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SEISMIC
ACADEMY JOURNAL

Special Issue : Annual conference "Building Retrofits"

Seismic Splendour : Celebrating Engineering Marvels

Spotlight Features

SEISMIC ACADEMY

A forum for **professionals**, **academicians**, **authorities** and **industry experts** to interact and disseminate knowledge on various aspects of **earthquake engineering with different stakeholders**, with an intent to **increase awareness** and develop their expertise on the subject.

Our Vision

To make seismic academy as one source of information and use it for promotion of all seismic initiatives in our country.

Rescue workers in Osmaniye, Turkey - 2023 By Onur Erdoğan (Wikipedia)

Our Advisory Board

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2024 Noto Peninsula Earthquake By Araisyohei - Own work, CC BY-SA 4.0

Turkey earthquake aerial view of collapsed buildings in Hatay

Building Retrofit : Seismic Academy Annual Conference 2025

INDIA HABITAT CENTRE, NEW DELHI

Hilti India Pvt. Ltd. established the Seismic Academy as a dedicated platform to foster dialogue and knowledge exchange among professionals, academicians, regulatory authorities, and industry experts on critical issues in earthquake engineering. The initiative is driven by a mission to elevate seismic awareness and technical proficiency across diverse stakeholder groups. With a vision to serve as a centralized information hub for all earthquake-related topics in India, the Academy has steadily evolved through a series of impactful initiatives. A significant milestone in this journey was marked on 16th October 2025, when the Academy hosted its Fourth Annual Conference at the India Habitat Centre, New Delhi. Themed "Building Retrofits," the event brought together leading professionals, consultants, researchers, academics, and government officials to share ideas and expertise. The full-day conference featured engaging discussions on the latest research, practical engineering approaches, awareness and new ideas in building retrofitting technology, highlighting the Academy's role in bringing together experts from different fields to share knowledge and collaborate.

> Advancing seismic resilience requires collaboration, education, and innovation. Through initiatives like the Seismic Academy and the upcoming SAFE handbook, we aim to empower engineers with knowledge and tools for safer, stronger structures.
>
> - Er. Jayant Kumar

Opening Remarks:
Setting the Tone for Seismic Collaboration

The conference commenced with a welcome address by **Er. Jayant Kumar, Managing Director of Hilti India Pvt. Ltd.,** who offered an insightful overview of the ongoing initiatives spearheaded by the **Seismic Academy**. In his remarks, he emphasized the critical need for cross-sectoral collaboration to enhance seismic awareness and preparedness. His address set a purposeful tone for the event, highlighting the Academy's commitment to advancing resilience through education, innovation, and strategic partnerships. In continuation of the awareness initiative, Er. Jayant Kumar also introduced an upcoming technical handbook titled **Seismic Assessment and Fortification Essentials (SAFE),** developed by Hilti India. This publication aims to serve as a comprehensive guide on structural strengthening techniques, reinforcing the Academy's mission to advance seismic resilience through informed engineering practices.

The morning session featured an insightful keynote lecture delivered by **Dr. Shailesh Agarwal, Executive Director of the Building Materials and Technology Promotion Council (BMTPC), Ministry of Housing and Urban Affairs (MoHUA).** A distinguished advocate of the "Affordable Housing for All" initiative under the Pradhan Mantri Awas Yojana (PMAY)-Urban, Dr. Agarwal emphasized the critical role of emerging housing technologies in accelerating **sustainable urban development.**

> **Emerging housing technologies and seismic awareness are the cornerstones of sustainable urban development.**
>
> -Dr. Shailesh Agarwal

> **By adopting IS 18289 standard, leveraging rapid visual surveys, and prioritizing soil-structure interaction, we can classify risks and act decisively**
>
> -Dr. Pradeep Kumar Ramacharala

He commenced his address by underscoring the significance of seismic awareness, particularly through the lens of industrial innovation. A key highlight was the introduction of the digitized **Vulnerability Atlas of India,** which offers comprehensive hazard zone mapping and readily accessible data on multi-hazard risks.

Dr. Agarwal further illustrated the practical application of this tool through a case study on the seismic retrofitting of a school building, executed in alignment with the Atlas and the retrofitting guidelines outlined in IS 13935. In his concluding remarks, he called for a nationwide emphasis on problem-solving aptitude, executional rigor, and skill development in **seismic safety.** He also advocated for the creation of detailed **seismic inventories**, including assessments of existing building stock, to strengthen the country's disaster preparedness and resilience framework.

Following the keynote, the first technical session was led by **Dr. Pradeep Kumar Ramacharala, Director of CSIR-Central Building Research Institute, Roorkee**. He focused on **earthquake safety assessment** of buildings in accordance with BIS standard IS 18289. Dr. Ramacharala began by outlining seismic risk in terms of hazard, vulnerability, and exposure and emphasizing that threat is a function of the latter two. He showcased macro and micro hazard maps of India, vital for urban planning, and explained the Rapid Visual Survey technique used for swift evaluation of existing buildings, both regular and irregular in configuration. This method enables correlation between structural typologies and potential damage. He highlighted the significance of soil-structure interaction and elaborated on IS 18289's provisions, including survey forms for quick data capture and a color-coded tagging system (GREEN, YELLOW, RED, BLACK) to classify building safety. RED-tagged buildings are deemed unsafe for occupancy, while BLACK-tagged structures require urgent retrofitting or demolition.

Dr. Ramacharala concluded by advocating for a proactive approach to **seismic risk mitigation,** underscoring the need for preparedness to build a safer and more resilient India.

The subsequent technical session was delivered by **Dr. Ajay Chourasia, Chief Scientist and Head of the Structural Engineering and 3D Concrete Printing Group at CSIR-CBRI, Roorkee**. His talk focused on risk assessment and retrofitting strategies, with a special emphasis on the Indian Himalayan region. Dr. Chourasia highlighted major structural failures in Indian towns and global earthquake disasters, underscoring the urgent need for resilience. He discussed the prescriptive approach and the development of region-specific fragility curves for condition assessment. Emphasis was placed on retrofitting techniques for masonry buildings and the use of drone-based technologies for structural monitoring. He concluded by advocating for a proactive vision towards building a vulnerability-free, risk-informed, and resilient infrastructure framework for India.

"From region-specific fragility curves to drone-based monitoring and advanced retrofitting, we must embrace risk-informed strategies to create a vulnerability-free infrastructure for India"

-Dr. Ajay Chourasia

The technical session was further enriched by a special lecture from **Dr. Augustino Marioni, Chairman of CECO Hirun India Pvt Ltd.** He spoke on the design principles of base isolation systems in accordance with IS 1893, detailing various types of isolators and their integration with structural systems to mitigate seismic forces. Dr. Marioni emphasized the critical need for uninterrupted operation of essential facilities, such as hospitals, during earthquakes. He compared rubber and steel isolators in terms of base shear and displacement limits for serviceability. A case study from Italy illustrated the practical application of base isolation, supported by test protocols outlined in EN 15129. He concluded by stressing the importance of dynamic testing to evaluate the non-linear performance of isolators and ensure seismic resilience.

"By integrating advanced isolators and dynamic testing, we can ensure uninterrupted operations and seismic resilience for essential facilities"

The 1st part of the conference ended with an engaging and vibrant session on "Student Competition", where participants selected based on preliminary submissions of their thesis work, presented their research conducted during their M.E. program. The session showcased a diverse range of dynamic and forward-thinking topics, including:

- Analytical studies on twisted high-rise buildings subjected to dynamic loads
- Non-linear static and dynamic analysis of Inzi-type overhead reservoirs
- AI-driven tools for seismic vulnerability assessment

Student Competition

For the first time, Seismic Academy organized a dedicated Student Competition as part of the annual conference. It served as a platform for students to present their rinnovative esearch work and this session served as a platform for students to present their innovative research and provided them with a valuable opportunity to showcase their work before a distinguished audience of academicians and industry professionals.

The afternoon session began with a Panel discussion chaired by **Mr. Amandeep Garg (Managing Director, Creative Design Consultants & Engineers Pvt. Ltd.), Mr. Pradeep Garg (Chief Engineer, Central Vista Project, CPWD), Mr. Manish Jain (Technical Director, AECOM), and Dr. Vasant Matsagar (Head-Civil Engineering Department, IIT Delhi).** The discussion explored the evolution of retrofitting guidelines and the development of upcoming standards encompassing structural audits, non-destructive and partial destructive testing, and the critical role of professionals. Panellists emphasized the importance of effective communication of these guidelines to building owners to ensure quality control, appropriate material selection, and proper execution at the jobsite. The application of modern technologies like base isolation to meet performance targets ranging from immediate occupancy to full operational levels was also discussed. The panel also addressed multi-hazard assessments and performance-based design, highlighting the need to align structural performance levels with the intended use of buildings. Challenges such as poor construction quality, inadequate maintenance, limited technical skillsets, and low awareness among building owners were acknowledged. The session concluded with a strong call for public awareness programs, webinars, seminars, and integration of retrofitting education into academic curriculum and certification programs to foster a culture of resilience.

“Retrofitting is more than engineering, it’s a culture of resilience. By evolving standards, embracing modern technologies, and fostering awareness through education and outreach, we can ensure safer structures and informed stakeholders for a disaster-ready future.”

The technical sessions were led by esteemed experts who facilitated insightful discussions on retrofitting strategies and technologies tailored to India’s seismic challenges. Their contributions enabled a rich exchange of ideas, fostering deeper understanding of structural vulnerabilities and practical solutions for enhancing resilience.

“Practicing condition assessment with site-specific seismic data, we can strengthen heritage buildings to modern infrastructure against tomorrow’s risks”

- Dr. Rohit Yadav

The last segment of the day comprised of case studies presented by **Mr. Arunava Bhattacharya, Manager Design at CDC Technical Services (P) Ltd.,** on the retrofitting of the Bagging Building at Chambal Fertilizers, India. He outlined the structural context, which included an existing railway track and platform, and the requirement to construct a connecting corridor for the bagging facility. Mr. Bhattacharya highlighted several onsite challenges, such as the presence of a live traction line, reliance on existing grid columns, and poor concrete quality identified through non-destructive testing (NDT).

The retrofitting solution involved installing girder-like arrangements between columns and strengthening both columns and footings to enhance overall stability. He also detailed the use of post-installed anchors (through bolts) designed and supplied by Hilti, which were engineered to convert tensile forces into shear to ensure structural safety and integrity.

Dr. Rohit Yadav, Founder & CEO of TeXeL Consulting Engineers, presented case studies on structural strengthening with a dual focus on condition assessment and site-specific spectra analysis. He outlined key factors necessitating structural evaluation, including distress, deterioration, and performance gaps.

The presentation featured real-time assessments of various structures, including ancient and heritage buildings, where causes of failure were analyzed ranging from design deficiencies to durability concerns. Strengthening interventions were tailored to specific structural components based on these findings. Dr. Yadav concluded by showcasing projects that incorporated site-specific seismic data, including **Peak Ground Acceleration (PGA), Return Periods, and Design Basis Earthquake (DBE)** parameters, to inform resilient retrofitting strategies.

