# TECHNOLOGY

Asian Outlook on Engineering and Technology

## AIT Solutions Celebrates 10 years of Providing Integrated Innovative Solutions

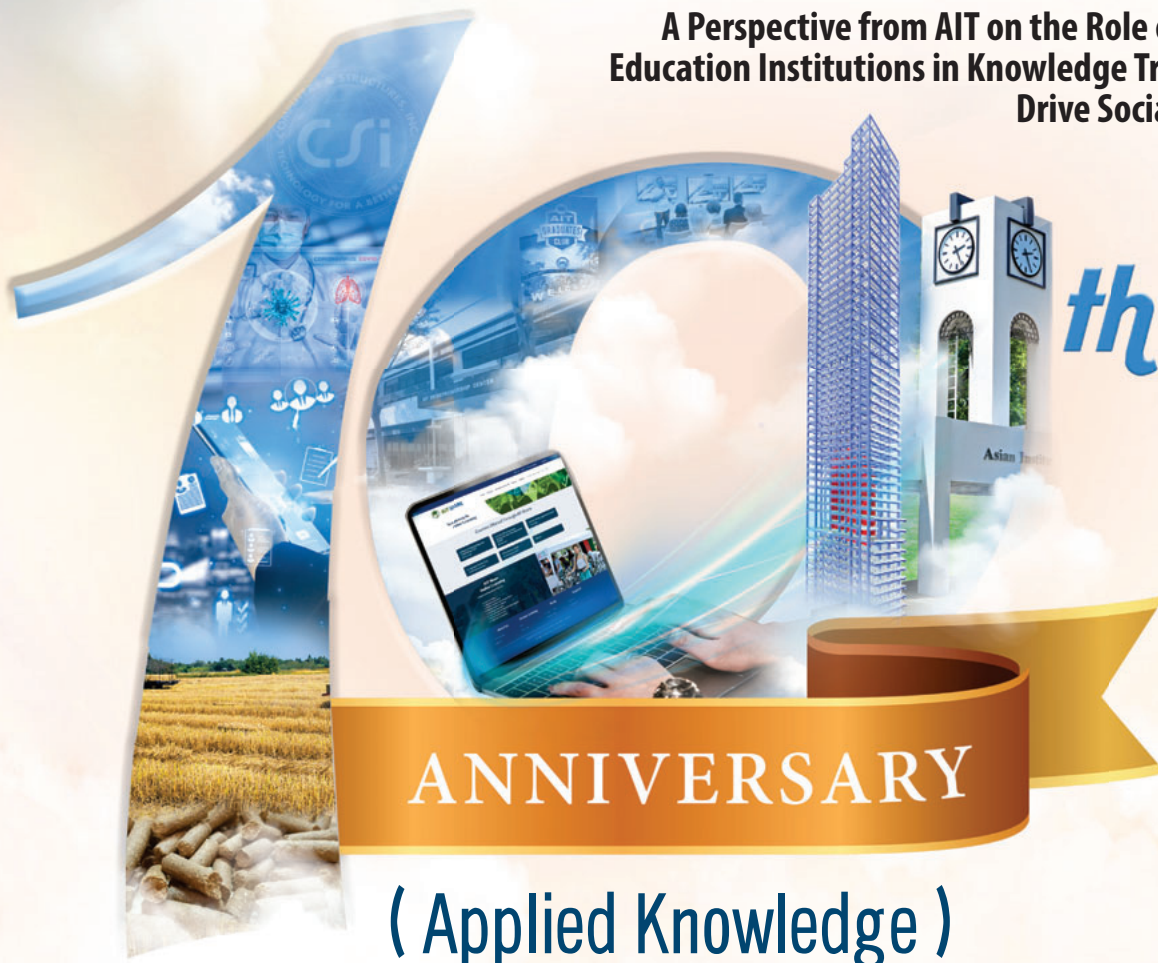### Digital Transformation in Healthcare

### Structural Health Monitoring and Post-earthquake Response Assessment of Tall Buildings

### Open Innovation Practices in Thai Software SMEs

### Producing Rice Straw Pellet Fuel for Multiple Benefits

### A Perspective from AIT on the Role of Higher Education Institutions in Knowledge Transfer to Drive Social Impact

10th

ANNIVERSARY

( Applied Knowledge )

*This magazine is a publication of the Asian Institute of Technology*

**AIT** Asian Institute of Technology

**AIT** Solutions

# Contents

## Featuring

## Also in this issue

# Editorial

## Editor's Note

**K**nowledge is, in general, theoretical understanding of a subject which is acquired through education or learning. Theory teaches us the experience of others. Applying the knowledge gives us in-depth understanding about how things happen in the real world through the act of personal experience. The best part of it is that additional knowledge that we gained through application will remain with us for a longer period. Also, we can learn how the knowledge learnt needs to be implemented in certain real life situations. Although knowledge is intangible, the practical application makes it tangible by doing with the skills to apply the knowledge.

In this issue, we focused on the knowledge and expertise of our Institute and partners which is applied to help the industry and make positive impact to society. Applied knowledge of various thematic areas, such as artificial intelligence, structural engineering, open innovation in software, and environmental engineering are presented in this issue. I am grateful to AIT faculties, colleagues and partners who shared their experience and knowledge, and colleagues of editorial team in editing and designing of this issue.

**Thaung Htut Aung**
Director, AIT Solutions
Asian Institute of Technology
thaunghtutaung@ait.ac.th

# Digital Transformation in Healthcare

*By Attaphongse Taparugssanagorn*

Today's world runs on rapid, exponential and, above all, perpetual change. The solution is not just industrial revolution, but an overall digital transformation in the things we make and the way we make them.
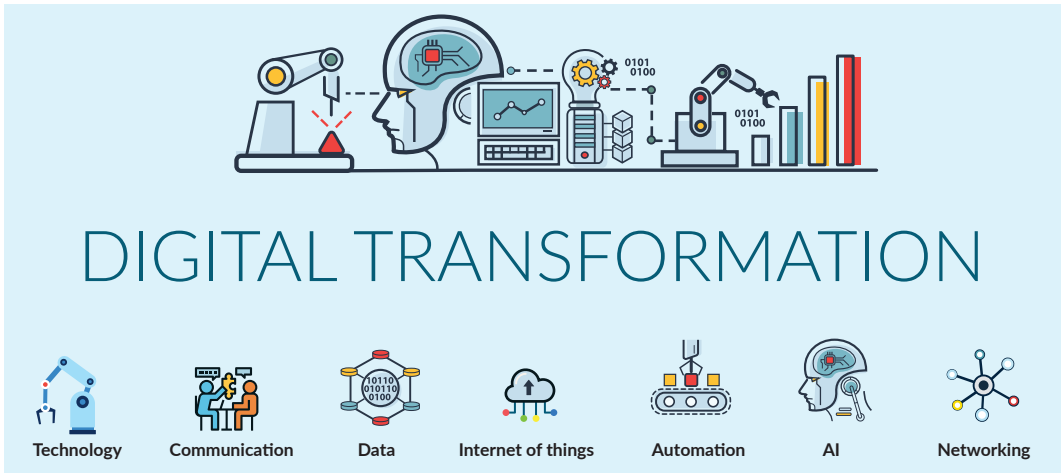
# Digital Transformation in Healthcare

**T**oday's world runs on rapid, exponential and, above all, perpetual change. The solution is not just industrial revolution, but an overall digital transformation in the things we make and the way we make them. The digitalized world of work enables a business model change that can provide new revenue and move us beyond Industry 4.0, called *"Industry X.0."*



DIGITAL TRANSFORMATION

Technology  Communication  Data  Internet of things  Automation  AI  Networking

*Digital technologies, some being developed specifically for healthcare and some coming from other areas, start to show ability to reduce healthcare costs overall while maintaining or improving quality of care.*

As Thailand aims within a decade to be the ASEAN digital hub, the government has put forward advancements in this digital transformation. One possibility in stepping forward the game across the industry sector is to first educate the people along with the innovative research. Artificial Intelligence (AI), and Internet of Things (IoT) are the key drivers under the upcoming spectacular infrastructure, 5G wireless technology. Connected things simplify our daily lives, but only if we can trust that they will not be collecting and sharing user data. The utility of Big Data comes into play here. IoT devices can generate a ton of data which can have meaningful interpretations if and only if it is done well. It is this data which helps IoT to change how organizations function. The 21st century is all about big data and analytics. There is a lot of data at human hands which are incomprehensible to our minds. Emerging technologies of today such as AI and machine learning has made it possible to accumulate, understand, and recognize patterns in the collected data offering eligible predictions and improvements only after we can trust that they will not be biased or unethical. 5G will help us connect faster, smoother, and more efficient and will help to advance smart communities and smart cities.



Digital transformation in healthcare is imminent following a similar trajectory as the digital transformation of other industries, like industrials. It has the positive impact of technology in healthcare. telemedicine, AI-enabled medical devices, and electronic health records are just its few concrete examples. Healthcare is under enormous pressure to cut costs and streamline operations, continuing to grow rapidly and will continue to do so with increasing trends in aging and chronic care. Digital technologies, some being developed specifically for healthcare and some coming from other areas, start to show ability to reduce healthcare costs overall while maintaining or improving quality of care. Innovation is the name of the game here, with the main goal of streamlining physicians' work, optimizing systems, improving patient outcomes, reducing human error, and lowering costs.

*Author:*

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Associate Professor
*attaphongset@ait.ac.th*

Department of Information and Communication Technologies (ICT), School of Engineering and Technology (SET), Asian Institute of Technology (AIT), Thailand

More specifically, the two following technologies are now the pillars for digital transformation in healthcare:

1.  **Internet of Things (IoT) Connected Wellness and Medical Devices:** Medical devices are becoming increasingly intelligent, connected, and robust for delivering optimized healthcare services. There is even an acronym for it: Internet of Medical Things (IoMT) aggregating connectivity of medical devices with Information Technology (IT).

2.  **Artificial Intelligence (AI) in Healthcare:** AI for discovering patterns from connected healthcare monitoring devices as well as patient transactions are providing tremendous opportunities for preventive care. There are many different types of AI preventive care models. In addition to aggregating and mining models from patient data, another benefit of AI in healthcare is to opt for a system of continuous learning within the system itself. Furthermore, the knowledge harvested from various medical sources including patients, connected devices, and medical staff such as doctors and nurses, can be digitized and automated. The combination between care options mined and discovered from patient data and the knowledge of experts provides increased opportunities in optimizing the patient care.

The applications as well as the implication of IoMT and AI for healthcare are tremendous. Here are some examples of healthcare applications with tremendous benefits to the patients as well as healthcare providers:

1.  **Wellness Tracking:** for better health and fitness using low energy sensor devices, such as Fitbit, smart watches and more recently wearables that can monitor heartbeat, temperature, and blood pressure. The data from these devices could be aggregated over time, combined with the knowledge of the best fitness coaches to provide personalized coaching.

2.  **Seniors Home Healthcare:** as demographically the baby boomers are about to retire and will constitute a large percent of the population. These seniors typically prefer to be in their homes than in rehab centers or worse hospitals. Connected monitoring and connected devices, including telecare, are providing tremendous opportunities for remote senior healthcare. The connectivity

solutions include pill reminders, connected tests, such as for glucose management, and intelligent motion detectors, e.g. for fall detection and protection, irregular movement, or no movement.

