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Original Article

Seismic Behaviour of Simple RC Frame Braced with Viscous Damper under Cyclic Loading- An Experimental Study

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Abstract *- This study investigates the impact of viscous dampers and their placement on the evaluation of monolithic reinforced concrete frames under cyclic loading using sensors. The response of a single Reinforced Concrete (RC) frame to seismic activity depends on its flexibility, and viscous dampers have shown the best performance in terms of improving seismic performance and endurance. In this research, a single RC frame of grade M30 was subjected to cyclic loading using a hydraulic compressor, and its seismic performance, including energy dissipation, floor displacement, and crack patterns, was assessed both without and with viscous dampers filled with highly compressible silicone liquid was placed at 100mm diagonally at each end. The failure pattern was examined under different cyclic loading using LVDT sensors and the strain gauge assessed the crack width, and it was found that the dampers placed at a 100mm distance exhibited the highest damping capacity of 5.83 KN. The results showed that the RC frame's displacement was significantly reduced by up to 19.89%, and the development of crack was controlled at the rate of 27.45 % with viscous dampers compared to the RC frame without a damper. Additionally, the incorporation of viscous damper in RC frames was demonstrated to provide a more significant increase in damping force and reduction in displacement during major seismic events.*

Keywords *- Seismic, Ductility, Damping, Sensor, Viscous Damper.*

1. Introduction

Structural mitigation against earthquakes is crucial for the safety of buildings and residents. In the event of seismic activity, Reinforced Concrete (RC) structures become more susceptible to sudden damage or collapse due to their poor ability to absorb and resist earthquakes. This is because RC structures typically lack the necessary ductility to withstand the forces of an earthquake, which can cause brittle failure in the structure due to poor design and connection between structural elements [1].

Additionally, inadequate reinforcement in concrete elements can make structures more vulnerable to seismic waves. Structures in earthquake-prone areas must consider seismic design, especially during retrofitting of older structures that may have experienced material degradation and lack of maintenance. Buildings with open ground floors and weaker structural support are particularly at risk of collapse during an earthquake.

Since long-term earthquake prediction is difficult, it is essential to design buildings that can withstand seismic activity by dissipating energy and incorporating elements such as shear walls and moment-resisting frames. In order to enhance the seismic resistance of structures, a control system can be implemented to absorb energy during seismic events. Various control systems, such as passive energy dissipation, base isolation, semi-active control strategies and active energy dissipation, have been proposed. Still, they each have their limitations in terms of cost, capacity, and adaptability [2].

Semi-active control systems offer a solution to the challenge of varying external loading conditions without an ample power supply, making them suitable for use during earthquakes. These systems utilize structural responses that are measured to determine the essential control forces. To mitigate the damage caused by earthquakes in vulnerable areas of structures, bracing systems are now commonly incorporated into their design.

These systems are designed to resist lateral forces generated during earthquakes, prevent excessive swaying and strain on the structure, and enhance its stiffness by reducing deformation and deflection. In reality, bracing systems redirect and channel seismic forces to designated paths, thereby reducing the concentration of stress in weak areas of the structure [3].

To create an efficient bracing system, it is crucial to choose the appropriate material based on the building's design, seismic zone, and load combination. Additionally, ensuring proper placement and compatibility of dampers with the structure is essential. To better understand the seismic behaviour of previously constructed reinforced concrete structures that were not designed to withstand earthquakes, push-over and non-linear time history studies can be used to assess their global and local reactions and seismic vulnerability.

This can help determine the seismic vulnerability of these structures. Considering the properties of masonry materials, theoretical procedures for assessing masonry strength, various modes of failure in infilled frames, and two analysis procedures for infilled frames, as well as a test program to investigate seismic response, a proposed design approach to improve performance, and the study of pinching in hysteresis loops during earthquakes, it is possible to evaluate the seismic vulnerability of RC structures with masonry infills [4].

It is essential to take into account the seismic pressures that are exerted on irregular buildings with floating columns, as they are more susceptible to damage when seismic forces are not considered during the design phase. Seismic fragility curves can be used to assess the likelihood of damage occurring. Additionally, the proper reinforcement details and the impacts of cyclic loads on the response of exterior beam-column joints in older reinforced concrete structures can affect the behaviour of these joints. Understanding how the loading rate influences the seismic performance of RC column members, which are essential for constructing structures that can endure dynamic loading [5].

The goal of conducting cyclic loading tests on reinforced concrete portal frames equipped with brace-type friction dampers was to evaluate the performance of the portal frames and validate the effectiveness of an innovative connection technique. However, a reliable jointing method is needed for the welded component located within the beam. The findings revealed that the dampers were successful in creating strong connections.

