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# Study on Global Earthquake Resistant Techniques for Implementation in Various Regions of India

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**ABSTRACT:** This study aims to analyze and evaluate the different global earthquake resistance techniques that can be implemented in various regions of India. The study involved a comprehensive literature review related to seismic techniques and their implementation, and case studies of buildings that were constructed using seismic techniques in the field of seismic engineering and architecture. The study concludes that the implementation of anti-seismic techniques is crucial to mitigate the impact of earthquakes in India. For optimal seismic resistance, a hybrid approach combining both structural and non-structural techniques is recommended. The study also recommends the need for further research and development to tailor these techniques to the specific needs and requirements of different regions of India.

**KEYWORDS:** Earthquake resistance, Structural engineering, Seismic safety, Regional seismicity, Seismic design.

## I. INTRODUCTION

Earthquakes cause significant damage to buildings, infrastructure, and human lives. In India, the risk of earthquakes is a major concern, which has a history of seismic activity. The construction industry plays a vital role in ensuring the safety and resilience of buildings and infrastructure against earthquakes. To this end, various seismic techniques have been developed and implemented globally, with varying degrees of success.

The objective of this particular study is to investigate global earthquake-resistant strategies and evaluate their viability in different parts of India. Additionally, the report aims to pinpoint optimal techniques for earthquake-resistant construction across India.

The paper discusses the seismic hazards faced by different parts of India and the importance of adopting earthquake-resistant measures in construction. The paper then delves into various global earthquake-resistant techniques, such as base isolation, energy dissipation systems, and reinforced concrete structures, to pinpoint optimal techniques for earthquake-resistant construction across India.

## II. RELATED WORK

**Deepak Sahay et al.** studied the gap between the main structure and base foundation system is composed of lead rubber bearings (LRB) which are a flexible arrangement of materials with high energy dissipation properties. This allows the base and foundation system to freely move with the force of the earthquake. While the top structure remains stationary. This is truly an amazing earthquake engineering Techniques. On the light of avoiding the risk, this may not be an impossible task as earthquake resistant measures in building involves only 2% - 6% additional cost depending on the type of building.

**Sudhir K. Jain** Studied on Earthquake safety in India: achievements, challenges and opportunities, Despite these early developments towards seismic safety, moderate earthquakes in India continue to cause thousands of deaths, indicating the poor seismic resilience of the built environment.

**Hing-Ho Tsang** *et al.* Studied Developing Earthquake-Resistant Structural Design Standard for Malaysia, this paper aims to record important milestones achieved by the authors and co-workers, who have been engaged for over a decade in developing the first seismic design standard for Malaysia in the form of a National Annex (NA) to Eurocode 8 (EC8). Non-design parameters (NDPs) were introduced in EC8 to resolve differences where consensus could not be reached amongst the European Commission member states during the drafting of EC8. Ironically, the authors encountered similar challenges as consensus over the NDP of the nation could not be reached. In addition, four major technical challenges stemming from outdated clauses in EC8 and their lack of fit for use in a low-to-moderate seismic environment were highlighted, discussed, and critiqued.

**Helen Goldsworthy and Nelson Lam** Studied Earthquake Resistant Design of Buildings and Education in Australia Seismic-resistant design is not seen as a static process, but one that is constantly evolving. The next stage may be towards a reliability-based performance assessment (a full probabilistic approach to performance assessment) in which all uncertainties in the earthquake intensity, the engineering computations and the acceptance criteria would be taken into account.

**Anjay Kumar Mishra and Ramesh Thing** Studied Structural Features for Earthquake-Resistant Load-Bearing Residential Buildings in Nepal includes plinth band, sill band, lintel band, vertical core, stitch and gable band were earthquake resistant features based on codal provision in 17 models but in implementation were not found in conventional building in previous day. The earthquake resistant features are plinth band, sill band, lintel band, vertical core, stitch and gable band in load bearing structure including 17 models of NRA provided design which are based on National Building Code (NBC).

**Ryo Tanabashi** Studied Earthquake Resistance of Traditional Japanese Wooden Structures, The most striking feature of Japanese wooden structures may be seen in the deep overhang of eaves of the houses. For the purpose of preventing the structural members from decay or corrosion, it has been necessary in this rainy land to have such a deep cave for every building. The technique of the wooden construction capable of carrying the long overhang had been developed in the mainland of China, and it was brought through Korea to this country in the 7<sup>th</sup> century, when a number of temples were dedicated by utilizing this technique. And an example of these temple buildings can be seen in Horyu-ji Temple in Nara, which has been almost perfectly preserved and is thought of as the oldest wooden structure in the world.