3.  **Intelligent Hospitals:** The aforementioned examples and there are so many others pertain primarily to the connected patient and the various services serving them. As in many other intelligent infrastructure, we are also witnessing the emergence of intelligent hospitals. IoT connectivity has many pragmatic and valuable applications for the overall operation of hospitals. Medical devices can be connected for precision and speed improving the patient experience; the hospital intelligent infrastructure as a building could be improved; and overall administrative efficiency could be optimized.

4.  **End-To-End Digitization:** With a digital transformation platform, we can realize end-to-end value streams connecting the patient, with her/his data, the healthcare providers, emergency services, and healthcare payers. This ultimate digital transformation in Healthcare needs task orchestration and monitoring through automated digitized processes that monitor, control, and optimize the resolution of preventive as well as emergency care situations. The end-to-end value stream connects the patient, his/her data, to primary, secondary, healthcare facility and emergency services. This needs an automated process engine to assign tasks and monitor the resolution of a potential emergency care situation.

One of the National Strategy has aimed to enhancing national security in all aspects; in which aspects of developing and empowering human capital; broadening opportunities to improve social equality and equity; improving public administration. These aspects can be achieved with the health strategic development and management

of the health system. Along with Thailand 4.0 by digitally connected health care system of the future, which includes efficient health care, success in reducing costs in public health management, seamless and secure sharing of healthcare data, relevant laws for controlled exchange of data between applications. These will help Ministry of Public Health create opportunities for innovation and adding value to health care services bringing the development and participation in the health system to create value in a long-term for sustainable development.

The Asian Institute of Technology (AIT) with its expertise in fundamentals of statistical signal processing (estimation, detection, and classification), wireless communications theory, IoT and AI, have been doing research on various fields related to Wireless Body Sensor Network (WBSN) for healthcare, Industrial IoT (IIoT) for automatically recognizing display instruments in factories, early fall detection using WiFi and deep learning, deep learning based music emotion recognition, AI based spectrum sensing and management for advance wireless communications, smart green house, just to name a few.

AIT is one of the secondments in the four-year European grant called Horizon2020 Marie Sklodowska-Curie Actions, Research and Innovation Staff Exchange (RISE) led by the University of Oulu, Finland. The project focuses on reliable cutting-edge technologies and models for verified wireless body-centric transmission and localization. In particular, we study and develop advanced solutions for the secure wireless exchange of health data. Information acquired by in- or on-body (wireless) sensors are transmitted to the smart hub for short-term processing and then to the cloud for long-term analysis. Additional information can come from environmental (wireless) sensors, on-demand analysis medical wireless devices, manual inserted data, etc. This requires interdisciplinary efforts in medical ICT, AI (deep learning), /IoT, and big data analysis. Another key objective of this project is

microwave localization, which is employed to locate objects and people within a building using signal processing or other sensory information. The following application will be investigated: person localization in homes and hospitals; person movements; tracking; sleep monitoring; heart beat monitoring; breath monitoring. Another application utilizing accurate localization is tracking of wireless capsule endoscope inside a human body, where millimetre accuracy is needed to track endoscope within a GastroIntestinal (GI) track. Both applications fall under the localization algorithm development.

Under the mutual agreement between the University of Oulu and the AIT, and the launched double degree program, students will have an opportunity to work on this challenging research, which has huge impact on health systems, medical instrumentation industry, medical practitioners and of course on the patients. It will allow medical assistance and monitoring moving towards an *"distributed care"* topology, easing pressure on hospitals as well as encourage enhanced recovery through home or local recovery placements. In addition, it will also enhance the potential and future career perspectives of the members and their students. In addition, at the AIT we will be launching a new Master's degree program in Internet of Things (IoT) Systems Engineering that students can follow to obtain a firm foundation preparing them for research and a career in the field. At the end of the program, students will be able to understand how to develop and implement their own IoT technologies, solutions, and applications and possibly leverage their research outcomes to address business challenges, for instance, their own startups, companies, or even to change their daily lives happening in individual homes increasing our convenience.

Definitely, Thailand can benefit from the research outcomes, innovation, and potential of manpower of the nation and will gradually undergo a major change towards a *"Thailand Health 4.0 - Smart Healthcare."*

*Under the mutual agreement between the University of Oulu and the AIT, and the launched double degree program, students will have an opportunity to work on this challenging research, which has huge impact on health systems, medical instrumentation industry, medical practitioners and of course on the patients.*



*The Kick-off meeting of the "ROVER," a EU Horizon2020 Marie Sklodowska-Curie Actions, Reseach and Innovation Staff Exchange (RISE) project took place in Brussels, Belgium on January 15, 2020. The venue is East and North Finland EU Office, 24 Avenue Palmerston, Brussels.*

# Structural Health Monitoring and Post–earthquake Response Assessment of Tall Buildings

*By S. M. Zia Uddin and  Thaung Htut Aung*

Structural health monitoring is becoming recognized in the domain of civil engineering as the proper means for damage detection, and safety evaluation of high-rise buildings in the earthquake-prone areas.

# Structural Health Monitoring and Post-earthquake Response Assessment of Tall Buildings

Structural health monitoring is becoming recognized in the domain of civil engineering as the proper means for damage detection, and safety evaluation of high-rise buildings in the earthquake-prone areas. Nowadays, acceleration sensors are installed in many high-rise buildings at specific floor levels to monitor the response of the building under wind and earthquake events in some countries. In case of an earthquake event, the data in each accelerometer is recorded and is used in evaluating the response of the building. This article presents a comprehensive method for *"Post-earthquake Response Assessment"* by efficiently using recorded acceleration data. It will provide the developers, residents, building managers, structural engineers, and government authorities with the structural assessment results and an overall picture of the seismic risk posed by the recent earthquake event.

As first phase of structural health monitoring and post-earthquake response assessment, actual dynamic properties including natural periods, mode shapes, and damping of the building is measured, using highly sensitive acceleration measurement system under ambient excitation.
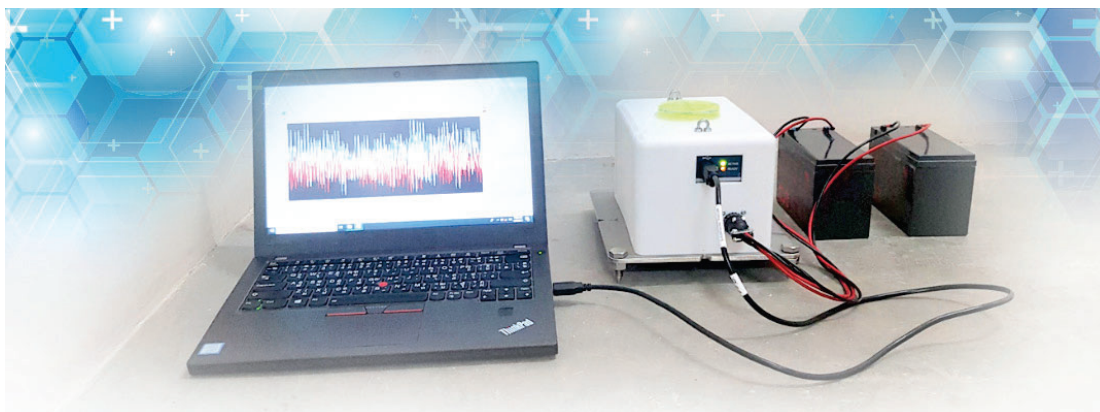


**Figure 1:** *Acceleration measurement system to determine building modal properties*
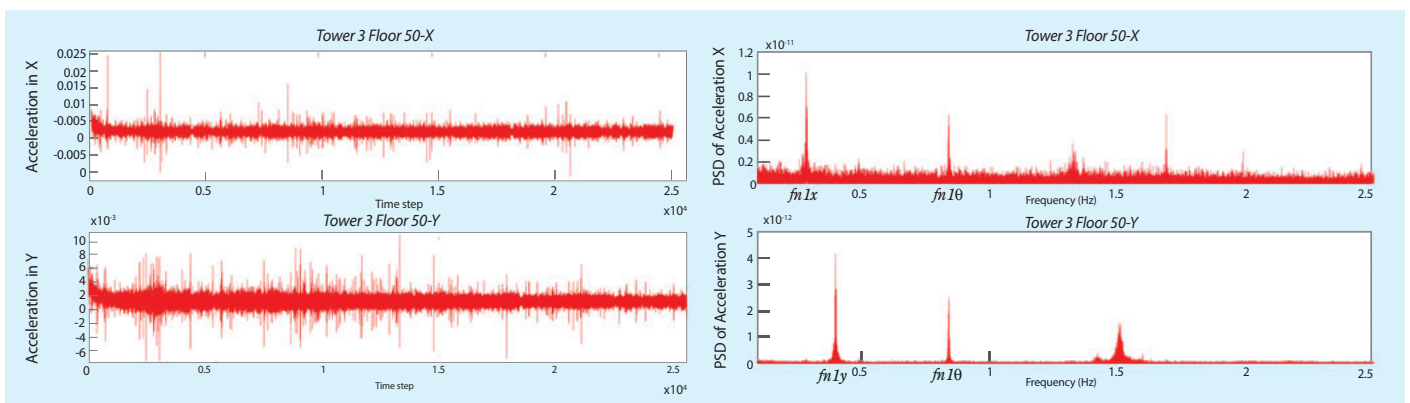


**Figure 2:** *Acceleration Time-history under ambient excitation*

**Figure 3:** *Fourier transform of acceleration time-history*

Acceleration time-history obtained from acceleration measurement system (Figure 2) can be Fourier transformed to get natural periods of structure. Structural damping is acquired by applying Random Decrement Technique (RDT). Fourier amplitude of moving, and reference stations data can be utilized to obtain normalized mode shape (Figure 5). Obtained results are baseline and used to calibrate Finite Element Model for post-earthquake response assessment.
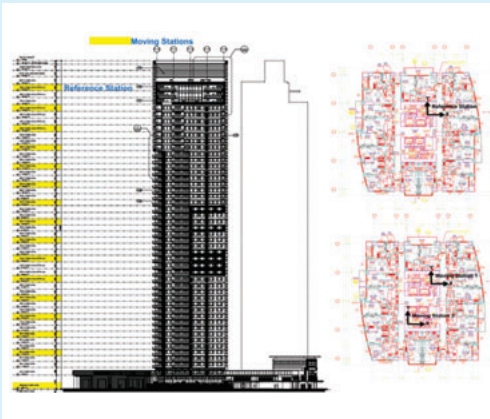
**Figure 4:** *Floors Measured for Ambient Vibration (Highlighted in Yellow)*
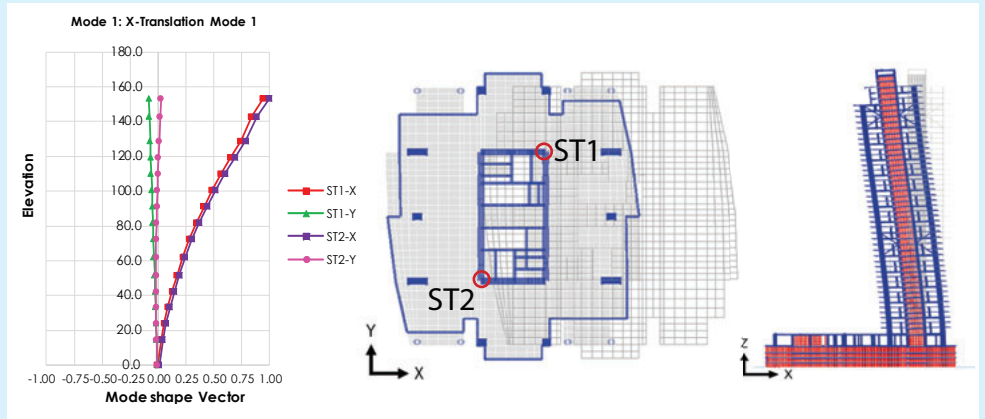


**Figure 5:** *Normalized Mode Shapes*

Case-study building is a 57-story building and 167 m tall above the ground. The main lateral force resisting system is the bearing wall system with special reinforced concrete core wall with outrigger system in weak axis of the core wall. Buckling restrained braces are used to couple the outrigger columns and core wall at two zones: Level 19 to 23 and Level 43 to 47.

