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Seismic Performance Assessment of a Mid-Rise Asymmetric Building Incorporating Rocking Shear Wall for Enhanced Structural Resilience: An Overview

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ABSTRACT - Scholars have created a damage avoidance design philosophy to minimize structural damage in recent years, as opposed to traditional design ideas that are largely damage-oriented. In addition to dispersion tools and restoring force systems, a rocking system aims to lessen seismic pressures on buildings' earthquake forces. These techniques have been adopted in order to reduce the impacts of seismic pressures and boost building structural resilience. Asymmetry in structural design is commonly associated with poor structural performance under severe earthquake stresses. During seismic occurrences, this imbalance has a substantial influence on the coupling of translational and torsional reactions, resulting in considerable lateral deflections, member forces, and probable collapse. The seismic performance of an asymmetric structure with rocking shear walls is compared to that of conventional shear walls in this study. Many performance characteristics have been investigated to determine if rocking shear walls are preferable to traditional shear walls. A detailed comparison is performed to demonstrate the advantages and use of rocking shear walls in decreasing seismic loads and enhancing the performance of mid-rise asymmetric buildings, particularly in earthquake circumstances. The findings of this study might be utilized to design more durable structures for earthquake-prone locations, as well as contribute to the advancement of seismic design technology in the field.

***Key Words*:** *Seismic Performance; Rocking Shear Wall; Seismic resilient devices; Mid-Rise Asymmetric Building*

1.INTRODUCTION

A shear wall is a form of structural component that is commonly used in multi-story or tall buildings, as well as structures in high wind or seismic activity zones. A shear wall's primary objective is to withstand lateral stresses produced on a structure by wind, earthquake, or, in certain cases, hydrostatic or lateral earth pressure. These loads often act in the direction of wind or seismic waves, and they act laterally to the building in one of two directions. Torsion effects can be substantial and difficult to assess due to a lack of symmetry in design. The usage of symmetric floor designs is the best way to prevent torsional impacts. Only if all efforts are taken to provide an appropriate failure mechanism will building behavior during earthquakes be excellent. Buildings having an unbalanced distribution of strength and stiffness in plan endure combined torsional and lateral vibrations during earthquakes. Torsion enhances the seismic demands of asymmetric structures beyond what translational deformation alone would need. Torsion effects increase as the eccentricity between the centres of mass and stiffness increases. Torsional vibrations create considerable extra displacements and forces in lateral load-resisting components of structures that remain elastic during an earthquake. However, the majority of building designs rely on inelastic reactions. In this scenario, torsional motion necessitates higher displacement and ductility.[1]

Traditional earthquake resistant building design typically relies on ductile details that are specifically chosen to withstand significant inelastic deformations and dissipate energy in a controlled manner, reducing force demands elsewhere in the structure and protecting the integrity of its global load-carrying systems. While structures built in this manner may provide an acceptable level of safety by avoiding catastrophic collapses during design-level earthquakes, they are vulnerable to two major drawbacks: significant cumulative damage in essential structural sections and residual deformations as shown in figure 1(a).

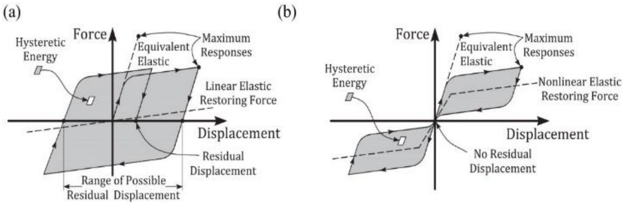


Fig.1 Characteristic behavior of (a) Conventional seismic resistant systems and (b) self-centering systems.[2]

Because ductile components are easily damaged, they must be fixed or replaced after a strong earthquake. The hysteretic nature of these elements, especially when damaged, can generate significant residual deformations in a building, posing challenges in post-earthquake repair and redesigning, and may eventually end in a structure's entire collapse. These are significant expenditures for structural and non-structural component damage, as well as business interruption. Furthermore, major damage to a large number of structures at the same time, especially critical infrastructure systems and networks, can create considerable barriers to post-earthquake emergency response and result in long-term disruption of regional or even national economies. [2]

2. Methodology

The project review included an in-depth approach to investigate the seismic assessment of asymmetric structures with rocking shear walls. To collect relevant articles, papers, reports, and research, a thorough literature search was undertaken utilizing databases, journals, and conference proceedings. Selection criteria ensured the inclusion of high-quality research, such as peer-reviewed publications, respectable conference papers, and reports from recognized institutes. To get information on rocking shear wall systems and compare them to conventional shear walls based on displacement, base shear, story drift, time period, and fragility curves, a systematic data-collection technique was used. The collected data was reviewed, categorized, and merged to explain noteworthy findings in relation to the study objectives. This study enabled a thorough examination of seismic assessment, yielding significant results and pointing to future research topics as illustrated by following flowchart.

