AUSTRALIAN NETWORK OF STRUCTURAL HEALTH MONITORING

Newsletter

ANSHM

Issue 23, March 2020

Contents

President Message

Tommy Chan

Professor in Civil Engineering, Queensland University of Technology

Dear All,

First of all, I would like to congratulate Jun for his recent promotion to Associate Professor. He is well deserved for the promotion. I am so pleased to see how each of the Executive Committee members develop in these many years that we work together for ANSHM. It's been so many years that we worked together, and actually the most I treasure is the friendship that I develop with each of the Executive Committee members.

We should also express our warm welcome to Dr Lawrence Hu who has replaced Kenneth Jacobs representing the Department of Transport and Main Roads (DTMR) to sit in the Advisory Board of ANSHM. Kenneth considers that Lawrence could be able to afford more time with ANSHM. Many thanks to Kenneth for helping ANSHM develop in the past few years since he joined our Advisory Board, being a very strong support of us from the DTMR. I believe that Lawrence will strengthen our connection with DTMR.

Lawrence, welcome on Board!

We should also welcome the following three new members to ANSHM, whose membership applications were approved at the last Executive Committee Meeting:

- Matej Krajnc of Sci-Meas
- Neil.Watson of Engineering Advice Pty Ltd
- Sam Bhasin of Bestech Australia Pty Ltd

In this month, I was invited by Prof Hong Hao and his team to give a presentation at the 1st National Workshop on Infrastructural Monitoring and Protection, celebrating the 5th Anniversary of Centre for Infrastructural Monitoring and Protection (CIMP), Curtin University. I presented a topic on "Structural Health Monitoring Technologies for Next Generation Structures" and shared the importance of establishing ANSHM ARC Training Centre for Smart Data Driven Next Generation Infrastructure. In the talk, I aimed to demonstrate the Importance of Data/ Information/Knowledge for next Generation Structures using SHM. Our next generation structures will be structures with sensors. However just using sensors to collect data will not automatically add values to a structure. In the talk I explained how data is distinguished from information and knowledge, and the importance of data and the importance of knowledge are presented as follows:

- Relationship of Data with Information and Knowledge
  - Data needs to be processed to become information
  - Data needs to be studied to become knowledge
- Importance of Data
  - Knowledge needs data to validate
  - Information without data or with fabricated data is disinformation
- Importance of Knowledge
  - Data without knowledge leads to wrong interpretation
  - Information without knowledge leads to misleading guidance

For a lot of occasions, people consider that SHM is just installing sensors on a structure, which is just on the level of data collection. That is the main reason why some people consider SHM expensive as they do not know how a SHM system could provide valuable information and knowledge, e.g. knowledge for future design. With such information and knowledge, it could help eliminate many uncertainties for the asset management teams and the asset owners to make decision. I used the recent coronavirus disease (COVID-19) outbreak as an example as what I shared in my last monthly updates. Since it is a new disease, we do not have much information and knowledge about it. Everyday we could search data related to COVID-19, like the numbers of confirmed cases, deaths and recovered, etc. in different countries. These we could only consider as data. Without proper information and knowledge that could be interpreted any way we like, especially it is a new disease. As stated in my last update, *as it is new, the knowledge about it is very limited and disinformation through various social media could cause unnecessary concerns …while some others consider that*

we should do more to stop the spreading.

Similarly, we could also collect and provide data for our bridges. For example, someone may have the information that Australian bridges are designed for a life span of 100 years. Then when we check the data about the ages of some of our iconic bridges like the Sydney Harbour Bridge in Sydney (opened in 1932) and the Story Bridge in Brisbane (opened in 1940), their ages are 88 and 80 at 2020, respectively. Then based on the design age of 100 years for Australian bridges, one can consider that these bridges are approaching their "expiry dates". What will happen if there is a sign putting next to the Sydney Harbour Bridge stating that "only 12 more years to go"? Will it cause public concern? It is just because of incomplete information being provided. Therefore data is important, it is equally important for us to develop adequate information and knowledge for structures. With SHM techniques and increasing implementations of SHM systems collecting data by installing sensors with sense, we could collect and provide more information and develop more knowledge for the structural health of structures. As mentioned in last monthly updates, *such information and knowledge could help mitigate risks, eliminate all the unnecessary concerns and take and plan for all the necessary and effective actions for the maintenance and operation of the structures and the safety of the public.*

There are a lot of misconceptions in SHM, e.g. SHM is simply installing sensors, SHM is just damage detection. I really look forward to having the training centre ATCSI established to help rectify these misconceptions.