> **“Innovative design with precision tools like post-installed anchors, we can overcome structural challenges and ensure safety and integrity in complex situations”**
>
> \- Mr. Arunava Bhattacharya

The conference concluded with a vote of thanks by M**r. Pulkit Kukreja (Head of Engineering, Hilti India Pvt Ltd).**

The Annual Conference 2025 themed as “**Building Retrofits**” served as a vital platform for participants to explore the latest innovations in seismic retrofitting from advanced materials and design methodologies to AI-driven assessment tools. Attendees engaged in meaningful dialogue on how these technologies can be applied to safeguard existing infrastructure, particularly in high-risk zones. By promoting awareness and collaboration, the conference marked a significant step towards building a more **earthquake-resilient India through targeted retrofitting initiatives.**

Photo of 19th-century illustration by North Wind Picture Archives/Alamy Stock Photo

Seismic Chronicles:
Lisbon 1755

Photo of Ruins of the Lisbon Cathedral by Jacques-Philippe Le Bas Archives/Alamy Stock Photo

When Disaster Became Design

On the morning of **1st November 1755**, Lisbon was shaken to its core. A violent earthquake, accompanied by a devastating tsunami and fires, shredded the medieval city. Entire neighbourhoods crumbled; much of the historic architecture was lost; thousands of lives were claimed.

In the face of such ruin, a choice was made, not just to rebuild, but to rethink. The old, narrow, winding lanes gave way to a new vision: wide, straight boulevards; grand public squares; a city layout drawn in rigid, rational geometry. The newly built district, known as **Baixa Pombalina**, became **Europe's first modern attempt at urban-planning born from catastrophe**.

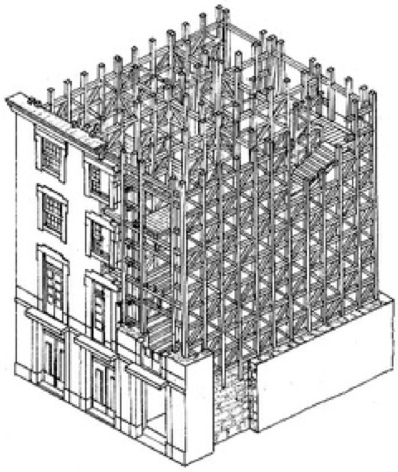


Figure 1a : Perspective representation of the Pombaline Cage inside buildings.

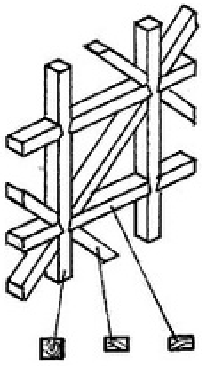


Figure 1b : Cage

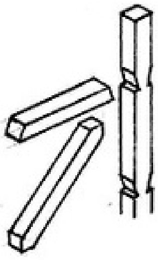


Figure 1c : Props

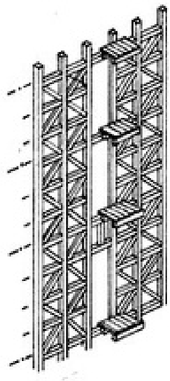


Figure 1d: Cage structure development in height

> **"Buildings would sway - but not shatter." referring to the ingenious seismic-resistant structure known as the Pombaline Cage: a timber-framed core embedded within masonry, designed to flex under seismic stress and absorb shaking rather than collapse."**

This **"cage"** (Figure 1b) concept, along with **fire-walls**, controlled **building heights**, and **reinforced foundations**, marked a historic shift, from mere rebuilding, **to resilient**, forward-looking design. Streets were widened, civic spaces opened; the city was reconstructed not just for commerce and aesthetics, but for safety, mobility, and long-term survival.

In effect, Lisbon did not simply rise from ashes, it was reborn: a vivid example of how **disaster can provoke design, how tragedy can lead to urban transformation, and how resilience can become architecture's silent hero.**

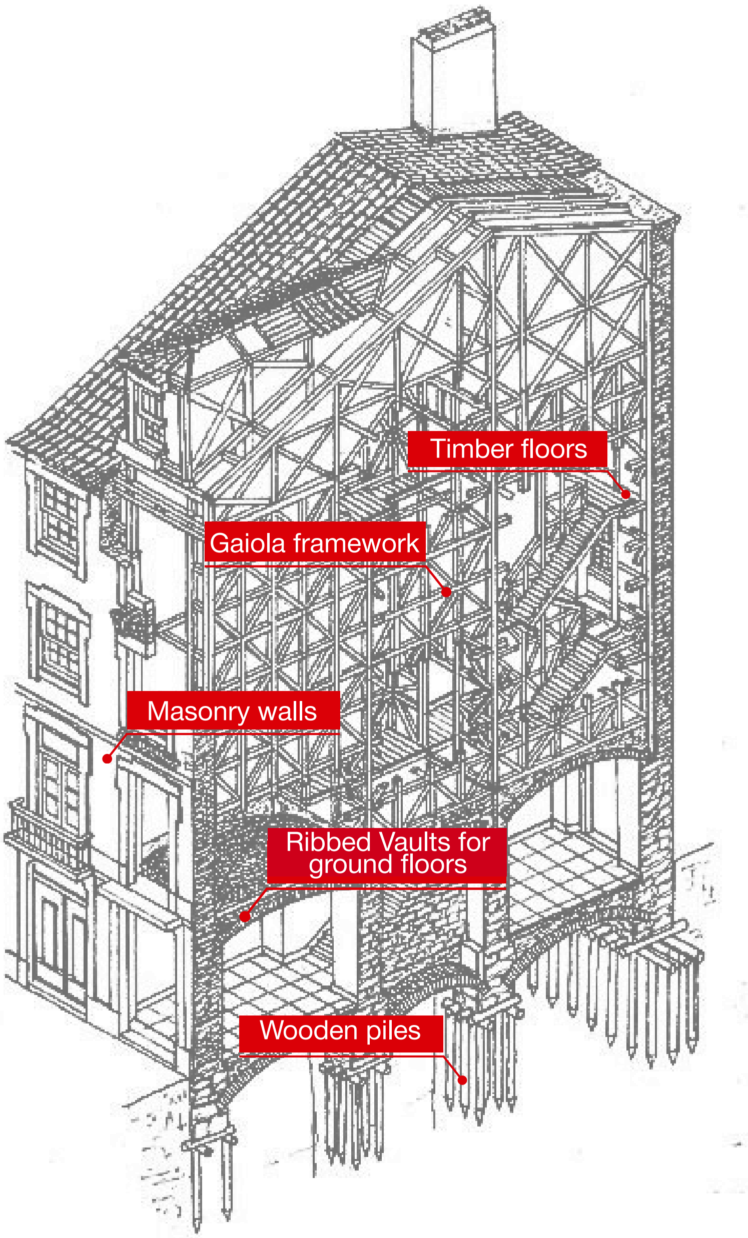


Figure 2: Representation of the Pombaline Cage inside buildings.

Source- Mascarenhas, J., Belgas, L., Branco, F.G., Vieira, E. (2024). The Pombaline Cage ("Gaiola Pombalina"): An European Anti-seismic System Based on Enlightenment Era of Experimentation. In: Endo, Y., Hanazato, T. (eds) Structural Analysis of Historical Constructions. SAHC 2023. RILEM Bookseries, vol 47. Springer, Cham. https://doi.org/10.1007/978-3-031-39603-8_5

Nonlinear Static and Dynamic Analysis of Intze Type Overhead Reservoir (OHR) on Frame Staging

By Abhiroop Dutta,
Construction Engineering Department, Jadavpur University

Project summary

Introduction

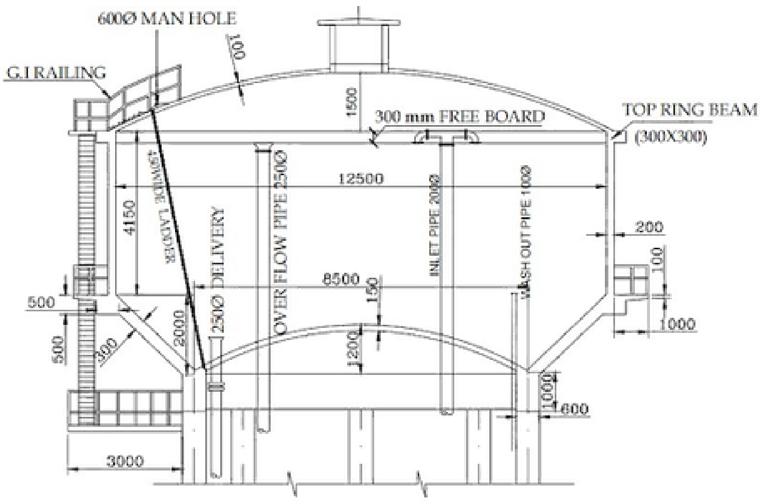
Frame Type OHR is one of the common water storages in public health infrastructure. There are several failure incidents of these OHRs, particularly during seismic events which has raised doubts regarding their seismic vulnerability. This study focused on the seismic performances of OHRs having different capacities adopting various linear and non-linear numerical analysis. Fragility curves of different OHR capacities have been developed for all the limiting performance levels of Immediate Occupancy (IO), Life Safety (LS), Collapse Prevention (CP).

Problem statement

Three Intze-type RCC OHR over frame staging structures of different capacities (300 cum, 600 cum & 900 cum) are modelled in the FE Platform for three types of analysis as follows.

1. Two Mass Modelling
2. Non-Linear Static Pushover Analysis (NLPOA)
3. Non-Linear Time History Analysis(NLTHA) and then Incremental Dynamic Analysis (IDA)

The various seismic parameters have been evaluated for different considered capacities. Comparative study with respect to their seismic performances, vulnerabilities and fragilities for OHRs of different capacities and for all the seismic performance levels have been made.



"There are several failure incidents of Frame Type OHRs, which have raised doubts regarding their seismic vulnerability."