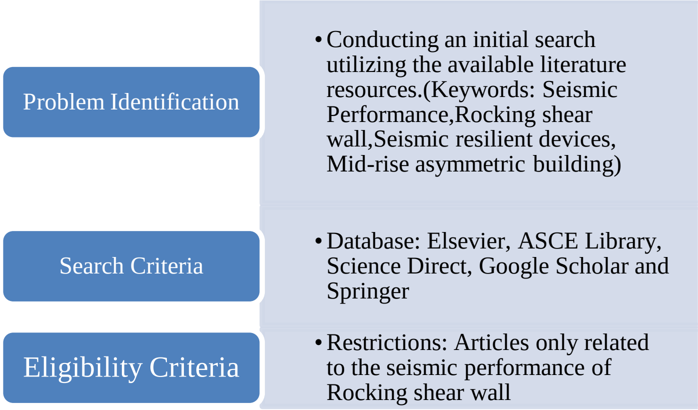


Fig.2 Flowchart of Methodology

3. Rocking Shear Wall

Reinforced concrete shear walls are widely employed as lateral load-resisting structures due to their advantageous properties such as high strength, ductility and, energy dissipation. The bulk of these devices rely on a flexural mechanism to move towards their base, where serious damage is envisaged. As a remedy to this problem, base-rocking devices have been developed, which avoid catastrophic structural damage while minimizing seismic pressures on the structure.[3]

Rocking shear walls are a specific kind of structural system used to enhance a building's seismic resistance. They have the remarkable ability to self-center, allowing them to return to their original vertical position when the earthquake has subsided. This behavior decreases residual displacements and allows the building to be recovered with as little damage as possible. Furthermore, the rocking action redistributes seismic stresses inside the structure. Gravity columns and vertical bracing are designed to absorb energy from the swaying wall while carrying these redistributed loads. When compared to conventional shear walls, this simplifies the design, reducing the need for highly ductile components and potentially saving construction costs.

The base-rocking system connection's contact surface is removeable, allowing for unfettered rotation and the discharge of bending force needs. At rocking portions, shear-induced sliding movement is assumed to be restricted. As a result, models of rocking behavior appear nonlinear and elastic, with negligible material nonlinearity and hysteretic energy dissipation. This system appears to be stable until excessive deflections or toe damage at the base reduces lateral stiffness, resulting in destabilization.

The capacity of rocking shear walls to dissipate energy improves earthquake resistance, allowing the building to tolerate extreme seismic activity while keeping structural integrity. Figure.3 depict an example of a rocking shear wall system and its components.

Fig.3 Rocking shear wall system

The rocking shear wall system's phenomenal implementation of self-centering behavior is owing to thorough design considerations and the insertion of unique components. A critical component is the selective placement of energy-dissipating devices inside the wall, such as replaceable fuses or yielding mechanisms. These devices are vital in collecting seismic energy and experiencing inelastic deformation during wall shaking, so preventing critical structural sections from being damaged excessively.[4]

Performance-based techniques for earthquake-resistant constructions necessitate evaluating performance at various seismic excitation levels. An alternate method based on residual deformations demonstrates that features such as hysteretic properties, post-yielding stiffness, and maximal ductility have a considerable effect on residual deformations. Self-centered systems cannot be compared to other systems without taking residual deformations into account.[5]

Rocking shear walls' self-centering mechanism decreases residual displacements and allows for speedier post-earthquake recovery. Internal energy-dissipating mechanisms provide the necessary restorative power for self-centering. This method enhances structures by lowering permanent displacements, allowing for easier access after earthquakes, and allowing for the inspection and maintenance of energy-dissipating equipment without requiring major intervention. Figure.4 shows the comparison of rocking wall systems and conventional shear wall systems.

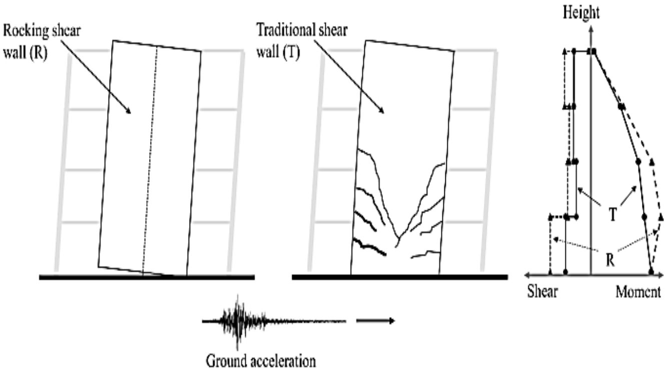


Fig.4 Comparison of rocking and conventional shear wall systems [14]

The purpose of self-centering lateral load-resisting devices is to eliminate residual drifts that occur after a big earthquake. A parametric SDOF study examined parameters and residual drifts and showed that restoring forces equivalent to at least half of the required dissipative component may reliably eliminate drifts in non-softening systems.[6]

Housner was the first to suggest the rocking structure idea. Because of the releasing constraint between the column bottom and the foundation on structures, the rocking structures can control the distribution of drift over the height of the building via rigid body rotation and mitigate the damage to primary structural elements caused by soft-story failure.[7]

There are two methods for producing rocking frame self-centering behavior. The most common way for creating the restoring force is to employ post-tensioned (PT) strands. Roke designed a self-centering concentrically braced frame to increase drift capacity before damage and prevent irreversible drift under seismic pressures.[8]

Eatherton and X. Ma conducted quasi-static and shake table experiments on a controlled rocking steel braced frames with replaceable fuses, with the goal of concentrating damage and eliminating residual drifts after unloading. However, prestressed stresses for PT strands are rather considerable, resulting in large structural member sizes, such as columns and braces, particularly for upper floors. [9,10,11,12]

According to Yahya C. Kurama's research, post-tensioned precast concrete walls offer ideal seismic properties but confront obstacles when subjected to earthquake loads. A hybrid precast wall system reinforced with mild steel reduces lateral displacements, especially in seismically active locations. Unbonded post-tensioned precast walls are constructed by post-tensioning precast wall panels with unbonded post-tensioning steel over horizontal connections at floor levels.[12] Figure.5(a &b) illustrates diagrammatic view of un-bonded post-tensioned wall along with its lateral behavior.

