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Enhanced Seismic Resilience

Prof. Dr. P. R.Bamane[1], Mr. Aashay Abhijeet Singasane[2], Ms. Vishakha Sonawale[3], Mr. Abhijeet Pawar[4]
[1,]Associate Professor, Department of Civil Engineering
[2,3,4]B.E. Students, Department of Civil Engineering,
G. A. Acharya Institute of Engineering and Technology, Shelu

Abstract: *In the past thirty years, moderate to severe earthquakes occurs around the world every year. Such events lead to damage to the concrete structures as well as failures. Thus, the aim is to Focus on a few specific procedures which may improve the practice for the evaluation of seismic vulnerability of existing reinforced concrete buildings of more importance and for their seismic retrofitting by means of various innovative techniques such as base isolation and mass reduction. So Seismic Retrofitting is a collection of mitigation technique for Earthquake engineering. It is of utmost importance for historic monuments, areas prone to severe earthquakes and tall or expensive structures.*

Keywords: earthquakes

I. INTRODUCTION

The existing building stock poses a much more serious and complex seismic safety problem when compared to safe earthquake design of new construction. The vast majority of structures located in seismic areas exhibit deficiencies in their resistance to earthquake loads due to a number of reasons, highlighted below. Older construction, designed according to earlier codes, may not comply with current seismic regulations since focus used to be primarily on warranting sufficient capacity for gravity loads alone. Moreover, the past thirty years have witnessed such a significant increase of knowledge in the field of earthquake engineering that even relatively modem structures may no longer meet the prerequisites of constantly-developing regulations. As a result, several shortcomings can be found in existing buildings such as irregular structural configuration, inappropriate member detailing for ductility and insufficient lateral stiffness, amongst others.

Further, precise structural assessment quite often stumbles on the unavailability of accurate design plans and the uncertainties regarding material properties, particularly in the case of old structures. In the case of earthquake-hit structures, evaluation of the level of damage can be difficult on occasions, and assumptions based on engineering judgment, rather than codified guidelines, are needed. The superior performance characteristics of new materials, such as fibre-reinforced polymers, may also be exploited. However, some of these highly efficient interventions are expensive (due to the production cost associated to such novelty materials) and require skilled workmanship. This often constitutes a big impediment in the majority of poorer earthquake-prone countries, and the use of familiar construction methods making use of traditional materials, such as steel and concrete, is a preferable solution.

In the case of reinforced concrete (RC) structures, the aforementioned difficulties constitute a particularly serious problem. This type of construction is widely used for critical public buildings, such as schools, hospitals, fire stations and public administration offices, amongst others. Also, this class of structures is commonly associated to large occupancy buildings such as multi-storey residential blocks, offices and hotels. However, despite the importance in safeguarding the seismic behaviour of such sensitive structures, there is very little codified criteria and guidelines for assessment and structural upgrading of RC buildings the problem, however, becomes more intricate when other factors, beyond the reach of regulations, are taken into account.

In fact, it is frequent for existing buildings to have suffered structural modifications applied by their owners without due engineering consideration, thus further hindering what may already be a low seismic resistance. Also, quality of construction may be poor, resulting in a defective design-implementation. The latter may lead to disastrous consequences, as recently highlighted by the devastation and human casualties resulting from the Kocaeli (Turkey) of

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17 August 1999 and, to a lesser extent, the North Athens (Greece) earthquake of 7 September 1999. There are three key concepts in seismic design that were fully developed by researchers and engineers. First, earthquake ground motions generate inertial loads that rapidly change with time. Thus, it is common that calculations include a term labelled with a unit of time (usually seconds) and these terms include periods of vibration or their inverse, frequencies; accelerations and velocities. In many other structural engineering problems such as calculations of gravity loads, no unit of time is used.

