IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684, p-ISSN: 2320-334X, Volume 23, Issue 3 Ser. 1 (May - June 2026), PP 67-72
www.iosrjournals.org

Comparative Study Of Base Isolators And Dampers

Kiran R Bargi
PG Student
Shri Dharmasthala College Of Engineering And Technology

Sameer Chitnis
Assistant Professor
Shri Dharmasthala College Of Engineering And Technology

Abstract
Base isolation and damping systems provide advanced seismic protection for structures. This research assesses the use of lead rubber bearings and fluid viscous dampers as seismic protection devices. Each of the systems was incorporated into a five-story reinforced-concrete frame and subjected to scaled design level and maximum ground motion records to evaluate the level of seismic demand. Nonlinear time-history analysis was performed to assess the response of the structures considering peak floor acceleration, inter-story drift, base shear, and post-event displacement. Base isolators were most effective in minimising inter-story drift and base shear demand for structures founded on firm ground. In existing buildings, fluid viscous dampers were found to provide superior performance due to the increased control of floor accelerations. The results presented guide structural engineers in the choice of seismic protection for a given site and structure based on the demands and goals of protection and performance.
Index Terms: *base isolation, dampers, fluid viscous dampers, rubber bearings, nonlinear time-history analysis, seismic performance, structural response.*

Date of Submission: 16-05-2026 Date of Acceptance: 26-05-2026

I. Introduction

Earthquakes are arguably the most damaging and unpredictable of all natural disasters. They are capable of causing various levels of destruction. Beyond simply causing a building to collapse, earthquakes can lead to the vertical separation of floors and the dislodgment of non-structural components. The 1935 Quetta earthquake is one historical example of the devastation an earthquake can bring; the earthquake levelled the city and left 30,000 to 60,000 people dead. The Kashmir earthquake of 2005 damaged over 450,000 buildings.

The goal of most conventional seismic design has been to allow a structure to absorb earthquake forces. However, there are many shortcomings to this design system. While most conventional designs will allow an earthquake to damage a structure without causing the structure to collapse, significant damage to the structure's components and non-structural components is likely to occur. In light of these shortcomings, the focus of conventional earthquake engineering design has shifted to decreasing the forces that a structure must support. Of the many systems that have sought to accomplish this, base isolation and supplemental damping systems have been the most researched and implemented.

Base Isolation

Seismic isolation stops the relative motions of buildings caused by the Earth’s movements. It does this by separating the effects of the Earth’s forces on the building. The system operates below seismic levels. It draws a line between the parts of the building that are affected by the seismic forces and the parts that are not. When this is done, the frequency of the isolated structure is significantly lower than that of a fixed-base structure.

The space between the base isolation system and the structure allows the building to move freely. Because of this, the acceleration of the building is less, and therefore the building is subjected to less inertial force. Practically, this means the isolation layer absorbs the relative movement while the superstructure acts almost like a rigid body. An isolated structure has a fundamental frequency significantly lower than that of a fixed-base structure.

Common base isolation devices include lead rubber bearings (LRB), high-damping rubber bearings (HDRB), and friction pendulum (FP) isolators. Lead rubber bearings contain a lead core, which makes them rigid under loads, and during earthquakes, it dissipates energy from strong lateral movements. High-damping rubber bearings use rubber that gives considerable damping during lateral loading. Pendulum isolators are also affected by lateral displacement, but unlike the rubber bearings, they are not affected by the frequency of the motions.

Base isolation has demonstrated success across several types of structures and various earthquake scenarios. In base-isolated multi-story framed buildings, studies have found reductions of 74.3% for roof story displacements and 90.1% for inter-story drifts, compared to fixed-base buildings. For the historical buildings that are particularly vulnerable due to their age, materials, construction techniques, and architectural restrictions, base isolation becomes essential. Since base isolation systems are implemented at the foundation level or below, they are relatively unobtrusive, and historical buildings are not significantly altered.