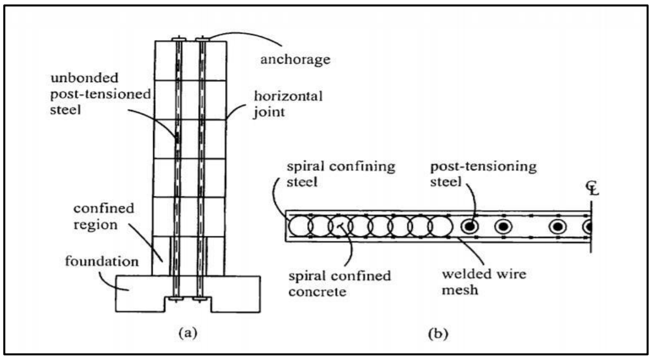


Fig.5a (i)Un-bonded post-tensioned wall (a) elevation view; (ii) half cross-section of base panel [12]

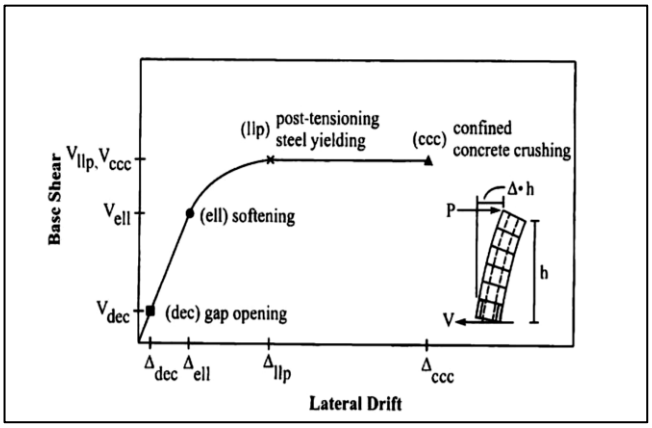


Fig.5(b) Lateral load behaviour of unbonded post-tensioned wall [12]

Xilin Lu investigated the seismic performance of a self-centered precast RC frame with shear walls, using self-centering precast RC shear walls and prestressed post-tensioned (PT) tendons for lateral force resistance. The study found satisfactory performance in the shear wall plane but sustained inter-story drift levels up to 2.45%.[13]

Zhipeng Zhai offers a novel rocking shear wall with a dual self-centering energy dissipation mechanism for earthquake resistance. The system is made up of a pinned RC wall, a pre-pressed disc spring friction damper (PDSFD), and a pre-pressed disc spring brace with a U-shaped steel damper (PDSBUSD). The study looks at seismic performance and provides mechanical and numerical models. The design optimises energy dissipation and self-centering while reducing RC wall damage. The method for dual-yielding energy dissipation is realised.[14]

Mark Browne discovered considerable benefits in rocking walls by utilising Ruaumoko's time history analysis software. While allowing for little displacement and drift, the rocking mechanism reduces moments, shear forces, and accelerations. Rocking, on the other hand, lacks energy dissipation, necessitating the installation of energy dissipation devices to increase the system's energy dissipation.[15]

Certain aspects of rocking wall systems have been demonstrated in the literature, as well as their capacity to improve seismic performance. The study focuses on their ability to reduce residual displacements, increase structural ductility, transfer energy, and minimise damage. To implement rocking wall structures successfully in seismically resistant structures, it is vital to understand their behavior as well as the design challenges involved. This will increase earthquake resistance and sustainability in earthquake-prone areas.

4. Mid-Rise Asymmetric Building

Asymmetric mid-rise structures have an unequal distribution of strength, stiffness, and mass, resulting in a variety of seismic responses and torsional effects. Torsion, or the structures' twisting or turning moment, is a critical component of these structures during seismic occurrences. Torsional deformation, in addition to translational deformation, creates additional stresses and displacements in asymmetric structures. To forecast and comprehend torsional effects, extensive study and design considerations are required. Asymmetric mid-rise buildings provide significantly stronger lateral responses than symmetric structures. During shorter time periods, a mid-rise structure is less likely to sustain non-structural damage than a low-rise structure. In contrast, an uneven distribution of strength, stiffness, or mass may result in non-uniform internal forces and localized damage during seismic occurrences. A detailed examination of lateral load response, torsional effects, and stiffness imbalances is required for the design of a mid-rise asymmetric building.[16]

Mitigation strategies such as repairing structural defects and reinforcing important spots may be required. Torsion effects can be reduced by employing regular and compact floor layouts, seismic separation joints in complex structures, and guaranteeing a favorable failure mechanism. In asymmetric structural inelastic behavior, controlling inelastic twists is critical. Torsional vibrations caused by earthquakes can induce extra displacements and forces in lateral load-resisting components of structures that remain elastic. The investigation of an asymmetric plan building with stiff diaphragms and elastoplastic structural components, with lateral resistance given along resisting planes, is described. Fig.6 shows the 3D view and plan view of an asymmetric building.