Key components of earthquake vibration control include:

- Seismic Hazard Assessment: Understanding the seismic hazard in a specific region is crucial. Engineers and seismologists analyse historical earthquake data and geological characteristics to estimate the potential ground motion at a site. This information informs the design and retrofitting of structures.
- Structural Engineering: Engineers design buildings and infrastructure to withstand seismic forces. This involves selecting appropriate materials, designing structural components like beams and columns, and employing innovative construction techniques to enhance earthquake resistance.
- Base Isolation: Base isolation is a technique that decouples a building or structure from the ground motion of an earthquake. By placing flexible bearings or isolators between a structure and its foundation, the building can move independently of the ground motion, significantly reducing the forces transmitted to the structure.
- Damping Systems: Damping systems are devices designed to dissipate the energy generated during an earthquake. These systems can include tuned mass dampers, viscous dampers, or friction dampers. They help reduce the amplitude of vibrations, minimizing structural damage.
- Retrofitting Existing Structures: Many older buildings were constructed without adequate seismic provisions. Retrofitting involves strengthening these structures using modern seismic-resistant techniques and materials to improve their earthquake performance.
- Advanced Materials: Researchers are continually developing advanced materials with enhanced seismic resistance properties. These materials may include fiber-reinforced composites, shape memory alloys, and self-healing concrete, among others.
- Monitoring and Early Warning Systems: Real-time monitoring and early warning systems can provide valuable seconds to minutes of advance notice before the arrival of strong seismic waves. This allows people to take cover and critical infrastructure to shut down, reducing the potential for injuries and damage.

Objective:

1. To Seismic Resistance Enhancement.
2. To Reduction of Structural Deformations and Displacements.
3. To Mitigation of Shear and Lateral Forces.

II. PROBLEM STATEMENT

The problem at hand is how to effectively control earthquake vibrations using a modified frame-shear wall system. Earthquakes are natural disasters that can cause immense damage to structures and endanger human lives. Traditional building structures are often unable to withstand the ground shaking caused by earthquakes, leading to collapsed buildings and Significant loss of life Thus, there is a need for a seismic design and retrofitting solution that can enhance the performance of buildings during earthquakes. The modified frame-shear wall system is proposed as a potential solution to address this issue. This system combines the benefits of frame and shear wall structures to create a highly resilient and earthquake-resistant building design.

The future scope of earthquake vibration control using modified frame-shear walls holds significant promise for advancing seismic resilience in building design and construction. As research and technology continue to evolve, here are key areas of future development and opportunities in this field

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Future Scope

- Advanced Materials: The development of high-performance materials with enhanced strength, ductility, and energy-absorption properties will play a crucial role. Researchers are likely to explore innovative materials, such as self-healing composites and smart materials, to improve the seismic performance of modified frame-shear walls.
- Multi-Hazard Resilience: Future research will focus on designing buildings that can withstand not only earthquakes but also other natural hazards, including tsunamis, hurricanes, and floods. Modified frame-shear walls may be adapted to provide multi-hazard resilience.
- Smart Sensors and Monitoring: The integration of advanced sensor technologies and real-time monitoring systems will become more prevalent. These systems will provide continuous data on structural health, allowing for proactive maintenance and rapid response during seismic events.
- Machine Learning and AI: Artificial intelligence and machine learning algorithms will be used to analyze vast amounts of structural data, enabling predictive maintenance, real-time structural assessment, and the optimization of retrofitting strategies for modified frame-shear walls.
- Innovative Structural Systems: Future designs may incorporate more complex and adaptable structural systems, such as reconfigurable frame-shear walls that can adjust their stiffness and damping properties in response to changing seismic conditions.
- Resilient Infrastructure: The concept of building resilience extends to critical infrastructure components like transportation systems, utilities, and lifeline networks. Modified frame-shear walls may be integrated into larger community-wide resilience strategies.
- Energy-Efficient Retrofitting: Retrofitting with modified frame-shear walls may increasingly focus on energy-efficient designs to align with sustainability goals. This could include the incorporation of renewable energy sources and energy recovery systems.
- Urban Planning: Researchers and urban planners will work together to develop holistic, community-wide resilience plans that incorporate modified frame-shear walls into the urban fabric, ensuring safe and resilient cities.
- Post-Earthquake Recovery: Studies on the socio-economic aspects of post-earthquake recovery and reconstruction will become more critical. Understanding the economic and social impacts of earthquakes and the role of modified frame-shear walls in recovery efforts will be explored.
- Global Adoption: The adoption of earthquake vibration control techniques, including modified frame-shear walls, will extend to more earthquake-prone regions globally. Collaboration between countries and regions with varying seismic risks will foster the exchange of knowledge and best practices.
- Regulatory Frameworks: Governments and regulatory bodies will continue to refine and enforce building codes and standards related to earthquake-resistant construction, incorporating the latest research findings into seismic regulations
- Community Engagement and Education: Public awareness campaigns and educational initiatives will emphasize the importance of earthquake resilience, encouraging property owners to invest in retrofitting projects, including modified frame-shear walls.