Post-earthquake response assessment is carried out after an earthquake event to evaluate the structural performance of the building. Dynamic properties of the building are re-measured after the earthquake under ambient excitation, and results are compared with baseline measurement outcomes for qualitative damage assessment of the building. Natural periods of buildings are expected to increase due to reduction of stiffness. Comparison of measured natural periods of the building before and after the earthquake is shown in Figure 6.

Data collected from acceleration sensors installed at ground floor or basement of buildings can be filtered to use as input ground motion to conduct different types of analyses; such as linear-static, nonlinear-static and nonlinear-dynamic analyses, as appropriate, to evaluate performance of the structure as shown in Figure 7.

Choice of analysis procedure and evaluation criteria depends on observed earthquake event. Response spectrum obtained through bottom sensor data plotted with response spectra used in design can be used to decide the analysis procedure and evaluation criteria. In case of minor earthquake events in which the spectrum determined from sensor is lower than Service Level Earthquake (SLE) spectrum, response spectrum analysis or linear response history analysis can be conducted with calibrated finite element model to evaluate the global and local responses of the structure for damage assessment.
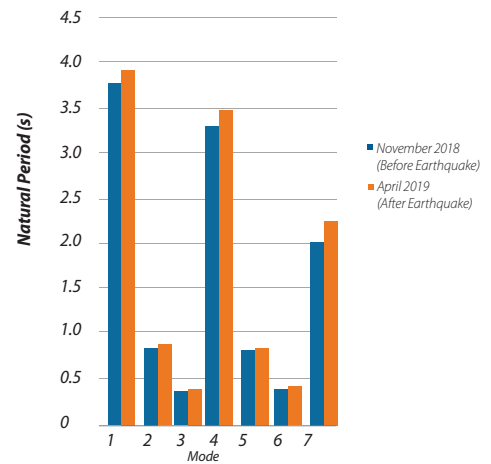


**Figure 6:** *Comparison of Natural Period of structure*
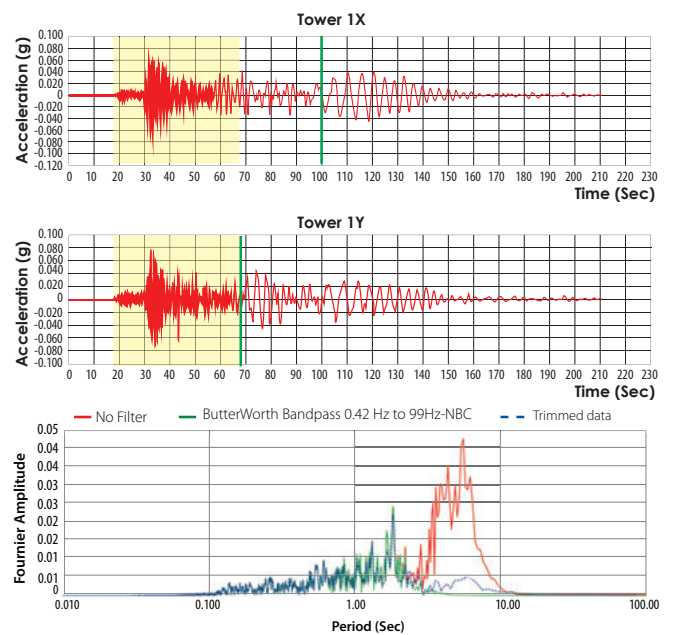


**Figure 7:** *Data filtering of acceleration results from sensor at Ground Floor*

Figure 8 shows the comparison of response spectra between design Service Level Earthquake and Measured Earthquake from the sensor at the ground floor. For that earthquake event, earthquake intensity is lower than intensity of design Service Level Earthquake that building was designed to remain essentially elastic.

Global responses obtained from sensors can be compared with the analysis results from finite element model to verify the reliability of analysis procedure and results. In Figure 10, the acceleration measured from sensors at three locations along building height is compared with the acceleration results from the response spectrum analysis using spectrum generated from measured acceleration from sensor at ground floor. It is found that acceleration results are reasonably match between measurement and finite element model.
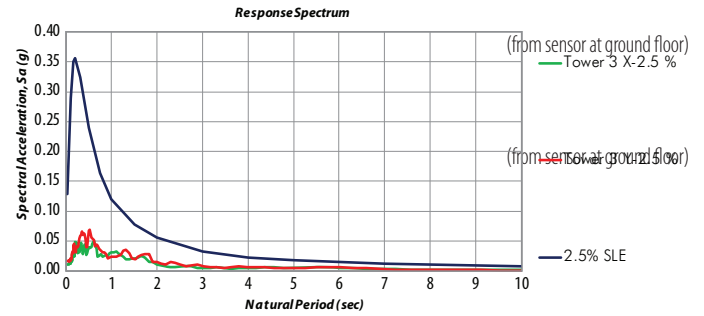


**Figure 8:** Comparison of response spectra between SLE spectrum and spectra developed from sensor data
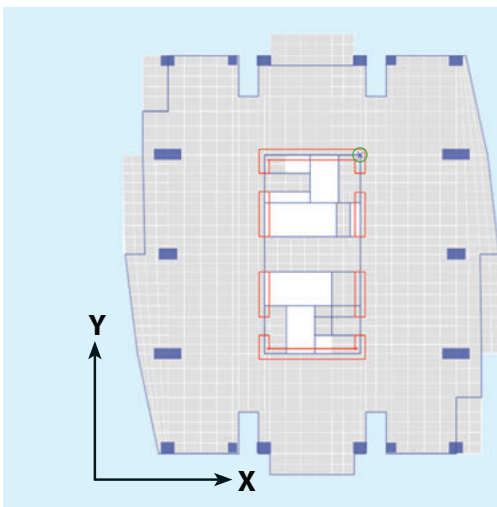


**Figure 9:** Typical floor plan of the building
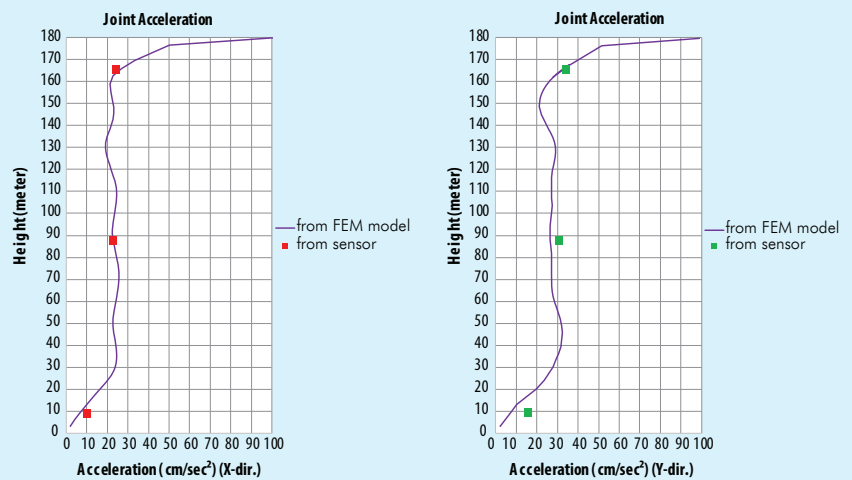


**Figure 10:** Joint Acceleration Response, Model vs Measurement

Global and local responses of the building can be compared between spectrum from measured earthquake and response spectra used in design to assess the demand forces and deformation against the existing capacity. Figure 11 compares the story drift of the building under SLE and Measured Earthquake. Figure 12 presents D/C ratios for axial-flexure interaction capacity of shear wall piers and Figure 13 presents shear D/C ratios of shear wall legs under Measured Earthquake demand. Having D/C ratios which are well below the elastic limit shows that shear walls remain essentially elastic after the earthquake.

In figure 14 and 15, D/C ratios of axial-flexure interaction capacity of outrigger columns and axial capacity of buckling restrained braces are checked to ensure that the members remain elastic after earthquake.
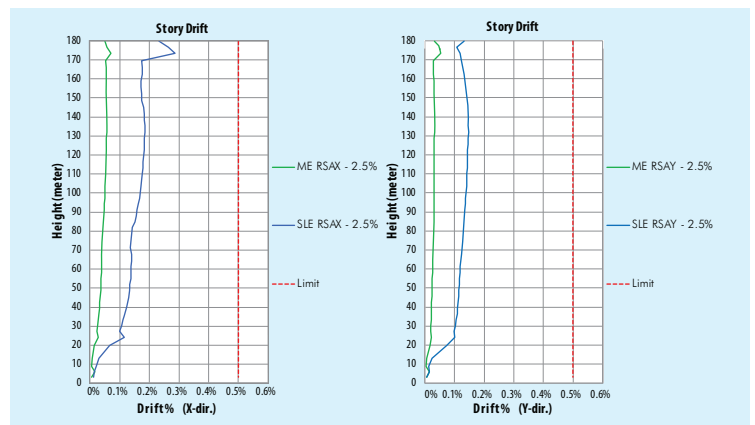


**Figure 11:** Story Drift Response, Measured Earthquake (ME) vs Service Level Earthquake (SLE) used in design

In case of strong earthquake events in which measured earthquake response spectrum is higher than Service Level Earthquake response spectrum, nonlinear response of the building can be occurred due to yielding of structural components. In such events, nonlinear finite element model needs to be developed to evaluate the post-yielding response of the building. Nonlinear response history analysis is conducted using the filtered acceleration data from the sensors at ground floor.

Structural health monitoring and post-earthquake response assessment can benefit several parties such as developers, residents, building managers, structural engineers, and government authorities. Information on the current structural health of the building, post-event condition of the building, the expected level of damage, and recommendations on the need for repair/ retrofitting can be provided to developer and building managers. An assessment of safety conditions, and immediate occupancy status can be informed to residents.

Structural engineers can obtain relatively detailed assessment on the magnitude, and location of the actual damage incurred in the building to improve the design practice of the buildings. This method of post-earthquake response assessment simplifies the visual inspection and guides the Nondestructive testing (NDT) of specific members.