Regarding the 5th Anniversary Workshop of CIMP that I attended, I should congratulate Prof Hong Hao and his team for organising such an excellent workshop inviting past and current members of ARC college of experts, presidents/directors of organisations to give their views on the future of structural engineering in Australia. Below are some of the photos taken during the workshop.

Photo 1 – Prof Hong Hao gives the Opening Speech

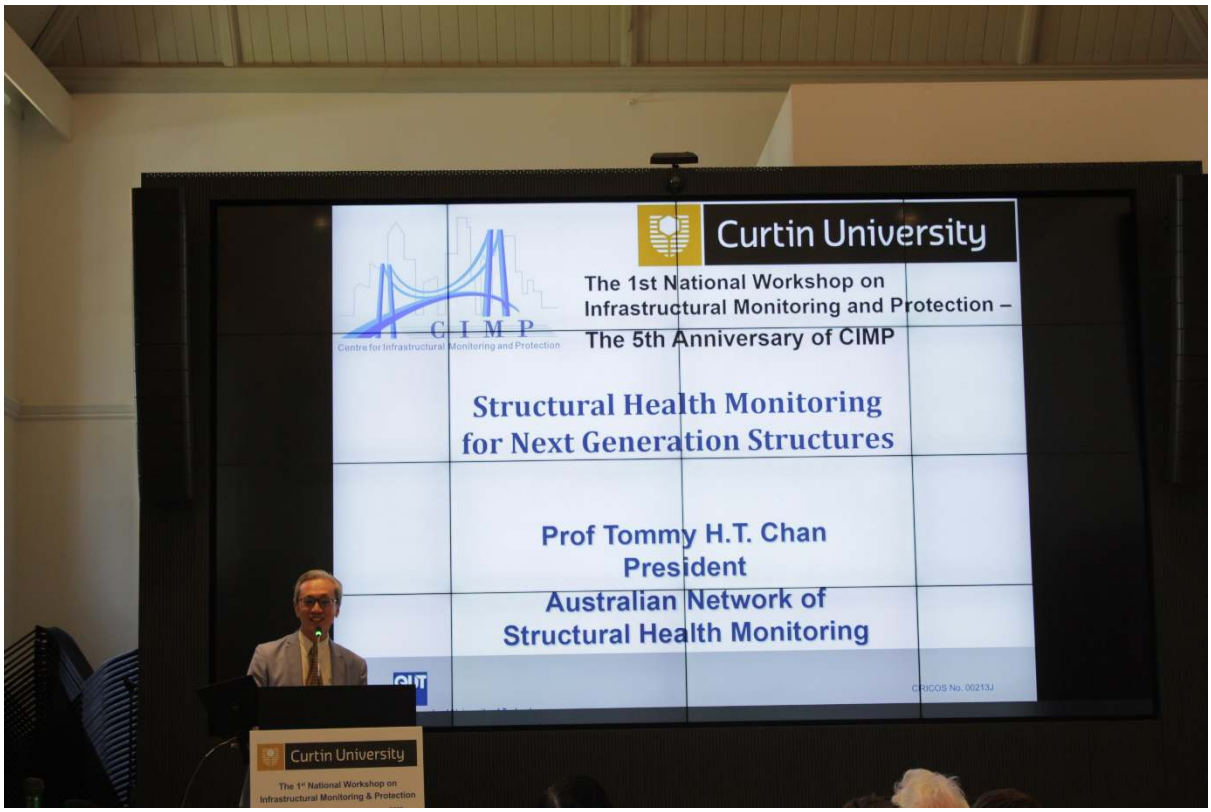


Photo 2 – The presentation that I mentioned earlier

Photo 3 – Tea Break

Photo 4 – Group Photo

Below are the updates of the month.

