

November 2025

This Magazine is a Publication of the Asian Institute of Technology

TECHNOLOGY

Asian Outlook on Engineering & Technology

EARTHQUAKE ENGINEERING: RESEARCH & PRACTICE



November 2025

CONTENTS



04

Probabilistic Seismic Hazard Analysis

Teraphan Ornthammarath

09

Expert Insights on 28 March 2025 Myanmar Earthquake

Pennung Warnitchai

12

Enhancing Teaching and Learning of Earthquake Engineering Through Online Resources

Andres Winston C. Oreta

18

Innovative Tools for Enhancing Engineering Education

Naveed Anwar

21

Post-earthquake Structural Health Monitoring: Modal Decomposition-based Interpolation Method

S. M. Ziauddin, Pennung Warnitchai, Teraphan Ornthammarath & Nakhorn Poovarodom

26

AIT Solutions News

ISSN 2286-9158

Technology Asian Outlook on Engineering & Technology, is published by AIT Solutions Asian Institute of Technology, 58, Moo 9, km. 42 Paholyothin Highway, Khlong Luang, Pathumthani 12120, Thailand

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Editor's Note



In this issue of Technology Magazine, we turn our focus to Earthquake Engineering, a field that bridges advanced research with practical applications aimed at safeguarding our built environment. The recent seismic events in the region have once again underscored the importance of continuous innovation, collaboration, and education in this critical discipline.

The articles featured in this edition highlight diverse perspectives and emerging directions in earthquake engineering. Our contributors share insights on enhancing the teaching and learning of earthquake engineering through online resources, post-earthquake structural health monitoring using modal decomposition-based interpolation methods, and probabilistic seismic hazard assessment, each providing valuable contributions to advancing both theory and practice.

This issue also includes an engaging Q&A with Prof. Pennung Warnitchai, who discusses the March 28, 2025 earthquake in Myanmar and its effects in Bangkok, offering expert perspectives on regional seismic risks. Additionally, Dr. Naveed Anwar shares his thoughts on innovative tools and approaches for enhancing engineering education, emphasizing the role of technology in shaping the next generation of engineers.

I extend my sincere gratitude to all contributors for sharing their expertise and perspectives on emerging technologies and their applications. I also appreciate the efforts of our editorial team in editing and designing this issue.

As a knowledge product of AIT Solutions, this magazine serves as a professional communication platform for experts and researchers, offering insights into the latest technologies, events, and developments in the field.

We welcome your valuable feedback and look forward to engaging discussions.

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Probabilistic Seismic Hazard Analysis



Probabilistic Seismic Hazard Analysis (PSHA) plays a vital role in assessing the potential ground shaking that structures may experience by estimating the probability of various levels of earthquake-induced ground motion over time.

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When engineers design a bridge, a hospital, or even a high-rise apartment building, critical question arises:

? How much shaking might this structure experience in its lifetime?

? My skyscraper has been designed to withstand what earthquake magnitude?

We cannot predict exactly when or where the next big earthquake will strike, but we can estimate the odds of different levels of shaking. That is the role of Probabilistic Seismic Hazard Analysis (PSHA) — the backbone of modern seismic design codes worldwide.

Earthquakes and the chance of occurring through a dice

Imagine that every fault line near a city is a dice. Some dice have more sides, some fewer — representing how often small or large earthquakes happen. Rolling the dice once may not tell you much but rolling them thousands of times gives you the odds of landing on different numbers.

In PSHA, scientists "roll the earthquake dice" mathematically. They ask:

? How often does each fault produce earthquakes?

For example, an earthquake magnitude 6 once in 100 years from one fault, but the other subduction zone might produce earthquake magnitude 6 once in 50 years.

Where is the earthquake location along this active fault? For example, an earthquake with magnitude 7 could occur in different segments along the fault.

? How would the ground shaking feel at my site?

What the Results Mean

The final output might say:

"There is a 10% chance that the shaking will exceed this shaking level in the next 50 years."

"This building has been designed to withstand an earthquake with magnitude 7 within 475 year return period."

That doesn't mean the shaking will happen — it simply gives engineers a scientific basis for design.

Think of it like car insurance: you don't know if you'll ever have an accident, but you plan for the possibility based on the odds.

What is PSHA?

PSHA provides an estimate of the frequency of exceeding specified levels of ground motion at a site by integrating the contributions of earthquakes of all possible magnitudes and locations (or distances from the site where hazard is being computed) in a consistent and explicit manner, Figure 1. Probabilistic methods can be viewed as inclusive of all deterministic events with a finite probability of occurrence. This method has many applications in the field of earthquake engineering, including the design or retrofitting of important structures (for example, nuclear reactors, bridges, dams, and hospitals) and the containment of hazardous waste. More recently, seismic hazard analyses have also been used for the determination of earthquake insurance coverage of private homes and businesses and risk assessment.

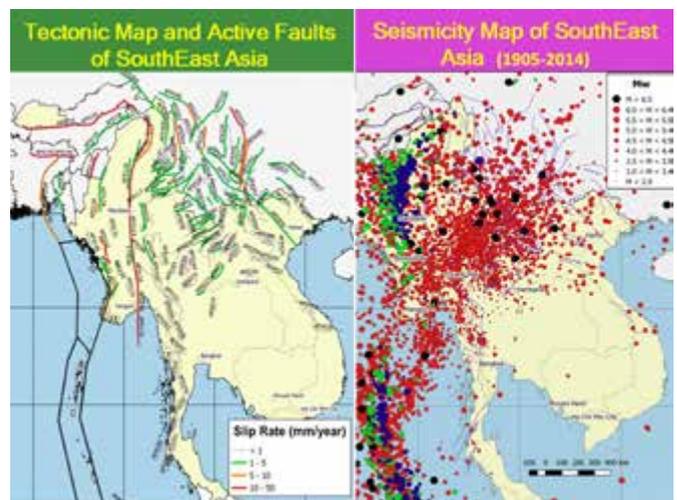


Figure 1: (Left) Active fault map in the mainland southeast Asia considered for seismic hazard assessment, and (Right) the shallow, intermediate, and deep seismicity from 1902 to 2018 used in determining seismic activity rate at different locations.

What are the Engineering Products of PSHA?

Some common results of PSHA including the seismic hazard maps, uniform hazard spectrum (UHS), the seismic hazard curve, the seismic hazard deaggregation, selected & scaled ground motion for seismic design of critical infrastructures.

PSHA Maps

The most widely recognized product of PSHA is probabilistic seismic hazard maps (e.g. US Seismic Hazard Maps) at different return periods. These hazard maps are generally the basis of other applications, such as seismic provisions in building codes, the setting of insurance premiums and risk assessments. Considering their applications and importance, seismic hazard maps are regularly reviewed and revised to reflect the most up-to-date scientific data (e.g. better constrained slip rates of active faults) and most recent computerized data interpretation (e.g. the implementation of planar and nonplanar faults). The map is often colored to delineate the level of the ground motion associated with the selected return periods (e.g. 475- or 2,475-return period), Figure 2.

What is the Return Period?

The current specification of the majority of seismic design codes in many countries adopts the reference return period of 475 years. The first application of this return period, i.e. a 475-year return period, as the basis of seismic design loads was ATC 3-06, [ATC, 1978]. The return period of 475 years was the result of selecting 50 years as the exposure time with 10 % probability of exceedance (section 2.2), although it was accepted that *'the use of a 50-year interval to characterize the probability is a rather arbitrary convenience, and does not imply that all buildings are thought to have a design life of 50 years'* [ATC, 1978].