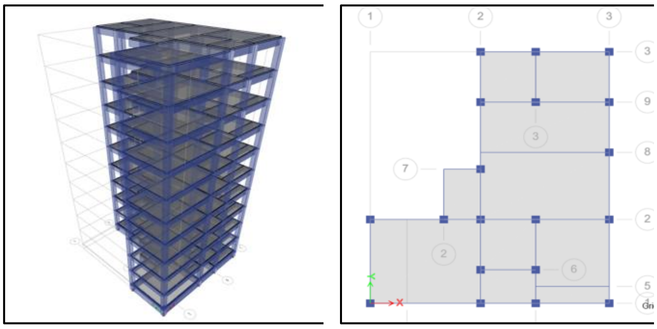


Fig.6 3D view and Plan view of Asymmetric building

5.0 Enhancing Seismic Resilience in Mid-Rise Asymmetric Buildings: Design Approaches, Dynamic Characteristics, and Failure Mechanisms

The study of mid-rise asymmetric buildings emphasizes the need of taking asymmetry into consideration during the design and evaluation stages. The investigations focus at seismic performance and features, dynamic characteristics, seismic response, vulnerability assessment, and design standards, among other things. The outcomes of these studies expand to the knowledge base of engineers and researchers, allowing them to create more effective design approaches and procedures to boost the seismic resilience of mid-rise asymmetric buildings.

Sriskanthan Srisangeerthanan's research looks at how in-plane diaphragm stiffness and strength affect seismic performance in multi-story modular structures. A simplified technique that takes shear deformation and connection deformation into account is used to calculate diaphragm service stiffness. According to the findings, increased flexibility leads in substantial inter-story drifts and inertial forces. The research proposes unique seismic design aspects, such as force and ductility amplification, for improved diaphragm connections in multi-story modular buildings.[25]

Li, Yingmin study investigates the influence of structure-soil-structure interaction (SSSI), soil-structure interaction (SSI), and fixed base (FB) assumptions on seismic behavior in mid-rise reinforced concrete buildings on soft soil. If the seismic gap distance is insufficient and the pounding potential exists, soil-structure interaction should be considered independent of building height.[24]

J. Ruiz-Garcia's research proposes a probabilistic technique for predicting residual drift needs in multi-story seismic performance assessments. It combines inelastic intensity measurements, aleatory uncertainty (i.e. record-to-record variability), and maximum inelastic displacement seismic hazard curves to provide site-building-specific hazard curves. The link between transient and permanent drift needs is determined by the mean yearly frequency of exceedance and the number of storys in the building.[17]

The study of the seismic performance of mid-rise asymmetric structures is critical for ensuring structural integrity and safety in the event of seismic activity. To acquire a better understanding of these structures' possible vulnerabilities, which have inequitable dispersion stiffness and strength in their lateral load-resisting systems, their behavior in terms of their lateral load-resisting systems must be thoroughly researched. When it comes to general evaluation, there are several factors to examine, such as dynamic response analysis, checking the lateral force distribution, and analyzing possible causes for failure to include in the study.

5.1 Dynamic Response Analysis:

One of the most essential techniques in assessing the seismic resistance of mid-rise asymmetric structures is dynamic response analysis. For this examination, the structure will be subjected to a typical seismic input, such as earth movements, and its response will be measured in terms of displacements, accelerations, and internal forces. Numerical modeling approaches such as finite element analysis or similar frame models are commonly used to simulate the behavior of the structure and analyze the features of its reaction.

5.2 Lateral load distribution:

The distribution of lateral loads throughout the structure of mid-rise asymmetric structures may vary substantially due to asymmetry. Torsion effects can result from an unequal distribution of mass and stiffness, which generates varying loads on each component. When evaluating a structure's lateral load distribution, it is critical to identify potential places of force concentration as well as structural weak spots. It also aids in determining the efficiency of the lateral load-resisting system and structural component compatibility.

5.3 Failure Mechanisms:

When evaluating the seismic performance of mid-rise asymmetric structures, a full understanding of the possible failure causes is required. Failure mechanisms include shear failures, flexural failures, torsional failures, and P-delta effects, however, this is far from an exhaustive list. The examination of various failure modes facilitates the identification of crucial structural areas that may undergo significant collapse, distortion, and localized damage. This can be caused by a variety of failure types. Based on this knowledge, the seismic resistance of a structure can be improved by retrofitting operations and mitigation strategies.

6.0 Seismic resilient devices and their applications:

Seismic resilient devices are used to lessen earthquake damage and strengthen buildings. In earthquake engineering, several different types of seismic-resistant technologies are employed to achieve various purposes. Here are some of the most prevalent forms of earthquake-resistant technologies, along with brief descriptions and recommended reading materials.

6.1 Base isolation systems

Base isolation systems are seismically robust technologies that isolate a building's superstructure from its base, enabling it to move freely during earthquakes. These devices are designed to decrease seismic energy transmission to the structure, resulting in less structural damage and better protection for people. Shock absorbers such as flexible bearings or isolators that lie between the structure and its foundation are examples. During an earthquake, seismic waves force the ground to move horizontally. A base isolation system's flexible bearings or isolators allow the superstructure to move independently from the ground. This decoupling decreases the transfer of seismic forces to the building, minimizing the chance of damage. Base isolation devices, in addition to permitting horizontal movement, aid in the absorption of seismic energy created during an earthquake. The flexible bearings or isolators absorb and disperse a considerable percentage of the seismic energy, reducing the overall stresses applied to the structure. Base isolation systems improve building resilience by separating the structure from ground motion and distributing seismic energy. They reduce structural damage, maintain building integrity, and safeguard inhabitants during earthquakes. Several variables impact the optimum isolator type for a base isolation system, including anticipated seismic hazard, structural elements, and design objectives. Rubber bearings, lead-rubber bearings, and friction pendulum bearings are common base isolation system isolators. Structures equipped with base isolation devices may endure seismic occurrences with less structural damage and improved occupant safety, providing appropriate protection from the earthquake's devastating consequences. [18]

