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A Review on High Rise Structure of Multi Story RC Frame and a Shear Wall

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ABSTRACT
Civil engineering encompasses the construction of diverse structures, prioritizing their safety, endurance, and functionality. The impact of earthquakes has become a critical factor influencing structures' stability and usability. The extent of earthquake-induced damage hinges on factors such as building type, soil characteristics, earthquake-resistant technologies, and the building's geographical location relative to shear walls. The repercussions of an earthquake are significantly shaped by the soil upon which a building's foundation rests. The altered ground motion during an earthquake can lead to foundation failures. Consequently, it's imperative to comprehensively study soil behaviors during the construction of structures featuring shear walls. Historical evidence underscores the earthquake resilience of shear walls. They enhance a building's structural integrity when subjected to lateral forces caused by seismic activity. This research is dedicated to scrutinizing the performance of diverse high-rise structures, comprising multi-story reinforced concrete frames with integrated shear walls.
Keywords — Multi Story, RC Frame, Shear wall, Earthquake, Lateral Forces.

I. INTRODUCTION

In emerging countries and megacities, a strategy to address burgeoning populations is the construction of tall buildings. Beyond contributing to urban aesthetics, these high-rise structures serve as symbols of progress and modernity. While super high-rise buildings (often exceeding 30 stories) capture attention, lower high-rise structures (approximately 8–20 stories) are widespread globally. Understanding the structural behavior of both types, particularly their response to earthquakes, holds paramount importance. A comprehensive grasp of their intricate dynamic characteristics is essential before individuals can comfortably reside in high-rise environments.

Reinforced concrete (RC) has been a dominant material for skyscraper construction for decades. Modern RC construction methods allow for diverse architectural shapes. Shear walls within RC buildings play a pivotal role in enhancing structural resilience against lateral loads like seismic forces and gravity loads such as wind. For optimal sustainable and resilient performance under normal and extreme loading conditions, the placement of shear walls demands careful consideration. In regions designated as high-seismic zones by geologists, earthquakes pose significant risks to life and property.

Guided by the seismic engineering research of the Bureau of Indian Standards (BIS), the IS 1893 code serves as a guideline for earthquake-resistant structural design. Its various editions, from 1962 to 2016, have evolved in response to seismic understanding. The initial edition divided India into six zones; this later simplified to four (II, III, IV, and V).

The 2006 Kutch Earthquake in Gujarat exposed vulnerabilities in construction standards, local regulations, engineering education, and safety protocols. Widespread destruction of structures between four and ten stories underscored the need for seismic awareness. The NPEEE initiative aimed to educate on earthquake-resistant building design, highlighting the impact of soft alluvium deposits and weak ground stories on devastation.

Resulting from these insights, the "Ductile design and detailing of reinforced concrete structures subjected to seismic forces" code (IS 13920-1993) was introduced, endorsing RCC walls due to their seismic performance. These vertical, plate-like RCC walls, ranging from 150 to 400 millimeters thick, contribute to earthquake resistance based on their successful track record.

II. SEISMIC BEHAVIOR OF SHEAR WALLS

The seismic behaviour of shear walls and their capacity to sustain lateral strains induced by earthquakes has been investigated. Huang et al. (2018) used shake table tests to analyse the dynamic response of coupled shear walls and RC frames. Interaction between shear walls and frames was found to have a major impact on load distribution and structural response. Wang et al. (2020) used numerical computations to investigate how the stiffness of boundary elements affects the seismic behaviour of shear walls.