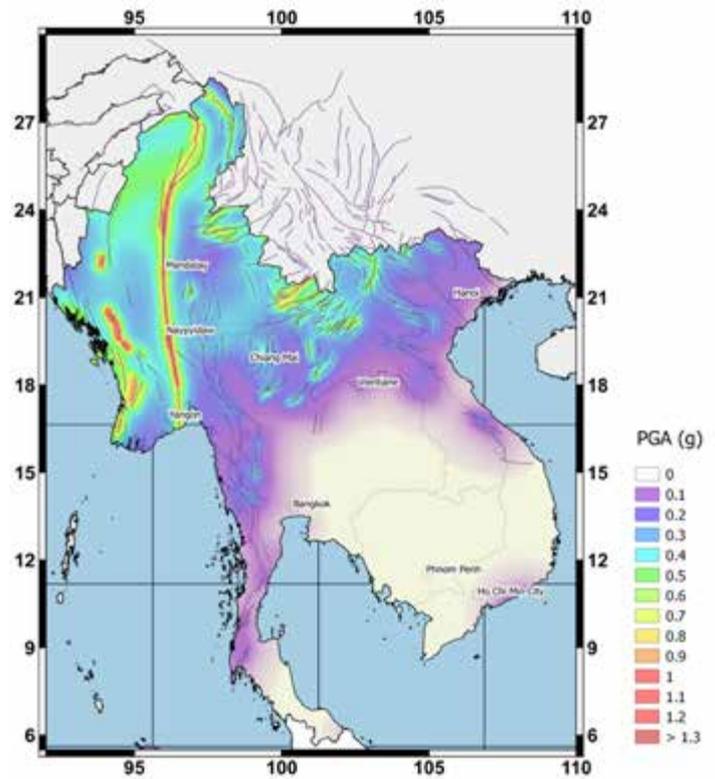


Figure 2: *PGA seismic hazard map for the mainland southeast Asia at 2475-year return period on rock condition ($V_{s30} = 760$ m/s).*

Algermissen and Perkins [1976] stated that 'for structures which should remain operable after large, damaging earthquakes, the 10% exceedance probability in 50 years seems reasonable', although the choice of 10% was adopted on the rather arbitrary basis of being a significance level often taken by statisticians *'to be meaningful'* [Bommer and Pinho, 2006]. Nevertheless, ATC 3-06 raises the question of defining the structural design level on the pre-selected return period ground motion, which is based only on expert judgment rather than modeling. This problem was discussed and this issue has later been reconsidered and reexamined. These considerations have led to the adoption of 2% in 50 years, a 2475-year return period, as the probability of collapse prevention (as called the ground motion from Maximum Considerable Earthquake, MCE) and of 10% in 50 years, a 475-year return period, as the probability of immediate occupancy (as called the ground motion from Design Basis Earthquake, DBE) as adopted the design levels in the 1997 NEHRP guidelines, IBC 2000, and FEMA 454.

The Uniform Hazard Spectrum (UHS)

UHS is derived from hazard curves by selecting oscillator response values for a specific exceedance frequency (e.g. 475-year return period). A common characteristic of UHS are smooth and broader shapes than real recorded response spectra since UHS represents the contribution of all considered earthquakes significant to a site. It is thus very important to extract controlling earthquakes from the results of PSHA through the process of seismic hazard deaggregation (Figure 3).

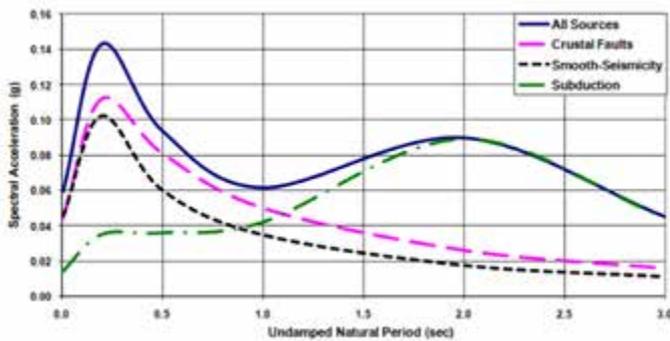


Figure 3: The Uniform Hazard Spectrum (UHS) at 2475-year return period for one project site showing contribution from different seismic sources.

Seismic Hazard Curve

A seismic hazard curve is a graph generated by Probabilistic Seismic Hazard Analysis (PSHA) that plots the annual frequency (or rate) of exceeding a certain level of ground motion against that ground motion intensity (e.g., peak ground acceleration) at a specific site. In essence, it shows the probability of different intensities of ground shaking occurring over time, providing critical input for seismic design and risk assessment. When "contribution from different seismic sources" is included, it means the hazard curve is derived from analyzing multiple possible seismic sources (e.g., specific faults or broad regions) and their associated earthquakes. The curve then sums the exceedance rates from each individual source to represent the total seismic hazard

for a site, identifying which sources are most influential (Figure 4).

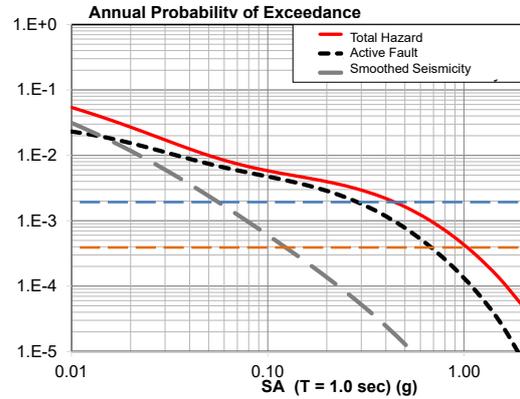


Figure 4: Computed SA (T = 1.0 sec) mean seismic hazard curves for considered site, and contributions of all considered seismic sources.

Seismic Hazard Deaggregation

PSHA integrates over all potential earthquake occurrences and ground motions to estimate the mean frequency of exceedance, ν , of any given spectral acceleration at the site. For improved communication and understanding, it is becoming common practice to display the relative contributions to the computed hazard at a specified annual rate of exceedance from different magnitudes, M , distances, r , and epsilons, ϵ , the number of standard deviations from the median ground motion as predicted by an GMPE [e.g. Bazzurro and Cornell, 1999]. The deaggregation process computes the relative contribution of different M - r - ϵ groups to the total hazard. This is obtained by accumulating in discrete M , r , and ϵ bins the mean annual rates of exceedance of a target ground-motion parameter value, SA^* . Dividing these annual frequencies, which represent the contribution to the hazard accumulated in a bin, by the total hazard, νSA^* , gives the probability that, given an exceedance of that ground motion value, it has been caused by a certain combination of M , r , ϵ . Two-dimensional deaggregation in terms of magnitude and distance is the most common form of deaggregation

representation. The deaggregation can be selected reference to PGA, SA, etc. It allows the definition of the earthquake controlling the local seismic hazard (dominant scenario earthquake) (Figure 5).

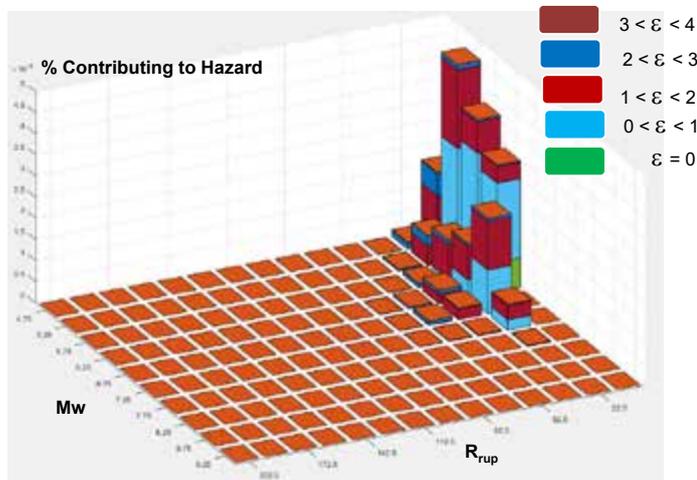


Figure 5: Seismic Hazard Deaggregation at S_a ($T = 0.2s$) at 475-year return period for one city showing the dominant earthquake is an earthquake magnitude 5.25 at 12 km from a considered site with epsilon between 0 and 1.

What is the difference between Deterministic and Probabilistic Seismic Hazard Assessment?

Deterministic and probabilistic approaches to assessing earthquake hazards and risks have differences, advantages, and disadvantages that often make the use of one advantageous over the other. Probabilistic methods can be viewed as inclusive of all deterministic events with a finite probability of occurrence. In this context, proper deterministic methods that focus on a single earthquake ensure that the event is realistic, i.e. it has a finite probability of occurrence. This points to the complementary nature of deterministic, and probabilistic analyses: deterministic events can be checked within a probabilistic analysis to ensure that the event is realistic (and reasonably probable), and probabilistic analyses can be checked by deterministic events to see that rational, realistic hypotheses of concern have been included in the analyses.

Determinism vs. probabilism, is not a bivariate choice but a continuum in which both analyses are conducted, but more emphasis is given to one over the other. Emphasis here means weight in the decision-making process, regarding whatever choices are available for risk reduction or loss mitigation. This includes system layout, design or retrofit levels, insurance, disaster planning, and recovery efforts. The widest perspective will be gained if both deterministic and probabilistic analyses are conducted. Both DSHA and PSHA approaches result in probabilistic statements about the design ground motion. In DSHA, the calculated ground motion has a probability of being exceeded given that the scenario earthquake has occurred. In PSHA, the ground motion has a specified probability of being exceeded in a given time period. The main purpose of a PSHA is to provide a method for selecting the deterministic scenarios that are "reasonable" from the large suite of possible scenarios (Figure 6) (magnitude, distance, and number of standard deviations).