ATCSI Proposal

I am pleased to let you know that we received the assessor comments of the proposal, which is earlier when compared to last year. We received a lot of good comments from the assessors. I am indebted to those who have contributed to preparing this strong proposal including those who are not included as chief investigators of the proposal but are still so keen to contribute as this is a work of ANSHM. It is all due to the team spirit that we have developed in the last ten years. The establishment of this ARC Training Centre will not only benefit those involved in the centre. It will also facilitate the advancement of the SHM technologies and also benefit all the members of ANSHM, the SHM community and also the whole country of Australia. Although many of the comments from the assessors confirm our Project Quality and Innovation, Feasibility, Investigator/Capability, and Benefit, there are still some comments that we need to address or clarify. I will work with the CIs, to prepare the rejoinder accordingly and submit it by the deadline of 12 March 2020.

First Executive Committee Meeting in 2020

Our 1st Executive Committee Meeting was held on 12 Feb 2020. This is the first time that Colin attended our Executive Committee since he was elected in the last AGM. John Vazey also attended

the meeting as an Advisory Board member to briefly introduce his plan on connecting the industry members and the academic members in ANSHM. Based on the tasks identified during the discussions in the last Advisory Board Meeting on 2 Dec 2020 and the last Annual General Meeting on 3 Dec 2020, we have allocated the EC members and John's roles and duties as follows:

i. Hong Guan will continue to be in charge of ANSHM Webpage
ii. Lei Hou will continue to work on Webforum as well as to review ANSHM Rules
iii. Jianchun Li as the Deputy President of ANSHM will prepare Who's Who of SHM in Australia, i.e. a document together with a standard ANSHM PPT for presentation for people to better understand what we have been doing and what we have achieved
iv. Alex Ng will continue to work as the Membership Officer and in charge of the promotion of ANSHM Core Membership.
v. Andy Nguyen will be our Annual Workshop Coordinator as well as External Affair with the assistance of Jun and Alex. Andy will coordinate with Jianchun to organize the 12th ANSHM Workshop in Sydney.
vi. John Vazey will be our Internal Affairs and Industry Coordinator.
vii. Xinqun Zhu will be in charge of ANSHM Workshops/Short Courses
viii. Mehrisadat Makki Alamdari will be in charge of preparing SHM Technical Notes with the assistance of Xinqun.
ix. Jun Li, Richard Yang, Andy (acting for Mehri while she is on a special leave in Japan) will be working as ANSHM Newsletter Editors
x. Colin Caprani, Tuan Ngo, Jianchun Li, Alex Ng and myself will be working in a task force for the Exploration of Funding Opportunities
xi. Hong Guan, Jianchun Li and myself will prepare the publication generated from the 11th ANSHM Workshop
xii. Jun, Andy, Tao Yu and myself will continue to edit the special issue in the International Journal of Structural Dynamics and Stability (IJSSD).

ANSHM Special Issue

We experience some delay in the editing process of the special issue in the International Journal of Structural Dynamics and Stability (IJSSD). It is because Tao Yu has moved to Hong Kong working at the Hong Kong Polytechnic University (HK PolyU). Because of the move from Australia to Hong Kong, the closure of the university campus of HK PolyU in November to December 2019, and then the outbreak of COVID-19 in Hong Kong, all these cause some delay on Tao's side. Anyway, now the situation is getting better, and Jun and Andy are prepared to assist Tao to expedite the review process.

Publication generated from the 11th ANSHM Workshop

As mentioned earlier, we will have a monograph for this publication. Hong Guan is preparing a submission to a publisher with the assistance of Jianchun and myself. We are thinking of what materials we want to publish and in what format to signify the 10th Anniversary of ANSHM by

describing the 10 year development of SHM technologies of our members to reflect the state-of-the-art research in Australia rather than limited to the development of individual organisation. More details will be forwarded in due course. Please respond when we start the calling of topics/abstracts. We will then review the topics and combine/modify topics to ensure quality and integrity of the book.