The non-linear behaviour of shear walls under seismic loads has been frequently simulated using finite element analysis (FEA). In order to accurately capture the flexural and shear behaviour of shear walls, including the initiation and propagation of plastic hinges, fracture patterns, and redistribution of stresses within the structure, researchers have created advanced FEA models (Gao et al., 2021). Understanding the seismic behaviour of shear walls continues to rely heavily on experimental investigations. To verify and supplement numerical models, scientists have undertaken shake table tests and quasi-static cyclic stress studies. Experiments like these shed light on how shear walls fail, how strong they are, and how they deform during earthquakes. The behaviour of shear walls under actual seismic loading has been the subject of recent research, with an emphasis on better instrumentation techniques (Chen et al., 2020). Recent studies have investigated how external variables affect shear walls' seismic behaviour. Aspect ratio, boundary element design, reinforcement details, and boundary conditions are just some of the variables whose impacts on the dynamic response of shear walls and their interaction with RC frames have been studied. In light of the results, it is clear that these considerations are crucial for making reliable predictions of shear wall response to seismic loading (Li et al., 2022). Complex non-linear behaviour of shear walls under seismic loads has been captured by cutting-edge analytical models. Concrete cracking, shear deformations, and concrete and reinforcing steel interaction are just some of the processes accounted for in these models. To reliably forecast the reaction of shear walls under different earthquake situations, experts have used advanced constitutive material models and non-linear analysis techniques (Wang et al., 2019).

Overall, we now have a better grasp of the non-linear response of shear walls thanks to the findings of recent studies on their seismic behaviour. The research has led to better shear wall-RC frame system design standards, reinforcement detailing practises, and analysis methods.

III. SEISMIC BEHAVIOR OF RC FRAMES

There have been a number of recent investigations into how RC frames behave in earthquakes and how shear walls affect that behaviour. Zhang et al. (2019) looked into how vertical abnormalities in RC frames affected the buildings' seismic response as a whole. Their research showed that these anomalies should be taken into account during the planning and analysis stages. In addition, Wang et al. (2021) used computational modelling to investigate how axial stress affects the seismic behaviour of RC frames. They found that shear walls increased overall structural stiffness and altered the redistribution of axial loads. In more recent research, Barros et al. (2019) looked into how factors such plastic hinge length and reinforcing details affected the seismic response of RC frames. There is a lot of curiosity in structural engineering about how RC frames react to earthquakes. Primary load-bearing systems in buildings and constructions often consist of RC frames. If you want to build things that can withstand earthquakes, you need to know how they behave non-linearly under stress. Extensive research has been done to better model and anticipate the behaviour of RC frames when subjected to seismic forces (Chen et al., 2021). Flexural failure, shear failure, and bond-slip failure at the beam-column connections are only some of the failure modes that can occur in RC frames subjected to seismic pressure. The evolution, interaction, and impact of these failure modes on the overall structural response have all been studied by researchers. Research into the causes of RC frame failure has led to new recommendations for design and retrofitting (Smith et al., 2019). Understanding the seismic behaviour of RC frames is greatly aided by experimental experiments. Scientists have studied the structural reaction under genuine seismic conditions by using shake table tests, pseudo-static testing, and cyclic loading studies. Experiments like these shed light on how RC frames fail, how strong they are, and how they deform under stress. In order to effectively capture the behaviour of RC frames, recent research has concentrated on adding cutting-edge measurement techniques including digital image correlation and strain gauges (Johnson et al., 2023)".

IV. SHEAR WALL-RC FRAME INTERACTION STUDIES

Magenes et al. (2015) looked into shear wall-RC frame systems to determine how loads are distributed and how energy is dissipated. Shear walls and RC frames in tall structures were studied for their seismic response in experimental and numerical investigations by Lai et al. (2018). The importance of using precise modelling tools to capture the non-linear behaviour and interaction effects was brought to light by their investigation. Accurately analysing a building's seismic reaction requires a thorough understanding of the interaction between shear walls and RC frames. The seismic behaviour of shear wall-RC frame systems under varying coupling conditions was recently studied by Tang et al. (2020), who used non-linear finite element analysis. The results showed that include the coupling effects was crucial to capturing the non-linear behaviour and forecasting the response with high precision. Additionally, Zhu et al. (2021) conducted experimental tests to assess the impact of coupling beams on tall buildings' seismic resilience. Their research confirmed that linking beams improve the structural performance and energy dissipation as a whole. When it comes to seismic design, the relationship between shear walls and RC frames is essential. Significant lateral load resistance is provided by shear walls, and additional structural stability is provided by RC frames. Accurately forecasting the reaction of the overall structural system under seismic loading requires an understanding of the behaviour and interaction between these two components (Chen et al., 2022). The interaction behaviour and seismic response of RC frames are profoundly affected by the positioning and arrangement of shear walls within the frames. Researchers have looked into how various distributions, spacings, and heights of shear walls affect the system's stiffness, strength, and energy dissipation capability. These analyses aid in determining the best locations and shapes for shear walls to achieve maximum seismic performance. For constructing safe and robust structures, knowing how shear walls interact with RC frames is essential. Improved design guidelines, analytical models, and retrofit procedures for boosting the seismic performance of buildings and structures have all been developed thanks to the results of studies examining the interaction between shear walls and reinforced concrete frames (RC frames). Dipali Patel (2015) The study involves the creation of 2-D models of 20, 30 and 35-storey RC frame buildings with shear walls. In the 2-D models, two exterior frames with shear walls are modelled as a single frame with double stiffness, strength, and weight.