The peak ground acceleration and peak spectral acceleration maps with relation to natural periods of the building from every event can be readily generated from the recorded data. The results from the system can be used to improve the attenuation relationships for the region if the sufficient number of sensors are deployed. The improved understanding from actual recorded data would help in improvement of building codes and will provide useful recommendations for structural safety. A country-level real impact of earthquake can be assessed after each event.
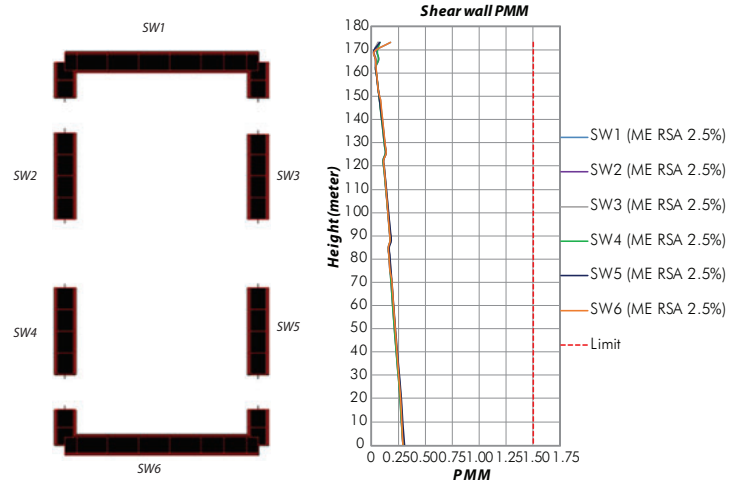


**Figure 12:** *Shear Wall Axial-flexure Interaction Response*
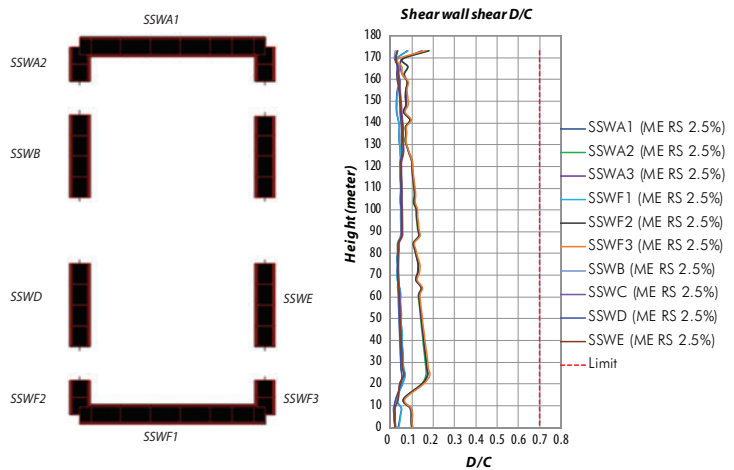


**Figure 13:** *Shear Wall Shear Response*
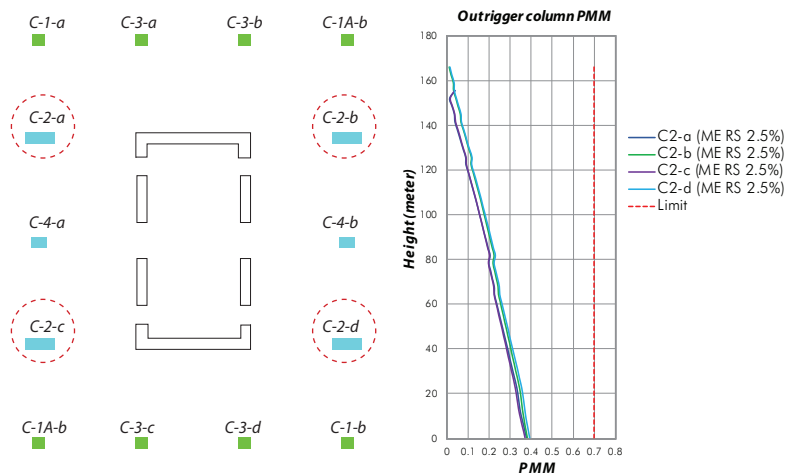


**Figure 14:** *Outrigger Column Axial-flexure Interaction Response*
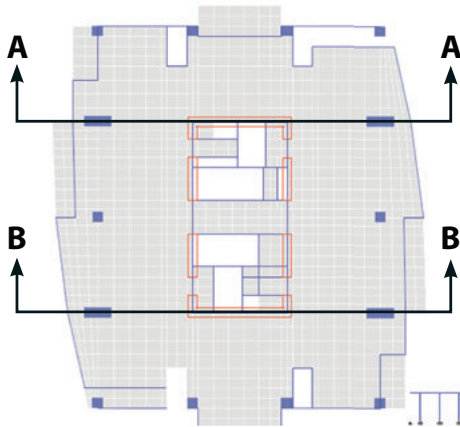
**Figure 15:** *Location of buckling restrained braces in plan*
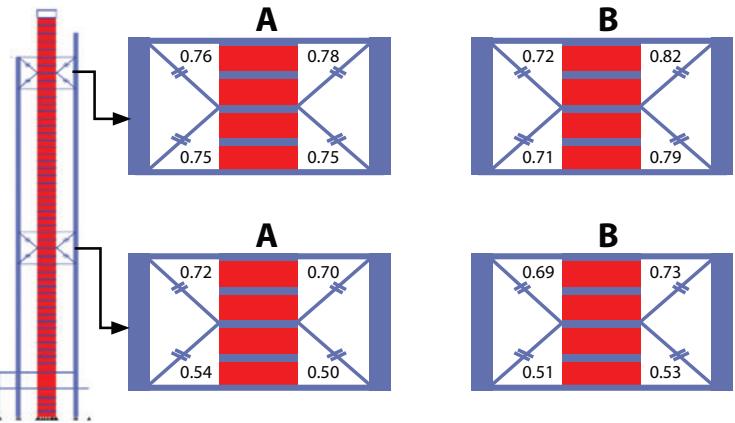


**Figure 16:** *Axial D/C ratios of buckling restrained braces*

## Structural Health Monitoring **Benefits**

**For Residents**
An assessment of safety conditions
Immediate occupancy status

**For Building Managers**
Information on the current structural health of the building
Information on the post-event response of the building

**For Developers**
Information on the current structural health of the building
Information on the event, information on post-event condition of the building and the expected level of damage
Recommendations on the need for repair/ retrofitting

**For Structural Engineers**
Structural engineers can obtain relatively detailed assessment on the magnitude, and location of the actual damage incurred in the building to improve design practice
Simplifies visual inspection

The National Disaster Risk Reduction and Management Council can use the outcomes of system to prepare plans and response strategies. This information, together with vulnerability maps, can help to estimate and predict the potential damage to allocate the resources. The city officials can get detailed information about the performance of the buildings in their jurisdiction immediately after an earthquake for emergency plan/recovery, certification or review etc. The detailed historical data of response for each building over time for various events can be maintained for subsequent evaluation.

# PROVIDING INTEGRATED INNOVATIVE SOLUTIONS FOR OVER 10 YEARS

For 10 years now, AIT Solutions (AITS) has been a hub for sharing and applying the knowledge and research outcomes of the Asian Institute of Technology (AIT), working together with its partners to support sustainable development of the region. AITS provides innovative and integrated solutions in technology, engineering, environment, development, and management for government agencies, international development organizations, and private companies. Our signature services revolve around ensuring safety of our built environment; these include Performance-based Design, Wind Tunnel Testing, Structural Health Monitoring and Software Development.

## Performance-based Seismic Design & Structural Design Review

In the last 10 years, we have carried out PBD for more than 120 tall buildings located in the areas of high earthquake activity. We conducted highly detailed earthquake simulations to check and improve the structural performance as well as cost-effectiveness.

We also conducted code-based structural design review of buildings and other structures to review the design and conformance to the codes.

## Wind Tunnel Testing

Wind tunnel testing services at AITS include the study of wind loads for structural system and cladding design with increased reliability and cost-effectiveness. The services also include pedestrian comfort and safety for outdoor areas and human perception to the motion for given wind environment.

## Structural Health Monitoring

By utilizing advanced analysis techniques, AITS provides the services to monitor the structural health of instrumented buildings and structures to improve safety and reliability and enable damage detection for post-earthquake condition assessment.

## Software Development

We develop customized desktop, web, mobile and cloud-based applications in various fields to fulfill the needs of our partners and clients.

**AIT** Asian Institute of Technology

**AIT Solutions**

# AIT SOLUTIONS

## INTEGRATED INNOVATIVE SOLUTIONS

### Est. 2010

The journey of AIT Solutions started in 2010 when AIT management decided to have a center that would serve as an interface that links academia and the industry. It was then called AIT Consulting as it was focusing more on consulting projects but it later evolved into solutions developer-provider, hence became known as AIT Solutions.

## 2010

**January**

Admiral Baysuites, Philippines, Services: Performance-based seismic evaluation

**June**

Establishment of AIT Consulting

**July**

AIT Consulting signed MoU with Sy^2+Associates Philippines

**December**

3rd Asia Conference on Earthquake Engineering (ACEE 2010), Bangkok, Thailand

Total projects ⚙ 26

Total employees 👥 20

## 2011

**January**

Official Inauguration AIT Consulting

Probabilistic seismic hazard assessment of Metro Manila, Philippines, Services: Probabilistic seismic hazard assessment

AIT CONSULTING

**February**

Seismic Evaluation of Ninoy Aquino International Airport Terminal 1, Philippines, Services: Seismic evaluation and retrofit design

**June**

Star View Condominium Project, Thailand Services: Performance-based seismic evaluation

Total projects ⚙ 27

Total employees 👥 38

Civil & Structural Engineering Solutions as well as IT Solutions are the signature services AIT Solutions provides. This is because AIT Solutions was the brainchild of Professor Worsak Kanok-Nukulchai, former AIT President and Dr. Naveed Anwar, former AITS Executive Director (2010-2019) who both came from AIT School of Engineering and Technology. Dr. Naveed led a team of Structural Engineers and IT experts which later expanded to different areas such as environment, development, and management.

# 2012

### March

Acqua Private Residences Project, Philippines
Services: Performance-based seismic evaluation

### August

Buddha Metta Statue Project, Thailand
Services: Wind tunnel testing and structural design review

Total projects ⚙ 44    Total employees 👥 45

# 2013

### June

Technology Magazine: The Inaugural Issue

### July

AIT Technology Event 2013 Bangkok, Thailand

East Gallery Place, Philippines, Services: Performance-based seismic evaluation

Total projects ⚙ 37    Total employees 👥 47

# 2014

## January

Technology Magazine: Green Technology

## March

Ireo Hotel and Office Towers, India, Services: Performance-based seismic evaluation

Sonata Residential and Hotel Towers, Philippines, Services: Performance-based seismic evaluation

## August

Performance-Based Design Seminar: Bangkok, Thailand

## November

Technology Solutions for Low-cost Housing, AIT, Thailand

Total projects
40

Total employees
48

# 2015

## February

Technology Magazine: Disaster Resilience

## June

Effective Bridge Management Systems Seminar 2015, AIT, Thailand

## July

Affordable Housing Design Competition

## October

Ayala Triangle Gardens Hotel and Office Towers, Philippines, Services: Performance-based seismic design peer review

Total projects
31

Total employees
52

# 2016

### January
AIT Consulting rebranded to AIT Solutions

### May
Technology Innovation - Collaboration for Innovation, AIT, Thailand

Sidhorn Midtown Hotel, Thailand, Services: Structural design review

### July
Langsuan Village Project, Philippines, Services: Performance-based seismic evaluation and code-based design review