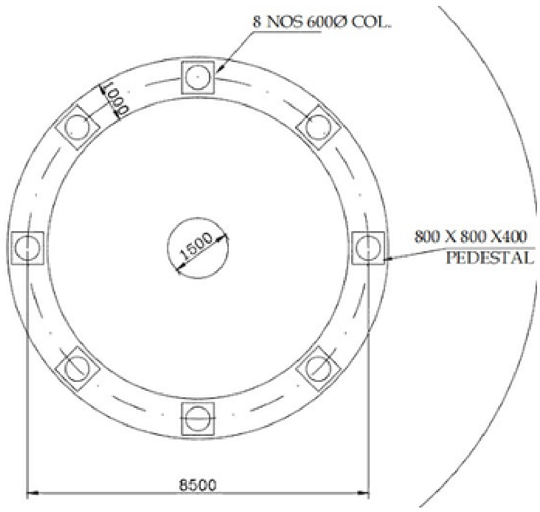


Figure 1a : Real life Existing Over Head Reservoir (OHR) and its Approved Drawings

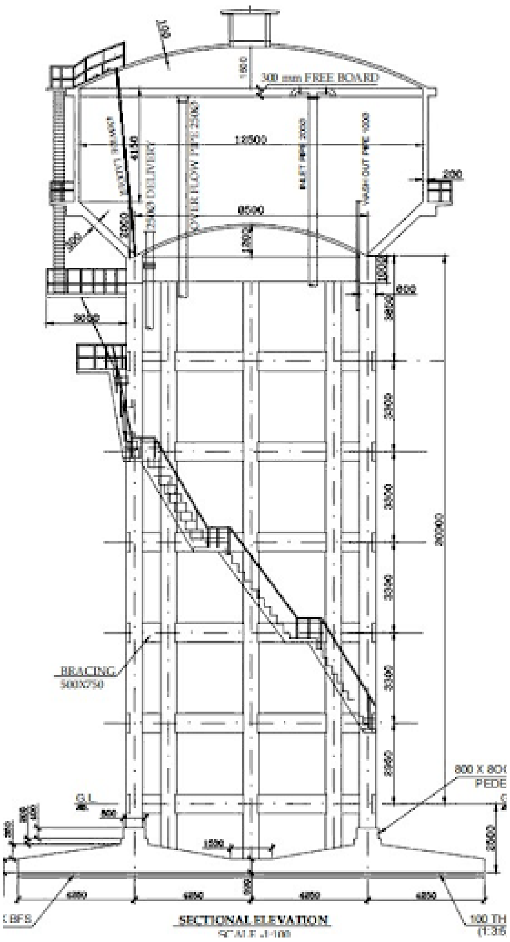


Figure 1b : Real life Existing Over Head Reservoir (OHR) and its Approved Drawings

Analytical/Numerical approach

The OHR structures have been modeled with frame and shell elements. Initially the iconic Housner's two mass model is adopted and subsequently Non Linear static Push Over Analysis (NLPOA) and Non-Linear dynamic Time History Analysis (NLTHA). Subsequently, Incremental Dynamic Analysis (IDA) with varying intensities have also been performed. Fragility Analysis have been attempted based on the results obtained from various IDA, to get an idea about their seismic vulnerabilities.

Potential outcomes/ Results/ Discussion

Numerical seismic analysis of Intze type of OHRs of different capacities in seismic zone of IV of IS 1893 Part-I (2016) adopting three different types of numerical models are compared as follows.
Housner's Two Mass Model provides Elastic Base Shear, also known as Design Base Shear of OHR structures, which have provided greater base shear margins for OHRs having lower capacities.

The Nonlinear Pushover Analysis (NLPOA) results, it seems that the ultimate base shear capacity at the performance level for 300 cum, 600 cum and 900 cum are about 870 KN, 2480 KN and 3270 KN. These base shear capacities are 4.26 times, 5.85 times and 4.20 times the respective linear design capacities. It seems that 600 cum OHR have better (40%) inelastic reserve capacity i.e. greater safety against MCE as compared to 300 cum and 900 cum capacities of OHRs.

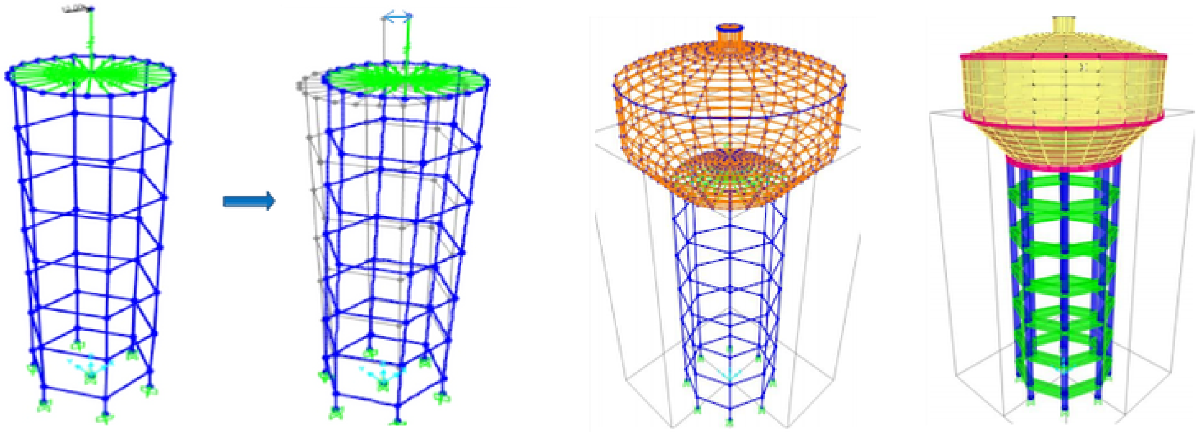


Figure 2: Numerical Models of OHR for Two Mass Model and for Frame+Shell FEM Model

The maximum inelastic top displacement of same staging height of 20 m forall the OHRs of 300 cum, 600 cum and 900 cum capacities seem to be 342 mm, 407 mm, 528 mm respectively, indicating greater flexibility & ductility for 900 cum OHR, which are in tune with the results of Two Mass Model impulsive time period.

The Global stiffnesses of 300 cum, 600 cum & 900 cum of RCC OHRs are about 10188 KN/m, 30172 KN/m and 50727 KN/m respectively. It seems that for Design Basis Earthquake (DBE) 300 cum OHR performs better than 600 cum capacity, which is better than 900 cum OHR. However, the performances of 900 cum OHR against Maximum Considered Earthquake (MCE) seems to be better than 600 cum, which is better than 300 cum OHR. The Global Ductilities of 300 cum, 600 cum and 900 cum OHR are likely to be 4.68, 6.90 and 11.26 respectively, which also indicate relatively greater ductility, toughness and safety margin for 900 cum OHR against MCE.

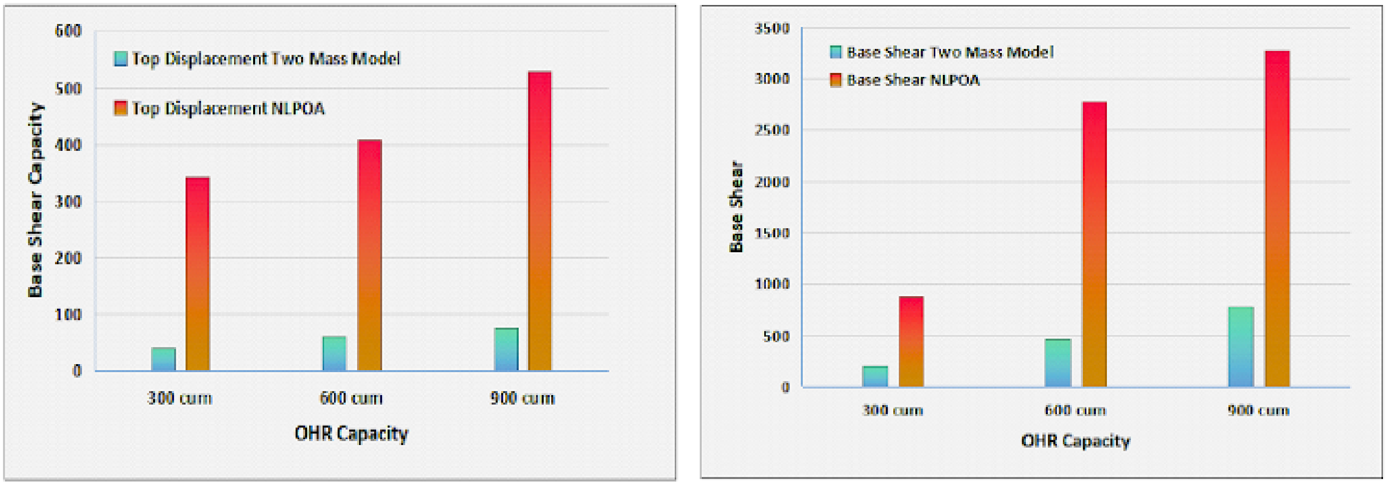
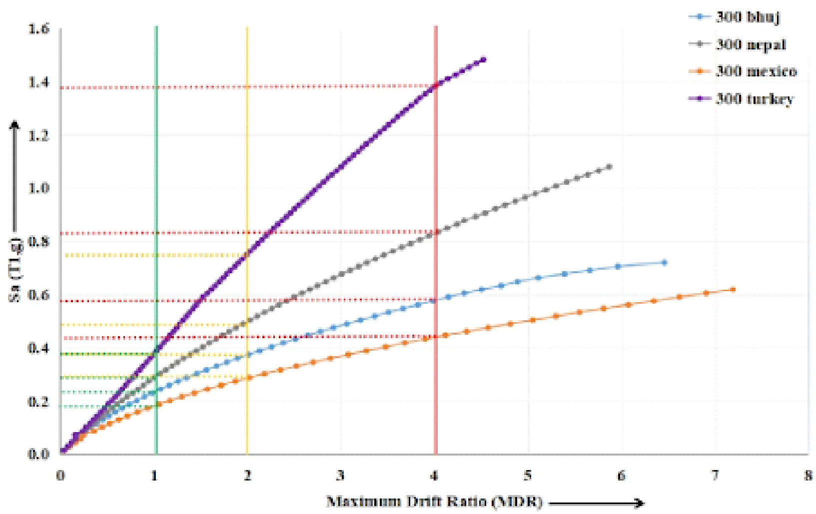


Figure 3: Comparison of Design and Ultimate Base Shear Capacity and Inelastic Top Displacements of OHRs

The greater Fragility of OHRs for the capacities in the decreasing orders of 300 cum, 600 cum & 900 cum for all the performance levels of IO, LS, CP, which are in tune with the NLPOA results.



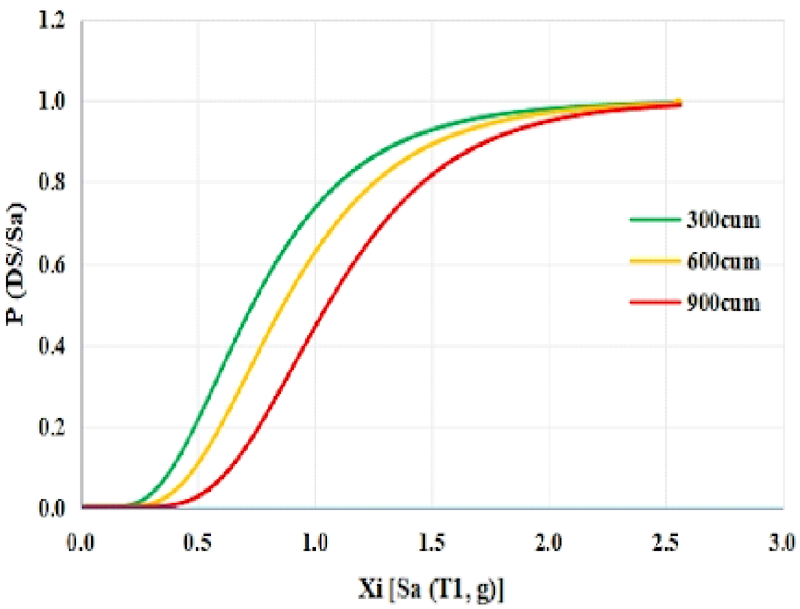


Figure 4: IDA Curve for 300 Cum OHR & Comparison of Fragility Curves at CP of different OHR Capacities

Conclusion

- It seems that the pushover analysis is approximate though computationally faster, where as incremental dynamic time history analysis based on non-linear time history analysis is more accurate but relatively with greater computational cost for the important infrastructure OHRs.
- Incremental dynamic analysis based on NLTHA outcomes seems to be more realistic and accurate for specific actual earthquake data.
- The Base Shear Capacities obtained from NLTHA based IDA are in tune with those from NLPOA, with greater details, indicating its importance and significance.
- In case of Immediate Occupancy (IO) performance level the fragility of these OHR structures are very close, whereas at Life Safety (LS) are well separated, and at Collapse Prevention (CP) are further separated indicating greater variations of seismic performances for different capacities of OHRs at higher performance levels.
- The fragility curves also become more inclined with lesser slopes indicating lesser rate of fragility increment at higher performance levels of greater capacities.
- Based on the linear and nonlinear static and dynamic numerical analysis of different OHR capacities with same staging height in Zone IV, greater risk may have imported for MCE though the design may be more reliable in case of lower capacity OHR.
- Nonlinear analysis may be suggested for Intze and other types of OHRs to ensure greater safety and making resilient infrastructure of public utility system for sustainable growth.