Fig.1 Representation of Base Isolators

Damping Systems

Whereas base isolation solves the problem of isolating the structure from the ground motions, damping devices try to solve the same problem in another way. In this case, it involves dissipation of energy within the structure. Dampers help the structure to behave properly during the occurrence of any shocks and vibrations. Supplemental dampers work under the principle that the energy applied to the structure during the sudden event will be absorbed both by the structure and the supplementary dampers.

There are various types of dampers depending on their working mechanism; friction dampers work based on surface friction, viscous dampers use fluid resistance, viscoelastic dampers have elastic and viscous behaviour, whereas tuned mass dampers (TMD) involve a secondary mass oscillation tuned to the natural frequency of the structure. TMDs can be used as passive control devices in tall buildings. This type of damper reduces the dynamic responses of linear structures without the need for energy sources or complicated hardware devices.

Passive dampers have proved to be very effective, but there are some problems with near-fault ground motions and also the strictness of the building codes. Therefore, there have been studies involving active and semi-active damping devices. Semi-active control devices such as magnetorheological (MR) fluid dampers can offer a compromise where the peak base drifts can be reduced by 18-28%, and the peak accelerations can be reduced by 5-15%.

Fig.2 Representation of Dampers

II. Literature Review

The Literature Review papers are elaborated with all details, including all factors to access the papers that are used as reference papers.

[1] Hosein Naderpour, Naghmeh Naji, Daniel Burkacki and Robert Jankowski have published a paper on **"Seismic Response of High-Rise Buildings Equipped with Base Isolation and Non-Traditional Tuned Mass Dampers"** and have concluded that this study showed that combining base isolation systems with non-traditional Tuned Mass Dampers (TMDs) creates an effective method for reducing seismic responses in high-rise buildings. TMDs alone achieved up to 20% reduction in response, and base isolation alone exceeded 70%. TMDs have a practical benefit since they don't require major structural changes. Using multi-degree-of-freedom and non-linear modelling methods was crucial to accurately capture both global and story-level dynamic responses.

[2] Pınar Usta has published a paper on **"Investigation of a Base-Isolator System's Effects on the Seismic Behaviour of a Historical Structure"** and concludes that the study explained base isolation systems, especially mixed Lead Rubber Bearing (LRB) isolators, are very effective at reducing seismic damage to historic masonry buildings and assuring their structural integrity intact. This protects buildings from severe earthquake effects up to a magnitude of 6.5. The minimal intervention needed for foundation-level installation means the historical texture and architectural integrity of heritage structures stay mostly undisturbed. These findings offer a useful approach for seismic retrofitting similar historic structures in earthquake-prone areas. They help reduce the vulnerability of cultural heritage around the world.

[3] Rincy M. A and Er. Shwetha Saju has published a paper on "Comparative **Study of RC Framed Building with Isolator and Dampers"** and concluded that structures with isolators and damping devices perform well during seismic loading. In a base-isolated structure, storey drift and storey displacement are reduced to a greater extent. Performance point of both base-isolated structure and structure with is increased as compared to the fixed-base structure. In a structure with a viscous damper, storey drift, storey acceleration and storey displacement are reduced. Viscous dampers have a better control effect on displacement. Overall, there is a significant reduction in the values of storey displacement, storey drift, and storey acceleration. Study shows that the fundamental period is approximately doubled in the isolated structure.

[4] Yamunarani T, Vijayalakshmi R and Siva Ramkumar M have published a paper on **"Controller Design for Earthquake Excitations using Smart Base-Isolated Structure"** and concluded that a discrete proportional-integral-derivative (PID) controller was revised for nonlinear structures incorporating base isolation with hysteretic friction pendulum systems. Multiple performance measurements (J1-J8) show that the proposed controller effectively controlled base drifts and superstructure reactions. Examining the time series data elaborates that the proposed controller successfully reduces superstructure accelerations and limits floor deviations. The PID controller becomes less suited when used in systems with considerable oscillation, temporal unpredictability, and nonlinearity. It is widely assumed that combining a competent controller, such as a PID controller, with a nonlinear technique can lessen the effects of seismic occurrences on structures with isolated foundations.