### September
The Estate Makati, Philippines, Services: Performance-based seismic evaluation

### November
Design of Tall Buildings seminar, Bangkok, Thailand

### December
Technology Magazine: Collaborative Innovation

Total projects ⚙ 20    Total employees 👥 57

# 2017

### January
Organized a first student innovation camp, AIT, Thailand

### April
Baltit Fort, Pakistan, Services: Structural assessment and risk mitigation

### July
Organized a second innovation camp

### November
Special Talk on Performance Seismic Based Design: Best Practices by Ron Klemencic, AIT, Thailand

Technology Magazine: Tall Buildings

### December
The Glaston Tower at Ortigas East, Philippines, Services: Performance-based seismic design peer review

Total projects ⚙ 27    Total employees 👥 69

# 2018

## January
AIT Builds Knowledge City Police Station Using Its In-house Technologies, AIT, Thailand

## May-June
Visionary Event in Structural Engineering, Bangkok, Thailand

## July
AIT Signs MOU for Smart City Initiative in Khon Kaen (with support from AIT Solutions)

## October
Launched Structural Health Monitoring Service

Supalai Icon, Thailand, Services: Wind tunnel testing

## August
Launched PMTB online degree for professionals

## November
7th Asia Conference on Earthquake Engineering (7ACEE), Bangkok, Thailand

Technology Magazine: Built Environment

**Total projects** ⚙ 36    **Total employees** 👥 79

# 2019

## January
AITS Executive Director Dr. Naveed Anwar promoted to Vice President for Knowledge Transfer

Developed mobile app integrated with Bluetooth low-energy beacon technology for the Khao Yai National Park

## March
Automating Precast and Prefabrication Design and Detailing through a Universal Plug-in Application, Singapore, Services: Software development

## April
Mr. Thaung Htut Aung succeeded Dr. Naveed as the new Director of AIT Solutions

## May
Launched AIT Share e-learning platform

## October
Launched Smart Learning Lab

## October
Launched CSI BIM Lab

**Total projects** ⚙ 39    **Total employees** 👥 72

# 2020

## June
AITS 10th anniversary

# Open Innovation Practices in Thai Software SMEs: External Technology Acquisition and Exploitation to Improve Software Process Innovation

By Thammanoon Charmjuree, Yuosre Badir, Umar Safdar

The software industry is currently playing an essential role in many areas of the global economy, growing rapidly, and of increasing importance for the international competitiveness of other high-technology industries as well as for the national economies.

# Open Innovation Practices in Thai Software SMEs: External Technology Acquisition and Exploitation to Improve Software Process Innovation

The software industry is currently playing an essential role in many areas of the global economy [1], growing rapidly, and of increasing importance for the international competitiveness of other high-technology industries as well as for the national economies [2]. To improve the compositeness of firms in this industry, Software engineers focus on improving Software process innovation performance (SPIP). Technology experts consider SPIP as probably the single most critical factor for reducing cost, time-to-market, improving performance, gaining competitive advantage, enhancing product quality and reliability, and creating economic success [3].

Considering the importance of SPIP and because its improvement can be achieved by increasing firms' ability to access external technological knowledge, ideas, and information, this study provides Software SMEs managers with a new insight into how to use open innovation to improve their SPIP. Specifically, this study examines how Thai Software SMEs may benefit from *"open innovation"* concept to improve their SPIP and gain competitive advantages. The data for this study was collected from 372 Software SMEs based in Thailand, and listed in the Department of Business Development (DBD) database, Ministry of Commerce of Thailand. Each of these firms has between 20-200 employees, and at least three years of filing financial statements.

## SPIP in Thai Software SMEs:

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Software process innovation refers to *"changes in the tools, techniques, procedures, or methodologies to a firm's process for producing software applications, aiming at lowering costs, time, and/or improving product quality"*. These changes take place through the adoption of technological innovation developed elsewhere, or new practices developed internally [4].

Over the last two decades, the Software Engineering community has shown special interest in SPIP in an effort to increase software product quality, as well as the productivity of software development. However, there is a widespread tendency to make a point of stressing that the success of SPIP is only possible for large companies due to availability of resources. In this study, SMEs were selected because of their limited resources. Unlike large firms, SMEs tend to have less resources to allocate to external technology trading and they are under pressure to maximize their income so that they can afford to invest in more products and services. In addition, SMEs in emerging markets, like Thailand, still tend to lack advanced knowledge and capabilities [5], which limits their opportunities for innovation. Therefore, this study focuses on Thai Software SMEs and examines how these SMEs involvement in the two dimensions of open innovation (explained below) influence their SPIP.

*Firms adopt open innovation strategy to improve their innovation performance by bringing knowledge into the organization (inbound open innovation) to accelerate internal innovation, or transferring knowledge outside (outbound open innovation) to expand the markets for external use of innovation*

# Open Innovation: A Brief Review



**Open innovation**: *inflows and outflows of knowledge to accelerate internal innovation and to expand the markets for external use of innovation*

There is a consensus among innovation scholars that knowledge is a vital antecedent for firm's innovation. To better understand knowledge as an antecedent of innovation, research on knowledge management has focused on knowledge creation, acquisition, and sources. Recently, there has been an increasing amount of attention to more open approaches to innovation, coined by Professor Henry Chesbrough [6] as *"Open Innovation"*. This open model emphasizes the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and to expa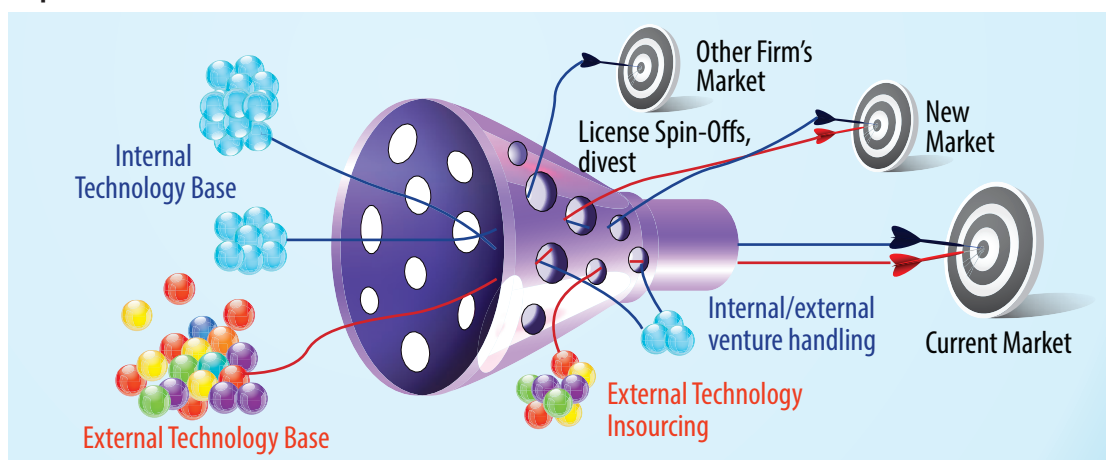nd the markets for external use of innovation, respectively [7]. Firms adopt open innovation strategy to improve their innovation performance by bringing knowledge into the organization (inbound open innovation) to accelerate internal innovation, or transferring knowledge outside (outbound open innovation) to expand the markets for external use of innovation [8]. While firms use open innovation for different reasons (e.g., new ideas for products/ services, solving work problems), this study focuses exclusively on firm's openness regarding external technologies.

The study considers both external technology acquisition (ETA) and external technology exploitation (ETE). The ETA represents inbound openness in which firms rely on the acquisition and absorption of external technologies (e.g., by means of in licensing agreements, strategic alliances, join ventures, working with universities and research centers, etc.) to complement their technology portfolios. The ETE, on the other hand, refers to a firm's purposive pursuit of actively commercializing its technological knowledge, either exclusively or in addition to using it internally for their own products and services, by means of out-licensing agreements, strategic alliances or joint ventures. In this sense, a firm may allow external partners to use some of its own technological knowledge which is not fully used by the firm (e.g., underutilized IP or a technological knowledge), but which still has economic value in the market for technology. The goal is to obtain monetary (e.g., licensing revenue or income from providing technology services to other firms) or non-monetary benefits (e.g., gaining access to external technology by means of cross-licensing or building stronger and trust-based relationship with other firms in the market).

# Main findings:

Overall, our results suggest that in order for Software SMEs managers to maximize the benefits of their open innovation strategy, they need to engage in both ETA and ETE. Managers are encouraged to see ETE not only as a source of income (by selling out their technological knowledge), but also as a source of internal process innovation performance improvement (i.e., SPIP), which in turn, increases the competitiveness of their technology. Here are the main findings of the study:

First, the results show that Software SMEs engaging in ETA is likely to improve the firm's SPIP. This is possibly because, to augment the benefits of their internal sources of knowledge firms often look for new and updated knowledge from external sources. Access to external sources of knowledge not only complement internal knowledge but also help them to avoid costly and time-consuming process of internal R&D activities. This externally acquired knowledge increases both the chances of producing more innovative technologies and help the firm to improve their SPIP.

Second, the results suggest also that engaging in ETE positively affects the Software SMEs' SPIP. A possible reason is that, to win against competitors and successfully commercialize their technology in this environment, Software SMEs need to constantly review and improve their tools, techniques, procedures, or the methodologies used internally to produce their technology and products, with the ultimate goal of lowering the development cost, reducing the time to market, and improving quality. By doing so, the software development process of a firm engaged in ETE will likely be updated, modified, or changed more frequently, and be more competitive compared with firms not involved in ETE.

Third, another interesting finding is that when Software SMEs engage in ETA activities, they will also improve their ETE. This is to say, Software SMEs not only acquire new technological knowledge from external sources to enhance their innovation performance but also tries to commercialize their innovation as well. Indeed, a higher ETA likely leads to a higher amount of new knowledge that finally is not applied inside the organization, opening up greater opportunities for commercializing unused parts of their increased pool of technological innovation and patents through ETE.

Fourth, our results suggest that the relationship between ETA and ETE becomes more stronger when the Software SMEs have a higher level of unabsorbed financial slack resources (i.e., Unabsorbed slack resources refers to currently uncommitted resources that are more easily redeployed elsewhere).

In fact, in order to integrate the externally acquired technological knowledge (ETA) with the internal knowledge, develop new combinations of technological knowledge, adapt successfully to external pressures for change in the technology or markets, firms need financial resources to invest in these activities. Due to its easy-to-deploy nature, unabsorbed slack may stimulate a firm to invest in, and experiment with, new technology and products, enter new markets, and support new innovative activities that might not be possible in a limited resources environment [9]. With more technology developed internally due to higher ETA activity and more investment, ETE becomes not only an option but also a requirement to capture value from such technology.

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Managers **need to build a carefully** selected set of systems, **processes,** & **mechanisms** that allow both **ETA & ETE** to flourish **simultaneously,** & thereby sustain competitive **performance**

## What Managers Need to Know:

This is important for managers who are reluctant to engage in ETE due to the possible risk of losing competitiveness (i.e. afraid of sharing their technology with others). To make the decision whether to engage in ETE or not, managers need to tradeoff between the possible risks (e.g., strengthening competitors through external knowledge exploitation) on the one hand and the benefits on the other hand. Besides the possible monetary and nonmonetary benefits, managers should also consider the positive influence on their internal processes, which are likely to increase the firm's competitiveness.

The benefits of having unabsorbed slack resources in the organization are well documented in the literature. Our results specifically show the benefits firms may gain from unabsorbed slack in the open innovation context. In order to maximize both monetary and nonmonetary benefits from ETE, and to improve their competitive position through process innovation improvement, it is important for managers to ensure the availability of unabsorbed slack. Open innovation research shows that the task of finding a technology provider, transferring the technology inwards, and absorbing it into commercially successful new products and processes is costly and time consuming [10]. Forming strategic alliances with carefully and strategically selected technology providers may help to build trust and reduce the transaction costs [11], which in turn, increases the level of unabsorbed slack.