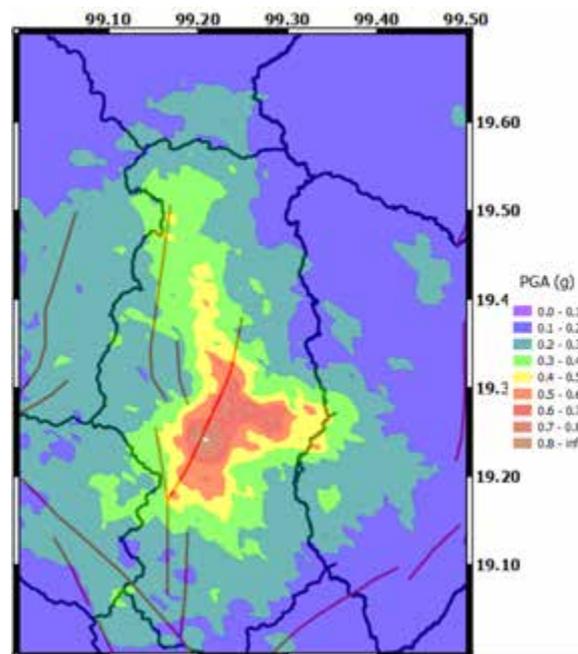


Figure 6: PGA earthquake scenario map for an earthquake magnitude 5.5 at 10 km distance from one city showing the deterministic event that could contribute as the dominant earthquake scenario for considered return period from the result of seismic hazard deaggregation.

Expert Insights

on 28 March 2025 Myanmar Earthquake

Prof. Pennung Warnitchai

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Following the magnitude 7.7 earthquake along Myanmar's Sagaing Fault on 28 March 2025, Bangkok experienced unexpected levels of shaking despite being nearly 1,000 kilometers from the epicenter. In this discussion, Prof. Pennung Warnitchai, Professor of Structural Engineering at AIIT's Department of Civil and Infrastructure Engineering, shared his insights on the event, explaining how Bangkok's deep soil basin amplified long-period seismic waves and what this means for the city's tall buildings and future seismic preparedness.



What happened during the 28 March 2025 earthquake, and why did Bangkok feel the shaking even though the epicenter was in Myanmar?



The earthquake occurred along the Sagaing Fault in Myanmar, with its epicentre nearly 1,000 km from Bangkok. At such a large distance, the seismic waves travelling through the regional tectonic plate should have weakened to a level that would cause no significant harm to buildings and structures. However, due to the presence of a large, deep soil basin beneath Bangkok and the surrounding provinces, the seismic waves, particularly long-period ones (about 2 to 8 seconds), were greatly amplified, making them strong again.

The sedimentary soil basin is more than 100 km wide, measured from north to south and east to west, and is about 800 m deep beneath Bangkok. The uppermost layer is soft clay, underlain by alternating layers of stiffer clay and sand. Our research team

has spent many years determining its key dynamic properties using a technique based on array microtremor measurements. We created a dynamic model of the soil basin, and our model predicted that the basin can amplify long-period seismic waves several times, making the surface ground motions strong and of long-period type.

This type of long-period ground motions can produce strong shaking effects on structures with long natural periods through resonant amplification, and Bangkok has a large number of such long-period structures—tall buildings. Many of these were shaken strongly and suffered some degree of damage. However, the effects on low- to mid-rise buildings with short natural periods were much less significant, as there is no resonant amplification in such cases.

Q What are the main seismic threats to Bangkok?

A Based on our seismic hazard assessment, the following are three possible earthquake scenarios with the greatest potential impact on Bangkok:

- An earthquake of magnitude 7.0–7.5 occurring along an active fault in **Kanchanaburi province**, about 200 km from Bangkok.
- An earthquake of magnitude 8.0 occurring along the **Sagaing Fault**, the longest and most active fault running through several cities in Myanmar into the Andaman Sea.
- An earthquake of magnitude 8.5–9.0 occurring in the **Arakan Subduction Zone**.

Although all these earthquake scenarios are possible, the likelihood of any occurring in our lifetime is quite low (less than 10%). However, the March 2025 earthquake, which was very similar to the second scenario, has already occurred and demonstrated that Bangkok is vulnerable to such distant earthquakes. We need to prepare ourselves for the other possible scenarios.

Q What types of damage were observed in the buildings in Bangkok after the earthquake?

A The Thailand Structural Engineers Association (TSEA) surveyed the damage and found that several hundred tall buildings in Bangkok and surrounding provinces suffered damage to their non-structural components (cracked partition walls, fallen ceilings, damaged facades, elevator problems, and drainage issues), while around ten buildings showed structural damage. In one 25-storey hospital, for example, reinforced-concrete shear

walls experienced concrete crushing and buckling of vertical reinforcement near the base of the walls, which might have been due to improperly overlapped vertical bars, creating weak zones that behaved in a brittle manner. One 33-storey office building under construction completely collapsed during the event.

Q What did the ground-motion recordings during the March 2025 earthquake reveal?

A Five seismic stations in Bangkok recorded ground accelerations. These records indicate that the ground shaking was of long duration (more than 2 minutes), long period (about 2 to 8 seconds), and low intensity (peak ground acceleration about 0.02g). Compared to the code spectra (DBE and MCE spectra), the spectral accelerations for natural periods of 3 seconds or less were well below code provisions. However, for natural periods of 5 seconds or more, the spectral accelerations were comparable to those of the code spectra, with some even slightly higher.

Q How does resonance affect buildings of different heights? How are building periods distributed in Bangkok, and which structures are most vulnerable?

A Resonance occurs when the period of ground shaking matches a building's natural period. The response spectra



of ground motion records from stations in Bangkok show several spectral peaks within a period range of 2 to 8 seconds, indicating that the ground shaking contains motions of many different periods. Therefore, resonance can occur in buildings ranging from 'not-so-tall' to 'super-tall', as long as their natural period matches one of these spectral peaks.

The Bangkok skyline has only around ten super-tall buildings (about 60 storeys or higher) with natural periods of around 6 to 8 seconds. However, the city has more than a thousand tall buildings ranging from 10 to over 50 storeys, with natural periods between 1 and 5 seconds. Within this period range, the most dominant spectral peak occurs at a period of about 3 seconds. This indicates that tall buildings of about 25 to 30 storeys were likely to be most affected by the earthquake. The initial damage data appears to support this point well.



What are the findings on the damping of tall buildings in Bangkok and why it is important?



The damping ratio, which quantifies how well a building dissipates energy, has a major influence on the response of the building, particularly when the resonance occurs. The lower the damping ratio, the higher the structural response. It is generally assumed that the damping ratio of tall buildings is about 2.5%, which is lower than that of low- and mid-rise buildings (5%). However, based on vibration records from a few instrumented tall buildings and tall building movement data obtained by a research team from the Institute of Science Tokyo using a pixel tracking method to analyse available video records, we found that the damping ratio of several tall buildings could be as low as 1%. This lower-than-expected damping ratio could be a key factor for the higher-than-expected damage observed in many tall buildings in Bangkok.



What strategies would you recommend to enhance the seismic performance of tall buildings in Bangkok?



Ground motions typically consist of a wide range of frequencies. In Bangkok, the presence of deep soft soil basins tends to amplify specific frequency components, particularly those associated with long-period ground shaking. This amplification results in the acceleration response spectra with several spectral peaks and valleys within the long period range.

Increasing structural stiffness or strength (by adding or enlarging structural components) may inadvertently shift the building's natural period towards one of these spectral peaks, thereby increasing seismic demands. Consequently, this approach could be counterproductive in soft soil conditions.

As previously discussed, structural damping plays a crucial role in mitigating seismic responses under long-period ground motions. The most effective strategy in this context is the incorporation of supplementary damping systems, which can reduce seismic demands regardless of the structure's natural period. Devices such as viscous dampers, viscoelastic dampers, friction dampers, and metallic dampers are particularly beneficial.

In conjunction with supplementary damping systems, structural walls should be carefully designed to be more ductile by mitigating brittle failure modes. These brittle failure modes include diagonal tension and compression failures due to shear forces, sliding shear at construction joints, instability in slender wall sections, compression reinforcement buckling, and failures related to lap splices and anchorage. Addressing these vulnerabilities can substantially reduce damage and significantly lower the risk of collapse during seismic events.