Student Competition Paper

AI-Driven Automated Screening for Seismic Vulnerabilities in Buildings

Chedapangu Seema
Earthquake Engineering Research Centre, International institute of information technology

Project summary

Introduction

The seismic safety of existing building stocks is a paramount concern in earthquake-prone regions globally. Current visual inspection methods, as outlined in manuals like FEMA P-154, are time-consuming, subjective, and difficult to scale across vast urban areas. This project addresses this critical gap by leveraging artificial intelligence, specifically advanced computer vision object detection models, to automate the rapid visual screening of buildings for key seismic vulnerabilities. This work demonstrates a proof-of-concept for a scalable, objective, and efficient first-pass assessment tool that can prioritize structures for detailed engineering evaluation.

Problem Statement

Millions of existing buildings worldwide contain latent seismic vulnerabilities such as soft stories, short columns, and critical crack patterns. Identifying these structures manually requires a massive effort from a limited number of qualified engineers, making city-wide risk mitigation programs slow and expensive. There is an urgent need for an automated system that can rapidly analyze building imagery at scale, providing consistent and data-driven preliminary assessments to optimize the use of expert resources and enhance community resilience.

Analytical/Numerical approach

A novel dataset was curated, comprising over 1,200 images of buildings sourced from public earthquake damage databases and original field photography. Each image was meticulously annotated using bounding boxes to label specific vulnerability classes—**Soft Story, Short Column, and Diagonal Crack—** using the LabelImg annotation tool.

The YOLOv8 (You Only Look Once) object detection model was selected for its state-of-the-art speed and accuracy. The model was trained on this custom dataset using a transfer learning approach, fine tuning pre-trained weights on a GPU-enabled platform for 150 epochs. The dataset was split into 70% for training, 20% for validation, and 10% for testing. A user-friendly web application prototype was subsequently developed using the Gradio library to provide an intuitive interface for image upload and real-time analysis.

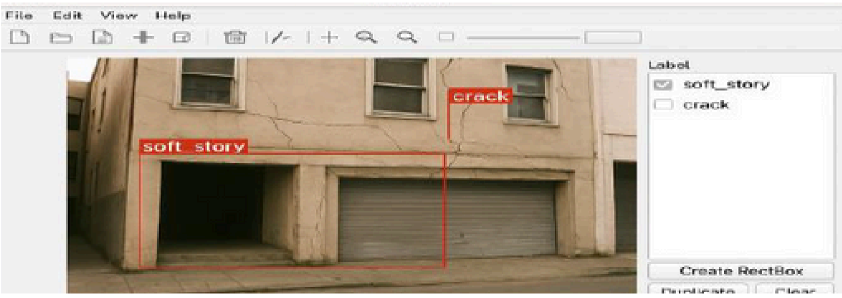


Figure 1: Manual annotation of training data using bounding boxes to label seismic vulnerabilities

Potential outcomes/ Results/ Discussion

The trained model achieved a strong mean Average Precision (mAP50) of **86.5%** on the held-out test dataset, demonstrating high proficiency in locating and classifying structural vulnerabilities. Class-specific performance was notable: **92% precision** for soft stories, **84% precision** for short columns and **83% precision** for diagonal cracks. These results confirm the viability of computer vision as a powerful tool for preliminary seismic screening.

The model successfully processes new images in real time, outputting annotated results with confidence scores, as shown in Figure 2. The primary discussion point centers on the model's role as a **force multiplier** for engineers rather than a replacement. It excels at rapidly and consistently handling large volumes of visual data, efficiently flagging potential seismic vulnerabilities for subsequent expert verification. Key limitations include its dependence on image quality and viewing angle, as well as the fact that the current model is trained on a limited dataset encompassing only common vulnerability types.
At present, the model's performance is optimized for low- to mid-rise reinforced concrete moment-frame buildings, which constitute a significant portion of the global seismically vulnerable building stock.

Figure 2 Model inference on a new image, successfully identifying and labeling a soft story vulnerability.

Conclusion

This project successfully developed a functional AI model capable of automating the first step in seismic risk assessment. The tool rapidly screens building imagery for critical vulnerabilities, offering a scalable solution for governments, urban planners, and engineering firms to efficiently prioritize resources and conduct city-wide audits. The outcomes pave the way for more resilient infrastructure by enabling proactive and data-driven decision-making.

Future work will focus on expanding the dataset to include a broader range of vulnerability classes and diverse architectural styles. Additional efforts will involve integrating the model with drone and street-view imagery APIs to enable automated, large-scale deployment, as well as enhancing accuracy through advanced model architectures such as Vision Transformers (ViTs).

Implementing earthquake safety in India

Professor C. V. R. Murty, PS Rao Chair Professor at IIT Madras and former Director of IIT Jodhpur

The session began with a warm welcome by Dr. Shailesh Agrawal, Executive Director of BMTPC. He highlighted the government's efforts to educate state governments and stakeholders on **thermal comfort, building safety, resilience**, and other aspects of **sustainable construction in India**. Dr. Shailesh emphasized that these webinars, conducted monthly, provide an excellent platform for **knowledge sharing** among experts from academia, industry, and related organizations.

Professor Murty opened the session by addressing the most important understanding towards the decision-making process for construction of structures (e.g., buildings). He emphasized that among the various factors influencing a building's performance such as functionality, sustainability, aesthetics, and economy, **safety** must remain the foremost priority.
Structures experience various types of forces, yet **earthquakes** consistently present a distinct challenge to their overall stability. Each **seismic event** serves as a reminder of this vulnerability. He reflected on the valuable lessons drawn from major earthquakes that have occurred across the globe over the past 140 years.

Earthquakes have a profound impact on people, the environment, and built structures.

1. Their effects often trigger cascading consequences across systems and communities.
2. Structural collapse is unacceptable under any circumstances.
3. **Earthquake-resistant design (eqRD)** for bridges differs fundamentally from that of buildings.
4. Damage to **non-structural elements** is often difficult to detect and assess.
5. Any form of damage, structural or non-structural is considered unacceptable in **resilient building design**.

Professor Murty mentioned that the philosophy behind **earthquake-resistant design** (Figure 1) has undergone significant evolution over the past six decades. While early approaches prioritized preventing structural collapse during severe seismic events, modern objectives emphasize minimizing structural damage, ensuring **post-earthquake functionality**, and reducing the necessity for **seismic retrofitting.**

He highlighted the enduring challenge structural engineers face in balancing safety, functionality, and cost. The design approach typically follows two paths: **resilient structures**, though potentially more expensive upfront, offer long-term benefits by mitigating risks and enhancing societal safety; whereas **risk-based designs** may reduce initial costs but can compromise safety during severe **seismic events**.

While Professor Murty urged that our first priority in earthquake-resistant design must be to prevent structural collapse to avoid loss of lives, he highlighted the critical need for a design approach that prioritizes both **structural resilience** and **minimal asset damage**. By doing so, the need for retrofitting can be significantly reduced. He advocated for decision-making to be guided by life-cycle cost rather than initial construction expenses, as this perspective effectively minimizes long-term consequences and enhances overall value.

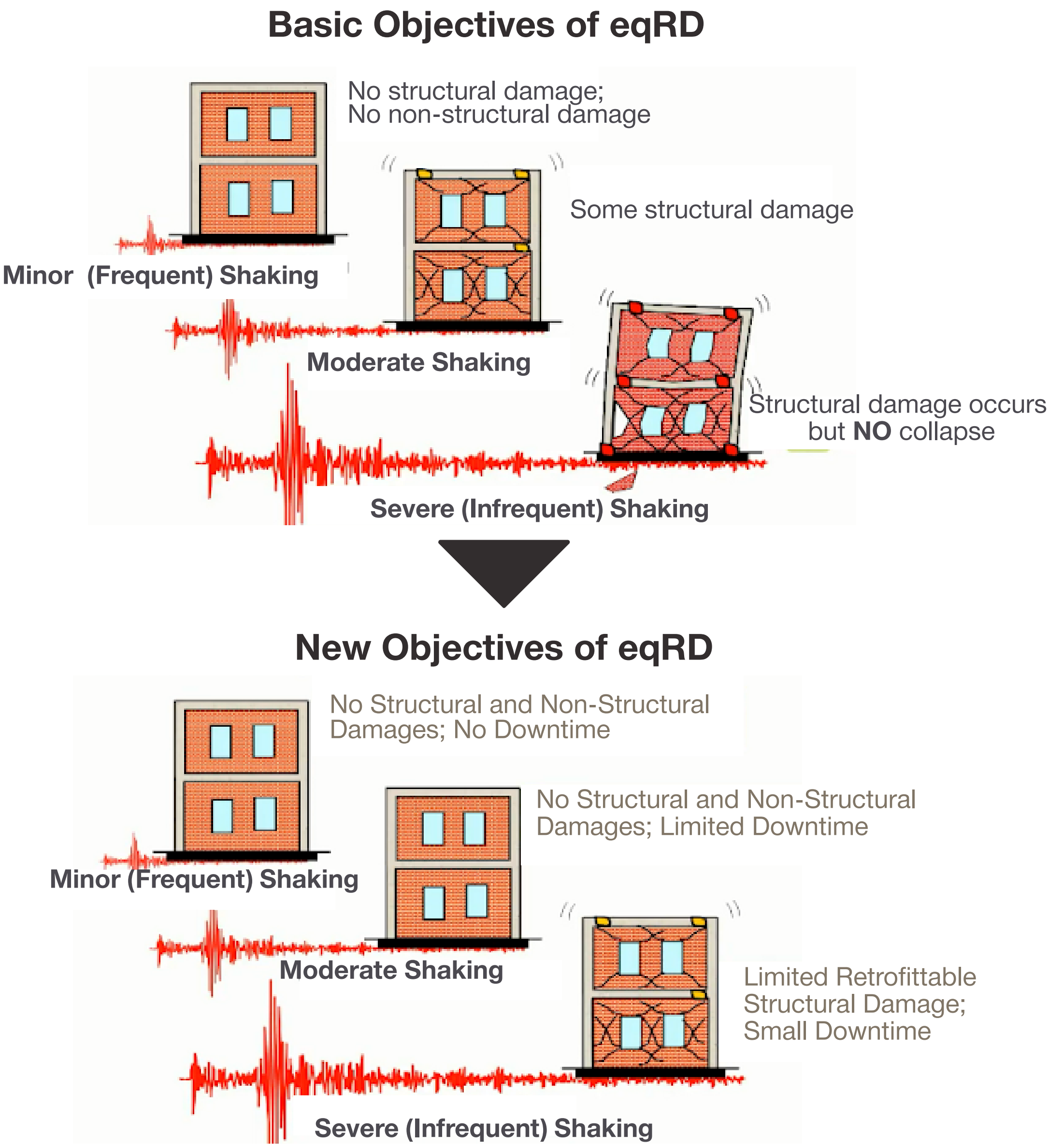


Figure 1: Objectives of Earthquake resistant design

Pre- and Post-Earthquake Preparedness Measures

He explained the need of awareness in terms of pre- and post-earthquake measures towards making an earthquake-resilient structure. The several aspects of the Earthquake disaster management cycle (Figure 2) are based on the pre- and post-earthquake awareness and activities and are outlined below.