Finally, to successfully reap the benefits from engaging simultaneously in both ETA and ETE, managers must make critical decisions regarding how to manage these two different approaches within the organization. Each reflects different mindsets and different knowledge management processes, and their co-existence may create tension and be enablers of ambidexterity. This is a challenge for managers, as prior research shows that managing tension and achieving ambidexterity in an organization is a difficult task [12]. Managers need to build a carefully selected set of systems, processes, and mechanisms that allow both ETA and ETE to flourish simultaneously, and thereby sustain competitive performance.

## MAY 2020



## Virtual Pitch Competition

**The Open Call:** AIT's Fight Against Covid-19 had a Virtual Pitch Competition categorized under Software and Hardware projects held on 15 May 2020. Six software projects presented during the morning session in front of the judges including Dr. Sarayoot Eaimkhong, Senior Consultant, Healthcare Innovation Management, NSTDA; Mr. Emmanuel Prado, Financial and Business Consultant; and Dr. Chaklam Silpasuwanchai, Assistant Professor, ICT, AIT. In the afternoon session, seven hardware projects pitched in front of the judges comprise of Dr. Volker Patzel, Assistant Professor, Department of Microbiology and Immunology, NUS; Mr. Jeff Hamilton, Founder, GoMo; and Prof. Manukid Parnichkun, Professor, Mechatronics, AIT.

**The winners for the software projects are:** Alpha Protect, a mobile app which utilizes Bluetooth and Beacon technology to find out the presence of any infectious person in the near vicinity; FreMen-Contra-COVID-19, a mobile app which uses spatio-temporal models developed in the robotics domain to forecast people density at exposed locations; Social Distancing Monitoring System, a camera (CCTV) application, that would monitor social distancing specially under queuing conditions.

**The winners for the hardware projects are:** Super Mask, a mask that has self-cleaning capability, improve communication while wearing the mask and include viral detectivity; Personalized Breathing Device, this product addresses the issues of air pollution and provides safe air for all to breath by filtering and sanitizing air with Nano-technology solutions; Wawe Air Purifier, a multifunctional highly efficient air purifier that has the combination of two technologies: HEPA (High-efficiency particulate air) and Photocatalysis.

The winners received seed funding of 50,000 THB for hardware projects and 35,000 THB for software projects and support from AIT Entrepreneurship Center (co-working space, promotion, and IP support). The winning teams are expected to make a final presentation on the development of their projects after three months, in August 2020.

## APRIL 2020



## AIT's Fight Against Covid-19

The AIT Entrepreneurship Center (AIT EC) released an Open Call: AIT's Fight Against Covid-19 in April inviting AIT community and alumni to take part in fighting the global pandemic that struck the world. The competition was looking for projects that can create real impact to fight Covid-19 within 6 months. The AIT President was behind this initiative and released 250k Baht that will be used as seed funding for the winning projects.



## AIT Ranks 19th in World in SDG1—No Poverty in Times Higher Education Impact Rankings 2020

AIT participated for the first time in the Times Higher Education (THE) Impact Rankings, which looks at global universities' commitment and performance in furthering the Sustainable Development Goals (SDGs). Over 850 universities from 89 countries participated in this ranking exercise by submitting input during 2019, and the results were just published on April 22, 2020 by THE. AIT ranks #19 in the world for SDG1—No Poverty, which indicates a well-deserved recognition of AIT's work in providing education to students from countries where poverty is an issue, of our research on poverty issues, and of our success in producing graduates who go back home to help their countries eradicate poverty. AIT submitted data for 13 of the 17 SDGs for this Ranking and placed in the 301-400 group for overall impact.

***Source:*** *AIT News*

## MARCH 2020



*Photo credit: AIT website*

## JANUARY 2020



## OCTOBER 2019





### AIT Moves School and Work Online

In the first quarter of 2020, the world was struck with a global pandemic known as Covid-19. On March 18, AIT officially closed, following the policy announced by the Thai Government, and all face-to-face classes were cancelled for the rest of the Spring Semester. However, learning has not stopped and continuing the education online. All its employees were asked to work from home. Following this, AIT Solutions already prepared its staff for the work from home condition as it trained the staff using remote desktop connection to be able to access their PC from their home to deliver our quality of service to our clients in timely manner despite the stressful times. All meetings were moved to e-meetings while other activities were postponed until the situation got better.

### Alumni Stays Connected with Alma Mater through AIT Graduates Club

AIT and AIT Alumni Association have jointly initiated the AIT Graduates Club (GC), a platform for long-term professional engagement between our graduates and their Alma Mater with focus on continuing education, career development, collaborative activities and connectivity. The club will provide extensive benefits to the graduates and opportunity to contribute to the Institute. GC was officially launched on 20 January 2020 at AIT campus. Located on the ground level of the Central Library, this space is dedicated to providing a home to graduates in AIT and for various activities conducted by the club, together with other units in AIT. AITGC is being managed by the Office of Vice President of Knowledge Transfer and AIT Alumni Association with the support from AIT Solutions.

### AIT Celebrates 60th Anniversary

It was a three-day anniversary event for AIT as it celebrated its 60 years that started on 23 October with 48th Governing Board Meeting hosted by the Thai chapter followed by Thai Style Gala Dinner. In the morning of October 24, HRH Princess Sirindhorn came to the AIT Campus to preside over the AIT 60th Anniversary Celebration Ceremony. Nine AIT alumni who have contributed significantly to AIT and to society were inducted into the AIT Hall of Fame. The distinguished keynote speaker was Professor Joyce McConnell, the new President of Colorado State University—the founding university of AIT.

### Smart Learning Lab

One of the highlights of the 60th anniversary was the launch of the Del Rosario Smart Learning Lab, a joint project of One Small Step Forward Foundation, AITAA Philippine Chapter, AITAA Headquarters, and AIT Solutions.

Named after its donor, Mr. Jamie Del Rosario of AITAA Philippine Chapter and Chairman of One Small Step Forward Foundation, this Smart Learning Lab is a multipurpose convertible room which can be used for classrooms, training, meetings and workshops and open to all users in AIT. This includes valuable equipment for new learning experiences using smart learning technologies. It is also equipped with latest technologies supporting fully Wi-Fi and flexible workspace, multi-user video conferencing and live pitch with a highly quality sound system. It is open for all students, faculties and staffs from the schools and centers across the campus and the entire Institute can benefit from it.

## OCTOBER 2019



## SEPTEMBER 2019





## MAY 2019



## APRIL 2019



### CSI BIM Lab

The Computers and Structures, Inc. (CSi), the pioneering leader in software tools for structural and earthquake engineering, has funded the construction and operation of BIM Lab under AIT Solutions. CSI BIM Lab, which is located next to Smart Learning Lab was also inaugurated during the 60th anniversary. CSI BIM Lab aims to advance the application of BIM in various aspects of building design, construction, management and operation and to support the development of tools that will be integrated into the CSI software and platform, as well as to provide a training environment for research students, professionals and industry interested in BIM applications.

### AIT Hosts 100x Research-to-Commercial Event

The 100 Innovations x Entrepreneurs (100x), Southeast Asia's First Research-to-Commercial Conference was organized by the Asian Institute of Technology in September 2019 to bridge the gap between academia and industry. At the two-day event, hundreds of students, academicians, startups, entrepreneurs from various industries, development agencies, NGOs, as well as investors and venture capitalists came together to discuss the latest innovations and ways to combine social impact research with new business ideas.

The Conference served as the venue to launch AIT's newest initiative, the AIT Entrepreneurship Center, a place for innovation, creation, and incubation to nurture and drive the entrepreneurial capabilities of AIT in collaboration with the industry to support the socio-economic development of the region. AIT President Eden Woon said: "*I expect the AIT Entrepreneurship Center to be a breeding ground for future business leaders as well as a learning center, where AIT students, faculty, and alumni come to share their knowledge to create innovations and businesses with the ultimate goal of enhancing economic and social development. It will also be an inclusive center, reaching out to interested outside academic and business parties, and it will be the home base for our new Entrepreneurship Minor.*"

### AIT Launches its own Online Platform

AIT Share, an e-Learning platform aimed at educators, executives, students, or anyone interested in furthering their knowledge was officially launched in May 2019. The new platform, which comes with the slogan *"Knowledge Worth Sharing,"* allows participants to acquire new knowledge, improve their skills, take certificate courses, and obtain professional masters-level degrees.

Dr. Naveed Anwar, AIT's Vice President for Knowledge Transfer who spearheaded the initiative when he was still the Executive Director of AIT Solutions, explained that AIT Share was an offshoot of a project they did with the Ministry of Construction in Myanmar, where they offered e-courses and merged these with classroom-based instruction. This hybrid model was then replicated for the Sri Lanka Ports Authority, and over time, they created the fully-fledged knowledge portal that is now called AIT Share. AIT Share is being managed by AIT Solutions.

AIT Solutions' long time Executive Director Dr. Naveed Anwar was promoted to Vice President for Knowledge Transfer (VPKT), a position that's responsible for overseeing the Entrepreneurship Center, technology transfer policy at AIT, commercialization of research, and fostering alumni and enterprise engagement, among others. Mr. Thaung Htut Aung, who was the Head of Civil & Structural Engineering Unit and who was one of the pillars of AIT Solutions succeeded Dr. Naveed as the new Director of AIT Solutions.

# A Perspective from AIT on the Role of Higher Education Institutions in Knowledge Transfer to Drive Social Impact

## An Interview with

## The AIT Vice President for Knowledge Transfer

Higher education institutions like the Asian Institute of Technology (AIT) is one of the actors that play an important role in creating and transferring knowledge and innovation to drive socio-economic development. The concept of Triple Helix (TH) and Quadruple Helix (QH) approaches are both grounded on the idea that innovation is the outcome of an interactive process involving different spheres of actors. The innovation-generating process typically involves the University, Industry, Government, for the Triple Helix approach while Quadruple Helix adds another actor which is the Civil Society. AIT has been embracing its role in the TH and QH approaches reaching out to industry, government, and society to drive social impact.

Almost a year after assuming his position as the AIT Vice President for Knowledge Transfer in April 2019, Dr. Naveed Anwar, the new Editorial Adviser of Technology Magazine, shares the crucial role of Knowledge Transfer in creating a wide range of opportunities for university, enterprises, government, and society to work together.

## What is the primary role of a university, to generate or to transfer knowledge?

Knowledge creation has been the key role of universities and will continue to be their key strength. Knowledge is created through teaching and learning process, research, innovation, intellectual discourses, and publications. Transferring knowledge has many facets, and part of knowledge transfer takes place during the knowledge creation process itself. However, here, we are talking about converting this knowledge into value that goes beyond the knowledge creation process and is used to directly create a process, product, or service that is used by and is useful to a large segment of society. Faculties, students, and researchers are the core of the process of knowledge creation. Their role will continue to be critical, and we would like to get them involved in the knowledge transfer process as well.

*Photo taken at the AIT Library*

# What has been done recently to achieve knowledge transfer at AIT?

Knowledge transfer and its application to practical aspects have been the key role of AIT since its inception. Recently, AIT launched Entrepreneurship Center (EC), which acts as a placeholder for these activities. In many universities, the Entrepreneurship Center is part of the Business School, but at AIT, we created an Institute-level Center to draw students and researchers from all three schools for greater integration and impact. Entrepreneurship Center is focused on creating opportunities for innovative knowledge transfer and application. It brings together the three aspects: providing a learning opportunity to our stakeholders through AIT's knowledge based on innovation and entrepreneurship; collaborating with alumni mentors, enterprises, industry experts; finally, building a social enterprise or transforming the ideas into prototypes in direction of knowledge application. As AIT increasingly engages with industry with the spirit of innovation and entrepreneurship, the Entrepreneurship Center would be pivoting many of the AIT-industry collaborations. To address the needs of our partners, also to make the AIT's research, invention, and innovations marketable, an arrangement of licensing and intellectual property office in AIT serves as an important knowledge application mechanism.



