear, and inter-story drift ratio	95.4	91.2	ETABS
[31]	20	IV	North-south	--	Seismic loading, properties of structural elements, and infill		96.7	93.4	SAP 2000
[32]	6	IV	North-south	--	Seismic loading and properties of structural elements	Base shear, storey drift, and inter-story drift ratio	94.2	89.8	ANSYS
[33]	12	III	North-south	--	Properties of structural elements, soil-structure interaction	Inter-story drift ratio, base shear, and storey drift	96.5	90.7	ETABS
[34]	15	IIB	Vertical	Numerical Analysis	Base Shear, Drift, Story Shear	Acceleration, Displacement, Strain	98.5	0.892	SAP2000
[35]	12	IV	Horizontal	Experimental Analysis	Base Shear, Story Drift	Acceleration, Displacement	95.7	0.921	OpenSEES

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Reference No.	No. of Story	Seismic Zone	Shear Wall Location	Methodology Used	Input Parameters	Output Parameters	Accuracy Result	Efficiency Result	Software Used
[36]	10	III	Vertical	Numerical Analysis	Base Shear, Story Drift, Story Shear	Acceleration, Displacement, Strain	97.8	0.885	ETABS
[37]	8	IIA	Vertical	Experimental Analysis	Base Shear, Story Drift	Acceleration, Displacement	94.2	0.857	ANSYS
[38]	6	IV	Horizontal	Numerical Analysis	Base Shear, Story Drift, Story Shear		96.5	0.901	ABAQUS
[39]	10	III	Vertical	Experimental Analysis	Base Shear, Story Drift		93.8	0.885	ANSYS
[40]	20	IV	Horizontal	Numerical Analysis	Base Shear, Story Drift, Story Shear		97.3	0.915	LS-DYNA
[41]	5	III	Horizontal	Experimental Analysis	Base Shear, Story Drift, Story Shear		92.5	0.842	Abaqus

The present study provides a literature review on various numerical techniques commonly employed for the seismic analysis of structures with shear walls.

- Finite Element Analysis (FEA) is a broadly utilized mathematical strategy that discretizes a mind-boggling structure into finite elements to break down the way of behaving of the construction under different stacking conditions. A few exploration papers have utilized FEA to examine the seismic way of behaving of structures with shear walls [5].
- Response Spectrum Analysis (RSA) is another straight static analysis technique regularly utilized in the seismic analysis of designs with shear walls [7].
- Pushover Analysis, then again, is a nonlinear static analysis method used to assess the seismic way of behaving of designs [8].
- Modal Analysis is a straight unique analysis strategy that recognizes the normal frequencies and comparing mode states of a design [11]
- The Energy-Based Approach is another strategy used to assess the energy dispersal limit of a construction during a seismic occasion. [12]
- Nonlinear Time History Analysis is a powerful analysis strategy that thinks about the nonlinear way of behaving of the construction under seismic stacking [13].
- Seismic Performance Evaluation is utilized to survey the seismic way of behaving of a construction based on specific performance standards. These techniques have been utilized in various examination papers to explore the seismic way of behaving of designs with shear walls, and their discoveries have contributed altogether to the headway of the field [5].

STRENGTH

Some of the advantages used in the research papers on “Seismic analysis based on shear wall” are:

- Capacity design, which ensures ductility and energy dissipation by designing structures to remain elastic under smaller forces and only yield under larger forces, has been popularly used [17]
- The finite element method, a numerical technique used to solve complex engineering problems, has been applied in the analysis and design of shear walls [18]
- Response spectrum analysis has been used to determine the maximum response of structures to a given seismic input, which is commonly used in seismic analysis of shear walls [19]
- Nonlinear static pushover analysis has been applied to estimate seismic performance by applying a series of static loads and measuring the response [23].
- Incremental dynamic analysis has been used to assess seismic performance under increasing levels of seismic loading, specifically for the performance of shear walls under different seismic scenarios [27].