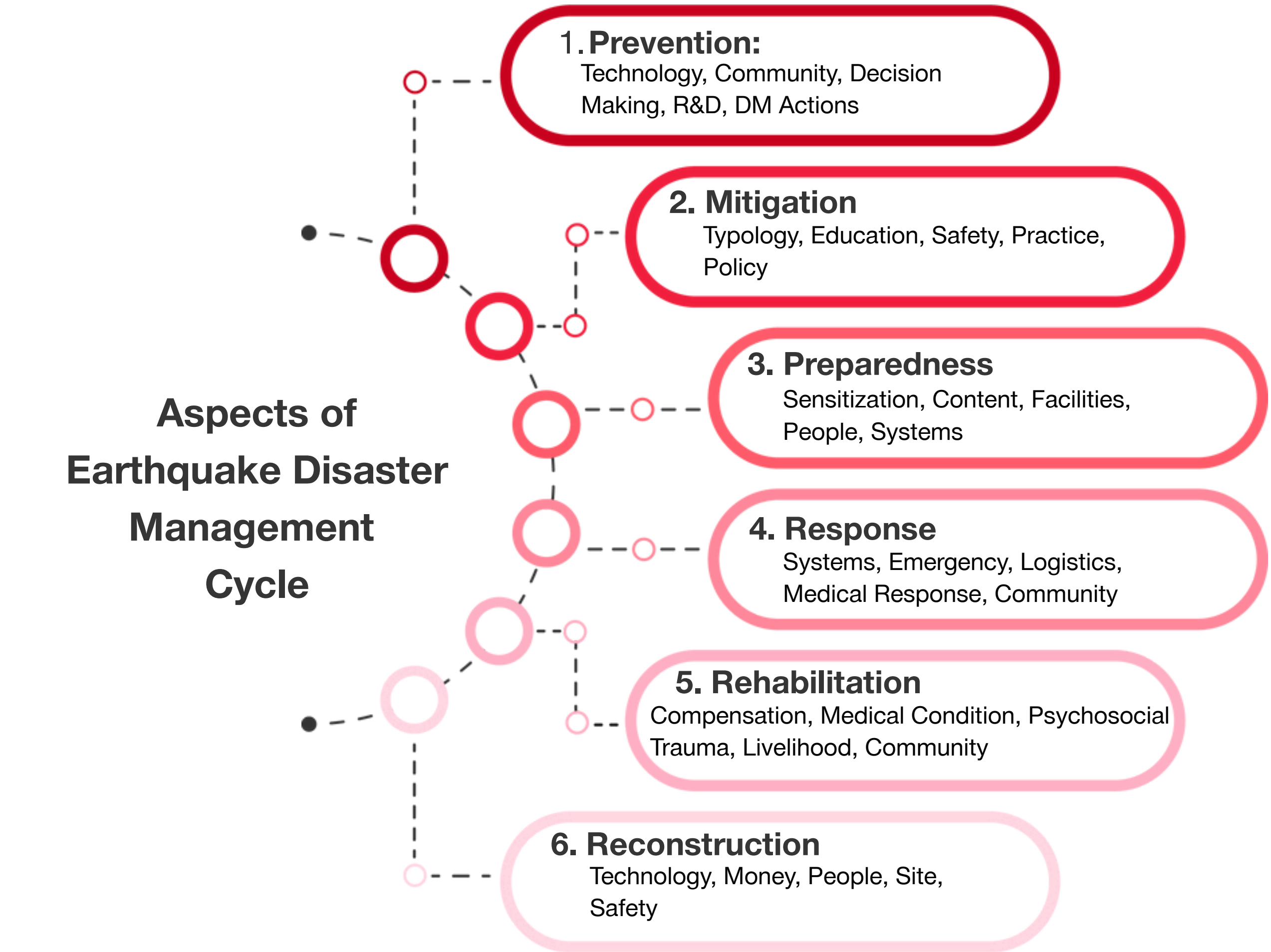


Figure 2: Earthquake disaster management cycle

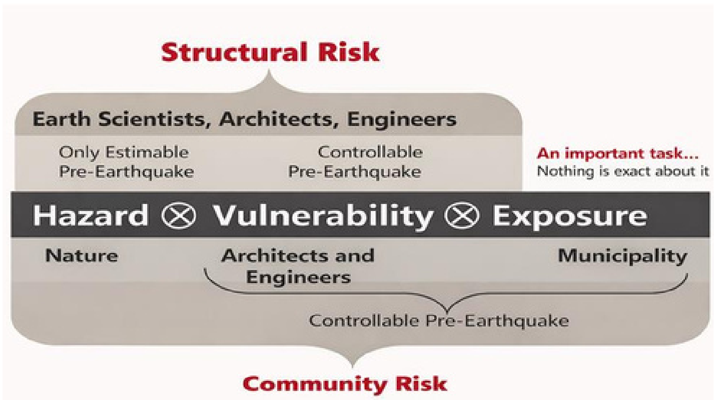


Figure 3: Golden Triangle

To deepen the understanding of earthquake-induced risk, he introduced the concept of the **"Golden Triangle"** (Figure 3) comprising Hazard, Vulnerability, and Exposure. The seismic risk is a product of seismic hazard, vulnerability and exposure. Hazard represents the seismic event itself, which is beyond human control. Vulnerability is the susceptibility of the built environment, and exposure refers to the number of people and assets affected. By enhancing **structural safety** to reduce vulnerability and strategically managing exposure, overall community risk can be substantially lowered even when the hazard (Figure 3) remains significant.

Resilience

Recovery time following an earthquake is a vital consideration in **structural design,** particularly for critical infrastructure where rapid functionality is essential. To address this, four distinct design methodologies - stiffness-based, strength-based, displacement-based, and energy-based offer varied approaches to enhancing **seismic resilience** (Table 1).

Table 1 : Design methods based on Recovery time and Resilience level

Design Method	Stiffness Based	Strength Based	Displacement Based	Energy Based
Recovery Time	Longest among all (not definite)	Moderate	Shorter	Shortest
Resilience Level	Lowest	Low	Moderate	High

Enhancing **structural safety** across India can significantly reduce the human and economic toll of earthquakes. The foremost priority should be minimizing vulnerability through resilient design, followed by managing exposure through strategic **urban planning** and balanced population distribution.

With rapid urbanization, there is a growing need for **infrastructure development** across the country, and the government is investing heavily in this area. However, there is a serious shortage of competent civil engineers to carry out **earthquake-safe construction.** It is essential to build the right level of expertise among both practicing and graduating engineers by equipping them with knowledge of modern technologies and the relevant regulatory framework.

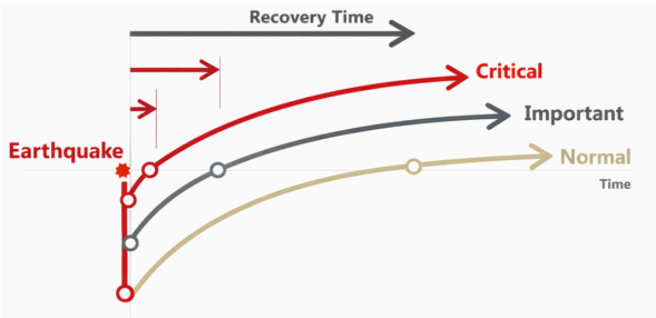
A frequent trend in building projects is the pursuit of architectural extravagance, which may not always align with structural requirements necessary to meet the **seismic demand** (Figure 4).

He encouraged engineers to transition towards designs that are both visually appealing and structurally regular, emphasizing that true resilience arises when form and safety are seamlessly integrated.

As a matter of fact, the structural cost in a building forms only about 10–15% of the total project cost.

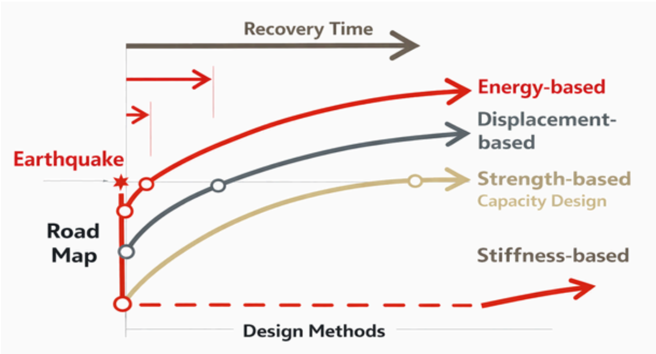
Improving **structural safety** raises construction costs by only 2–4% which is a modest investment for protecting lives and property.

He stated that ensuring safety is a collective responsibility shared by architects, engineers, contractors, homeowners, developers, educators, geotechnical experts, professional bodies, the judiciary, and even the media.