Overall, the dampers demonstrated their ability to enhance seismic response control and energy dissipation capabilities of RC buildings [6]. In steel-framed structures, dual-pipe dampers have shown superior performance compared to single-pipe dampers. These dampers offer several advantages, including a simple structure, low cost, high energy absorption, and consistent operation [7]. By incorporating bracing systems and infilled frames in structures of medium and high-rise height, it is possible to increase the lateral load capacity of reinforced concrete shear walls. Numerical modelling results have shown that both approaches significantly improve stiffness, lateral strength, and energy dissipation compared to a conventional frame [8].

A proposal has been made to install a rectangular opening in the RC slab above the damper to address the impact of slab openings on structural behaviour. This proposal, along with experimental and numerical simulation results, has been presented to verify the effectiveness of this solution [9]. The use of metallic dampers in RC beam-column systems has also been discussed.

Retrofitting existing reinforced concrete structures with a friction damper-disc-springs system and a concentric braced frame can significantly improve their seismic performance, leading to lower seismic life cycle costs. This is because these systems eliminate residual drift and reduce inter-story drift. Our research focuses on velocity-dependent and displacement-dependent devices, testing protocols, and a parametric investigation of hysteretic dampers in bracing systems of framed buildings.

Hysteretic dampers are energy dissipation devices that improve the seismic performance of civil structures during earthquakes by minimizing damage by dissipating energy input. Steel yield dampers and braces are an effective system for enhancing the strength and structural behaviour of concrete frames during seismic activity.

This results in increased strength and reduced damage in comparison to control frames, making them a promising solution for enhancing the resistance of concrete structures in regions prone to earthquakes. The utilization of friction dampers has been demonstrated to be not only cost-effective but also simple to install and maintain in the context of seismic protection of reinforced concrete frames.

Furthermore, this method has been found to enhance structural response and decrease the requirement for damping. Our assessment compares the seismic performance of Single-Degree-of-Freedom (SDOF) structures supported using fluid viscous dampers to understand their effectiveness in reducing seismic impacts. It analyzes factors such as structural dynamic properties, damping ratios, and nonlinearity. The seismic mitigation performance of structures with FVDs under near-fault pulse-type ground motions is the focus of this evaluation.

The goal of this study is to evaluate the potential of viscous dampers as a means of minimizing the effects of earthquakes on buildings. Despite their proven ability to effectively manage building structures during earthquakes, their practical application in real-world buildings remains limited [14]. This research aims to establish the optimal performance and cost-effectiveness of viscous dampers under a variety of operating conditions.

A hybrid simulation approach is used, which combines numerical modelling and analysis with experimental validation through the use of reinforced concrete frames [15]. We hope that this study will help to fill gaps in our understanding of the seismic behaviour of a simple reinforced concrete frame supported with viscous dampers when subjected to cyclic loading conditions.

Previous research has primarily focused on complex frame configurations or various damping systems, overlooking the unique challenges and opportunities associated with simpler RC frames. The primary goal of this research is to present data and insights based on practical experience regarding the effectiveness of viscous dampers in increasing the earthquake resistance of fundamental reinforced RC frames. The outcomes of this study will offer valuable information on the optimal utilization of viscous dampers in construction.

Additionally, the findings will guide performance, cost, and functionality while also providing direction on these aspects. Ultimately, the objective of this research is to improve the effectiveness of building design to make structures more resilient to earthquakes during seismic events.

2. Materials and Methods

This research focuses on evaluating the characteristics of a Reinforced Concrete (RC) structure comprising cement concrete and reinforcing steel. The design of the various components of the frame was based on assumed or specified material properties. Still, it is essential to recognize that these properties may vary due to construction variations that occur under quality control measures as per IS: 8112-1989.

Consequently, determining the actual material properties of the frame is necessary to ensure compliance with relevant RC construction codes. Moreover, understanding the actual properties of concrete and steel is critical for analyzing how the simple RC frame will react under various loading conditions [16]. To accomplish this, a range of standard tests were conducted on each component of the RC frame, as outlined in the subsequent sections in accordance with IS: 4031-1-1996.

2.1. Properties of Cement Concrete

The construction of the RC frame used Grade 43 Ordinary Portland cement and locally sourced fine aggregate that adhered to Zone-II standards. The cement was tested to ensure it met the specified physical property limits. The natural fine aggregate was put through a sieve analysis, and it was found that over 90% of it passed through the 4.75mm sieve, while the coarse aggregate was also analysed similarly, with the 10mm sieve being the largest size.

The bulk density of the fine aggregate was approximately 10% higher than that of the coarse aggregate. Additionally, the concrete's compressive strength was evaluated by casting and curing three cubes for 28 days, and its average compressive strength was measured to meet the target strength as per the mix design of the concrete.

2.2. Properties of Reinforcement Steel

In this research, the Reinforced Concrete (RC) framework was strengthened with two types of steel, TMT bars with a specified yield strength of 500 MPa, which served as longitudinal and transverse reinforcements in all frame members except the beam and columns, which had shear reinforcements made of high-strength wires. The tensile properties of these reinforcing steels were determined using a Universal Testing Machine (UTM).