**Alessandra Marini** *et al.* Studied Technology options for earthquake resistant, eco-efficient buildings in Europe, the report, a detailed analysis of the main characteristics of European buildings in terms of age, size, ownership, location, structural typology is presented in order to define the predominant typology of the European existing building stock; the seismic hazard in Europe and the earthquake vulnerability of European buildings are then analysed; and finally, energy consumptions and environmental impacts in terms of use of resources, construction and demolition (C&D) wastes and CO<sub>2</sub> emissions are described.

### III. METHODOLOGY

#### 1. ADVANCE SEISMIC ISOLATION

Advanced Seismic Isolation is a technology used in the design of earthquake-resistant buildings to limit the amount of seismic energy delivered to the building during an earthquake. The method employs flexible bearings or pads that separate the structure from the ground, allowing it to move independently of ground motion.

#### 2. STEEL FRAMES

Steel frames are a popular earthquake-resistant building construction technology. They are built to withstand the lateral stresses induced by ground motion during an earthquake. Steel frames are constructed from steel beams and columns that are bolted or welded together to create a stiff structural system. The steel members are robust and ductile, which means they can bend and flex under extreme stresses without breaking. Steel frames have a high strength-to-weight ratio, which is one of their advantages.

#### 3. CROSS BRACING

Cross-bracing is an earthquake-resistant technique commonly used in building construction. It entails the placement of steel diagonal braces between the structural members of a building's structure. These braces form an X or V shape, resulting in a rigid network of interconnected elements capable of resisting lateral stresses caused by seismic activity.

#### **4. REINFORCED CONCRETE**

Reinforced concrete is a technology for earthquake resistance that is commonly utilized in building construction around the world. It entails reinforcing concrete structures with steel bars or mesh, which enhances the strength and durability of the structure during seismic activity.

There are various advantages of using reinforced concrete as an earthquake-resistant technology. Reinforced concrete can be utilized in a variety of constructions ranging from tiny residential structures to large commercial complexes, and it can be modified to satisfy various seismic hazards and building codes.

#### **5. MASS DAMPER SYSTEM**

Mass damper systems are an earthquake-resistant method that is used in building construction to reduce the effects of seismic activity. They are made up of a mass attached to the top of a building structure that is free to move in reaction to seismic waves. The mass damper system works by counteracting the movement of the building during seismic activity, decreasing stress and strain on the structure and assisting in the prevention of damage or collapse.

#### **6. ACTIVE CONTROL SYSTEM**

Active control systems are a relatively recent earthquake-resistant approach that employs advanced technologies to actively manage and minimise the impacts of seismic activity on building structures. These systems are made up of sensors, actuators, and control algorithms that work together to monitor building movement and apply counteracting forces to alleviate stress and strain on the structure.

#### **7. STRUCTURAL WALL**

Structural walls are a form of earthquake-resistant method used in building construction to offer support and stability to the structure. These walls are intended to survive seismic activity by absorbing and redistributing seismic energy.

Structural walls are often made of reinforced concrete or masonry and are strategically positioned throughout a building to offer additional support and rigidity. They can be created in a number of shapes and sizes, based on the building's individual needs and the seismic dangers in the area.

#### **8. JOINTED FRAME STRUCTURES**

Jointed frame structures are an earthquake-resistant technology used in building construction to increase building seismic performance. They are made up of a succession of frames that are joined together at precise points by joint connections.

#### **9. BASE ISOLATION**

Base isolation is an earthquake-resistant technology that involves employing flexible bearings or pads to separate a building or structure from the ground. The bearings or pads are meant to absorb seismic wave energy and decrease the transfer of that energy to the structure. Base isolation can considerably reduce earthquake damage by isolating the building from the ground.

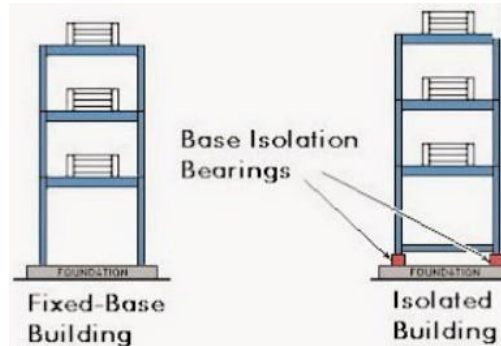


Figure1: Base Isolation.

## 10. DAMPING SYSTEM

Damping systems are an earthquake-resistant approach that involves the use of devices to diffuse or absorb the energy generated by seismic waves. These devices are intended to lessen the vibration and movement of a building or structure during an earthquake, hence lowering the danger of damage or collapse.