ENHANCING TEACHING AND LEARNING OF EARTHQUAKE ENGINEERING THROUGH ONLINE RESOURCES



By leveraging technology, students and professionals can better understand seismic risks, analyze structural performance, and develop practical skills for disaster risk mitigation and resilient design

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Recognizing the need for future civil and structural engineers to understand the importance of earthquake engineering in professional practice especially in earthquake-prone countries, the current directions is to introduce earthquake engineering as a major or elective course in the curriculum in civil engineering. Many universities all over the world including the United States do not have a course in earthquake engineering at the undergraduate level (Jayamon 2018). As a result, there have been proposals on sample syllabi for a course on earthquake engineering and structural dynamics in civil engineering undergraduate curriculum. Jayamon (2018) proposed a syllabus that highlights lectures on basic concepts in structural dynamics (modeling and dynamic analysis of damped and undamped single and multi-degree of freedom systems) and earthquake engineering (different lateral

load resisting systems, equivalent lateral load analysis of the building structure based on the provisions in ASCE 7 and requirements of seismic design guidelines for strength and serviceability limits). The proposed syllabus by Jayamon (2018) has almost the same content as existing syllabi in earthquake engineering from other universities like CE447 Seismic Design of Structures Syllabus by J. Kent Hsiao of Southern Illinois University Carbondale and CE 184 Introduction to Earthquake Engineering by Richard Armstrong of California State University - Sacramento.

Project-based learning is also emphasized in many proposed syllabi. In the syllabus proposed by Jayamon (2018), the major requirement is a case study based project where the students complete the design of an office building in a specific geographical location. The project requires students to do assignments like use appropriate online tools to find the seismicity of the given location and select suitable ground motions that can be used in the analysis of the building, modeling of single and multi-degree of freedom systems and solving the system for computing strength and deflections, design simple frame structures based on equivalent lateral force methods to apply code provisions. The last stage of the project includes the design and detailing of different elements in the lateral load resisting system.

With the advancement of online resources, applications and technology engaging student-centered learning activities that complement the lectures and quizzes and enhance the learning about earthquakes and their impacts to the built environment can now be introduced in the courses related to earthquake engineering. The author explored the integration of technology to enhance the teaching and learning in the course syllabi of courses related to earthquake engineering at De La Salle University. These activities including traditional exams and problem sets are

integrated into an outcomes-based course syllabus.

Online Resources & Technology

In the present times, the internet has become the source not only of rich and comprehensive information but also online tools and applications which makes it an alternative to the traditional library when it comes to research. Many websites and publications related to earthquake engineering are accessible for public use in the internet. Videos from YouTube are accessible for download or viewing. Hence, several exercises and projects can be designed using online platforms in the learning and application of earthquake engineering principles. Among these online-based activities are:

1. The Philippine Institute on Volcanology and Seismology (PHIVOLCS) has developed online and mobile applications specifically applied to the Philippine context. Among the online resources used in both the undergraduate and graduate courses are:

Hazard Hunter is the country's one-stop shop for hazard assessment (Figure 1). You will be informed if a location is prone to seismic, volcanic, or hydrometeorologic hazards. Reports on hazard assessment and critical facilities and areas in the vicinity of the site that are prone to different hazards can be generated. This tool is useful when the students conduct hazard assessment at a site which is an important step in disaster risk assessment and mitigation of a project.



Figure 1: *Hazard Hunter*

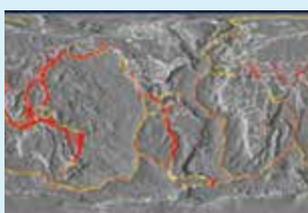
"How safe is my house?" is a rapid assessment and self-check for earthquake safety of Concrete Hollow Block (CHB) Houses in the Philippines developed by PHIVOLCS, JICA and ASEP. The checklist is used by students in their assignment on self-check of their respective houses (Figure 2).



Figure 2: *How safe is my house assessment*
 (<https://howsafeismyhouse.phivolcs.dost.gov.ph/>)

"Understanding Earthquakes and Disasters: Photo-Video Presentations" consists of eight short photo-video presentations (Figure 3) developed by the author (Oreta 2008). Before online lectures were conducted and YouTube was not yet popular then, the author played these videos in the classroom and conferences using a DVD player or a computer with Windows Media Player. The photo-video presentations present images with text and music on a specific topic on the impact of earthquake hazards – ground shaking, surface rupture, liquefaction, tsunami, landslides – to the community and infrastructures. The photo-video presentations were used in the classroom lectures in the courses on Earthquake Engineering and Disaster Management. In an online class, students watch the videos asynchronously and then write a reaction paper. The materials were also used in public awareness campaigns and conferences for professional organizations.

Understanding Earthquake & Disasters



QuakeBasics
(4.28 min)



Buildings: Shake, Rattle & Roll
(4.39 min)



Bridges are Falling Down
(5.52min)



On Shaky Ground
(5.55min)



Beware of Tsunami
(4.28 min)



Disaster & Development
(5.22 min)



Learning Lessons: 1990 Luzon EQ
(5.32 min)



Preparing for the Big One
(5.14 min)

Figure 3: *Titles of the Photo-Videos on Understanding Earthquakes and Disasters (Oreta 2008)*

2. FEMA 154 RVS Level 1 Screening Method:

It was applied on selected essential buildings. The FEMA 154 is a side walk survey of a building where a Rapid Visual Screening (RVS) method is used to assist decision makers in classifying the buildings into those that require detailed investigation and those that do not. Sample outputs are shown in Figure 4. Through this tool and exercise, students understand concepts on seismic vulnerability of buildings. The document is available at FEMA website.



Figure 4: Sample FEMA 154 RVS

3. Pacific Earthquake Engineering Research Center (PEER):

It is a web-based ground motion database that provides tools for searching, selecting, and downloading ground motion data. The NGA-West2 ground motion database includes a very large set of ground motions recorded

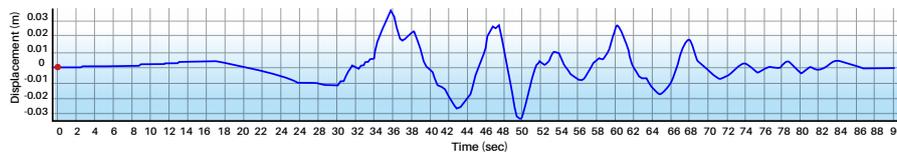
in worldwide shallow crustal earthquakes in active tectonic regimes. The database has one of the most comprehensive sets of meta-data, including different distance measure, various site characterizations, earthquake source data, etc. A student exercise on Earthquake Ground Motion Analysis is one activity where the PEER website was utilized. The students were first required to select and describe a recent significant earthquake – its location, impact with respect to damages and loss of lives accompanied by photos. Then they download a ground motion data related to the earthquake and analyze for acceleration, velocity and displacement for maximum responses and Fourier/Power spectra.

4. SeismoSignal:

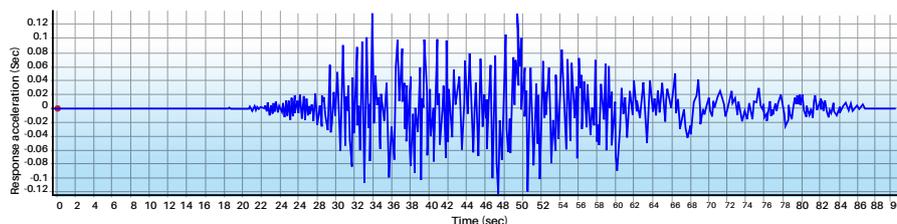
It is a free academic license software. It was used to process the earthquake time history data downloaded from PEER for acceleration, velocity and displacement for maximum responses and Fourier/Power spectra (Figure 5). The extracted time history acceleration data was then transferred to MS Excel for the application of dynamic analysis of a damped SDOF or MDOF system subjected to ground acceleration using Newmark’s Beta numerical integration method. Various problems on seismic performance using earthquake data can be designed like the investigation on how the system be modified or retrofitted by changing the dynamic properties of the SDOF or MDOF system so that the maximum displacement can be reduced. SeismoSignal is very useful in a course on Structural Dynamics.



Peak ground motion parameters.



Displacement Time History of 1999 Chi-Chi Earthquake, Taiwan.



Response Acceleration Time History of 1999 Chi-Chi Earthquake, Taiwan.



Parameter	Magnitude	Time (s)
Peak Ground Acceleration (g)	0.13563	49.545
Peak Ground Velocity (m/s)	0.4084155	48.87
Peak Ground Displacement (m)	0.03474	35.86

Figure 5: 1999 Chi-Chi Earthquake Time History Data downloaded from PEER and processed by SeismoSignal

5. Structural Earthquake Response Analysis 3D or STERA3D:

It is an integrated software for seismic analysis of buildings with various structures (reinforced concrete, steel, masonry, base isolation, response control, etc.) in three dimensional space developed for research and educational purposes. STERA3D has a visual interface to create building models and show the results easily and rapidly. In the graduate seminar on Earthquake Disaster Mitigation, a case study about "Seismic Performance of an Irregular Building," each group modeled and analyzed a specific type of irregular building using STERA3D. They perform both push-over analysis and time-history analysis to determine the performance of the irregular building and identify potential weaknesses. They reanalyzed using

STERA3D at least one retrofit method and compared to the original model. A sample output is shown in Figure 6.