Mini-Symposium (MS26) in SHMII-10

Andy has recently announced and made the first call for abstracts for our mini-symposium (MS26) in the upcoming SHMII-10 conference in Porto, Portugal in June-July 2021. MS26 is being organised by Andy, Alex and myself. Please submit your abstract directly through conference website and select theme no. 26 – "Latest advances on SHM and smart structures in Australia/Oceania". You could contact any of the three MS organisers for updating your status or if you have any queries on this mini-symposium.

ANSHM Newsletter

As mentioned earlier, the Newsletter editorial team is formulating an article/technical note collection plan for a two-year cycle. A document to register interests to submit articles in quarterly ANSHM newsletters is now created and shared on Google Drive for the upcoming article collection. The link will be circulated to ANSHM members including student and industry members to register their interest to submit articles.
https://docs.google.com/document/d/1XJX9qhxEfIkXSVluWDV5rvROuYySM-hWn-q9n8o-Tzw/edit?usp=sharing

In the next sections, we will have one article from our members. This article introduces a living laboratory project at Curtin University for building structural condition monitoring and benchmark studies.

With kind regards,

Tommy Chan
President, ANSHM
www.ANSHM.org.au

AUSTRALIAN NETWORK OF STRUCTURAL HEALTH MONITORING

Newsletter

Living Laboratory Project at Curtin University for Benchmark Structural Health Monitoring

Jun Li, Hong Hao, Gao Fan, Yu Xin
Centre for Infrastructure Monitoring and Protection, School of Civil and Mechanical Engineering, Curtin University, Bentley, WA 6102, Australia.
Emails: junli@curtin.edu.au; hong.hao@curtin.edu.au;

Curtin University, Australia has developed a 'Living Laboratory Project' on an iconic engineering Pavilion Building 215 in Curtin Bentley Campus, designed and built in 2012, for Curtin engineering students and researchers with an engaging and innovative teaching and research platform. Building 215 is a three-storey steel-concrete composite building structure, consisting of two parts. One part of this building is a three storey reinforced concrete structure with several shear walls, and the other part is a steel structure with a large open space and two footbridges in levels 2 and 3. Fig. 1(a) and (b) show the elevation view of this building and the footbridges inside the building, respectively.

(a)

(b)

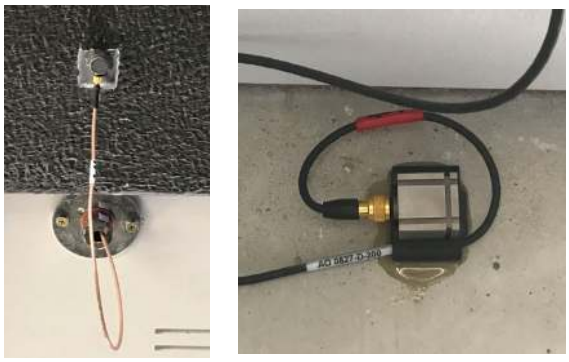
Fig. 1. (a) Elevation view of Building 215; (b) Footbridges in Building 215

The Living Laboratory Project provides an exclusive benchmark platform on a building structure in Curtin University, Western Australia, to perform, but not limited to, the following research tasks:

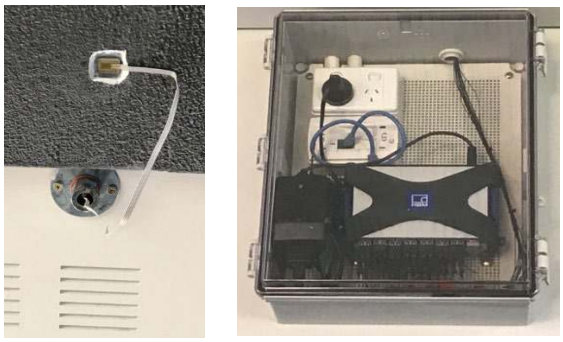
1) Conduct the operational modal identification based on the vibration monitoring data to obtain the natural frequencies, mode shapes and damping ratios of the building, and analyse the effect of environmental and loading conditions on the vibration characteristics of the building;
2) Develop the initial finite element model of this building according to the design drawings, and obtain the analytical vibration characteristics, i.e. natural frequencies and mode shapes;
3) Perform the model updating to fine-tune the initial finite element model to represent the real structure, and investigate the uncertainty effect on the model updating process;
4) Validate the effectiveness and accuracy of developed approaches on modal identification, model