## 11. EARTHQUAKE-PROOFING TECHNOLOGIES

Earthquake-proofing technologies are a combination of strategies and practises meant to lessen the danger of building damage or collapse during an earthquake. These technologies are generally utilised in seismically active areas, such as the Pacific Ocean's Ring of Fire, which encompasses countries such as Japan, New Zealand, and Chile.

## 12. FIBER-REINFORCED POLYMERS (FRPS)

Fiber-reinforced polymers (FRPs) are composite materials created by mixing fibres like carbon or glass with a polymer matrix like epoxy or polyester. Because these materials are lightweight, strong, and long-lasting, they are ideal for use in earthquake-resistant structures.

## 13. SOFT-STORY RETROFITTING

Soft-story retrofitting is a technique used in earthquake-prone areas to reinforce buildings with weak or "soft" stories, which are generally found in multi-story structures where the ground level is used for commercial purposes, such as retail stores, parking garages, or lobbies.

## 14. SOIL IMPROVEMENT

Soil Improvement is an earthquake-resistant approach employed in the United States and around the world is soil modification. The quality and qualities of the soil on which a building is built can have a significant impact on its seismic performance. Soft or unstable soil can enhance the shaking during an earthquake, resulting in increased structural damage or collapse. Soil improvement techniques try to reduce this risk by stabilising the ground and making it less susceptible to liquefaction, settlement, and lateral spreading.

## 15. RESILIENT DESIGN

Resilient design is a method that aims to make communities and infrastructure more resilient to natural disasters and other disruptions. It entails designing characteristics into structures and infrastructure that allow them to endure and recover from shocks and pressures, such as earthquakes.

In the context of earthquake-resistant design, resilient design may include a combination of previously discussed techniques and strategies, such as base isolation, damping systems, and structural walls, as well as other measures such as redundant systems, flexible layouts, and modular construction.

## 16. ENERGY DISSIPATING DEVICES

Energy Dissipating Devices are one of the approaches utilised in earthquake-resistant design. They are intended to absorb earthquake energy and minimise the quantity of seismic energy transmitted to the structure. These devices function by introducing a controlled amount of damping into the structure, which minimises the amplitude of the earthquake's vibrations.

## 17. BUCKLING RESTRAINED BRACES

Buckling-Restrained Braces are specialised steel braces used to distribute energy during an earthquake. Buckling-Restrained Braces are made up of two steel tubes joined by a series of metal plates. A unique substance fills the area between the tubes to prevent buckling under load.

Buckling-Restrained bracing absorb and distribute energy during an earthquake by buckling and yielding, rather than breaking or collapsing like traditional bracing.

## 18. SEISMIC DAMPERS

Seismic dampers are a form of passive control system intended to mitigate the impacts of earthquakes on buildings and structures. They are also known as seismic energy dissipation devices. These devices function by absorbing or dissipating the energy created by seismic waves, lowering the intensity and duration of the seismic reaction.

Seismic dampers exist in a variety of shapes and sizes, but their basic role is to absorb seismic energy and transform it to another type of energy, such as heat or deformation. Fluid dampers, friction dampers, and viscoelastic dampers are the most frequent forms of seismic dampers.

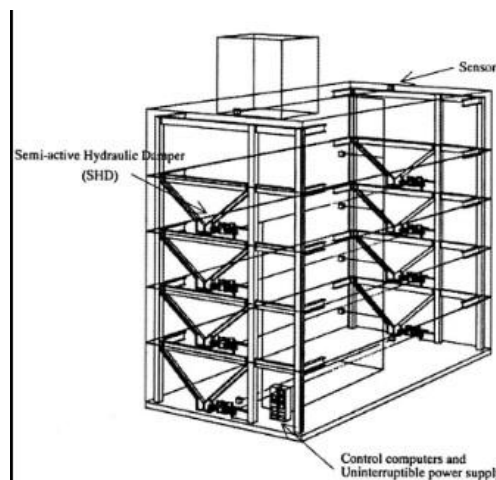


Figure2: Seismic Dampers.

## 19. PILE FOUNDATION

Pile foundations are a sort of deep foundation that is used to transfer a structure's loads deep into the ground. They are typically employed in regions where the soil is soft and compressible, or when the soil has a low bearing capacity. Pile foundations are also used in earthquake applications. .

Pile foundations are constructed up of long, slender columns that are pushed deep into the earth and are usually composed of steel or concrete. A pile driver or drilling rig can be used to drive the piles into the ground. The piles' depth is determined by the soil conditions and the weight of the structure they will support.