*AIT Entrepreneurship Center hosts various events online and onsite. (Photo above was during an event before Covid-19 pandemic)*



*AIT President Dr. Eden Woon giving his opening remarks for 100X event.*

Last year, in line with the launch of EC, AIT organized the 100 Innovations X Entrepreneurs (100x) event. The event created a community spearheaded by AIT and its partners which aims to apply innovation and entrepreneurship for social impact, and supports Research to Commercial (R2C). The community is active since then and some of the members have started a dialogue for research and collaboration with AIT through joint projects, also the possibility of a startup, or co-development of ideas to a scalable solution.

We have also launched the Intellectual Property Support Office (IPSO) at AIT to ensure that all the AIT research work has a legal authority to become Intellectual Property. Furthermore, IPSO aims to support successful licensing arrangements which would build long-term relationships with our stakeholders often leading to more research collaborations and expansion of AIT's research into commercial domains. In brief, AIT is moving strategically ahead to create a plethora of opportunities with enterprises to create social impact.

In May 2020, an online pitch competition was organized for students, faculties and alumni to present projects that can create real impact to fight Covid-19. Those ideas also provided a glimpse of how the innovative teachings, research, and entrepreneurial spirit nurtured by AIT can provide a feasible solution to current challenges faced by society. Industry experts judging the competition resonated the idea in harmony that these events could provide an example of how universities can lead in developing solutions for current challenges faced by society or enterprises.

## How is AIT reaching out to the different collaborators of the helices models (TH/QH)?

AIT has been playing its role as one of the actors in TH/QH through its knowledge base arising from education and research, and more importantly through its outreach, which also has been strengthened via continuous innovation and need assessment of the industry, government, and society. AIT acknowledges the overarching perspective that the needs in society are diverse; as diverse and dynamic, are the needs of industry and enterprises. This acknowledgment brings together schools, academic programs, regional centers in AIT to work together to provide innovative solutions that would be applied by the industries. Many of the events, programs, and most importantly the main pillars of AIT: Education, Research, Executive Education, Solutions adheres to the applied knowledge cycle.

AIT, and many other universities across the globe, believe that a dedicated mechanism is required to achieve the high-impact partnership and engagement with Enterprises. With this in mind, the Enterprise Engagement Office (EEO) was established as an initiative for such interaction. Such a dedicated mechanism will also play an important role to bridge a gap between AIT and industry by being a point of contact aiming for integrated, longer-term, incremental approaches. EEO at AIT aims to work closely with all the centers and units in AIT to establish collaboration based on mutual benefits which ranges from joint events and networking to enterprise learning and consultancy and also branding with AIT through longer terms activities like innovation awards and research grants. To make the communication, collaboration much stronger through knowledge transfer initiatives, AIT Enterprise Engagement Alliance (EEA) will be launched soon. EEA will be a strategic platform where enterprises, and AIT partners, can collaborate with no financial or legal commitments, or engage with AIT for activities like creating innovative solutions, enterprise learning using AIT's expertise and facilities, and finally are also welcome to engage in creating longer-term impact and branding with AIT.

For the government, we work together to support them in this journey of transition arising out of shifts in skills demand or digital disruption through AIT Extension, a center at AIT for lifelong learning, professional development, and continuing professional education. AIT Extension is offering an International Masterclass: Introduction to Artificial Intelligence. Similarly, other courses for professional development like data analytics for upskilling is being offered by AIT to support our partners, government, and society.

*AIT has been playing its role as one of the actors in TH/QH through its knowledge base arising from education and research, and more importantly through its outreach, which also has been strengthened via continuous innovation and need assessment of the industry, government, and society.*

## AIT has a large network of alumni that becomes part of the other actors in helices model, how is AIT engaging with its alumni?

AIT acknowledges that one of its most valuable assets is its alumni. We have started a club especially for alumni to connect with them in terms of professional engagement as well as providing a place for them whenever they visit AIT. This club, launched in collaboration with AIT Alumni Association, provides extensive benefits to the graduates and opportunity to contribute to the Institute. One of the opportunities from alumni to give back not just



to their alma mater but to the society is sharing their knowledge and skills through *"Alumni Talk Series,"* a series of webinar conducted by different alumni focusing on various topics. Launched during the pandemic, this knowledge sharing activity has featured eight alumni so far and many more are interested to host their own webinar.

Pursuing innovation and knowledge transfer in higher education institutions are crucial to create both intellectual capital for the stakeholders in TH and QH approaches. By doing this, the stakeholders can develop their learning capabilities and create the knowledge in their organizations.

Investment in knowledge management and transfer can transform the knowledge into new ideas which will result in new products and solutions with positive societal impact.

**Reference:**
*Using the Quadruple Helix Approach to Accelerate the Transfer of Research and Innovation Results to Regional Growth*
*https://cor.europa.eu/en/engage/studies/Documents/quadruple-helix.pdf*

The AIT Entrepreneurship Center is a place for innovation, creation, and incubation to nurture and drive the entrepreneurial capabilities of AIT in collaboration with the industry to support the socio-economic development of the region. Launched in the last quarter of 2019, it aims to equip students and faculty with the spirit of innovation and start-ups

*"I expect the AIT Entrepreneurship Center to be a breeding ground for future business leaders as well as a learning center, where AIT students, faculty, and alumni come to share their knowledge to create innovations and businesses with the ultimate goal of enhancing economic and social development. It will also be an inclusive center, reaching out to interested outside academic and business parties, and it will be the home base for our new Entrepreneurship Minor."*

*– Dr. Eden Woon, AIT President*

## EC SPACES

EC features different spaces that cater to the needs of all its members, whether individual or teams. We have the Creator Space that can be used as a co-working or meeting space, pitch area, and for hosting various events from expert talks to hackathons. We have the Maker Space to build your own prototypes and test your ideas. We have the Support Space to help members in creating their startups from mentors to IP support.

**Meet, innovate and create**
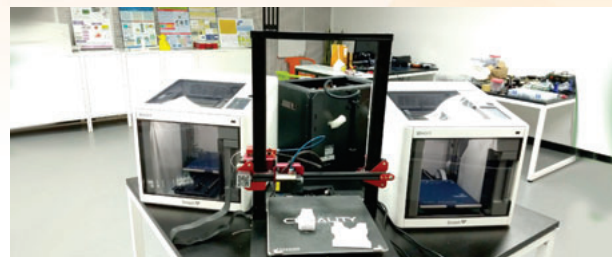
**Build your own prototypes**

**Get help from professionals**

**Start your own company**

EC is open to collaborate with individuals or organizations in terms of hosting events, organizing pitch competitions/ hackathons, or co-developing a project that has social impact. Please contact us to schedule a meeting.

# EC EVENTS

Events are part of what make EC alive and interactive. Every week, there is something going on at EC, may it be an expert talk, workshop, lecture, hackathon, face-to-face or online.

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**AIT** Asian Institute of Technology

# Producing Rice Straw Pellet Fuel for Multiple Benefits

*By Nguyen Thi Kim Oanh*

Rice is one of the most important staple foods, not just in Asia, but around the world. Southeast Asia (SEA) houses several world top rice exporting countries and the region collectively produces over 200 million tonnes of rice annually.

# Producing Rice Straw Pellet Fuel for Multiple Benefits

## Background

Rice is one of the most important staple foods, not just in Asia, but around the world. Southeast Asia (SEA) houses several world top rice exporting countries and the region collectively produces over 200 million tonnes of rice annually. A huge amount of rice straw (RS) is generated in the region, of which about 120 million tonnes is burned in the field each year. This rice straw field open burning (RSOB) activity releases large quantities of toxic air pollutants, e.g., 1.65 million tonnes of fine particulate matter (PM$_{2.5}$: inhalable particles with diameters ≤2.5 μm) and 11.0 million tonnes of toxic carbon monoxide (CO) annually. The RSOB smoke contains many carcinogenic volatile organic compounds (VOCs) and semi-VOCs (both in particulate and in gas phases). Annual emissions of semi-VOCs from RSOB in SEA are estimated at 63 g I-TEQ of dioxins (toxicity equivalent to the most toxic congener), 31 thousand tonnes of polycyclic aromatic hydrocarbons (PAHs) and 27 tonnes of organochlorinated pesticides (Kim Oanh et al. 2018). Key climate forcing agents, including the greenhouse gases (GHGs) and short-lived climate pollutants (SLCPs, such as black carbon particles) are also emitted. The RSOB activity thus affects not only local air quality but also regional/global climate (Kim Oanh et al. 2011; Kim Oanh et al. 2015; Shindell et al. 2012; UNEP&WMO 2011).

Worldwide, RSOB has been reported to induce a high risk of personal exposure to the toxic pollutants (Wu et al. 2006; Torigoe et al. 2000 and references therein). However, presently the adverse effects of crop residue emissions in SEA receive by far less attention from the local and international communities as compared to the catastrophic transboundary haze caused by forest fires. In fact, in some SEA countries such as Vietnam and Philippines, the crop residue field open burning contributes larger amounts of toxic pollutants than the forest fires (Kim Oanh et al. 2018). Further, RSOB takes places in paddies located near places where people live and work hence increasing the potential exposure to the toxic emissions. The smoke is being transported by wind to deteriorate the air quality in the adjacent urban areas (Tipayarom and Kim Oanh,

**Photos:** Rice straw field open burning in SEA



*a) RSOB in Hanoi, Vietnam, May 2020 (Source: Dan Tri Newspaper)*



*b) RSOB in Pathumthani (Photo by Kim Oanh N. T.)*

2007; Narita et al. 2019). The RSOB activity is more intensive during the dry season when air pollution is already high due to the stagnant meteorological conditions hence the emissions further intensify haze episodes (Tipayarom and Kim Oanh, 2020).

Pathum Thani province, where the Asian Institute of Technology (AIT) is located, has a large annual rice production, e.g. about 420 thousand tonnes in 2018. RSOB is intensive during the dry months from November to April, when most farmers apply this method. The level of carcinogenic PAHs (14 USEPA priority compounds) measured in the rural area of Klong Luang during the intensive RSOB days was above 400 ng/m³ that is 60 times above the level measured in a remote area of Khao Yai national park (Tipayarom and Kim Oanh,

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2020). On the seasonal average, at AIT during the dry season, RSOB contributed 14 μg/m³ of $PM_{2.5}$ (41% of total $PM_{2.5}$ mass) which is well above that measured during the wet season with 4 μg/m³ (26% of $PM_{2.5}$ mass) (Narita et al. 2019).

Farmers in SEA prefer RSOB method for land preparation because it can quickly clear the surface biomass while requiring less labor and also helping control undesirable weeds and pests. Meanwhile, the traditional uses of RS as cooking fuel and for animal feedstock decline as farmers become wealthier. As a result, RSOB activity becomes widespread and the effects of smoke can be felt on both local and regional scale, especially during the dry season.

## Non-burning Alternatives for Rice Straw Management

Rice straw is a valuable resource which should be recovered rather than to be disposed of by open burning. There are several non-open burning alternatives including the off-site uses of RS as medium for mushroom cultivation, animal feed and bedding, garden mulching or for composting. But several constraints exist, for example, the presence of a high silica content in RS affects the livestock's digestion capability. Further, RS can be converted into bio-char, processed fuel, and building materials. The labor and cost for collection and transportation of bulky loose RS remain a challenge.