In conclusion, the integration of technology in earthquake engineering education offers immense benefits for students and professionals alike. With the available online resources and tools, the teacher simply needs to design student centered learning and problem-based learning activities to enhance the understanding and mastery of earthquake engineering concepts and applications in the real world. The use of the internet for learning and research developed in the student's life-long learning skills and addressed specifically the student outcome on the "ability to use techniques, skills, and modern engineering tools necessary for engineering practice."



EQDM Graduate Seminar: Group Exercise #3 & Case Study using STERA-3D

SEISMIC PERFORMANCE OF AN IRREGULAR BUILDING USING STERA-3D: Model and analyze an irregular building using STERA3D. Perform Push-Over Analysis and Time-History Analysis. Discuss the performance of the irregular building and identify potential weaknesses. Reanalyze using STERA3D at least one retrofit method and compare to the original model.

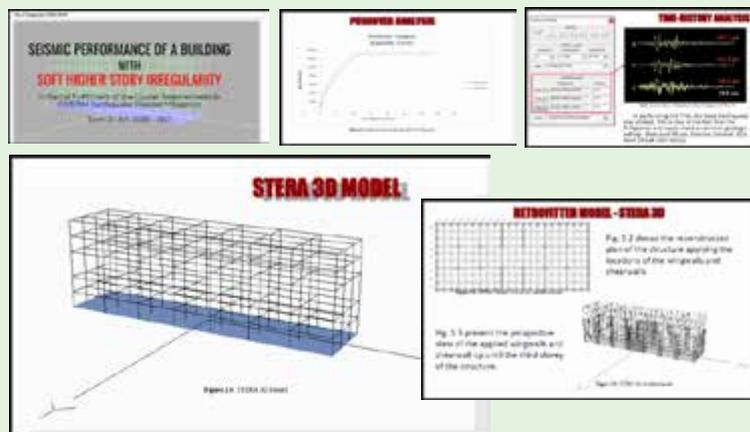


Figure 6: STERA3D Exercise

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Online Resources Links:

- Hazard Hunter. <https://hazardhunter.georisk.gov.ph/>
- How safe is my house?: <https://howsafeismyhouse.phivolcs.dost.gov.ph/>
- FEMA 154. https://www.fema.gov/sites/default/files/2020-07/fema_earthquakes_rapid-visual-screening-of-buildings-for-potential-seismic-hazards-a-handbook-third-edition-fema-p-154.pdf
- PEER NGA West. <https://ngawest2.berkeley.edu/>
- SeismoSignal. <https://seismosoft.com/products/seismosignal/>
- STERA_3D. <https://rc.ace.tut.ac.jp/saito/software-e.html>

Innovative Tools for Enhancing Engineering Education

Engineering education is changing fast—maybe faster than ever. With technology advancing at breakneck speed and real-world problems getting more complex by the day, there's a big question hanging over us: are we really preparing young engineers for what they're going to face?

Dr. Naveed Anwar has worn a lot of hats—structural engineer, educator, software developer, and someone who's spent years trying to bridge that often-frustrating gap between the classroom and actual practice. We sat down with him to talk about how digital tools, visualization, and simulation might just reshape the way the next generation of engineers learns.

Dr. Naveed Anwar

CEO, CSI Bangkok,
& Adjunct Faculty in Structural
Engineering at AIT



You've been in both academia and practice for quite a while now. If you had to characterize the current state of engineering education, what would you say? And what's the biggest challenge new engineers face when they step into the professional world?



Look, we've definitely made progress—especially in how we deliver content. But understanding? That's where we're still falling short. Engineering schools are still heavy on calculations, codes, design checks—all important stuff, don't get me wrong. But there's often no context. Students graduate knowing how to use software, but if you ask them "Why the structure behaves a certain way?", you get blank stares.

The real challenge isn't a lack of knowledge—it's a lack of connected knowledge. Students learn analysis in one box, design in another, construction in yet another. But the professional world? It demands you integrate everything—materials, disciplines, decisions. Our job now is to rebuild that continuity in how we teach.



You've talked before about this gap between classroom learning and real practice. Why do you think it's still there? What needs to change?



The gap exists because practice has evolved way faster than education has kept up. Walk into a modern structural design office and you'll see people working in 3D, with parametric models, in completely data-driven environments. But walk into most classrooms? Students are still doing manual steps and isolated examples.

We need to move away from just teaching topics and start building understanding. Students should see how equations actually translate into physical behavior. How your design assumptions play out in performance. How each decision you make fits into the bigger picture of a project's lifecycle. Once they have that mindset, the tools and codes become easy to pick up.



You advocate for an approach where students learn through tools and simulations, not just lectures or textbooks. What does that actually look like?



When students interact with a model, something clicks. They stop memorizing and start reasoning. Think about it—if a student applies a load to a beam and immediately sees the bending, shear, and curvature evolving in front of them, that experience sticks. Way longer than any derivation I could put on the board.

Learning through tools means creating an environment where theory, computation, and visualization all live together. Instead of separate software for analysis, design, and drawing—which is what we usually have—we create small, focused applications. Each one lets students explore a single concept at a time. Stiffness. Ductility. Stability. And they connect it to actual design thinking. It's like giving them a laboratory for ideas.



We've heard you and your team are developing a new digital platform that brings learning, analysis, and design together in one place. Where did that idea come from?



Honestly? Years of frustration. Watching students learn advanced design procedures without really grasping the fundamentals. It bothered me. I wanted to create a space where an engineer can move seamlessly from concept to computation to insight—without having to jump through hoops.

The platform we're building is modular and interactive. Each module focuses on one concept—material behavior, moment-curvature, frame response that sort of thing. But they all connect under one ecosystem. We're not trying to replace commercial analysis software. We're trying to complement it with educational clarity.

Basically, we're building a digital 'school of practice' where learning happens by doing, observing, and reflecting. The same way we learn in real life.



How do technologies like visualization, simulation, and AI actually help students understand complex concepts? Can these tools genuinely enhance understanding, or are they just automation?



They're definitely more than just automation—when you use them thoughtfully. Visualization lets students see what the equations are describing: stress flows, deflected shapes, energy dissipation. Simulation lets them test 'what if' scenarios that would take hours to work out by hand, if you could even do it at all.

AI adds another layer. Picture a digital mentor that tells a student, 'Your design is safe, but it's not efficient—try reducing stiffness here,' or highlights which parameter has the biggest influence on drift. AI doesn't replace the teacher. It extends the teacher's reach and gives every student their own personalized feedback loop.



Your background is mainly structural, but these ideas seem relevant across all civil engineering disciplines. How would this model apply to areas like geotechnical or water or transportation?



Because the principles are universal. Every civil engineering discipline works with models of reality—whether it's soil, flow, traffic, or structure. They're all governed by equations that describe behavior. What differs is the domain, not the philosophy.

If we can teach students to think in terms of relationships—cause and effect, input and response, assumptions and limitations—then the same platform concept extends naturally. A soil stress visualization tool or a flow simulation module follows the same logic as a beam deformation tool. Once you've built the framework, it becomes a template for cross-disciplinary education.



What does the future learning environment look like to you? Will digital tools replace traditional teaching?



No, technology won't replace teachers. But teachers who use technology will replace those who don't. The future classroom will be blended—a dialogue between human mentorship and digital exploration.

Lectures will get shorter and more conceptual. Students will spend more time in interactive labs—not just physical ones, but digital ones—where they can manipulate models, test ideas, and see the consequences instantly. Assessment will shift from 'did you get the right answer' to 'how did you get there.'

The teacher's role evolves from content delivery to curating experience. That's the real transformation.



A lot of educators want to integrate technology but don't know where to begin. What's your advice?



Start small. Stay purposeful. Pick one topic where visualization can really make a difference—say, shear behavior or buckling—and use a simple interactive model or open-source tool to demonstrate it. You'll be amazed at how much better comprehension gets.

Institutions should encourage this kind of experimentation, not just buy more software licenses. The goal isn't to teach tools—it's to teach through tools. When technology becomes a medium for insight rather than just a shortcut for calculations, both teachers and students rediscover what makes engineering exciting.



What excites you most about where engineering education is headed?



The possibility of connecting learning, research, and practice in one continuous loop. Imagine a student exploring a digital model, validating it with lab data, then applying those same principles in a real project—all within the same ecosystem.

The real innovation will happen when universities, researchers, and practitioners share a common digital environment for learning and creation. That's when education stops being just preparation for practice—it becomes practice itself.