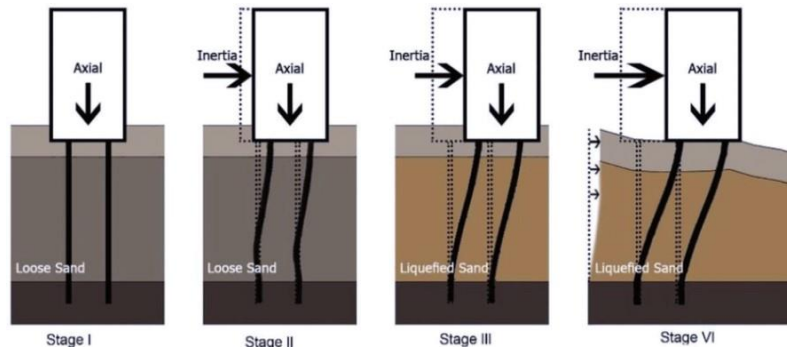


Figure3: Pile Foundation.

## 20. SEISMIC ISOLATION BEARINGS

Seismic isolation bearings are a type of earthquake-resistant technology used to mitigate the effects of seismic activity in buildings and bridges. These bearings are intended to disconnect the building or structure from the ground, preventing ground motion from being communicated to the building during an earthquake. This decreases the amount of force and energy that the building must absorb, which can aid in the prevention of damage or collapse.

## 21. SHEAR WALLS

Shear walls are an important component of earthquake-resistant building design, providing strength and stability to structures in seismically active areas. Shear walls are vertical walls that are designed to withstand lateral stresses caused by earthquakes or wind loads. These walls, which are normally constructed of reinforced concrete or masonry, are strategically positioned throughout a building to offer structural support and stability.

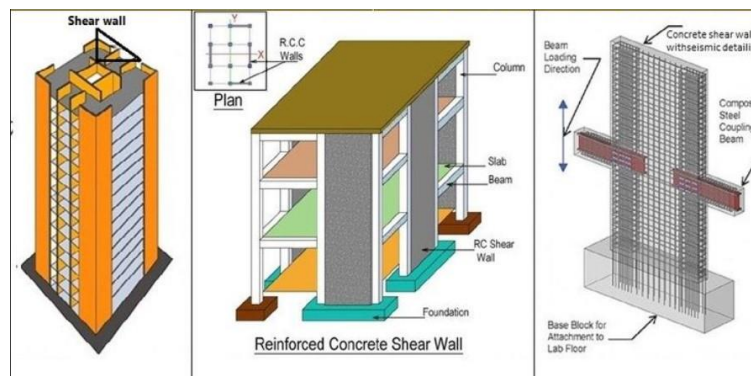


Figure4: Shear Wall

## 22. DUCTILE DESIGN

Ductile design is an earthquake-resistant building design technique that focuses on designing buildings that can withstand severe deformation without failing. Structures that are designed to be ductile can withstand the strong forces created during an earthquake, minimising damage and safeguarding inhabitants.

One of the fundamental principles of ductile design is to guarantee that structural elements such as beams, columns, and connections have suitable strength, stiffness, and ductility. This can be accomplished by utilising high-performance materials such as high-strength steel and reinforced concrete. These materials can absorb a lot of energy and distort without collapsing, therefore the structure can be stable even under strong seismic loads.

### 23. SLOPING FOUNDATIONS

Sloping foundations are another earthquake-resistant technology used in architecture to improve seismic safety. Sloping foundations are designed to produce a gradual transition between the foundation and the surrounding soil, reducing the influence of seismic waves on the building.

slope foundations are meant to be somewhat elevated above the surrounding ground level, with a slope gradient towards the building's perimeter.

This slope aids in the distribution of seismic forces from an earthquake throughout the foundation, reducing stress concentration in any one area.

### 24. RETROFITTING

Retrofitting is the practise of updating or changing existing structures to make them more earthquake resistant. This technology is frequently utilised in seismically active areas where older buildings may not fulfil contemporary seismic safety standards.

### 25. USE OF LIGHTWEIGHT MATERIALS

This method involves the use of materials that are lighter in weight than typical building materials while being robust and durable enough to bear the weight of the building.

There are various advantages to using lightweight materials in earthquake-resistant building. For starters, it can reduce a building's weight, making it less susceptible to damage during earthquakes. Second, because less material is required to make the structure, it can lower overall building costs. Finally, lightweight materials are frequently easier to transport and install, reducing construction time and labour costs.

## IV. EXPERIMENTAL RESULTS

India is a country with high seismic activity due to its location on the Indian Plate, which is in constant collision with the Eurasian Plate. Generally, areas that fall under seismic zones III, IV, and V, which are considered to be the most seismically active zones, require earthquake-resistant construction techniques.