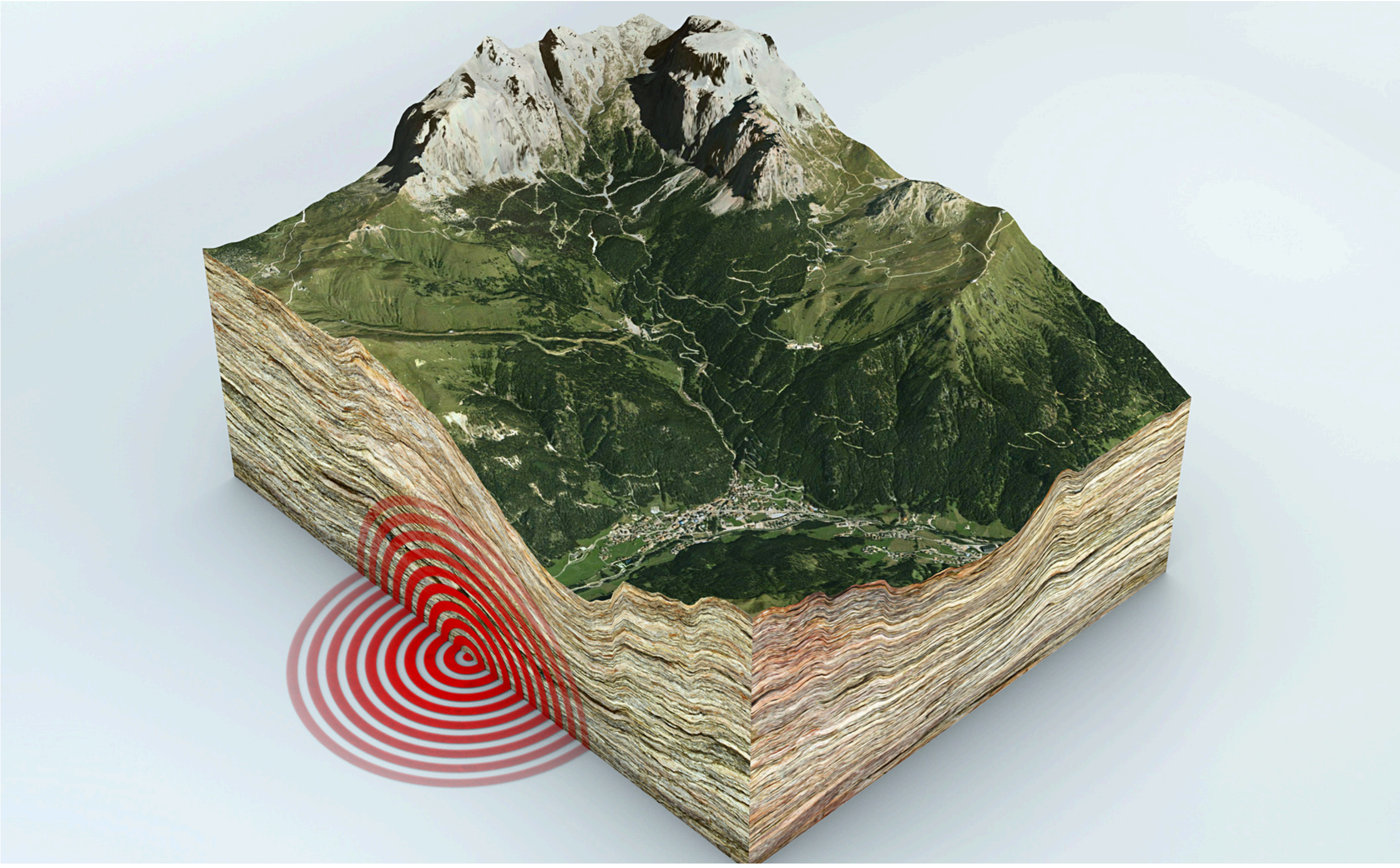
New Structures Resilience

Figure 4 : New structure seismic resilience



Design Methods Resilience

Figure 5 : Design methods seismic resilience



Prof. Murty highlighted that a significant portion of India's building stock remains highly vulnerable to earthquakes. The challenge, he said, lies not only in constructing safer new buildings but also in addressing the existing risk in the current built environment. To meet this challenge, two urgent measures must be implemented across the nation: **retrofitting of existing structures** and establishing a robust technical regime to ensure **structural safety.**

Prof. Murty emphasized that retrofitting efforts should start with homes of ordinary citizens, whether in rural areas or urban neighborhoods to prevent structural collapse and loss of life during earthquakes. He stressed that the first step is to formally announce and implement a **National Retrofitting Policy**. This initiative, he noted, should be led by the government through a consultative process, building on the existing policy framework provided by the **National Disaster Management Authority (NDMA).**
An effective retrofitting strategy relies on the use of suitable technologies and standards that reflect India's varied construction practices and **seismic conditions**. Prof. Murty emphasized the need for:

1. Full-scale experimental testing to validate retrofit methods, Preparation of design and retrofit standards, supported by commentaries, handbooks, and practical examples and Pilot projects to demonstrate that retrofitting can be achieved within a short time frame and with limited resources.
2. Building Technical Capacity.
3. Establishing a Technical Regime: comprising of laws, standards, licensing, and accountability.
4. Financing Retrofitting through Existing Mechanisms.
5. Reforming Technical Education: to better equip graduates and practicing engineers with up-to-date knowledge in **earthquake-resistant design** and **retrofitting.**
6. Risk Profiling and Prioritization: to identify the level of seismic vulnerability and prioritize critical assets as hospitals, schools, and lifeline buildings.

The session concluded with an engaging Q&A, followed by a formal vote of thanks.

Seismic Microzonation:
A Strategic Approach to Urban Earthquake Resilience

Dr. Kapil Mohan, Scientist-E, National Center for Seismology, MoES

Introduction

India's urban centers are expanding rapidly, often in regions prone to **seismic hazards**. This growth, coupled with the country's location in **high-risk zones**, makes **earthquake resilience** a critical priority. One of the most effective tools for mitigating seismic risk is **seismic microzonation**, (Table 1) a scientific process that subdivides a region into smaller zones based on **earthquake hazard potential.** This approach enables informed urban planning and disaster risk reduction strategies, ensuring safer cities for millions.

Table 1 : Levels of Seismic Microzonation

Level	Description
Level A (1:100,000 to 1:50,000)	• Rudimentary level of study • Least expensive study • Based on a compilation and interpretation of available data
Level B (1:25,000 to 1:10,000)	• Provides more reliable results than those for Level A. • Specific surveys are generally carried out during this study level, including drilling, trenching, geological sampling etc. • Cost of this study remains reasonable
Level C (1:10,000 to 1:5,000)	• Carried out in areas where a very detailed level of mapping is required – areas of high earthquake hazard risk. • Specific surveys and detailed calculations are involved. • Cost of this study is high

Understanding Seismic Microzonation

Dr Kapil explained the Seismic microzonation and how it involves mapping ground motion characteristics by considering **source, path, and site conditions**. It integrates geological, seismological, and geotechnical data to predict how different areas will respond during an earthquake. The ultimate goal is to **minimize damage, loss of life, and societal disruption** by enabling site-specific design and planning.

Historical Perspective

He also shared that the concept of microzonation dates back to the **1755 Lisbon earthquake**, which revealed how soft soil amplified destruction. Subsequent disasters, such as the **1923 Great Kanto earthquake** and the **1985 Mexico City earthquake**, reinforced the importance of understanding soil amplification effects. These events laid the foundation for modern **seismic hazard mapping.**

International Scenario

The standard seismic microzonation studies were conducted in several parts of the world, e.g., Yenisehir–Bursa, Turkey (Dikmen and Mirzaoglu, 2005), Bucharest, Romania (Moldoveanu et al., 2004), Mohammadia–Algiers and Blida, Algeria (Bouchelouh et al., 2014; Bousbia and Sbartai, 2019), Beijing, China (Liu et al., 2014), Las Vegas, USA (Scott et al., 2006), Bam City, Iran (Motamed et al., 2007), Fukuoka, Japan (Yasuda et al., 2011), Italy (Falcone et al., 2021), Socorro, Mexico (Sanford and Holmes, 1962) and many more.

Global and Indian Initiatives

The session covered Global and Indian initiatives. Globally, milestones include the formation of the **International Association for Earthquake Engineering (IAEE)** in 1963 and the publication of the ISSMFE Manual in 1993. In India, seismic zonation maps under **IS 1893** classify regions into Zones II–V based on **Peak Ground Acceleration (PGA)**. The Ministry of Earth Sciences (MoES) has spearheaded microzonation projects for **30 major cities** (Figure 1), focusing on high-risk zones (III, IV, and V).

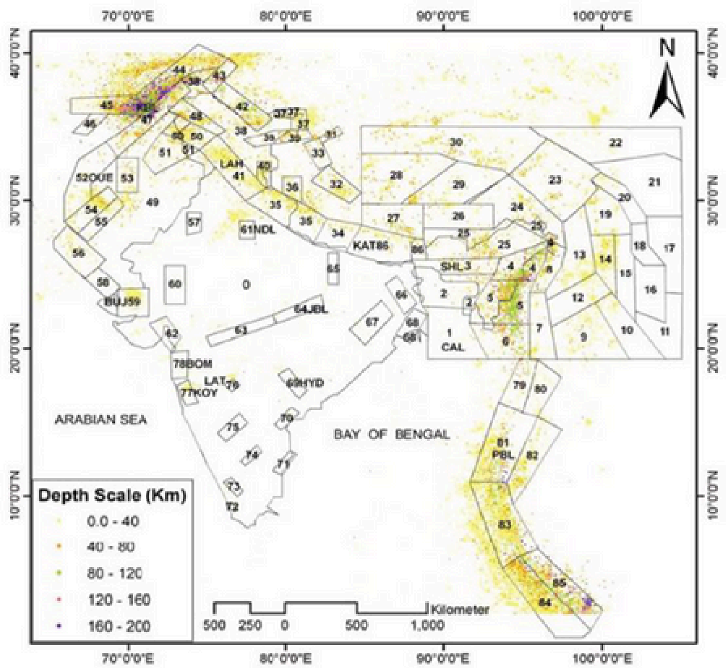


Figure 1: The eighty six potential seismic zones considered for the probabilistic seismic hazard map of India (after Bhatia et al,. 1999)

Objectives and Deliverables

Dr Kapil emphasized on Microzonation studies which aim to:

- Identify geological units, faults, and seismotectonic features.
- Evaluate shear wave velocity, predominant soil frequency, and ground response.

Key deliverables include:

- **Hazard maps** (PGA, PSA)
- **Liquefaction and landslide susceptibility maps**
- **Site classification maps**
- Comprehensive **hazard index maps** for urban planning.

Seismic Microzonation: A Strategic Approach to Urban Earthquake Resilience I NIDM

Techniques and Approaches

Microzonation employs a combination of (Refer to Figure 2):

- **Geophysical Surveys:** Microtremor analysis, MASW, down-hole tests.
- **Geotechnical Investigations:** Boreholes, Standard Penetration Tests (SPT), Cyclic Triaxial Tests.
- **Analytical Methods:** Deterministic and probabilistic hazard assessments, GIS-based integration using the **Analytic Hierarchy Process (AHP).**

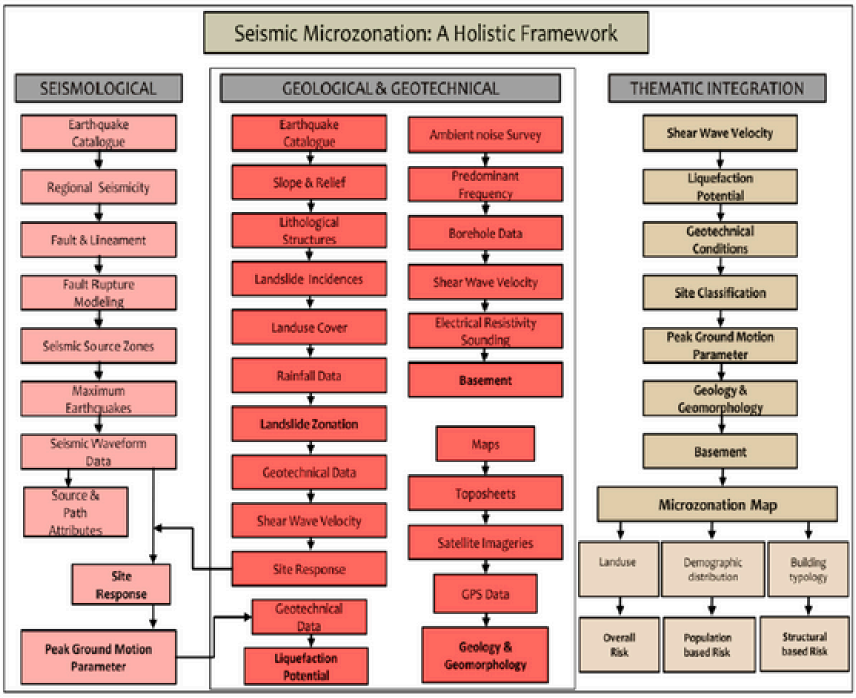


Figure 2: Holistic Seismic Microzonation Framework

Deliverables of Seismic Microzonation:

The deliverables of the Seismic Microzonation, demanded by various stakeholders like **BIS, Municipal Corporations, PWD, Civil Engineering Department, NDMA, State Disaster Management Authorities,** etc., are as follows:

- Regional seismotectonism
- Geological & geomorphological mapping
- Seismic & engineering bedrock configurations
- Predominant frequency distribution map
- Site classification map
- Site amplification map
- Site-specific ground motion prediction equations

- Deterministic & probabilistic hazard maps
- Liquefaction, landslide & tsunami hazard maps
- Spatial variation of PHA, PGA & PSA (bedrock & surface levels)
- Socio-economic impact evaluations (vulnerability & risk)
- Land-use planning & structural development guidelines
- Comprehensive seismic hazard map (weighted combination of all factors)

Case Studies

He also presented some cities like **Delhi and Kolkata** which have already benefited from detailed hazard index maps released in 2016. Recent studies in **Bhubaneswar, Chennai, Coimbatore, and Mangalore** were completed in 2025, with eight more priority cities underway. Outputs include **Vs30 maps, liquefaction susceptibility maps, and spectral acceleration contours**, which are vital for engineering and planning. (Refer to the figure 3)

Role in Urban Planning and Disaster Risk Reduction

Seismic microzonation supports:

- **Safe site selection** for critical infrastructure.
- **Land-use zoning** to regulate development in hazard-prone areas.
- **Engineering design inputs** for earthquake-resistant structures.
- **Emergency response planning** and public awareness campaigns.