- Equivalent static analysis, a simplified method to determine seismic forces, has been commonly used in the design of shear walls [28].
- Pseudo-dynamic analysis used to predict the behavior of shear walls under seismic loading. In this analysis seismic response is simulated using scaled-down versions of ground motion [14].
- Modal pushover analysis was used to estimate seismic performance. To find the response of shear walls under seismic loading, mode shapes of the structure was used [15].
- Time history analysis has been used to simulate the dynamic response of structures to actual seismic records and study the response of shear walls under actual seismic loading [16].
- Seismic performance evaluation, a comprehensive method to evaluate seismic performance, has been used to assess the performance of shear walls under different seismic scenarios [19].
- Performance-based design has been used to design structures based on their desired performance levels under different seismic scenarios and specifically to design shear walls with specific performance goals [7].
- Seismic reliability analysis has been used to evaluate the probability of failure of structures under seismic loading and specifically to evaluate the reliability of shear walls under different seismic scenarios [8]
- Displacement-based design, a method to design structures based on their displacement capacity under seismic loading, has been used to design shear walls with specific displacement capacities [6]

GAPS

On the basis of literature review, some potential research gaps in the research papers on seismic analysis based on shear wall include:

- Lack of studies considering the effects of different construction materials on the seismic behavior of shear walls [1].
- Limited research on the seismic performance of tall buildings with multiple shear walls in high seismic zones [2].
- Insufficient understanding of the dynamic response of coupled shear walls under seismic loading [3].
- Need for further investigation on the influence of soil-structure interaction on the seismic response of shear walls [4].
- Scarcity of research on the impact of various design parameters, such as reinforcement detailing and spacing, on the seismic performance of shear walls [11].
- Insufficient analysis of the seismic performance of slender shear walls in tall buildings subjected to multi-directional loading [8].
- Limited research on the behavior of shear walls with openings under seismic loading [9].
- Lack of studies on the seismic performance of composite shear walls with different materials, such as concrete and steel [20].
- Need for further investigation on the influence of non-structural elements, such as infill walls and façade systems, on the seismic behavior of shear walls [21]
- Insufficient understanding of the seismic behavior of coupled shear walls with varying stiffness and strength properties [23].

WEAKNESSES

On the basis of literature review, some weaknesses in the research papers on seismic analysis based on shear wall include:

- Simplistic model assumptions for shear wall analysis may result in inaccurate predictions of shear wall behavior and seismic response. [25]
- Neglecting the contribution of non-structural components in seismic analysis can lead to an underestimation of the seismic demand on the shear wall system [27].

- Incorporating the effects of soil-structure interaction is often neglected in shear wall analysis, leading to inaccurate predictions of seismic behavior [4].
- Ignoring the effect of shear deformation in the analysis of coupled shear walls may lead to inaccurate prediction of the seismic response of the structure [10]
- Lack of consideration of the effects of horizontal loads other than seismic loads, such as wind loads, can lead to inaccurate prediction of shear wall behavior and response. (Kocaturk and Kocaturk, 2021)
- Simplistic modeling of the concrete material properties may not fully capture the complex behavior of the material under seismic loads, leading to inaccurate predictions of shear wall response [27].
- Assuming that the shear walls are perfectly rigid and do not deform under seismic loads can lead to an overestimation of their strength and a underestimation of their displacement capacity [4].
- Neglecting the effect of higher mode contributions to the seismic response can result in an underestimation of the seismic demands on the shear wall system [10].
- Simplistic assumptions for the boundary conditions of the shear walls may result in inaccurate predictions of their behavior and response under seismic loads [27].
- Neglecting the effect of concrete cracking and its influence on the shear wall behavior under seismic loads may lead to an underestimation of the deformation capacity and an overestimation of the strength [27].
- Assuming that the shear walls behave linearly under seismic loads may lead to an underestimation of the displacement demands and an overestimation of the strength [4] Simplistic assumptions for the distribution of horizontal loads on the shear walls may lead to an inaccurate prediction of the shear wall behavior and response under seismic loads [10].
- Neglecting the effect of geometric irregularities, such as setback or variation in floor heights, may lead to an underestimation of the seismic response of the structure and the shear wall system [27].
- Neglecting the effect of axial load on the shear wall behavior under seismic loads may lead to an underestimation of the deformation capacity and an overestimation of the strength. [27]
- Assuming that the shear walls behave independently and neglecting the effect of their interaction in the analysis may result in inaccurate predictions of the seismic response of the structure and the shear wall system [4].

CONCLUSION

In conclusion, the extensive review of more than 30 research papers on seismic analysis based on shear walls has provided valuable insights into the advancements and limitations of the current state of research. Shear walls have been proven effective in improving the seismic performance of buildings in high seismic zones. Various hardware and software tools have been employed for the seismic analysis of buildings with shear walls, including finite element analysis, response spectrum analysis, and pushover analysis. However, the accuracy and efficiency of the analysis are largely influenced by the methodology and software used, with some tools providing better results than others. There are many areas which can be more focused to achieve the better result such as experimental validation of the result and dynamic soil structure interaction.

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