- Northern India: The region is highly prone to earthquakes due to the Himalayan region. The use of reinforced concrete frames with shear walls, base isolation, and steel bracing is common in this region.
- Eastern India: The region is prone to earthquakes due to the presence of the Shillong Plateau. The use of framed structures with concrete shear walls, base isolation, and steel bracing is common in this region. These Shear walls act as a diaphragm to resist lateral forces caused by earthquakes. Base isolation and steel bracing are also used in some buildings to improve their seismic resistance.
- Western India: This region is prone to earthquakes due to the presence of the Deccan Plateau. The most common earthquake-resistant technique used in this region is the use of reinforced concrete frames with shear walls. This system is similar to the one used in Northern India. Base isolation and steel bracing are also used in some buildings to improve their seismic resistance.
- Central India: This region is less prone to earthquakes compared to other regions of India, but earthquake-resistant techniques are still used in construction. the use of reinforced concrete frames with shear walls. Steel bracing is also used in some buildings to improve their resistance to earthquakes.
- Southern India: This region is also less prone to earthquakes compared to other regions of India. The most common earthquake-resistant technique used in this region is the use of reinforced concrete frames with shear walls. Base isolation and steel bracing are also used in some buildings to improve their seismic resistance.



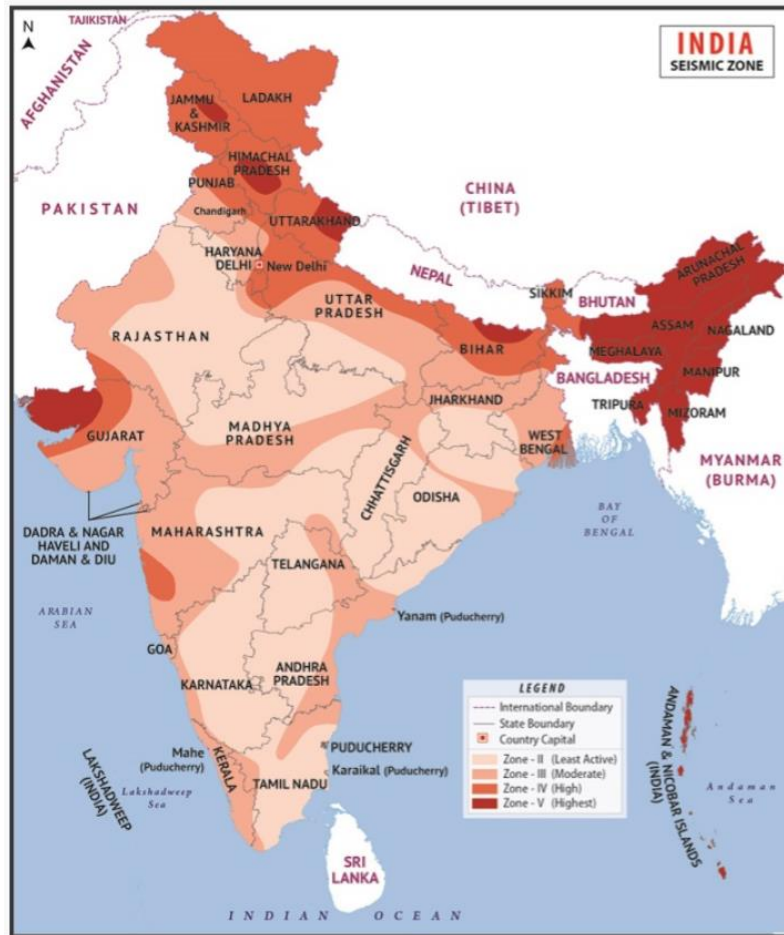


Figure5: Seismic Zone

### V. CONCLUSION

The research found that reinforced concrete frames with shear walls are the most commonly used technique in all regions of India, with base isolation and steel bracing also used in some buildings. The suitability of these techniques varies based on the seismic hazard of the region and local building codes and regulations.

From the result of this study, it can be concluded that worldwide earthquake-resistant techniques for implementation in various locations of India, it can be concluded that there are various effective earthquake-resistant techniques accessible internationally can be adopted and implemented.

The study emphasized the need of implementing seismic-resistant design principles into building planning and construction, such as the use of appropriate materials, foundation systems, and structural designs.

The study indicates that using earthquake-resistant technology is critical to minimizing the damage and loss of life caused by earthquakes. India can reduce the vulnerability of its buildings and infrastructure to seismic threats by implementing earthquake-resistant technology.

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