Interior frames without shear walls are modelled as a single frame with equivalent stiffness, strength, and weight. The frames are connected by rigid links at each floor level. The 2-D plane frame model is used to investigate the lateral force distribution between the exterior frames with shear walls and the interior frames without shear walls. Analysis results indicate that the frame with shear wall is capable of bearing more than 50% of the load up to the bottom seven or eight storeys, while the lowermost three storeys take approximately 75% of the total storey shear. Overall, this study provides useful insights into the interaction between shear walls and RC frames and can inform the design of more effective building structures. Sangketa Sangma(2015) Reinforced concrete (RC) frame-shear wall buildings are widely used as a structural system for tall buildings. The system is designed such that the frames independently resist 25% of the design base shear while the remaining 75% of the base shear is resisted by the shear walls. To ensure the desired level of performance under specific hazard levels, the Unified Performance-Based Design (UPBD) method can be employed for performance-based design of such structures. In this study, two RC frame-shear wall buildings with heights of 16 and 20 stories were analysed and designed using SAP2000 v14. Frame elements were modelled as beams and columns, while shear walls were modelled as wide columns. Column sizes were determined based on maintaining 3% to 4% steel in the column to meet the design demand. Nonlinear default hinges were assigned to the column and beam elements based on FEMA 356, while user-defined hinges were provided for the shear walls. Nonlinear time history analysis was conducted using spectrum compatible ground motions (SCGM). The study aimed to assess the suitability of the UPBD method for designing RC frame-shear wall buildings to meet target performance objectives at IO performance level with 1% drift.

V. NON-LINEAR ANALYSIS METHODS

Non-linear seismic response analysis of shear wall-RC frame systems has been studied using a number of recently developed numerical approaches. Non-linear finite element analysis was used to model the response of such structures to seismic forces. To evaluate the seismic performance of shear wall-RC frame structures, Khatiwada et al. (2023) performed non-linear static and dynamic analyses, such as pushover analysis and time history analysis. The results of their studies proved that these techniques were successful in recording the non-linear features of the responses.

The seismic response of shear wall-RC frame systems has been studied extensively using non-linear analysis techniques. A numerical modelling strategy based on fibre beam-column elements was proposed by Hatzigeorgiou et al. (2010) to capture the non-linear behaviour of RC frames. The results of their investigation confirmed that the proposed model provided reliable predictions of the structure's overall response and deformation characteristics. In addition, shear walls subjected to seismic loading were modelled non-linearly by Chen et al. (2020) using a multi-scale modelling approach. In order to reliably forecast the shear wall response, the study stressed the significance of accounting for material variability and non-linear effects.

VI. CONCLUSIONS

Numerous authors have previously investigated the analysis of shear walls within reinforced concrete frame buildings. From these studies, noteworthy insights have emerged. For instance, considering soil-structure interaction in a base-isolated structure leads to an augmentation of the structure's natural period. The impact of soil-structure interaction is most pronounced when dealing with soils of soft to medium consistency. As the number of stories in a building increases, both the base shear and displacement also increase. Notably, the strategic placement of shear walls plays a pivotal role in managing base shear and displacement. The positioning of shear walls significantly influences the distribution of forces, and hence, their location must be chosen judiciously. Shear walls can efficiently absorb horizontal forces, particularly when they possess substantial dimensions.

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