6.2 Damping systems

Damping systems are earthquake-resistant devices that absorb seismic energy to avoid vibrations and structural damage. This system collects and emits seismic energy. This method also enhances structural robustness. Damping systems used in earthquake engineering include viscous dampers, tuned mass dampers, and friction dampers. Hydraulic cylinders filled with a viscous fluid are used in viscous dampers. During an earthquake, hydraulic fluid is squeezed into tight channels, creating resistance and dispersing seismic energy. This technology contributes to lowering the amplitude of vibrations in the structure. Tuned mass dampers are made up of a mass that is attached to the structure with the help of springs and dampers. The TMD is adjusted to the structure's inherent frequency. When seismic vibrations occur, the TMD oscillates in the opposite direction as the vibrations, damping the motion and lowering the structure's dynamic response. Friction dampers use sliding surfaces between two components that move relative to one another during an earthquake. Friction is generated at these contacts, absorbing energy and decreasing the amplitude of the structure's oscillations. Damping system selection and design consider structural elements, required damping level, and design objectives. These systems are frequently integrated into a structure's structural components. [19,20]

6.3 Energy Dissipation Devices:

Yielding devices are designed to absorb energy by plastic deformation or by adding yielding materials such as steel plates or energy-absorbing polymers to undergo controlled deformation or yielding. By dissipating energy in a regulated manner, yielding devices safeguard the main structural elements from excessive forces. Metallic dampers conserve energy by taking advantage of intrinsic metal features like hysteresis and damping. These devices are made of metallic pieces or bracing that bend cyclically during seismic events, dispersing energy and reducing structural reaction to earthquake pressures. The energy dissipation device is tactically incorporated into the structural system to dissipate energy at specified areas such as columns and beams, depending on the demands of the building as well as the structural design.[21] Figure.7 depicts various rocking frames and walls for concrete buildings.

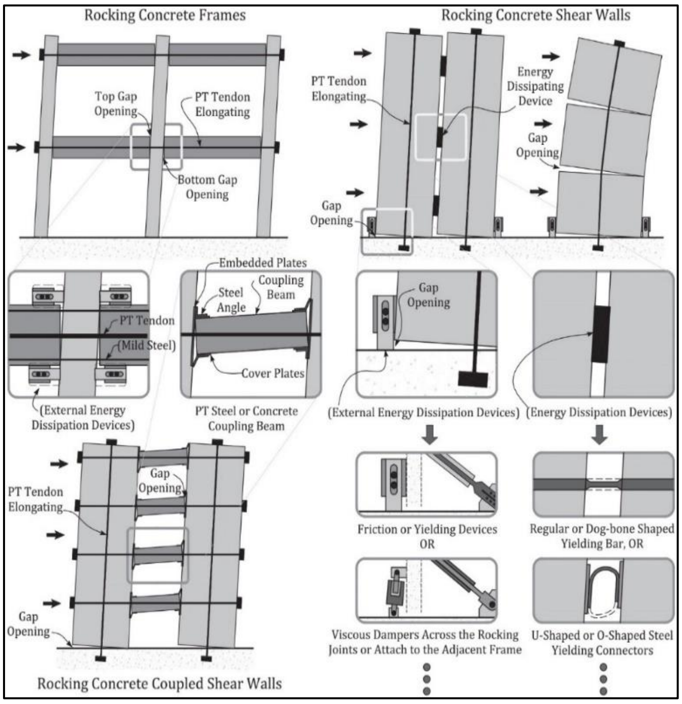


Fig.7 Rocking frames and walls for concrete buildings

7.0 Seismic performance assessment of a Mid-rise Asymmetric Building

A mid-rise asymmetric building's seismic performance assessment entails evaluating its behavior and response under seismic loading conditions, with the goal of understanding the building's ability to withstand and safely dissipate seismic forces, identifying potential weaknesses, and proposing appropriate retrofitting or design measures.

7.1 Structural Response Analysis

The first step in the evaluation process is to conduct a thorough structural response analysis. During this technique, seismic stresses are applied to the building model, and its dynamic response is evaluated. A range of analytical methodologies, including linear and non-linear dynamic analysis, may be used to anticipate the structure's behavior in various seismic scenarios. Non-linear analysis on reinforced concrete structures may be performed using a variety of computer applications. Some of these software, such as LARSA, SAP2000, ABAQUS, NISA, and ANSYS, use finite element methods (FEM) to evaluate structures.

7.2 Performance Evaluation Metrics:

Performance evaluation metrics are used to study the structural reaction and measure the performance of a structure. Inter-story drift, base shear, floor acceleration, and residual displacements are all common measures. These factors contribute to a building's capacity to remain stable, resist excessive deformation, and prevent damage during seismic occurrences.

7.3 Seismic Vulnerability Assessment:

The seismic susceptibility of a building's lateral load-resisting systems is evaluated to identify potential risks and shortcomings. Each structural component, such as shear walls, beams, and columns, must be evaluated for seismic resistance. Vulnerable components are identified and assessed for their impact on the overall building response.

7.4 Retrofitting Strategies:

Depending on the results of the seismic performance study, retrofitting solutions to increase the structure's seismic resistance may be offered. These remedies might include reinforcing or updating weak structural components, enhancing connections, adding extra lateral load-resisting materials, or installing seismic dampening devices.