[5] Maliha Mehar Qambrani , Fizza Mirza and Muhammad Habib have published a paper on **"Comparative Seismic Response Analysis of a Multi-Storey Building with and without Base Isolators under High Magnitude Earthquake"** and have concluded that this study proves that base isolators significantly reduce storey displacements, drifts, and shear in multi-storey buildings in Balochistan's high-seismic-risk Zone 4. LRB isolators effectively increased stiffness, energy dissipation, and building time period from 0.8 s to 2.03 s, mitigating the earthquake impact by preventing resonance and reducing deformations.

[6] Huayan Pu, Xin Luo, Wei Jiang, Kaka Dong and Xuedong Chen have published a paper on **"Modelling and Control of Hybrid Vibration Isolation System for High-Precision Equipment"** and concluded that the paper has illustrated the dynamic modelling and control of the hybrid isolation system to suppress vibration of the high-precision equipment. The resulting controller attenuates the transfer gain from the base vibration to the platform, and also provides compensation to the direct disturbance on the platform.

[7] Juan C. Rarnallo, Erik A. Johnson, B.E Spencel; JK and M.K. Sain have published a paper on **"Semiactive Building Base Isolation"** and concluded that A comparison study of two "intelligent" base isolation systems, fully active and semiactive dampers, was performed. The response to several earthquake excitations was computed. The semiactive damper was able to accomplish nearly as much as the fully active damper. With the semiactive damper, the peak base drifts were decreased by at least 18.3% compared to the optimal passive linear damper, with a simultaneous reduction in the peak accelerations by at least 4.7%. The least improvement was seen for the Kobe. This study suggests that semiactive dampers, such as magnetorheological fluid dampers, show significant promise for use in base isolation applications with greatly reduced power requirements as compared to the active systems.

[8] Chenghao Wu, Yu Li, Haoyu Li, and Kai Zhang have published a paper on **"Parametric Study on Seismic Energy Response of Base-isolated Structures**" and concluded that in this paper, the rules of seismic energy response and energy distribution of base-isolated structures are investigated. The results of the study are obtained as follows: With the increase of lead core diameter, or the stiffness ratio, the seismic input energy can be enlarged, and the isolation effect of the lead rubber bearing can be reduced. The seismic energy response of a base-isolated structure is quite different for different seismic motions. Especially, if the duration of seismic motion is long or the natural period of the base-isolated structure is close to the predominant period of seismic motion, the seismic energy response of the structure may be amplified.

III. Problem Statement

To analyse the model for a normal building with and without base isolators and dampers. The models are of eight types, and analyzing the earthquake loads on the building.

Objectives of the problem statement

- Evaluate seismic performance of control systems
- Compare linear and nonlinear viscous dampers
- Assess response using ETABS software

IV. Methodology

- Using ETABS software, modelling of a G+10 building with all the loads.
- The loads used are

i) Floor load: 3 KN/m^2 (LL)
ii) Roof live: 1.5 KN/m^2 (LL)
iii) Floor finish: 1.5 KN/m^2 (DL)
iv) Main wall load: 11.73 KN/m (DL)
v) Partition wall load: 5.1 KN/m (DL)
vi) Parapet wall loads: 6KN/m (Roof DL)

- The beams and column sizes are being applied and assigned to the model.
- All types of load combination, cases and patterns are being applied to the model.
- The base isolators are applied, and dampers are applied.
- The model is being checked with all the parameters and analysed.
- The model is being cross-checked with the values.

V. Results

The result suggests the modelling and analysis of the models with components, with criteria used to obtain and come to a conclusion which of the models is safe in consideration of the economy and structural safety. As the tabular column shows the values obtained from the modelling.