A data acquisition system was used to record the force and deformation of the coupons online. Tensile stress was calculated by dividing the force carried by each coupon by its original cross-sectional area, and the tensile strain was calculated as the ratio of the coupons' tensile deformation to their respective gauge lengths. The extensometer used in the test had a gauge length of 25mm, which was determined by measuring the distance between the holding clamps.

2.3. Simple RC Frame

The experimental study focuses on the main components of a simple RC frame, which consist of a footing measuring 1600mm x 550mm x 100mm, two columns measuring 1000mm x 75mm x 75mm, and a beam measuring 1000mm x 75mm x 75mm as shown in Figure 1. The primary reinforcement for each frame member consists of high-yield Thermo Mechanically Treated (TMT) bars, while the beam and column shear reinforcements are made of high-strength wires in the form of TMT bars.

The RC footing is constructed with primary reinforcement in both directions. This includes 8 bars with a diameter of 10mm, spaced at 50mm intervals, and 10 bars with a diameter of 10mm, spaced at 200mm intervals. The side cover has a width of 20mm, and the hook length is 50mm with a development length of 280mm. The beam sections are constructed using four 8mm diameter TMT bars on both zones of the neutral axis.

The columns are designed with 8mm diameter TMT bars of 4 numbers as longitudinal reinforcements, with a reinforcement percentage of 3.1%. Similarly, the beam also had high-strength wires with a diameter of 3mm, spaced 50mm apart from each other along its entire length, following the specifications of IS: 1893, 2002. The beam and column members have a cover thickness of 15mm.

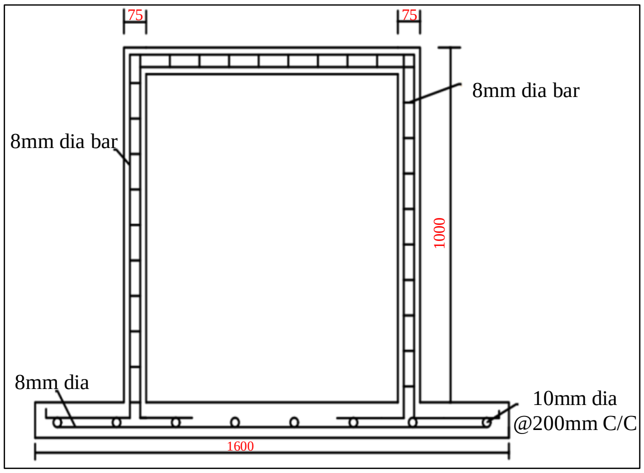

Fig. 1 Reinforcement detail of simple RC frame

2.4. Casting of RC Frame

As shown in Figure 2, the formwork for casting was designed to be more accommodating in order to make casting in the horizontal position easier. The formwork made up of plywood was built to the required dimensions, with a tolerance limit of about 2.5mm, following the formwork made of oiled plywood to facilitate the removal of the cast specimen.

The reinforcement caging was prepared in accordance with the reinforcement detailing. The necessary cover was inserted into the beam and column members after the position of cage reinforcement in the formwork [2]. The casting process started with the footing, then moved on to the column, and finished with the beam application. Following that, the top surfaces of the casted frame members were finished and levelled [3].

Each specimen goes through a manual compacting of the members. The frame members are allowed to cure by conventional method over 28 days by using covered gunny bags and applying water at regular intervals.

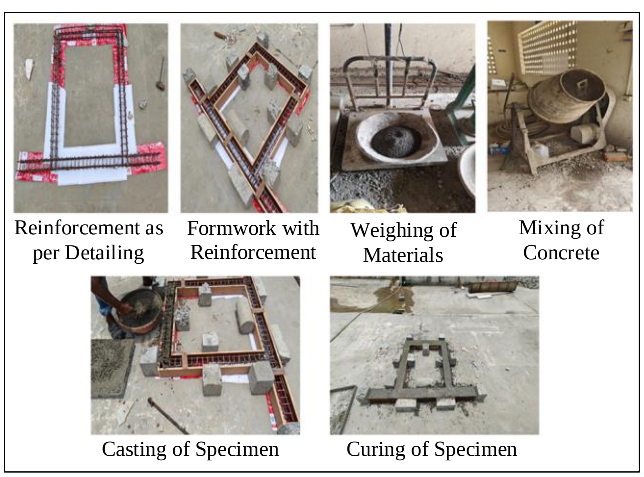

Fig. 2 Simple RC frame construction

2.5. Fluid Viscous Damper

The behaviour of structures under dynamic loads is challenging to predict and analyse due to the complexity of the problems involved [4]. Researchers have been striving to develop approaches to control and reduce the structural responses to dynamic loads.

One commonly used device for this purpose is the Viscous Damper (VD), which is a damping mechanism that generates damping force through the viscosity of the fluid. It is employed in structures to dampen wind or ground motion excitation [5]. Viscous damping is a linear damping model and is considered the simplest theoretical model for energy dissipation. The energy dissipation mechanism of viscous damping is often represented by a "dashpot."