Stefano Pampanin's study recommends a partial retrofit approach based on standardized solutions as a practical and effective upgrading technique, particularly when considering a large intervention at the territorial scale. Fiber-reinforced polymers, low-invasive metallic diagonal haunches, post-tensioning wall systems, and selective weakening procedures are addressed as alternative retrofit tactics and technological solutions.[26]

7.5 Code Compliance and Standards:

The evaluation should take into account local building norms and standards to guarantee compliance with seismic design requirements. It is critical to ascertain if the facility satisfies the performance objectives and safety standards established in the applicable building regulations.[22]

7.6 Experimental Testing and Validation:

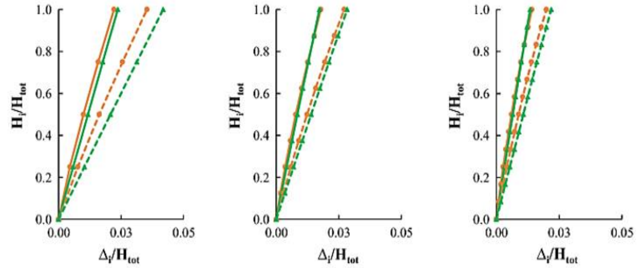
Shake table tests or scaled models, for example, might be utilized to evaluate assessment findings and confirm the efficacy of proposed retrofitting processes. The experimental results provide light on the behavior and reaction of mid-rise asymmetric buildings during seismic events. [23]

8.0 Comparative Analysis of Conventional Shear Wall and Rocking Shear Wall

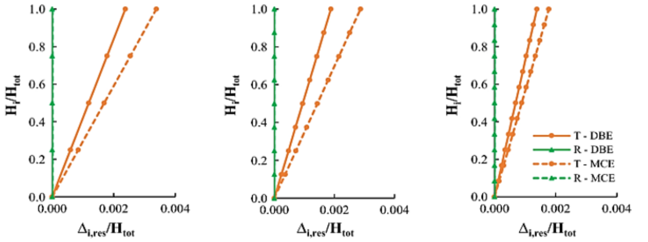
Both rocking shear walls and traditional shear wall systems play important roles in shear wall system design, development, and assessment. These functions are carried out by displacement, base shear, tale drift, time period, and fragility curves. However, the significance of these metrics and the consequences they imply may differ depending on the individual traits and behaviors of each system. These criteria aid in understanding the seismic reaction of the walls, as well as their capacity for energy dissipation, structural integrity, and vulnerability, so guiding the design process and allowing for better-informed decisions.

8.1 Displacement

Shear walls are typically built to withstand lateral pressures primarily through flexural and shear deformations. Traditional shear walls exhibit linear displacement behavior up to the elastic limit, followed by inelastic behavior as loads increase. Typical shear walls encounter higher displacements as lateral pressures grow, which can cause considerable damage and collapse. Rocking shear walls are shear walls that have a self-centering mechanism. These walls are meant to rock in a controlled manner during seismic occurrences, distributing energy and decreasing transmitted forces to the rest of the building. An initial linear reaction is followed by a period of rocking motion in the rocking shear wall displacement behavior. When compared to traditional shear walls, rocking shear walls usually have less total displacement. The regulated rocking action absorbs energy, reducing total structural movement. This reduction in displacement can result in improved performance, less damage, and improved post-earthquake functionality. Several aspects, including as wall geometry, base design, and material selection, must be carefully considered while building a rocking shear wall. For optimal rocking behavior and adequate energy dissipation, proper detailing and reinforcing arrangements are critical. Figure.8 depicts the performance of traditional shear wall and rocking shear wall structures created with direct displacement.



(a) Normalized displacements. 4-story (left), 8-story (center) and 12-story (right) structures



Residual displacements. 4-story (left), 8-story (center) and 12-story (right) structures

Figure.8 Performance of traditional shear wall and rocking shear wall structures designed using the direct-displacement

8.2 Base Shear

A comparison of conventional shear walls vs rocking shear walls in terms of base shear may reveal variations in lateral pressure resistance. The base shear is an important measure that defines the total lateral force applied at the base of the surface during seismic occurrences. The table below compares conventional shear walls versus rocking shear walls in terms of base shear. Figure.9 shows the relationship between base shear and roof drift. (a) Unbonded post-tensioned precast wall; (b) Effect of unbonded post-tensioning steel

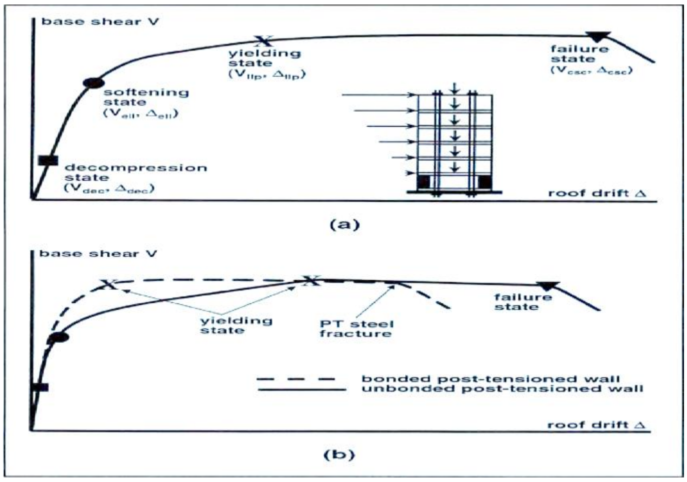


Figure.9 Base shear-roof drift relationship (a) unbonded post-tensioned precast wall (b) effect of un-bonding of the post-tensioning steel