updating, condition monitoring and long term progressive deterioration detection. One example could be by using the artificial intelligence and machine learning techniques, i.e. deep learning based neural networks and the big data analytics to perform the structural condition monitoring and damage identification.

Building 215 has been instrumented with a long-term structural health monitoring (SHM) system with various types of sensors, including accelerometers, seismic sensors, strain gauges, outdoor temperature and humidity sensors, wind speed and direction sensors, to continuously acquire structural vibration responses and environmental conditions. The SHM sensory system is installed on the four components of this building, that is, the main building structure, the roof truss, the footbridges and the stairs. A tri-axial seismic accelerometer is installed underground outside the building to record the ground motions. 18 high sensitivity tri-axial accelerometers are mounted on all the levels of the three-storey building to monitor the global vibrations of the whole building structure. Another 18 single axis accelerometers and 6 strain gauges are installed on the footbridges at the second and third levels of the building, and further 5 single axis accelerometers are installed on the steel stairs. A weather station is installed on the roof of the building to measure the external environmental conditions, i.e. temperature and humidity, wind speed and direction. Fig. 2 shows some photos of the installed single-axis and tri-axial accelerometers and strain gauges, and the data acquisition system. Compared to other SHM systems, the system in Curtin also consists of a senor to monitor ground vibrations, which enables recordings of ground motions and building structural responses should an earthquake occur in the region.



(a) (b)



(c) (d)

Fig. 2. Some typical sensors and data acquisition system: (a) Single-axis accelerometer; (b) Tri-axial accelerometer; (c) Strain gauge; (d) Data acquisition system

Fig. 3 shows the end-user interface of the live SHM system on this instrumented building. This system is running 24 hours/7 days. A sustainable long term cloud-based data storage strategy has been designed to collect all the measurement data. The sampling rate of all the sensor is set as 50Hz, as the natural frequency of the building is low. Environmental condition data are recorded every minute. This living laboratory project develops a comprehensive and valuable vibration monitoring system to record a large amount of data under various environmental conditions (temperature, humidity, and wind conditions etc) and loading events (even extreme events like earthquake) for structural condition monitoring and environmental effect analysis. This building provides an exclusive validation platform to study the impact of environmental conditions to the structural conditions and detect the possible progressive degradation based on the long term data.