The primary driving force behind the operation of fluid viscous dampers is the dissipation of energy that occurs as a result of fluid flowing through orifices. These devices primarily consist of a stainless-steel piston, a steel cylinder divided into two chambers by the piston head, and a damper filled with silicon-based compressible hydraulic fluid with a viscosity of 350mm^2/S.

Highly compressible silicon fluids used in structural dampers have physical and chemical properties that contribute to their performance, including variable viscosity, high compressibility, wide temperature range, and resistance to oxidation and chemical reactions [6]. These fluids are engineered to be non-toxic and non-corrosive, ensuring long-term performance and consistency. Figure 3 depicts the components of the damper used in this study [7].

In general, in a viscous damper, the fluid flows from one chamber to another through the orifice as the piston moves (e.g., from left to right or right to left), resulting in a loss of energy due to the movement of fluid from a larger area (cylinder chamber) to a smaller area (orifice) and then from a smaller area (orifice) to a larger area (cylinder chamber).

The operation of fluid viscous dampers is possible in a temperature range of 40-70 degrees Celsius [8]. The function that represents the damping force of the damper is dependent on the pressure difference across the piston head, and it is proportional to the velocity of the piston, which is given in the equation below.

$$F_d = C_\alpha |\dot{U}_{\mathrm{d}}|^\alpha Sgn(\dot{U}_{\mathrm{d}})$$

The way in which viscous dampers behave in structural dynamics is influenced by adjustments made to the fluid flow properties through modification of the constant parameter associated with orifice shape. This makes viscous dampers crucial elements, characterized by a damping ratio denoted as $C\alpha$, the velocity of the piston Ud, and the sign function sgn(.).

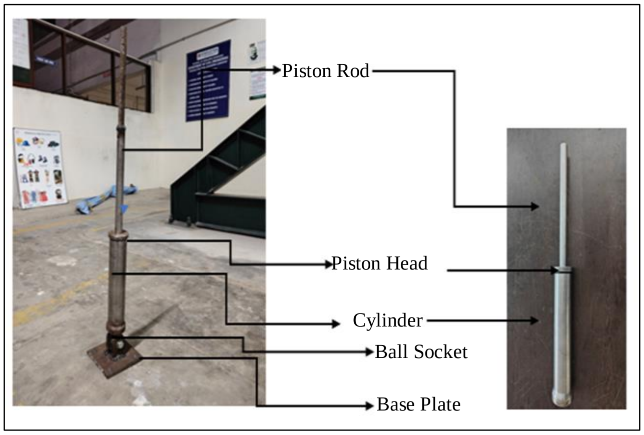

Fig. 3 Viscous Damper specification

They are typically designed for earthquake protection within the range of 0.3 to 1.0. Viscous dampers have a dual nature, exhibiting linear behaviour at Fd < 14 C < U for 14 1 while also displaying non-linear force application at U > 1. However, there are concerns regarding the amplification of structural stiffness during high-frequency excitations and the emergence of viscoelastic characteristics beyond the cut-off frequency [9].

Despite their proven effectiveness in reducing base shear on bridge piers, there are reservations about these aspects. Notably, temperature variations have little impact on viscous dampers in contrast to their viscoelastic counterparts [10]. Nonetheless, constant monitoring is necessary to prevent oil leaks resulting from seal degradation.

Current research is exploring ways to enhance the effectiveness of dampers through real-time orifice control, with a focus on reducing the likelihood of deck unseating at expansion joints with narrow seat widths during seismic events [11].

2.6. Experimental Setup

This research employs time history load tests to assess the RC frame performance under cyclic loading conditions. For that, a hydraulic actuator with a capacity of 50kN for tension and compression was utilized to apply lateral load to a reinforced concrete frame. The actuator was equipped with force and displacement transducers to measure the applied force and displacement.

The actuator was supported by a steel box-section column reaction frame fixed at a height of 0.75 meters from the reaction floor. The piston was placed 120 millimetres away from the set point, which enabled it to move 120 millimetres in both directions. To prevent the frame's vertical movement and sliding under lateral load, the RC footing was securely held to the robust floor using base supports and wooden blocks. The actuator assessed the lateral strength and displacement response of the frame at the west side, with LVDTs and strain gauges placed at the top and bottom of the frame, 100 millimetres away from the piston. The displacement transducers' positions along the height of the columns remained constant for all specimens, and a state-of-the-art data acquisition system was used to collect data during the time history loading test. Figure 4 illustrates the experimental setup.