If you had to sum up your philosophy on education in one sentence, what would it be?



Engineering education shouldn't just teach us how to design structures—it should teach us how to think structurally about everything.

Post-earthquake Structural Health Monitoring: Modal Decomposition-based Interpolation Method

Modal Decomposition-Based Interpolation is an alternative approach to numerically estimating the motions of non-instrumented floors, which is based on the theory that complex dynamic responses of a structure can be decomposed into modal responses, and the dynamic responses of the structure can then be approximated as a sum of a few modal responses in most practical cases.



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When Seconds Count

Earthquakes don't just shake buildings—they shake confidence of inhabitants on the safety of buildings after earthquakes. In the aftermath, fear often drives people to evacuate even structurally sound buildings. This can lead to substantial financial losses due to business and occupancy disruptions. On the other hand, if a building sustains substantial damage during the mainshock but the occupants are not evacuated, casualties may occur if aftershocks cause the structure to collapse. The question is urgent: **how do we know, quickly and accurately, whether a building is safe?**

The Role of Accelerometers

The most practical solution lies in **accelerometers**. These sensors are widely available and easy to install. When an earthquake occurs, accelerometers record acceleration time histories, which engineers

can analyze to understand how the building responded to the seismic event. From these records, engineers can estimate:

- **Peak floor acceleration** (important to assess damage of non-structural components like suspended ceilings, light fixtures, and mechanical equipment)
- **Lateral displacement** (required to estimate inter-story drift responses)
- **Inter-story drift** (the relative movement between floors, critical to assess structural performance and damage of non-structural components like partition walls, façade, and vertical piping)

However, there is a challenge in the financial aspect: installing accelerometers on every floor of a high-rise building is costly. Most buildings only have sensors on a few floors, leaving gaps in the data.

Common Approach—and Its Limits

Generally, engineers use **cubic spline interpolation** to estimate the motion of the non-instrumented floors numerically. This technique requires installing a sensor at the base and roof of the building, as well as on some intermediate floors, to estimate the structural response on non-instrumented floors. While effective for capturing low-frequency motions, its accuracy decreases significantly for high-frequency vibrations.

Modal Decomposition-based Interpolation: Advanced Approach for Accurate Estimation

Modal Decomposition-Based Interpolation is an alternative approach to numerically estimating the motions of non-instrumented floors, which is based on the theory that complex dynamic responses of a structure

can be decomposed into modal responses, and the dynamic responses of the structure can then be approximated as a sum of a few modal responses in most practical cases. The mathematical expression of this procedure is presented in Equation (1)

$$\ddot{\mathbf{u}}^t \cong \Phi \ddot{\mathbf{q}} + \mathbf{l} \ddot{u}_g(t)$$

Equation (1)

$\ddot{\mathbf{u}}^t$ = Floor acceleration responses

Φ = Modal matrix

$\ddot{\mathbf{q}}$ = Vector of modal acceleration coordinates

\mathbf{l} = Influence vector of which every element is unity

$\ddot{u}_g(t)$ = Horizontal ground acceleration

Solving Equation (1) for Instrumented Floors:

1. $\ddot{u}_g(t)$ and $\ddot{\mathbf{u}}^t$, are obtained from the accelerometer on the ground floor and instrumented floors above.
2. Modal matrix, Φ , is computed based on the measured acceleration records of instrumented floors.
3. Equation (1) is solved by the least squares method to estimate **modal acceleration coordinates, $\ddot{\mathbf{q}}$** .

Solving Equation (1) for Non-instrumented Floors:

1. Same equation, Equation (1), is applied to estimate the acceleration of non-instrumented floors. $\ddot{\mathbf{u}}^t$ is **unknown vector** at this time.
2. Φ , normalized mode shapes of non-instrumented floors are approximated from the trendline of normalized mode shapes of instrumented floors from the previous step.

3. \ddot{q} , vector of modal acceleration coordinate, which is calculated in the previous step, and $\ddot{u}_g(t)$, ground accelerations are used to estimate the **unknown**, \ddot{u} of non-instrumented floors.

Practical Application

Modal Decomposition-based Interpolation method (MBI) was applied to a 15-story hospital reinforced concrete building in Chiang Rai, Thailand. The building was instrumented with accelerometers on eight floors (Ground, 2nd, 6th, 7th, 10th, 11th, 14th, and Roof). On November 17, 2023, a magnitude 5.7 earthquake struck, providing an ideal test scenario.

- Fourier amplitude spectrum of the roof acceleration records indicates that the building's response can be approximated by the contribution of the first six modes.
- Recorded acceleration data from **just five floors** (Ground, 2nd, 7th, 11th, and Roof) is utilized to estimate acceleration responses along the height of the building using the MBI method. Estimated acceleration responses of the 6th, 10th, and 14th floor levels are compared to the corresponding recorded outcomes.
- Both the recorded and estimated (i.e., estimated using the MBI method) acceleration responses are double integrated to estimate the displacement responses. Outcomes of the 6th, 10th, and 14th floor levels are compared.
- Displacement responses are further used to estimate inter-story drift responses, and the outcomes of 7th, 11th, and 15th (roof) floor levels are compared.

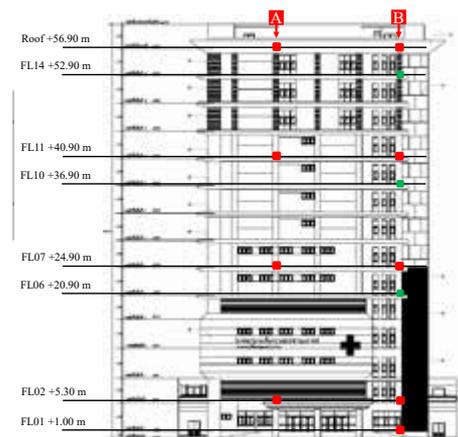
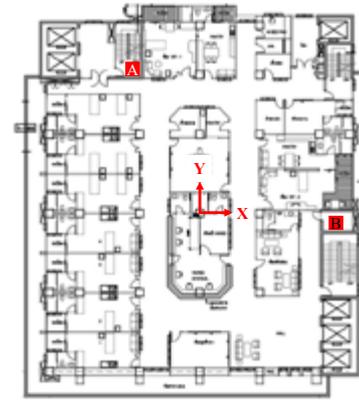


Figure 1: Chiang Rai hospital building with accelerometer locations

Buildings can be equipped with accelerometers, and acceleration records can be used to estimate relevant responses to prevent unnecessary evacuation of buildings. Due to their extravagant cost, accelerometers are usually installed on a few selected floors of high-rise buildings. This study explored a modal decomposition-based interpolation method (MBI) to estimate acceleration, displacement, and inter-story drift responses at every floor level of a building using acceleration records from a limited number of floors. However, these responses are insufficient for effective post-earthquake structural health monitoring, as they don't reveal internal forces or inelastic deformations—responses critical for evaluating structural damage. Although the MBI method can be extended to identify the damaged state of structural components, exploring that potential is beyond the scope of this paper.

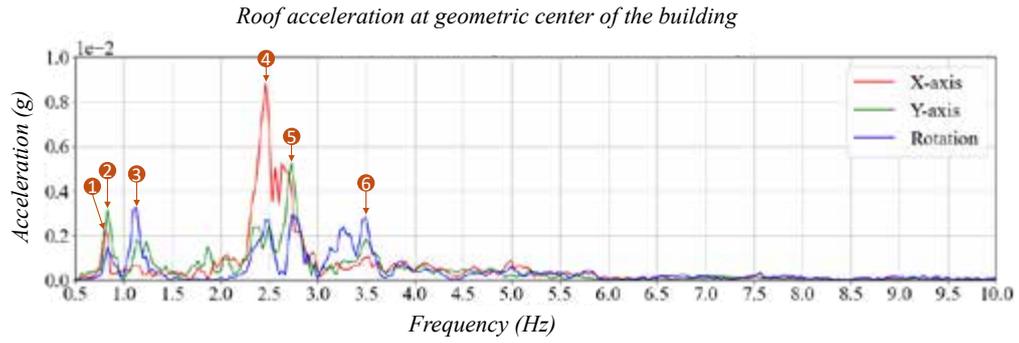


Figure 2: Post-earthquake system identification through Fourier amplitude spectrum