The use of loose RS as cooking fuel in a simple tripod cookstove is traditionally practiced in rural areas of Asia. However, this low efficient cooking system consumes great amounts of fuel and generates high emissions that affects air quality indoor and outdoor. Densification method can be applied to produce RS derived solid fuels and include, for example, roped/bundled, briquettes

and pellets, which have higher fuel density and are easier to store and transport than loose RS. Further, clean cookstoves can be used to burn the RS derived fuel, instead of dirty coal briquettes or dung paddies, and produce less emissions. However, these conversion technologies are not yet fully developed or adapted for RS.

## Development of Pelletizing Machine to Produce Rice Straw Pellets

The air quality group at AIT has conducted the research on RSOB emissions and assessed the impacts on air quality and climate forcing during the last two decades. Recognizing RS as a valuable resource, we work to identify alternatives to recover energy from this agricultural waste allowing farmers to commoditize waste prone to burning.

In the Partnerships for Enhanced Engagement in Research (PEER)-SEA project *"Assessment of impacts of the emission reduction measures of short-lived climate forcers on air quality and climate in Southeast Asia"* (2012-2016), sponsored by USAID, we quantified the RSOB emissions in SEA and assessed the impacts on air quality and climate forcing using a chemistry transport modeling system (Permadi et al. 2018). A spin-off project under the Sustainable Mekong Research Network (SUMERNET) Phase 3, sponsored by Swedish Sida *"Turning rice straw into cooking fuel for air quality and climate co-benefit in selected GMS countries"*, 2016-2018, was conducted jointly with the Energy program at AIT and research partners in Thailand, Vietnam and Cambodia to examine several options to turn RS into cooking fuel, i.e. roped/bundled, ground, and briquettes. A laboratory scale pelletizing machine was developed in this project which successfully produced RS pellets that can be burned

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effectively in a gasifier cookstove (GCS). The GSC-pellet cooking system was demonstrated in the project sites in Cambodia, Thailand and Vietnam and gained a general acceptance from farmers. A few shortcomings have been documented, such as the strongly sintered ash remained in GSC after burning of pellets is difficult to remove from the stove and is too hard to apply directly for soil conditioning.

A supplementary award from the PEER-SEA project has provided resource for translating evidence-to-action in a demonstration project *"Technology acceleration to transfer rice straw derived fuel and gasifier-cookstove in Vietnam"*, 2017-2018. In this project we successfully developed a prototype full-scale pelletizing machine and produced RS pellets in Hanoi. The pellets are burned well in the selected Mimi-Moto GCS without visible smoke. Certain modifications of the feeding materials and pelletizing technical conditions make the ash, remained after the pellets burning, soft enough to be removed easily from the stove and also to apply directly on soil. This cooking system has a high thermal efficiency hence consuming less fuel for cooking a meal. The emission measurements showed that the amount of $PM_{2.5}$ emitted from CGC-pellets when burning 1 kg of pellets is only about a third (1/3) of that from RSOB. Use of RS pellets for cooking, both domestic and commercial, also helps cut down the consumption of fossil fuel and wood fuels hence providing multiple benefits. Examples of multiple benefits of using the technology are listed below:

- Provide a workable alternative to recover energy from this valuable agricultural waste

- Avoid RSOB hence reducing emissions from this activity for clean air and climate co-benefits

- Reduce dependency on wood fuel (reduce deforestation) and on fossil fuel (reduce climate impacts)

- Reduce indoor air pollution when cooking with clean GCS-pellet system

- Create new income source to farmers through selling RS and/or RS pellets.

**Photos:** Rice straw pellet production in Vietnam funded by PEER-SEA, 2018



*Grinding machine*



*Pelletizing machine*



*Produced RS Pellets*

**Photos:** GCS-Pellet cooking system: demonstration and pilot application in Hanoi

## Summary and Outlook

The successful development of suitable pelletizing machine to produce RS derived cooking fuel creates an opportunity to meaningfully use this valuable agricultural waste and at the same time creates an income source for farmers. Application of the technology helps minimize the RSOB practice that brings in multiple benefits for clean air and climate.

A complete package of RS grinding-pelletizing machine should be further developed and demonstrated in the region to bring the technology closer to end-users. The demand, willingness to pay by users and potential environmental impacts should be analyzed. A business model may be developed which involves participation of the private sector to produce and market RS pellets. Modifications of the feeding material mixture and the pelletizing technical conditions may be investigated to produce pellets for other purposes, e.g. for animal feedstock, organic fertilizers and soil conditioning.

For successful elimination of RSOB practice in SEA, along with the technology, formulation and implementation of appropriate policies should be in the place. For example, a strict ban on RSOB can be enforced along with subsidies/incentives provided to the business start-up to enhance wide application of the technology in the region. Awareness raising focusing on the negative impacts of RSOB, specifically the effects of smoke on human health, is necessary to encourage farmers to use non-open burning alternatives, including the RS pellet production.

## Acknowledgments

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# CSi BIM Lab @ A I T



**Smart Learning and BIM Development**

Supported by
AIT Alumni, CSI USA and AIT Solutions

Building Information Modeling (BIM) is one of the most efficient tools that the Engineering and Construction Industry can use to turn data into value by involving the generation and management of digital representations of physical and functional characteristics of a project through its life cycle.



**The Computers and Structures, Inc. (CSi)**, the pioneering leader in software tools for structural and earthquake engineering, partnered with AIT Solutions to establish CSi BIM Lab at AIT for the advancement of the application of BIM in various aspects of building design, construction, management and operation. The lab will carry out research and development for platforms and application of BIM and support the development of tools that will be integrated into the CSi software and platform. Training and workshop will also be provided to professionals by AIT experts in collaboration with external partners and industry leaders.
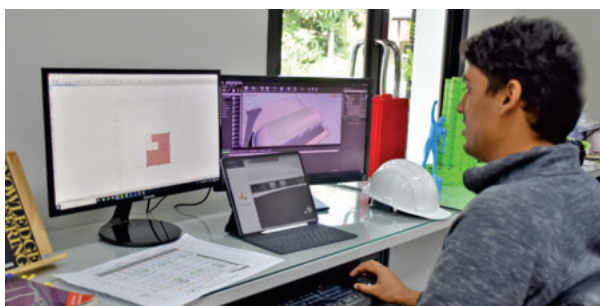
## Key Services

- 3D BIM modeling (Transforming 2D drawings to 3D BIM from provided drawings)
- BIM Clash detection
- BOQ and quantity take-off from highly detailed BIM models

## Key Projects

### Model Checker Project

BIM models from different companies might have different format of BIM data. The target is to create software that can read and check from different data format. To do this, we use Industry Foundation Class File Format (IFC) as a standard format for data transfer.

We currently use IFC format to obtain BIM model into our BIM viewer application. The BIM model and data is shown in Figure 1.1. The data for each element can be viewed to check the standard of the Building data for given standards.
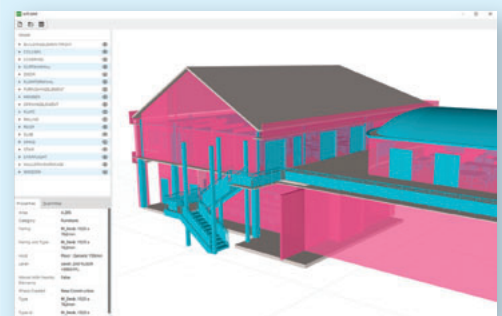


*Figure 1.1: BIM data imported from IFC format*

## BIM Data Transfer for Structural Engineering

We transfer BIM data into various applications, especially for structural engineering. In the field of structural engineering, it would be useful if the data can be directly transferred between the BIM model and the structural model.

An alternative approach is to transfer Autodesk Revit Data into Game Engines. The benefit of using game engines is that it provides support for high definition graphics. Figure 2.1 is an example of BIM data representation using Unreal Engine. This would make it more realistic for visualization, especially for virtual reality and augmented reality.
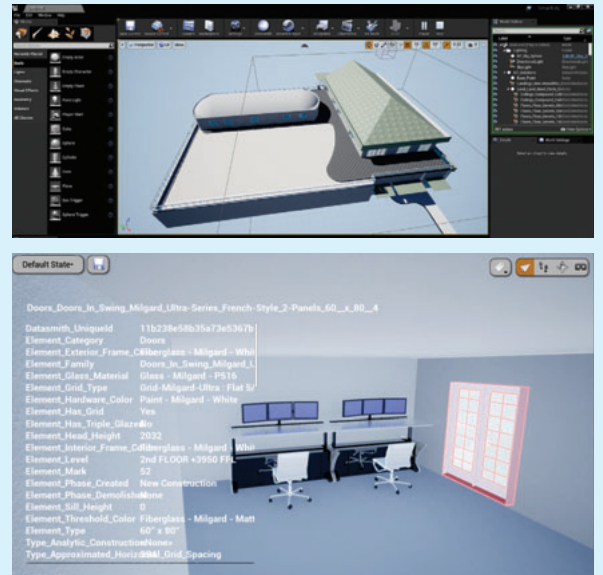


*Figure 2.1: BIM Model using Unreal Engine*

## Simplified Mesh for Scanned Data Analysis for Finite Element Model

Scanned point cloud typically contains non-structural or architectural parts, for example, tree, furniture. It would be time consuming to manually remove them before further applications. To address this problem, we automate it by comparing scanned data with BIM data (Figure. 3.1). The unused parts which are typically far away from the BIM model will be removed. Then the required part of the scanned data remains (Figure 3.2).



*Figure. 3.1: Point cloud of with about 55 million vertices mapping on the structural object (the blue object)*

After cleaning the data, BIM model is used as a guideline to create the mesh with highly detailed (Figure 3.2). Since it is difficult in practices for use the mesh with high detailed, the mesh is simplified to be a grid like mesh as shown in (Figure 3.3). The comparison of developed view between highly detailed meshed model and simplified meshed model is shown in Figure 3.4. This simplified meshed model would be useful for creating finite element model.
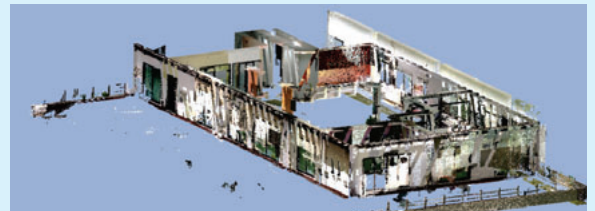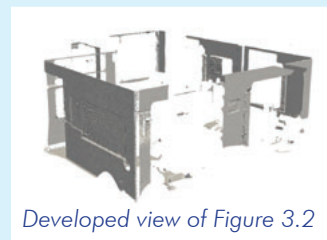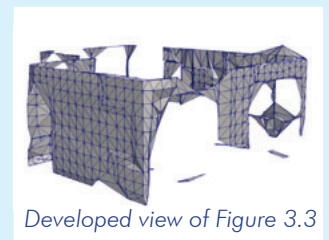


*Figure.3.2: Remaing poind cloud after mapping (about 10 million vertices remain)*



*Figure.3.3: Simplifed triangulated mesh*



*Developed view of Figure 3.2*



*Developed view of Figure 3.3*

*Figure.3.4: Comparison of developed view between highly detailed meshed model of Figure 3.2 and simplified meshed model of Figure 3.3.*

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