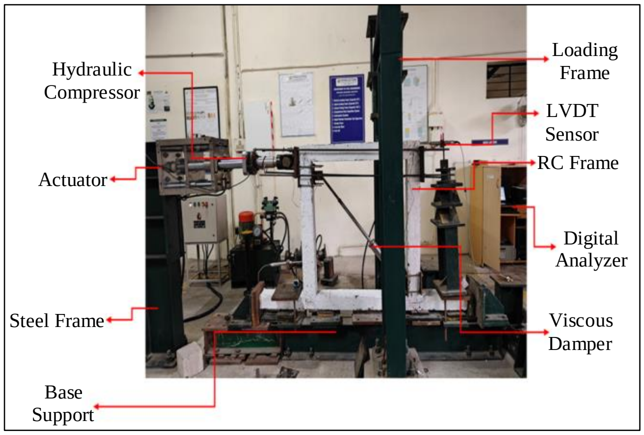

Fig. 4 Loading frame with accessories

3. Experiment Analysis

3.1. Loading History of Viscous Damper

The use of time history loading is a cost-effective method for evaluating seismic performance, as opposed to using shake-tables. This technique entails subjecting the test structure to variable displacements and then calculating the inertial forces that the structure would experience during an earthquake based on the observed inertial forces and deformations during testing [27].

The large and tall structures' seismic performance can be assessed using dynamic forces generated by actuators, which apply pressure to a large reaction frame. To study the performance of a fluid viscous damper in reducing seismic energy, it was subjected to seismic loading using the Bhuj earthquake 2001 time history loading, as shown in Figure 5.

This study involved examining lateral strength, damage propagation and energy dissipation. In the displacement control mode, lateral loads were applied to the upper surfaces of the specimen [28]. The seismic loading was simulated using the Bhuj Earthquake 2001 ground motion data, with the current input to the damper fixed at 0A and 3A. The displacement response of the Bhuj earthquake 2001 ground motion data was used as the input loading history, and the response of the damper was measured in terms of the force it offered against displacement.

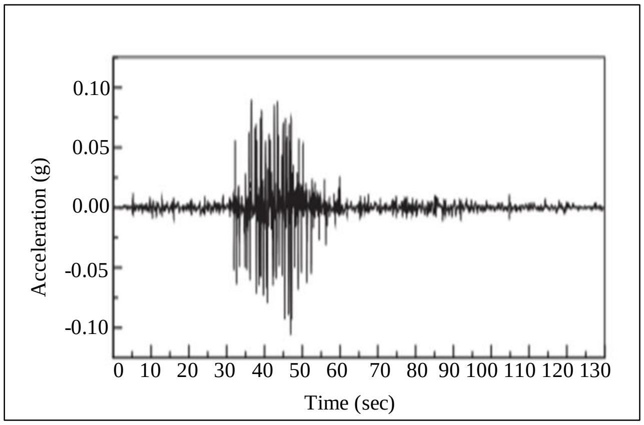

Fig. 5 Loading history, Bhuj earthquake 2001- India [16]

3.2. Force Vs. Displacement Response of Dampers

In this study, the hysteresis behaviour of a fluid viscous damper was investigated through a time history loading test conducted at currents of 0A and 3A. The resulting hysteresis loops were determined based on Force vs Displacement measurements, as depicted in Figure 6. The non-linear properties of the viscous damper, including the hysteresis behaviour, are of particular interest in this study. The damping force produced by the viscous damper at 0A current is significantly different from the force produced at 3A current. The model has been found to offer an acceptable level of accuracy, especially for moderately complex tasks.

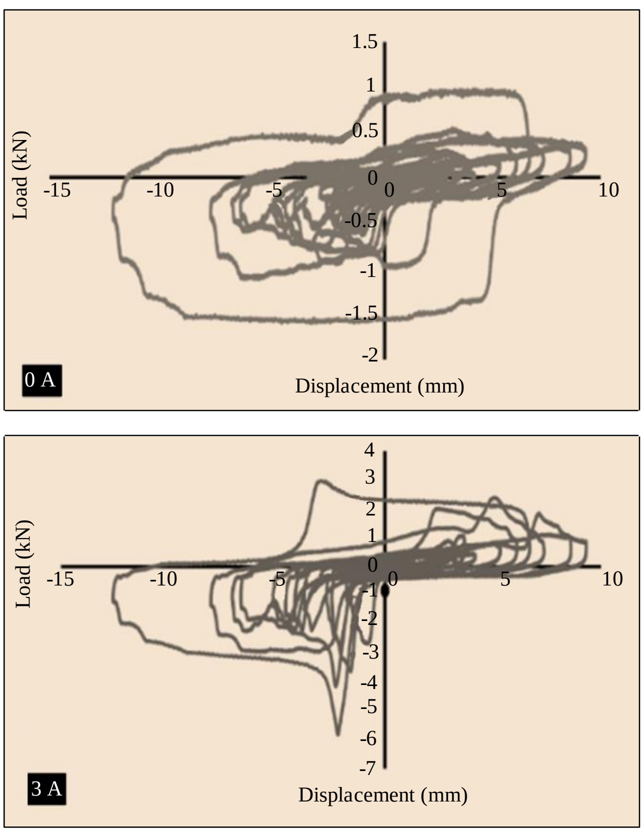

Fig. 6 Force Vs. Displacement responses of a viscous damper

The zero-force area experienced a pinching effect due to strain hardening. When the current was increased in the horizontal direction, hardening was observed in the region subjected to the highest force. In contrast, in the vertical orientation, softening was noted in the zero-force area. The fluid viscous damper at 3A demonstrated its ability to generate a maximum damping force of 5.73 kN on its own.