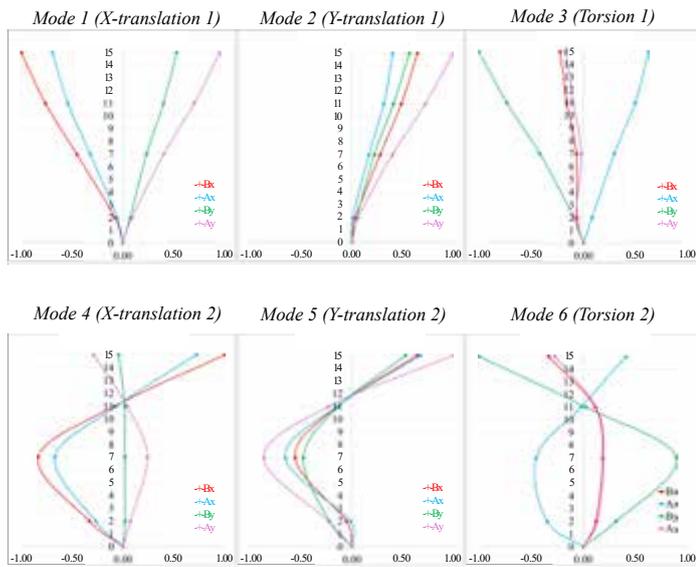


Figure 3: Normalized mode shapes at A and B locations

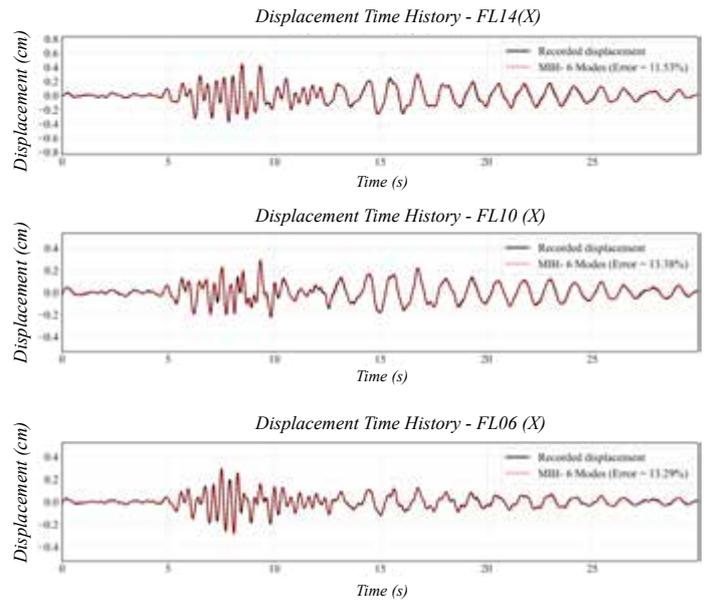


Figure 5: Time history of floor displacement responses

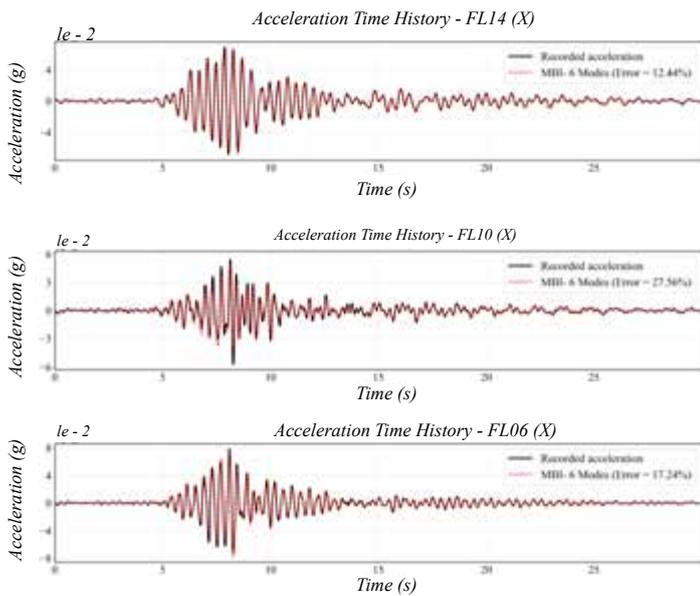


Figure 4: Time history of floor acceleration responses

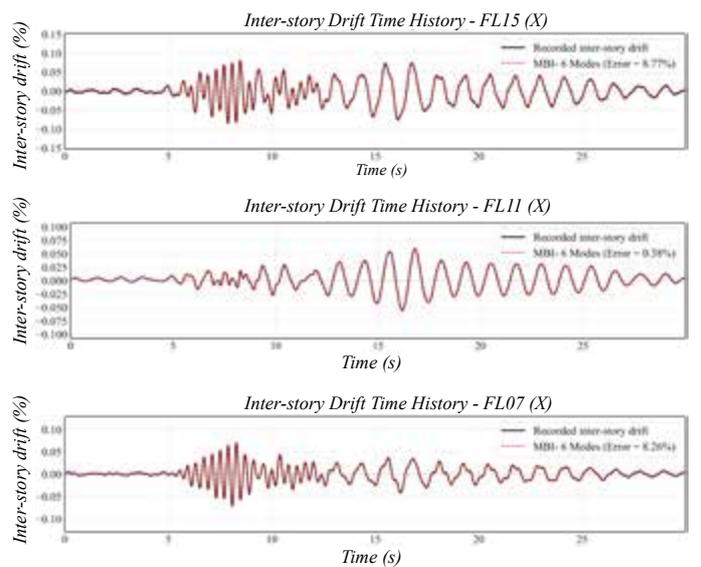


Figure 6: Time history of inter-story drift responses

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24 November 2025



AIT Solutions and HAKI Partner to Advance Structural Engineering

The Asian Institute of Technology (AIT) and Himpunan Ahli Konstruksi Indonesia (HAKI) have signed a Letter of Agreement, marking a new chapter of collaboration between AIT Solutions and HAKI. This partnership aims to strengthen knowledge exchange in the field of structural engineering through a series of in-person, hybrid, and online activities. Key focus areas include: Structural Performance-Based Seismic Design, Wind Engineering, and Structural Health Monitoring.

14 November 2025



AIT Solutions - ACECOMS: CSI Software Online Forum

AIT Solutions and ACECOMS hosted the CSI Software Online Forum in the month of November, led by Structural Engineering experts Mr. Thung Htut Aung, Executive Director, AIT Solutions and Mr. Keerati Tunthasawatana, Director, ACECOMS. The session served as a platform for engineers to interact with experts, addressing real-world queries on ETABS, SAP2000, SAFE, and PERFORM3D applications.

10 November 2025



Thai Takenaka International visit to AIT Solutions

On 10 November 2025, AIT Solutions (AITS) welcomed professionals from Thai Takenaka International for a technical engagement focused on wind engineering applications in building design.

The visit began with an overview of AIT Solutions comprehensive wind engineering services—from design consultation and wind studies to physical model fabrication, followed by observing the operations at AIT-TU Wind Tunnel facility.

27 October 2025



AIT and College of Engineering and Architecture-USTP-CDO sign Letter of Agreement and conduct CSI Software Workshops

AIT Solutions, in collaboration with the University of Science and Technology of Southern Philippines (USTP) in Cagayan de Oro, conducted a two-day workshops on CSI Software – SAP2000 (20 & 21 Oct, 2025) and on ETABS (27 & 28 Oct, 2025) for the Civil Engineering faculty and undergraduate students of USTP.

14 October 2025



Thai Nishimatsu Construction Co., Ltd. (Thailand) visits AIT Solutions

AIT Solutions hosted professionals from Thai Nishimatsu Construction Co., Ltd. (Thailand) for a technical engagement on wind engineering applications in building design in the month of October. An overview of AIT Solutions' wind engineering services from design consultation and wind studies to model fabrication and a tour of the AIT-TU Wind Tunnel facility were the highlights of the visit.

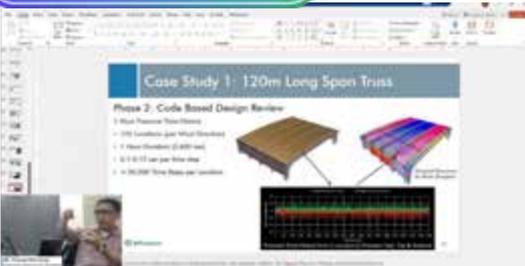
11 October 2025



Key Considerations in High-Rise Building Design for Thailand

Mr. Keerati Tunthasawatana, Director, ACECOMS, AIT Solutions, in the month of October, presented on "Key Considerations in High-Rise Building Design for Thailand" at an EIT professional development event. The session explored practical applications of ETABS in high-rise analysis, covering wind loads, seismic analysis, and shear wall design.

10 October 2025



AIT Solutions and ACECOMS: CSI Software Online Forum

AIT Solutions and ACECOMS hosted the CSI Software Online Forum in the month of October, led by Structural Engineering experts Mr. Thaung Htut Aung, Executive Director, AIT Solutions and Mr. Keerati Tunthasawatana, Director, ACECOMS. The session provided a platform for engineers to interact with experts, addressing real-world queries on ETABS, SAP2000, SAFE, and PERFORM3D applications.