Conventional shear walls endure lateral stresses principally through flexural and shear deformations. The base shear in a typical shear wall is proportional to the lateral loads and the height of the structure. The base shear rises as the lateral stresses grow. Conventional shear walls rely on the wall's shear capacity to withstand and distribute base shear throughout the structure's height. Rocking shear walls feature a substantially lower base shear than typical shear walls. This drop in base shear is related to the rocking motion's energy dissipation process. Some of the seismic energy is absorbed and dissipated when the wall shakes back and forth, resulting in less transmitted base shear. When compared to ordinary shear walls, rocking shear walls have the benefit of reducing transmitted base shear. The wall's rocking motion absorbs energy, resulting in decreased total base shear. The ability to rock shear walls to distribute energy improves their seismic performance while reducing the demands on the foundation and other structural components. A rocking shear wall's design must take into account elements such as wall geometry, base construction, and the selection of appropriate rocking mechanisms. Proper design and detailing are required to achieve the desired rocking behavior and successfully reduce base shear. The highest differences in horizontal displacement at the roof, wall uplift, and base shear were 1.9%,3.9%, and 6.8%, respectively. Variations in horizontal displacement at the roof, wall uplift, and base shear with and without rotational inertia components were 0.9%,0.2%, and 2.7%, respectively. Figure.10 illustrates the proportion of base shear and the uplift of horizontal displacements.

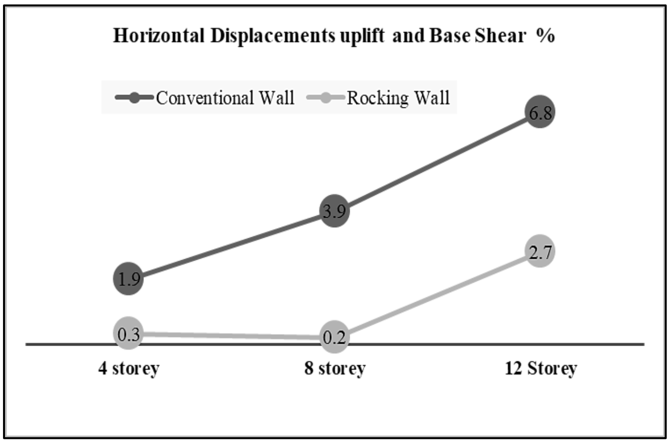


Fig.10 Horizontal Displacements Uplift and Base Shear %

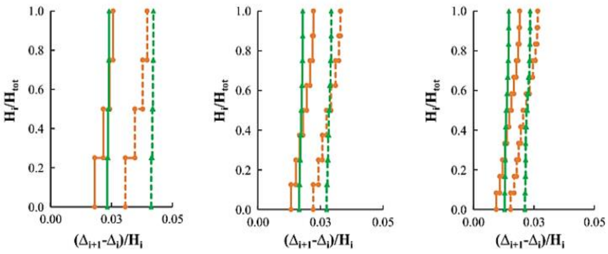
Horizontal Displacements uplift and Base Shear %		
Story	Conventional Wall	Rocking Wall
4 story	1.9	0.3
8 story	3.9	0.2
12 story	6.8	2.7

Table.2 Summary of Conventional Wall and Rocking Wall Analysis (Mark Browne)

8.3 Story Drift

In terms of story drift, a comparison of conventional shear walls with rocking shear walls can give insight into their unique behaviors and performance under lateral stresses. The phrase "story drift" refers to the horizontal displacement that happens during seismic events between a structure's many levels or stories. Conventional shear walls usually have greater story drifts than rocking shear walls. Because typical shear walls are strong, lateral displacements are increased, particularly in upper stories. The stiffness of the wall resists lateral loads and causes bigger inter-story drifts owing to flexural and shear deformation. The rocking motion of the building assists in the transfer and dissipation of seismic energy, resulting in less inter-story drift. The capacity to self-center rock shear walls allows the structure to re-center itself after a seismic event, reducing residual deformations and story drifts. In terms of reducing tale drift, rocking shear walls outperform standard shear walls. The rocking motion of the wall absorbs and disperses seismic energy, resulting in decreased lateral displacements between levels. This reduction in story drifts helps the overall structural integrity and seismic performance of the structure.

The design of a rocking shear wall must take into account aspects such as wall geometry, base connections, and the selection of appropriate rocking mechanisms. The objective is to develop optimal rocking behavior that successfully eliminates tale drifts while maintaining the structure's structural stability and integrity. A comparison of story drifts between conventional shear walls and rocking shear walls shows that rocking shear walls have the ability to decrease lateral displacements and improve mid-rise structure seismic performance. Figure.11 displays normalized inter-story drifts for four-story, eight-story, and twelve-story structures.



Normalized inter-story drifts,4-story(left),8-story(center)and 12-story(right)structures

Fig.11 Performance of traditional shear wall and rocking shear wall structures designed using the direct displacement

8.4 Time Period

A time period comparison of conventional shear walls with rocking shear walls can reveal differences in their dynamic characteristics and seismic reactivity. The time period of a structure is the length of its primary vibration mode, which defines its overall dynamic behavior. Conventional shear walls, as opposed to rocking shear walls, may have a shorter fundamental time period. The stiffness and rigidity of traditional shear walls result in higher stiffness-based frequencies and shorter vibration durations. Because the time duration is shorter, it suggests higher stiffness and a faster response to seismic pressures.

The rocking behavior of the wall offers flexibility, resulting in lower stiffness-based frequencies and longer vibration durations. The longer time span suggests reduced rigidity and a slower reaction to seismic shocks. The extended time period of rocking shear walls may be useful in monitoring a structure's dynamic reaction. The rocking motion's flexibility allows the wall to absorb and disperse seismic energy over a longer period of time, decreasing total force demands and increasing seismic resistance. When determining the time period of a building, variables such as wall geometry, material quality, and the desired degree of seismic performance must all be taken into account. Rocking shear walls are constructed for longer periods of time to give flexibility and absorb seismic energy, whereas traditional shear walls are constructed for shorter periods of time to provide higher stiffness and faster reaction. A study of conventional shear walls with rocking shear walls over time reveals differences in their dynamic characteristics and their impact on overall seismic performance. During the most extreme rocking excursions, the natural duration of free vibration of the wall rises by a factor of three. The amount of base shear transmitted through the wall is reduced as a result. Figure.12 shows time intervals in seconds. (Mark Browne et al., 2006).