3.3. RC Frame Acceleration under Cyclic Loading

In this research, we carried out a displacement-controlled time history load test on two RC frames with and without damper provision to evaluate their load-bearing capacity and assess damage propagation. The test entailed applying a maximum displacement of 9.75mm at the beam level. The response of the frame with a fluid viscous damper at 3 A current to the time history load was scrutinized, focusing on the evaluation of cracks in the joints, such as the number and type of cracks. We assessed the overall performance of all tested specimens by analyzing the lateral load versus displacement and lateral acceleration versus time.

3.3.1. RC Frame without Damper

The Bhuj earthquake 2001 ground data was used to introduce a simple RC frame without a damper, as shown in Figure 7, with seismic loads corresponding to the cyclic load increment of 20-160kN.

Fig. 7 RC frame without damper

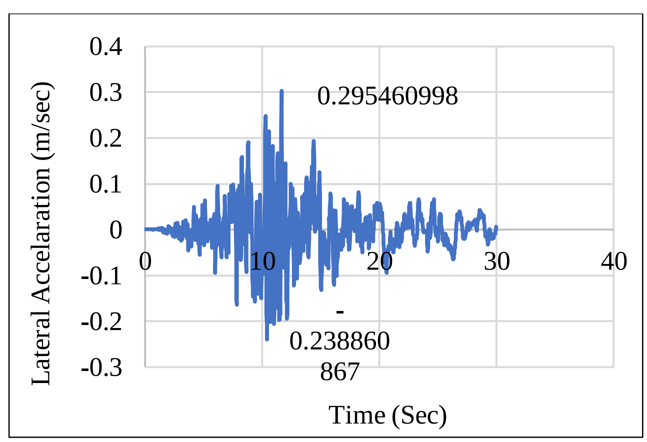

Fig. 8 Lateral acceleration Vs. Time of RC frame without dampers

The lateral acceleration was measured using an LVDT sensor attached to the frame, and the readings were recorded simultaneously.

As shown in Figure 8, the failure of the plain RC frame began at 7 seconds, and it reached a minimum lateral acceleration of 0.29 m/sec at 12 seconds. The crack started at the same time as the failure and reached its maximum extent at 30 seconds. From this observation, it can be concluded that the failure pattern of the RC frame without a damper shows notable performance beyond the failure limit compared to the load history analysis of the Bhuj Earthquake ground data.

3.3.2. RC Frame with Damper

Figure 9 shows the viscous damper and sensors connected diagonally to this RC frame prototype. The ground data from the Bhuj earthquake of 2001 were used to develop a simple RC frame with a damper, with seismic loads equivalent to cyclic load increments of 20-160kN.

Fig. 9 RC frame with damper

The lateral acceleration was measured with an LVDT sensor mounted to the frame and recorded concurrently. The breakdown of the plain RC frame occurred at 15 seconds and reached a minimum lateral acceleration of 0.47 m/sec at 20 seconds, as shown in Figure 10.

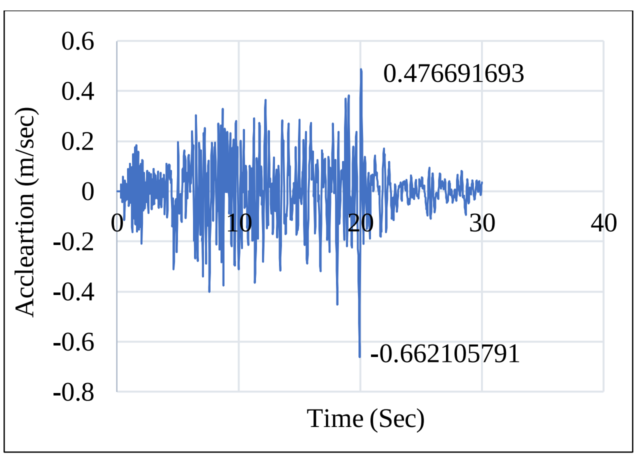

Fig. 10 Lateral acceleration Vs. Time of RC frame with dampers

The fracture began concurrently with the failure and reached its maximum extent after 30 seconds. According to this finding, the failure pattern of the RC frame with a damper shows a significant improvement in the extent of failure limit when compared to the RC frame without a damper and the load history analysis of the Bhuj earthquake ground data.