Components	Normal building	Normal Building + Base Isolators	Normal Building + Dampers	Normal Building + Base Isolators (Alternative odd numbers)	Normal Building + Base Isolators (Alternative even numbers)	Normal Building + Base Isolators +Dampers	Normal Building + Base Isolators +Dampers (Alternative odd numbers)	Normal Building + Base Isolators +Dampers (Alternative even numbers)
Dead load (DL) (*10^{-3})	0.14836	0.14836	0.116968	0.065851	0.072798	0.116968	0.065851	0.072798
Live load (LL) (*10^{-3})	0.010307	0.010307	0.061658	0.034804	0.038247	0.061658	0.034804	0.038247
DL+LL (*10^{-3})	0.034027	0.034027	0.2645387	0.14927	0.164479	0.2645387	0.14927	0.164479
1.5(DL+LL) (*10^{-3})	0.05104	0.05104	0.39808	0.223905	0.246718	0.39808	0.223905	0.246718
Earthquake (EQ)	45.15615	45.15615	35.477315	39.551291	39.302299	35.477315	39.551291	39.302299
EQ-X	45.15615	45.15615	35.477315	39.551291	39.302299	35.477315	39.551291	39.302299
EQ+X	45.15615	45.15615	35.477315	39.551291	39.302299	35.477315	39.551291	39.302299
EQ-Y	52.773849	52.773849	42.327596	46.866908	46.579139	42.327596	46.866908	46.579139
EQ+Y	52.77389	52.77389	42.327596	46.866908	46.579139	42.327596	46.866908	46.579139
Roof Live Load (*10^{-3})	0.000048	0.000048	0.005188	0.002851	0.003293	0.005188	0.002851	0.003293