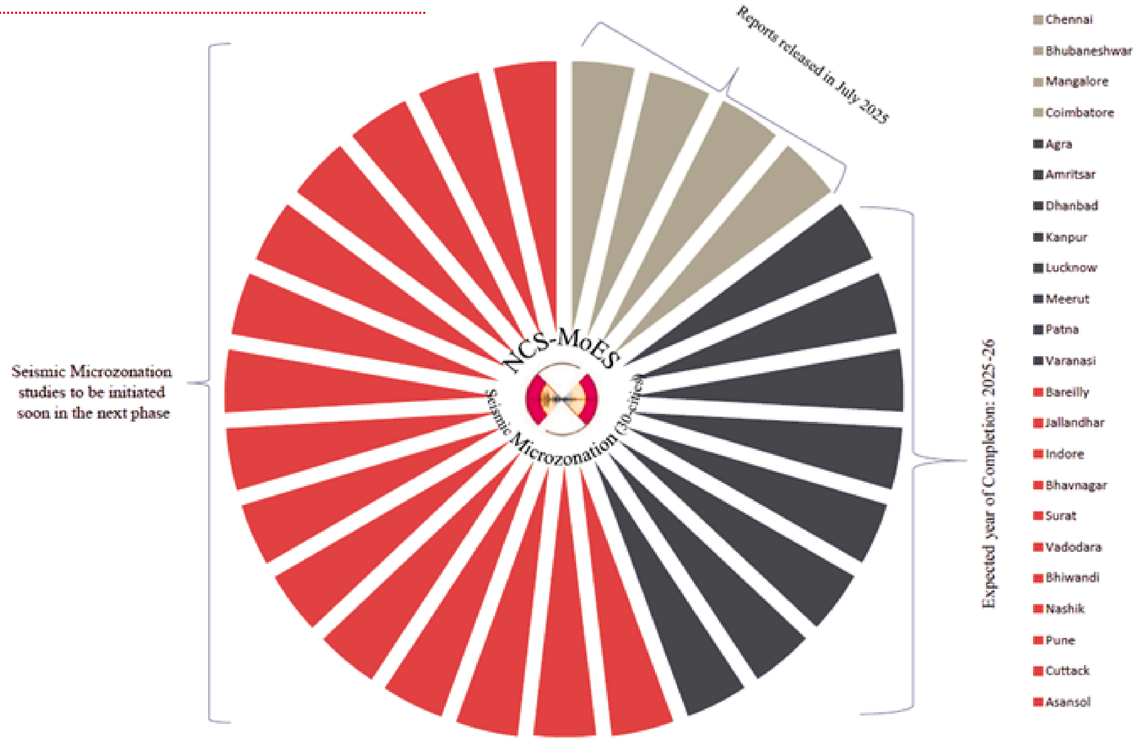


Figure 3: Seismic Microzonation Studies to be Initiated Soon in the Next Phase

Role of Microzonation in – Urban Planning & Land Use

• **Safe site selection:** Helps identify low-hazard zones for critical facilities (hospitals, schools, emergency services).

• **Land-use zoning:** Guides planners to regulate development in areas prone to strong shaking, liquefaction, or landslides.

• **Sustainable development:** Enables cost-effective and resilient construction by understanding site-specific seismic behavior.

• **Post-earthquake reconstruction:** Supports prioritizing damaged areas and rebuilding safer, more resilient infrastructure.

Key Takeaways

His concluding remark was that Seismic microzonation is **not optional**, it is essential for sustainable urban development in seismic zones. By integrating geology, geotechnics, and seismology, cities can achieve accurate hazard mapping and informed planning. Future priorities include:

- Microzonation for all major cities.
- Incorporation into **building codes**.
- Nationwide **public awareness programs.**

Engineering Design & Building Codes

• **Improves building codes:** Microzonation provides local ground-response data to refine seismic design standards.

• **Site-specific design inputs:** Engineers use parameters such as PGA, PGV, and spectral acceleration to design earthquake-resistant buildings and lifelines (tunnels, pipelines, utilities).

• **Supports retrofitting decisions:** Identifies vulnerable structures needing strengthening to meet updated safety requirements.

• **Cost-effective design:** Prevents under-design (unsafe) and over-design (unnecessary cost) by accurately defining seismic demand.

Shanghai Tower
Engineering Earthquake Resilience in the Sky

The Shanghai Tower is a **mega-tall structure** located in the Lujiazui financial district of Pudong, Shanghai, China. With 632 meters (2,073 feet) height and 128 stories, it is the **tallest building in China** and second tallest in the world after Burj Khalifa. It was designed by the American architectural firm Gensler and the construction was completed in 2016. Additionally Its 120° spiral twist makes this structure the **world's tallest twisted tower** and a landmark achievement in **vertical urbanism**. It functions as a mixed-use development, organized into nine cylindrical vertical zones (or "neighborhoods") containing office space, retail, a luxury hotel (J Hotel), and public observation decks. The shape of the tower shows a beautiful **integration between the architectural and structural design.**

Shanghai is situated in a region susceptible to seismic forces. Crucially, the tower is built on the historically soft, alluvial soil of the Yangtze River delta. This soil condition significantly amplifies the challenge for foundation engineers, as soft soils can dramatically increase the destructive effects of seismic waves, leading to issues like site amplification (where ground shaking is intensified) and potential liquefaction, even during moderate earthquakes. As a result, the tower's design needed to address both the immediate effects of **seismic tremors** and the underlying ground instability, positioning the foundation system as its foremost and most vital safeguard.

Standing tall at **632 meters**, the Shanghai Tower is not just an **architectural wonder —** it's a symbol of how **engineering innovation** meets the forces of nature. Located in one of the most dynamic and seismically active regions of eastern China, the tower's designers had to ensure that this supertall structure could withstand powerful earthquakes without compromising safety or comfort.

Shanghai's soil conditions, combined with the challenges of wind and seismic loads, made the tower's design one of the most ambitious engineering projects of the 21st century.

Shanghai lies in a **moderate earthquake zone**, where the ground acceleration can reach up to 0.1 g during a strong seismic event.
Although not as earthquake-prone as western China, the **soft alluvial soils** beneath Shanghai can amplify ground motions. For a building over 600 meters tall, this can lead to large swaying and serious **structural stress.**

Designers followed the **Chinese Seismic Design Code** (GB 50011-2010) and adopted the **performance-based seismic design (PBSD)** philosophy that checks how the building performs under different earthquake levels, rather than relying only on simple force calculations.
Shanghai Tower stands out for its earthquake resilience due to its **innovative structural system, aerodynamic shape, and advanced damping technologies** (Figure 3) that help it withstand seismic forces.

Figure 1: The Shanghai Tower's architectural vision blends modern performance with historical Chinese garden design principles.

120-Degree Twist: The tower spirals a total of 120 degrees from base to crown. This shape was chosen to dramatically reduce wind load and to minimize the torsional effects caused by wind vortices, a benefit that translates directly to seismic resilience. (Refer to figure 1)

Double-Skin Façade: The dual-layered transparent glass façade creates an internal space that functions as a thermal buffer, insulating the inner building and significantly reducing energy consumption for climate control.

Vertical Zones: The structure is divided into nine vertical zones, or "neighborhoods," separated by mechanical floors, each featuring a naturally ventilated sky garden acting as a communal public space.

The Shanghai Tower was designed to stay safe and functional even during very strong earthquakes along with gravity and wind loads.

Strong Core and Mega columns

The structural parts of the tower that provide stability, and thus resistance against lateral and vertical forces, are a concrete core that interacts with outriggers and four paired super columns placed at 45° angle. The super columns are composed of specially designed steel profiles that are covered and filled with concrete to increase **fire resistance and mechanical strength.** All beam to super column connections are encased in concrete as well to ensure a proper and stiff performance of the complete structure. In addition, a two floor tall mega frame is added between all the super columns every 12 to 15 floors, which divides the tower into nine zones. The mega frame is constructed as a double belt truss of structural steel.

The mega framework functions together as a **dual structural** system with the core, outriggers, and super column system, while the core **resists twisting (torsion)** (Figure 2), and the mega columns and connecting outriggers absorb bending forces. This makes the tower extremely stable even when the ground shakes.

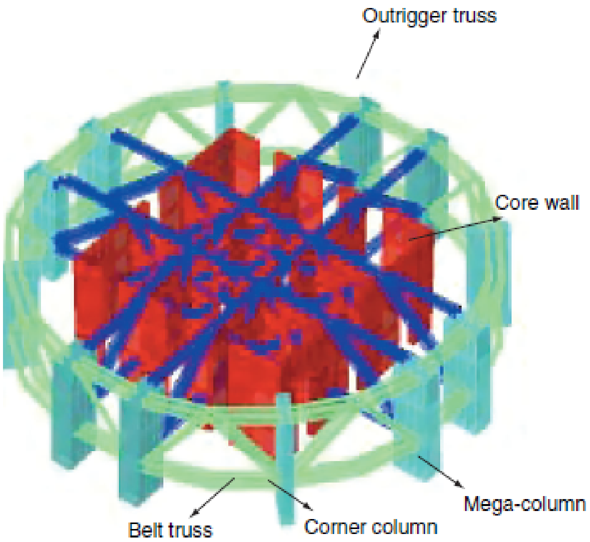


Figure 2: Strong Core and Mega Columns - Shanghai Tower

Deep and Stable Foundations

The Shanghai Tower stands on a **6-meter thick concrete mat supported by 947 deep piles,** each driven 86 meters into the ground.
This strong base spreads the load evenly and prevents settlement or tilting during earthquakes. High-strength reinforced concrete for the massive raft and deep piles are designed to withstand immense compression and shear forces from the unstable subsoil.

Structure: A **hybrid steel-and-concrete system** for the super-trusses and a high-performance, ultra-strong concrete mix for the central core to maximize stiffness and shear strength.
Facade: Dual-layer, low-iron glass for transparency, energy efficiency, and thermal insulation.