1 October 2025



Asian Institute of Technology and Xavier University - Ateneo de Cagayan Strengthen Collaboration in Structural Engineering

The Asian Institute of Technology (AIT) and Xavier University – Ateneo de Cagayan (XU) signed a Memorandum of Agreement (MoA) to strengthen collaboration in structural engineering in the month of October. Facilitated by AIT Solutions to engage in joint research, technical mentorship, and knowledge-sharing activities and education in structural engineering practice.

29 September 2025



Tokyo-Thailand Networking Seminar - Urban Resilience Technology

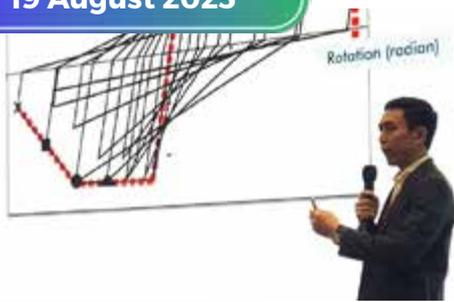
AIT Solutions participated in the Tokyo–Thailand Networking Seminar in September, organized by the Tokyo SME Support Center. Mr. Keerati Tunthasawatana presented "Advancing Tall Building Resilience: Structural Assessment & Monitoring", and showcased AIT Solutions' work in PBSO, Wind Engineering, and Structural Health Monitoring.

23 September 2025



AIT Solutions collaborates with Indian Institute of Technology Bombay to conduct a webinar on "Resilience-Based Seismic Design"

AIT Solutions in collaboration with IIT Bombay conducted a webinar on Resilience Based Seismic Design in the month of September, led by Mr. Thaung Htut Aung and Mr. Shabir Ali Talpur. Prof. M.N. Shariff (IIT Bombay) as the moderator, discussed methods to minimize structural damage and improve post-earthquake recovery during the session.

19 August 2025

A presentation on “Enhancing Seismic Resilience” at HAKI Annual Seminar 2025 by AIT Solutions Executive Director

AIT Solutions Executive Director Mr. Thaung Htut Aung delivered a presentation on “Enhancing Seismic Resilience – Special Considerations in Performance-Based Seismic Design (PBSD) Practice” at the Annual Seminar of the Indonesian Society of Civil and Structural Engineers (HAKI), held on 19–20 August in Jakarta, Indonesia. The talk emphasized seismic design philosophy, modeling, and collaboration for advancing earthquake resilience.

14 August 2025

AIT Solutions takes part in the 3rd Thailand Symposium on Earthquake Research (TSER 2025) as a sponsor

AIT Solutions sponsored and participated in TSER 2025, held in the month of August under theme “Lessons Learned from the March 28, 2025, Earthquake.” The symposium gathered experts to discuss seismic hazards, preparedness, monitoring, and recovery, highlighting collaborative approaches to resilience.

23 July 2025

AIT Solutions, ACECOMS & CSI Bangkok Attract Strong Industry Interest at International Engineering Expo 2025

AIT Solutions, ACECOMS, and CSI Bangkok in the month of July, showcased innovations in structural engineering at the International Engineering Expo. The team presented CSI Software advancements, PBSD, Wind Engineering, and Structural Health Monitoring applications to professionals and decision-makers.

29 May 2025

AIT Solutions and ACECOMS at ASEP Conference 2025

AIT Solutions and ACECOMS, in collaboration with CSI Bangkok, participated in the ASEP Conference 2025 under the theme “Transforming Communities Towards a Better Quality of Life.” Held in the month of May in the Philippines. The team exhibited structural engineering innovations and CSI software advancements.

28 May 2025

AIT Solutions and ACECOMS Showcase Structural Engineering Services at the 30th National Conference on Civil Engineering, Thailand

AIT Solutions and ACECOMS joined the 30th National Conference on Civil Engineering, organized by EIT in the month of May. In the designated booth area AIT Solutions and ACECOMS exhibited advanced structural engineering services, innovative design tools, and software solutions, drawing strong engagement from participants.

8 April 2025

AIT Solutions at the Seminar on Performance-based Design of Tall Buildings, Indian Institute of Technology Roorkee

AIT Solutions participated in a seminar conducted by IIT Roorkee on Performance-Based Design of Tall Buildings, in the month of April. The event brought together experts from AIT, IIT Roorkee, Mahidol University, and CSI Bangkok to discuss innovations in tall building design and structural resilience.



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OUR SERVICES

Together we can build a resilient future using advanced engineering technology

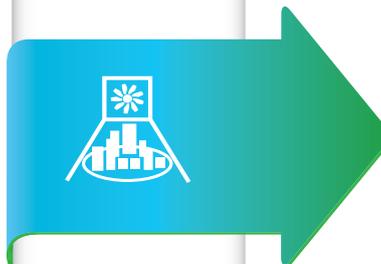
Performance-based Seismic Design

- Conduct highly detailed modeling & structural analysis.
- Evaluate the structural performance explicitly to meet code intended objectives or enhanced performance levels.
- Improve cost-effectiveness in design.
- Provide structural design recommendations for structural design enhancements.



Wind Tunnel Testing

- Conduct wind tunnel laboratory testing.
- Provide wind loads for structural design.
- Provide cladding pressure for cladding design.
- Check public comfort and safety in public areas.
- Check the aerodynamic stability of bridges.



Structural Evaluation of Existing Buildings

- Conduct detailed assessment of structural system based on as-built conditions.
- Provide retrofit and strengthening solutions if required.



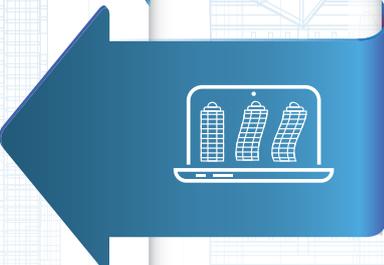
Structural Health Monitoring of Buildings

- Evaluate the response of the buildings using acceleration sensors under earthquakes.
- Check the safety of structural system and re-occupancy of residents in post-earthquake scenarios.



Structural Design Review

- Check compliance with applicable codes & standards to ensure public safety.
- Review the serviceability & strength requirements of structural system & components.
- Review the detailing of primary structural components.
- Report on the comments & findings.



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Shaping the Future: The Impact of Professional Master in Structural Design of Tall Buildings on Civil Engineering

In the ever-evolving field of civil engineering, the construction landscape is reaching new heights – quite literally. With the increasing demand for skyscrapers and tall structures, the role of structural engineers has become more crucial than ever. To meet this demand and equip civil engineers with specialized skills, Professional Master in Structural Design of Tall Buildings (PMTB) is shaping the future of civil engineering.



Professional Master in Structural Design of Tall Buildings

PMTB is a response to this growing demand for specialized expertise. These programs go beyond the foundational principles taught in traditional civil engineering education, delving into the complexities of tall building design, including structural systems, seismic considerations, and wind dynamics. The curriculum is designed to provide students with a holistic understanding of the challenges and innovations inherent in tall building design and construction.



Real-World Application

Theoretical knowledge is valuable, but its real worth is realized when applied to practical scenarios. PMTB includes hands-on projects that allow students to apply their learning to real-world situations. This practical experience is invaluable in preparing civil engineers for the challenges they will face in their careers.



Interdisciplinary Approach

The design and construction of tall buildings require a multidisciplinary approach. PMTB encourages collaboration between engineers, architects, and other professionals. This interdisciplinary approach mirrors the real-world challenges faced by civil engineers working on complex projects, fostering teamwork and effective communication skills.



Specialized Knowledge

One of the keyways in which these programs shape the future of civil engineers is by offering specialized knowledge. Students are exposed to advanced topics such as performance-based seismic design, and wind engineering and structural health monitoring. This specialized knowledge equips graduates with a competitive edge, making them sought-after professionals in the field of structural engineering.



The Rise of Tall Buildings

In recent decades, the global skyline has been transformed by towering structures that defy traditional engineering norms. Tall buildings are not merely symbols of architectural prowess; they represent the intersection of art, science, and functionality. As cities expand vertically, there is a pressing need for engineers who possess a deep understanding of the unique challenges associated with designing and constructing tall buildings.



Recommendation

The Professional Master in Structural Design of Tall Buildings is playing a pivotal role in shaping the future of civil engineering. By providing specialized knowledge, fostering an interdisciplinary approach, promoting real-world application, this program prepares engineers to tackle the complexities of designing and constructing the skyscrapers that define our modern cities. As the demand for tall buildings continues to rise, the graduates of these programs are well-positioned to lead the way in creating the structures that will shape our urban landscapes for generations to come.



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