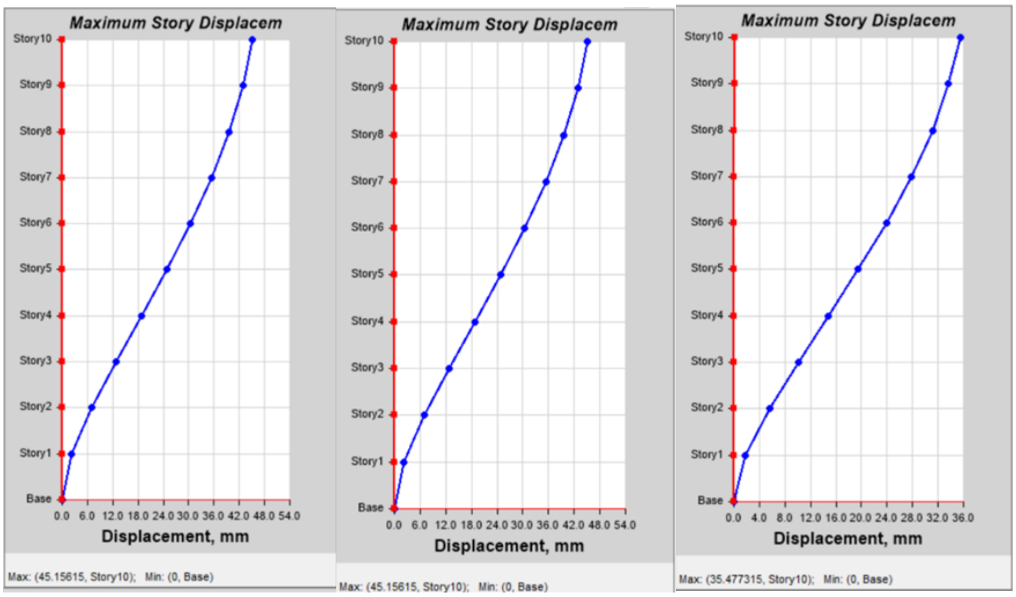

Fig 3: Graphical Representation of EQ loads

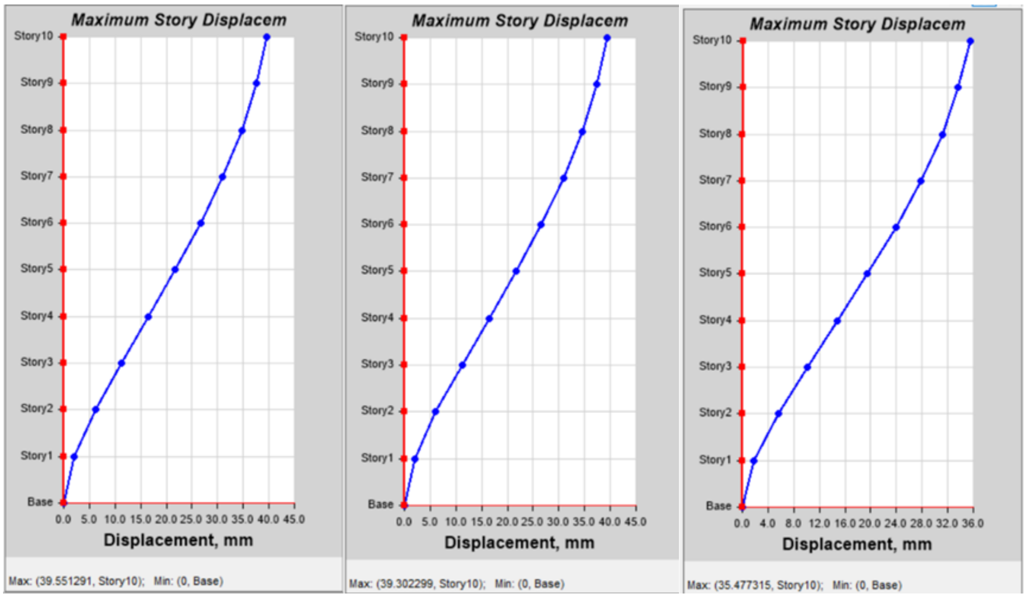

Fig 4: Graphical Representation of EQ loads

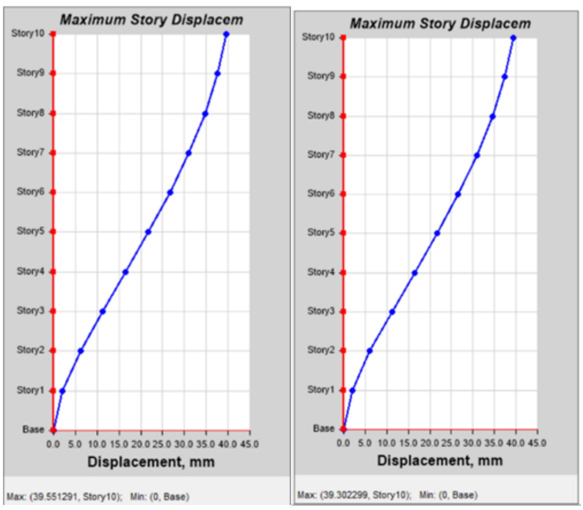

Fig 5: Graphical Representation of EQ loads

VI. Conclusion

- Base isolators and dampers work together in a way. Base isolators help by separating the building from the ground movement. This reduces the energy that gets into the building during an earthquake. It results in movements and forces on the building. Dampers help by using materials to absorb the energy of the earthquake. This helps control how much the building shakes.

- Using one of these might not be enough. Base isolators can let the building move more during some earthquakes. Dampers can't stop shakes from getting into the building. This can hurt things inside the building that're sensitive.

- When you use both base isolators and dampers together, it works well. It's like having two layers of protection. The base isolators help stop the earthquake energy from getting into the building. The dampers help absorb any energy that does get in. This helps reduce how much the building shakes and moves.

- This is especially important for buildings that need to stay safe and be working after an earthquake. Hospitals, emergency centres and data centres need to keep working. Buildings with people in them also need to be safe.

- It might cost more at first. It's worth it. You save money because you don't have to fix much damage after an earthquake. The building also doesn't have to close for long. Engineers can adjust how the base isolators and dampers work to fit each building.

- Experts think that using base isolators and dampers together should be the way to build in areas with earthquakes. It helps buildings stay safe and strong. It's also a value because it helps buildings last longer and costs less in the long run.