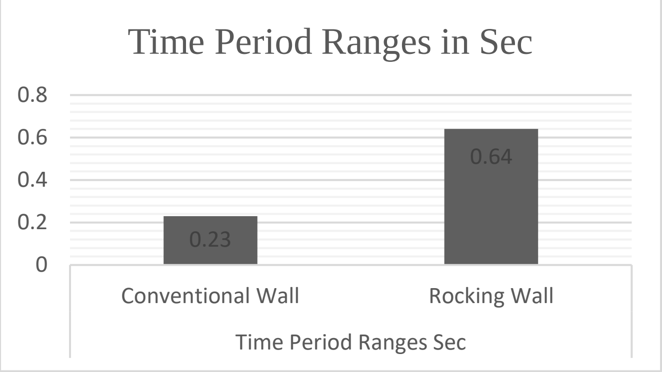


Fig.12 Time Period ranges in seconds

8.5 Fragility Curves

The fragility curves of conventional shear walls and rocking shear walls may be compared to learn more about their seismic performance and susceptibility. certain a certain ground motion intensity, fragility curves show the likelihood of exceeding a specific damage stage or performance level..

Conventional shear walls are often more flimsy than rocking shear walls, rendering them more vulnerable to damage during seismic events. The stiffness of traditional shear walls can place greater demands on structural components, increasing the likelihood of reaching or surpassing set damage thresholds. Rocking shear walls are less brittle than ordinary shear walls, signifying greater earthquake resistance. The rocking behavior enables energy dissipation and redistribution, which reduces demands on individual components while enhancing the building's overall seismic performance. Rocking shear walls have been shown to be more successful than conventional shear walls at reducing the likelihood and severity of damage. The rocking motion absorbs energy, spreading seismic stresses and protecting the building's most susceptible components. When developing fragility curves for conventional shear walls and rocking shear walls, elements such as wall geometry, material properties, and the required level of seismic performance must be taken into account. A comparison of the fragility curves of conventional and rocking shear walls shows that rocking shear walls have superior seismic performance and are less susceptible to earthquakes due to their decreased fragility and higher capacity to distribute seismic energy. Figure.13 shows the fragility behavior of rocking wall structures.

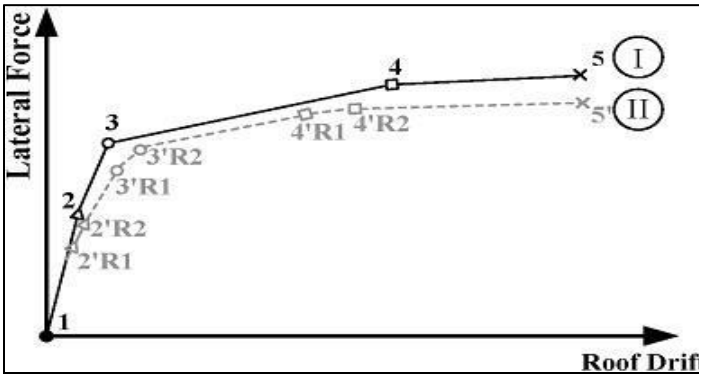


Figure.13 Fragility behavior of Rocking shear wall structures

9.0 SUMMARY

This study investigates the efficiency of rocking shear walls in analyzing the seismic performance of mid-rise asymmetric buildings. The seismic performance of asymmetric constructions with rocking shear walls is compared to that of conventional shear walls. The study emphasizes the benefits of rocking shear walls in decreasing seismic stresses and enhancing performance. The paper emphasizes the significance of structural asymmetry and translational-torsional interaction in design and evaluation. Rocking shear walls are unique methods for transferring seismic energy via controlled rocking motion, self-centering behavior, and force redistribution. The study evaluates displacement, base shear, tale drift, time period, and fragility curves to assess the performance of both wall systems. It advises designers and academics on how to enhance earthquake design methodologies and seismic-resistance measures. The findings can be used to improve the seismic resilience of structures in earthquake-prone areas and to create seismic design approaches.

10.0 CONCLUSION

Rocking shear walls are specialized structural solutions that use controlled rocking motion, self-centering features, and seismic force redistribution to absorb seismic energy and lower transmitted forces. The study emphasizes the need of taking structural asymmetry and translational-torsional coupling into account when evaluating seismic performance. The findings have practical significance for improving seismic resilience in earthquake-prone structures and progressing seismic robust technology.

11.0 RESEARCH CONTRIBUTION

This research contributes considerably to the knowledge and use of rocking shear walls in the seismic performance analysis of mid-rise asymmetric buildings. The comprehensive study emphasizes the efficiency of rocking shear walls in resisting seismic loads and increasing asymmetric building performance. It emphasizes the need of considering structural asymmetry in design and evaluation, as well as accounting for translational-torsional coupling during seismic events. Engineers and researchers may build and evaluate structures that are safer and more robust by including rocking shear walls into the design and assessment methods, reducing the effect of earthquakes and assuring community well-being. The rocking wall system reduces structural damage but does not protect non-structural components from drift-induced damage, hence extra deformation-compatible components must be used.

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