III. IMPORTANCE IN STRUCTURAL STABILITY

Shear walls play a crucial role in ensuring the structural stability and integrity of buildings, especially in situations where lateral forces like wind, seismic activity, or other horizontal loads are a concern. Here's an exploration of their importance in structural stability:

Lateral Load Resistance:

Primary Function: The primary purpose of shear walls is to resist lateral forces that can cause horizontal movement or deformation of a building. These forces can result from factors such as wind, earthquakes, or even human activities like pushing against walls.

Stabilizing Influence: Shear walls provide a stabilizing influence on the building, preventing it from swaying excessively in response to lateral loads. This minimizes the risk of structural damage, discomfort for occupants, and potential structural failure.

Wind Resistance:

Wind Loads: Shear walls are equally vital in areas susceptible to high winds. They resist wind loads and prevent the building from swaying excessively or experiencing structural damage due to wind-induced vibrations.

Maintaining Occupant Comfort: By limiting the lateral movement of the building, shear walls help maintain the comfort and safety of occupants during strong wind events. Excessive sway can cause discomfort and even motion sickness.

Load Distribution:

Load Transfer to Foundation: Shear walls ensure that lateral forces are safely transferred to the building's foundation. Without shear walls, these forces could cause structural damage to various components of the building or lead to foundation failure.

Uniform Distribution: They help distribute lateral forces uniformly throughout the structure, preventing localized stress concentrations that could lead to structural weaknesses or failures.

Structural Integrity:

Integral Component: Shear walls are an integral part of a building's structural system, working in concert with other load-bearing elements such as columns, beams, and foundations.

Enhanced Strength and Stiffness: Shear walls are designed to be stronger and stiffer than other structural components, ensuring that they can effectively absorb and resist lateral forces.

Occupant Safety:

Protection of Life: By providing stability and resistance to lateral loads, shear walls contribute significantly to the safety of building occupants. They reduce the risk of injuries and fatalities during natural disasters or extreme weather events.

Code Compliance

Building Codes: Building codes and regulations in earthquake-prone and high-wind areas often mandate the use of shear walls and specify their design criteria. Compliance with these codes is essential for obtaining building permits and ensuring structural safety.

IV> HIGHLIGHT THEIR EARTHQUAKE PERFORMANCE BEFORE AND AFTER MODIFICATIONS

Highlighting the earthquake performance of a building before and after modifications with modified frame shear walls demonstrates the effectiveness of retrofitting in enhancing seismic resilience. Here's a comparison of earthquake performance for a hypothetical mid-rise apartment building before and after retrofitting:

Before Modifications:

Seismic Vulnerabilities: The building, like many older structures, had vulnerabilities that made it susceptible to damage or collapse during earthquakes. It lacked the necessary lateral strength and ductility to withstand seismic forces.

Structural Integrity: During a seismic event, the building experienced significant lateral sway and deformation, potentially leading to structural damage, non-structural component failures, and compromised occupant safety.

Risk to Occupants: The building posed a substantial risk to the safety of its occupants during earthquakes, as it could not adequately protect against the potential for structural failure or collapsing walls.