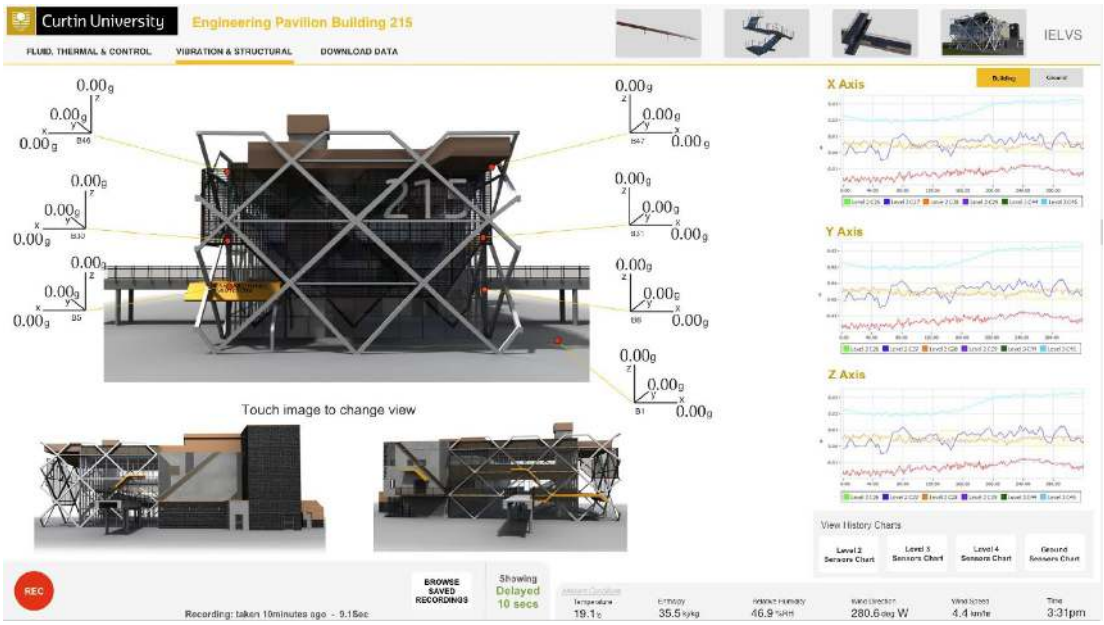


Fig. 3. End-user interface of the live SHM system of Building 215

Fig. 4 shows the measured responses from the steel frame under ambient vibrations. The measured vibration responses are pre-processed with a band pass filter between 0.5-20Hz, and then used for frequency spectrum analysis and modal identification. Fig. 5 shows the Standardized Auto-Regressive (SAR) power spectrum in the frequency domain. Five typical vibration modes with natural frequencies ranged from 1.14Hz to 4.29Hz are identified. These are consistent with the understanding that the building structures have usually low natural frequencies. Optimal sensor locations are identified based on a preliminary modal analysis with the initial finite element model of the building developed in SAP 2000, and experiences from senior researchers and engineers. Fig. 6 shows the built finite element model that consists of 1186 nodes, 1321 frame and truss elements, and 50 shell elements. Vibration characteristics, i.e. natural frequencies, are obtained from the initial model and compared with the measured ones, as listed in Table 1.

Table 1. Measured and analytical frequencies of the initial finite element model (Hz)

Mode	Measured	Initial Model
1	1.14	1.16
2	1.76	1.85
3	2.59	2.42
4	3.40	3.52
5	4.29	3.87