> **"Strength with style: The Shanghai Tower's spiral form and cutting-edge dampers redefine seismic safety"**

Tuned Mass Damper (TMD)

Near the top of the tower, beneath the "Shanghai Smart Eye" sculpture, a **1,000-ton steel pendulum** acts as a tuned mass damper. (Refer to Figure 3)

When the building sways during an earthquake or high winds, this pendulum moves in the opposite direction, counteracting the sway through inertia, reducing vibrations and keeping the building comfortable for occupants. The TMD uses eddy current damping with powerful magnets and a copper plate which is induced during the motion to **reduce building sway by up to 45%.**

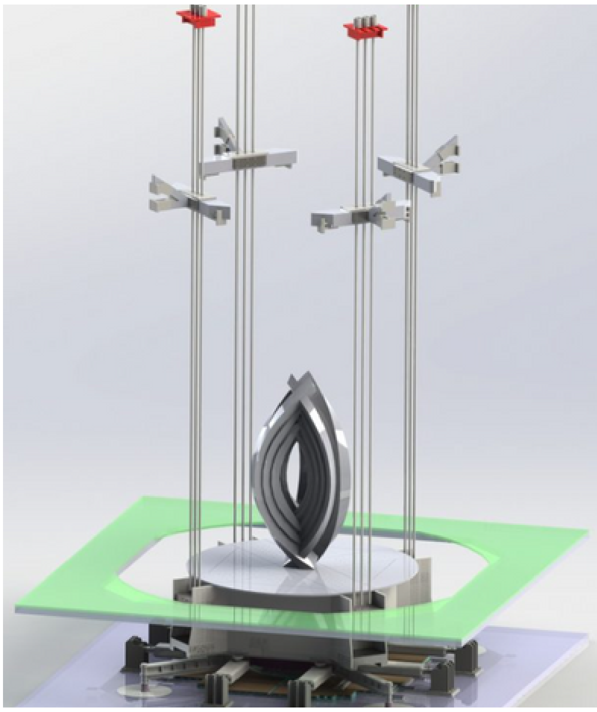


Figure 3: Tuned Mass Damper - Shanghai Tower

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Upcoming Webinar by Seismic Academy

UPCOMING EVENTS

What is expected from the webinar?

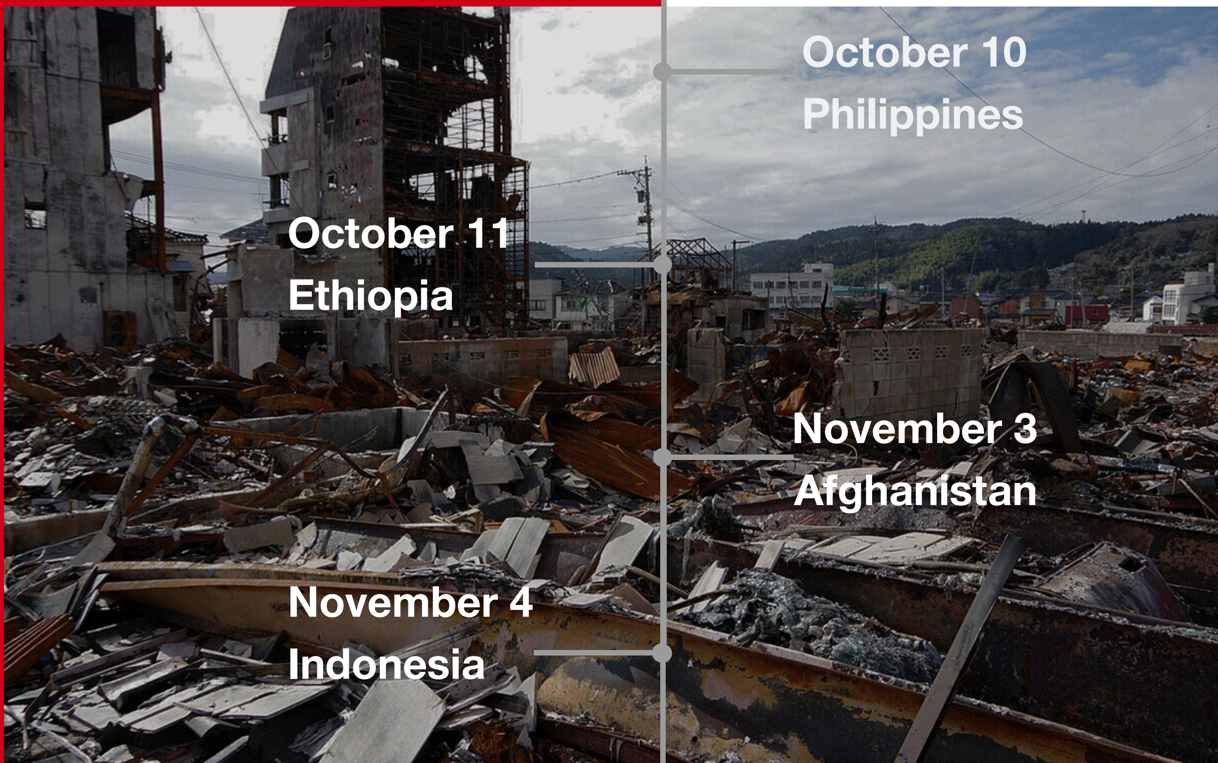
Steel structures form the backbone of modern infrastructure, and their safe, efficient design requires adherence to evolving national standards. This webinar focuses on the theme of seismic design and safety of steel structures, with insights from IS 18168 and IS 1893. The session will cover essential topics such as design strategies, ductility detailing of steel buildings, and connections.

Tracking Recent Earthquakes

July 29–30 (Aftershocks)
Russia

October 2
Turkey

October 7
Papua New Guinea



October 10
Philippines

October 11
Ethiopia

November 3
Afghanistan

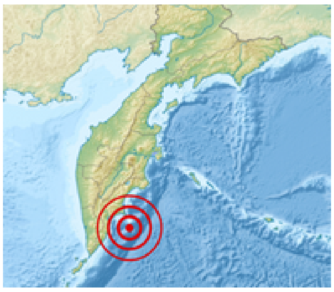
November 4
Indonesia

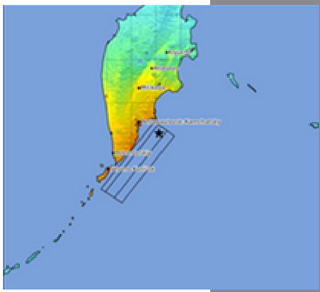
2024 Noto Peninsula Earthquake.
By Hurohukidaikon - Own work, CC BY 4.0

November 9
Mexico
Japan

November 21
Bangladesh

Russia



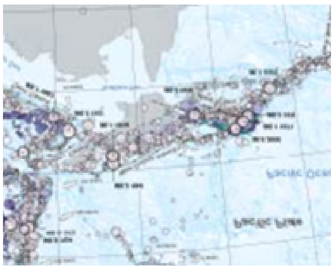


Date: Aftershocks of 29th-30th July, 2025
Magnitude: 6.0-6.1
Epicenter: Pacific coast of the Kamchatka Peninsula - 35 km depth
Impacts: No casualties or injury reported

Turkey

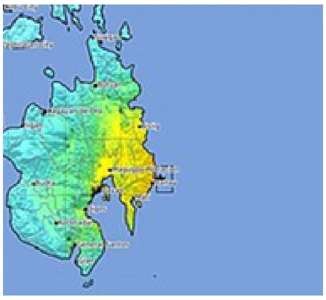
Date: 2nd October, 2025
Magnitude: 5.0
Epicenter: 9 km from Marmara Ereğlisi, Tekirdağ – 10 km depth
Impacts: Seventeen people injured and four buildings damaged in the Istanbul area

Papua New Guinea



Date: 7th October, 2025
Magnitude: 6.6
Epicenter: 20 km west of Lae – 103.9 km depth
Impacts: Some huts collapsed and power and internet outages occurred

Philippines

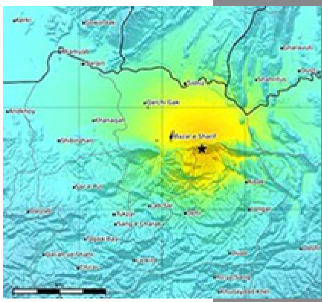


Date: 10th October, 2025
Magnitude: 7.4
Epicenter: 12 km east of Santiago – 10-23 km depth
Impacts: 10 dead, 1027 people injured

Ethiopia

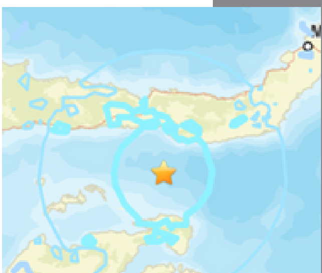
Date: 11th October, 2025
Magnitude: 5.6
Epicenter: 55 km NE of Mek'ele – 10 km depth
Impacts: 1 dead, 9 people injured, at least five homes destroyed, 1,452 structures and 74 water wells damaged, and more than 43,400 people displaced in the Berhale-Dallol-Koneba-Mekelle area

Afghanistan

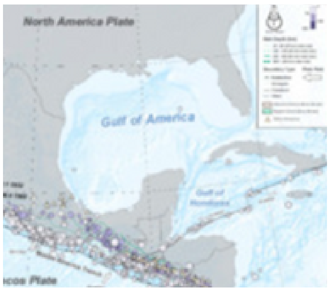
Date: 3rd November, 2025
Magnitude: 6.2
Epicenter: located in Nahri Shahi District, Balkh Province - 28 km depth
Impacts: 31 dead, 1172 injured

Indonesia



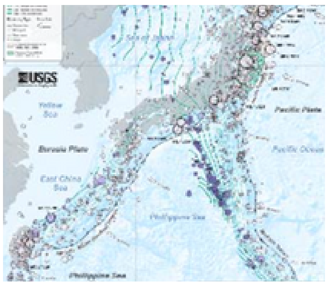
Date: 4th November, 2025
Magnitude: 5.9
Epicenter: 66 km S of Gorontalo - 118 km depth
Impacts: The walls and ceilings of a school collapsed in Banggai Regency, and some homes and buildings damaged in Bone Bolango

Mexico



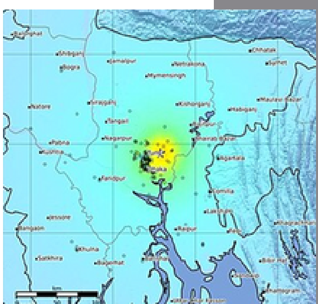
Date: 9th November, 2025
Magnitude: 5.6
Epicenter: 75 km NNE of Santa Rosalía - 10 km depth
Impacts: The facade of a building collapsed in Guaymas

Japan




Date: 9th November, 2025
Magnitude: 6.8
Epicenter: 126 km E of Yamada- 10 km depth
Impacts: A tsunami with heights of 20 cm was observed in Kuji and Ōfunato and 10 cm at Miyako

Bangladesh



Date: 21st November, 2025
Magnitude: 5.5
Epicenter: Near Madhabdi, 14 kilometres southwest from Narsingdi- 10 km depth
Impacts: 10 dead, 629 injured

SEISMIC ACADEMY

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