After Modifications with Modified Frame Shear Walls:

Enhanced Seismic Performance: The retrofitting project incorporated modified frame shear walls, which significantly improved the building's seismic performance. These shear walls added lateral strength and ductility to the structure.

Reduced Structural Deformation: During subsequent seismic events, the building demonstrated controlled lateral sway and deformation. The modified frame shear walls absorbed and dissipated seismic energy, preventing excessive movement.

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Structural Integrity Preserved: The retrofitting measures preserved the structural integrity of the building, minimizing damage to load-bearing elements and ensuring that the structure remained stable.
Improved Occupant Safety: The retrofitting with modified frame shear walls greatly enhanced the safety of the building's occupants. It reduced the risk of injury or loss of life by preventing structural failure or wall collapses.
Resilience to Seismic Events: The building, now equipped with modified frame shear walls and other retrofitting measures, demonstrated resilience to seismic events. It could withstand a range of earthquake magnitudes while ensuring occupant safety and minimizing damage.

V. DISCUSS CHALLENGES IN IMPLEMENTING MODIFIED FRAME SHEAR WALLS

Implementing modified frame shear walls as a retrofitting technique for existing buildings poses several challenges and complexities. While these systems offer significant benefits in terms of seismic resilience, there are various obstacles that engineers, contractors, and building owners may encounter during the retrofitting process. Here are some key challenges in implementing modified frame shear walls:

- Structural Assessment: One of the initial challenges is conducting a thorough structural assessment of the existing building. This assessment involves evaluating the building's current condition, identifying vulnerabilities, and determining the most suitable retrofitting strategy. Assessments can be time-consuming and require specialized expertise.
- Design Complexity: The design of modified frame shear walls must consider the specific structural and seismic characteristics of the building. It involves complex engineering calculations to ensure that the retrofitting system provides the required lateral strength, stiffness, and ductility while maintaining the building's overall structural integrity.
- Compatibility with Existing Structure: Integrating modified frame shear walls into an existing building can be challenging, especially if the building's original design did not account for seismic considerations. Ensuring that the retrofitting system is compatible with the existing structure and architecture can be a delicate balancing act.
- Space Constraints: Retrofitting with modified frame shear walls may require additional space within the building footprint, either internally or externally. In urban environments with limited space, finding suitable locations for shear walls without disrupting building functionality can be a significant challenge.
- Occupant Disruption: Retrofitting projects can disrupt the occupants of a building. Depending on the extent of work required, occupants may need to temporarily relocate, which can lead to logistical challenges and increased project costs.
- Cost Considerations: Retrofitting with modified frame shear walls is an investment. The cost of materials, labor, engineering expertise, and project management can be substantial. Building owners may need to carefully assess their budget constraints and consider the long-term benefits.
- Code Compliance: Retrofitting projects must comply with local building codes and regulations, which can vary from one jurisdiction to another. Navigating the regulatory landscape and ensuring code compliance can be a complex and time-consuming process.
- Skilled Labor Shortage: Finding skilled labor with expertise in seismic retrofitting techniques, including modified frame shear walls, can be a challenge. Retrofitting projects require specialized knowledge and experience.
- Material Availability: The availability of specialized materials and components needed for modified frame shear walls can vary by location. Sourcing materials that meet engineering specifications may require additional effort and cost
- Quality Control: Ensuring the quality of work during retrofitting is crucial for the long-term performance of the building. Strict quality control measures are necessary to prevent errors and ensure that retrofitting is carried out correctly.

- Project Duration: Retrofitting projects can take a significant amount of time, from the initial assessment and design phase to construction and post-retrofit evaluation. Lengthy project durations can lead to disruptions and increased costs.

VI. SUMMARY

In summary, the future scope of earthquake vibration control using modified frame-shear walls is marked by technological advancements, interdisciplinary collaboration, and a holistic approach to resilience. As our understanding of seismic hazards deepens and engineering practices evolve, these systems will continue to be at the forefront of efforts to protect lives and property in earthquake-prone regions.

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