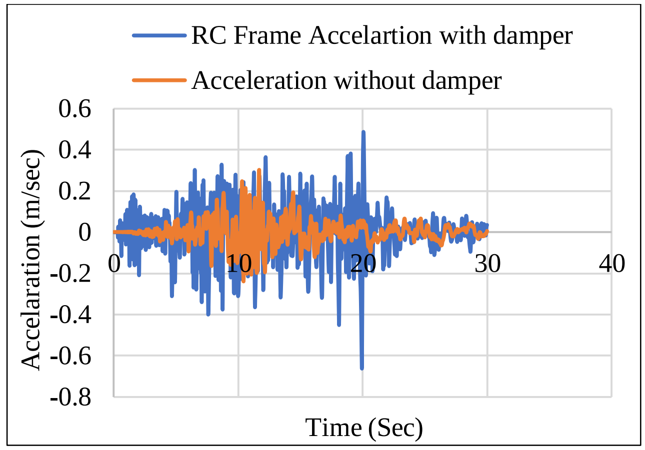

Fig. 11 Lateral acceleration Vs. Time of RC frames

After analysing the results presented in Figure 11, it is clear that incorporating a viscous damper in RC frames under cyclic loads greatly improves their ability to withstand earthquakes compared to plain RC frame elements. This enhancement can be attributed to the damper's capacity to dissipate seismic energy, resulting in reduced structural damage and improved overall stability [12].

Furthermore, the damping effect minimizes structural deformations, ensuring better structural integrity and potentially lowering repair and maintenance expenses. This comparison highlights the significant benefits of integrating viscous dampers in RC frames to enhance seismic resistance, offering a practical and effective solution for mitigating seismic risks in structural engineering.

3.4. RC Frame Displacement under Cyclic Loading

The analysis of RC frame displacement under cyclic loading involves studying the behaviour of the structure during repeated loading cycles, identifying weak points, evaluating post-loading stability, comparing displacement responses, establishing safety margins, and enhancing seismic resilience [30].

In this study, the RC frame with and without the provision of a damper was subjected to a series of cyclic loading and tested until the failure. The displacement value of each specimen is described in Table 1. The LVDT sensors are employed in this experiment to monitor and examine the displacement caused by the load. usually, these sensors are placed at the two-diagonal outside edges of the frames adjacent to the damper [13].

During loading conditions, the RC frame responds and gets displacement from its initial position. Figure 12 represents the displacement condition of the RC frame with and without a damper subjected to cyclic loading.

Table 1. Displacement of RC frame under cyclic loading

Load (kN)	Displacement (mm) without Dampers	Displacement (mm) with Dampers
20	6.18	5.32
40	7.34	5.62
60	7.75	5.71
80	8.2	6.54
100	8.58	6.89
120	8.9	7.19
140	9.36	7.53
160	9.75	7.81

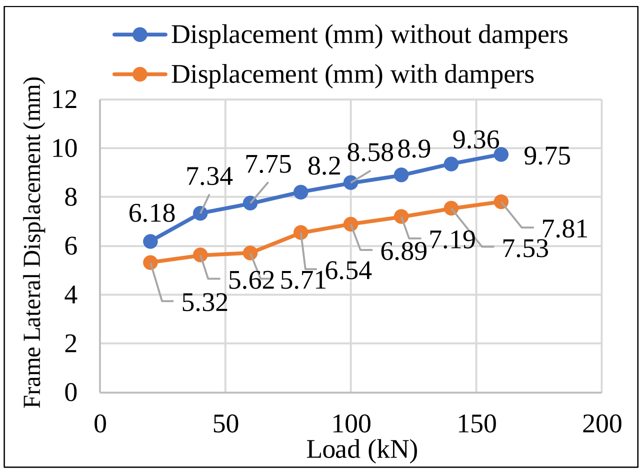

Fig. 12 Lateral displacement of RC frames

Based on the observations, it was evident that the RC frame without viscous dampers had a maximum displacement of 9.75mm under a failure load of 160 kN. In contrast, the RC frame with a connected viscous damper showed a displacement of 7.81mm under the same load condition.

This comparison highlights a substantial 19.89% reduction in displacement for the RC frame equipped with a damper compared to its non-damped counterpart. This difference emphasizes the effectiveness of viscous dampers in reducing displacements during structural failure loads. The reduced displacement indicates improved structural stability and reduced susceptibility to excessive deformations, demonstrating the tangible benefits of using dampers to enhance the seismic performance and resilience of RC frames.

3.5. RC Frame Crack Pattern under Cyclic Loading

Studying the crack pattern in RC frames subjected to cyclic loading is essential for understanding their structural behaviour and potential failure modes. By analysing various aspects such as crack initiation, propagation, width, distribution, evolution, and stability, as well as the impact of reinforcements, engineers can evaluate the structural health, anticipate potential failure modes, and develop suitable reinforcement or retrofitting strategies to improve the frame's durability and seismic resilience [14]. Figures 13 and 14 depict the crack pattern that appeared in both RC frames with and without damper.


Fig. 13 Crack pattern of RC frame without damper


Fig. 14 Crack pattern of RC frame with damper

In this study, the crack pattern was assessed by a strain gauge fixed at all four corners of the frame, as shown in Figure 15. The details observed by the strain gauge were transferred to the computer and compiled with the analysis software to analyse the pattern of crack at each increment of cyclic loading.

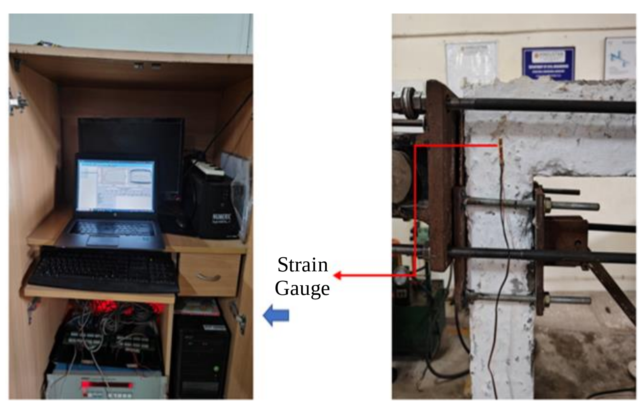

Fig. 15 System compiled with strain gauge for crack analysis

Under each increment of loading, the crack was closely observed. The crack value for both frames is given in the Table 2 below. The significant displacement experienced by the inner fibre of the RC frames led to intense stress, resulting in cracks forming along all the edges.

Figure 16 illustrates the crack width patterns for RC frames, comparing those with and without viscous dampers. It's evident from this observation that the RC frame without a damper exhibited larger crack widths, reaching 1.75mm. However, when equipped with a damper, the crack width reduced notably to 1.21mm, marking a 27.45% improvement compared to frames without dampers. This emphasizes the dampers' effectiveness in controlling and reducing crack formation, showcasing their potential to enhance the structural integrity and resilience of RC frames under cyclic loading.

Table 2. Crack width of RC frame under cyclic loading

Load (kN)	Crack Width (mm) without Dampers	Crack Width (mm) with Dampers
20	0.18	0.12
40	0.34	0.26
60	0.57	0.31
80	0.72	0.54
100	1.02	0.89
120	1.19	0.91
140	1.36	1.02
160	1.75	1.21

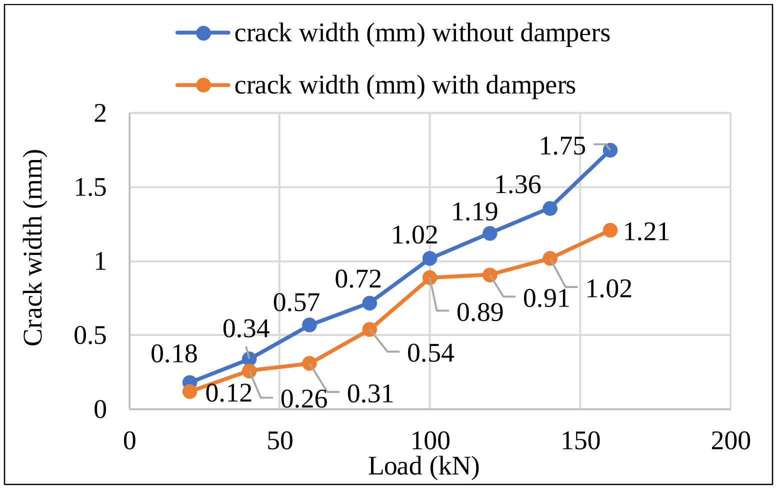

Fig. 16 Crack pattern of RC frames

4. Conclusion

The objective of this research is to design a fluid viscous damper system for RC frames in seismically active regions and evaluate their performance. To achieve this, a research setup was created, which included lateral and base supports, as well as equipment to measure displacement.

The behaviour of the frame with the fluid viscous damper was then examined through time history load experiments conducted under cyclic loading conditions. The results of the study were validated based on the effects of the experiments, and various parameters were analyzed. Ultimately, the study concluded that the fluid viscous damper system was effective in improving the performance of RC frames in seismically active regions, which were derived from the observations.

1. The maximum amount of movement experienced by the RC frame under cyclic loads was found to be 9.75 millimetres without a damper and 7.81 millimetres with a damper.
2. An LVDT was used to evaluate the response of the top floor of an RC frame. The results indicated that the RC frame equipped with a viscous damper showed a 19.89% reduction in maximum displacement compared to a constructed RC frame.
3. The strengthened frame also displayed a maximum acceleration of 0.47 meters per second, which was slightly better than the load history study of the Bhuj earthquake. Additionally, it showed a significant improvement in crack resistance, at 27.45% in frame force, compared to the simple RC frame.

4. The beam-column joints were the primary locations where initial shear cracks appeared in both specimens within the first seven seconds of the tests.
5. During the test, visual observations were recorded, and cracks were identified and registered after the test was completed. The RC frame with a damper showed better seismic response than the one without a damper, demonstrating the value of incorporating viscous dampers into RC frames to enhance damping force and reduce displacement during significant seismic events.

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