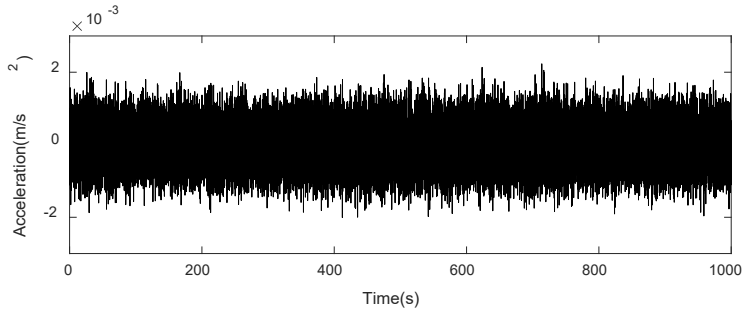


Fig. 4. The measured response from the steel frame under ambient excitations

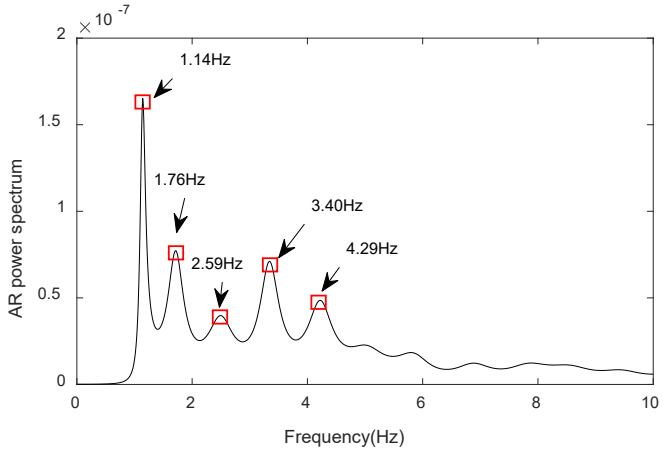


Fig. 5. SAR power spectrum of the response on the steel frame

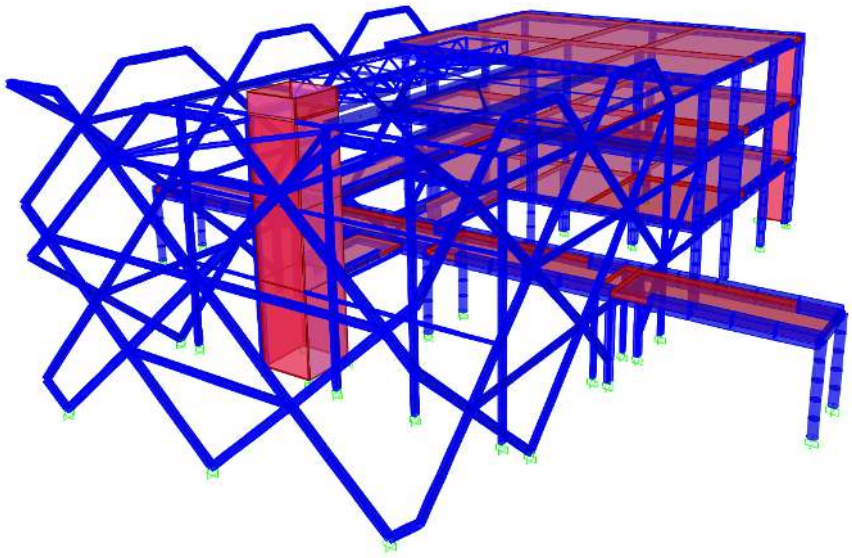


Fig. 6. The initinal fintie element model of Building 215

Two earthquakes occurred in Lake Muir area, about 330km from Perth, Western Australia, as shown in Fig. 7, were successfully recorded by the installed SHM system on Building 215 on 16 Sep 2018 and 9 Nov 2018, respectively. Some basic information regarding these two earthquakes are listed in Table 2, provided by Geoscience Australia @ https://earthquakes.ga.gov.au/. The locations of these two earthquakes are close to each other with a separation distance of 3.8km. Figs. 8 and 9 show the recorded ground motions, acceleration responses at two typical locations on the steel frame and concrete structure, and their corresponding spectrum information. It can be observed that the energy of the monitored earthquakes is mainly within the frequency range below 6 Hz, and the vibration modes of the building structure from 1-4Hz are well excited.

Table 2. Basic information of two monitored earthquakes

	Earthquake I	Earthquake II
Epicentral Time	16/09/2018 12:56:24	09/11/2018 05:07:00
Longitude	116.902	116.787
Latitude	-34.407	-34.423
Magnitude	5.3 (Mw)	5.2 (Mw)
Depth	2km	3 km

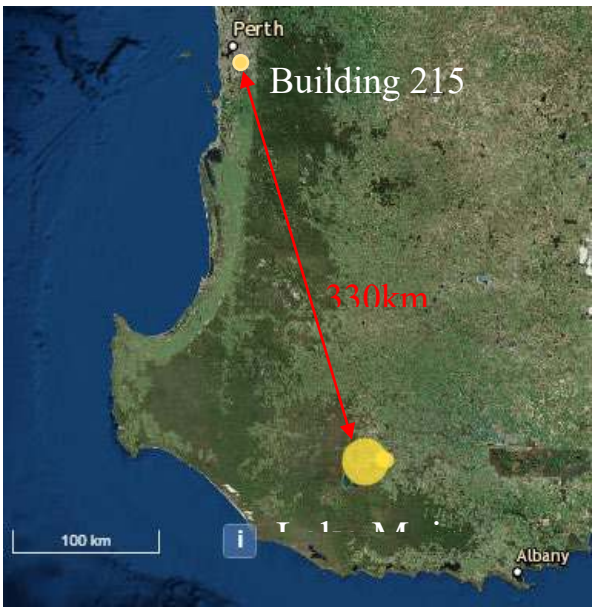


Fig. 7. The location of earthquakes

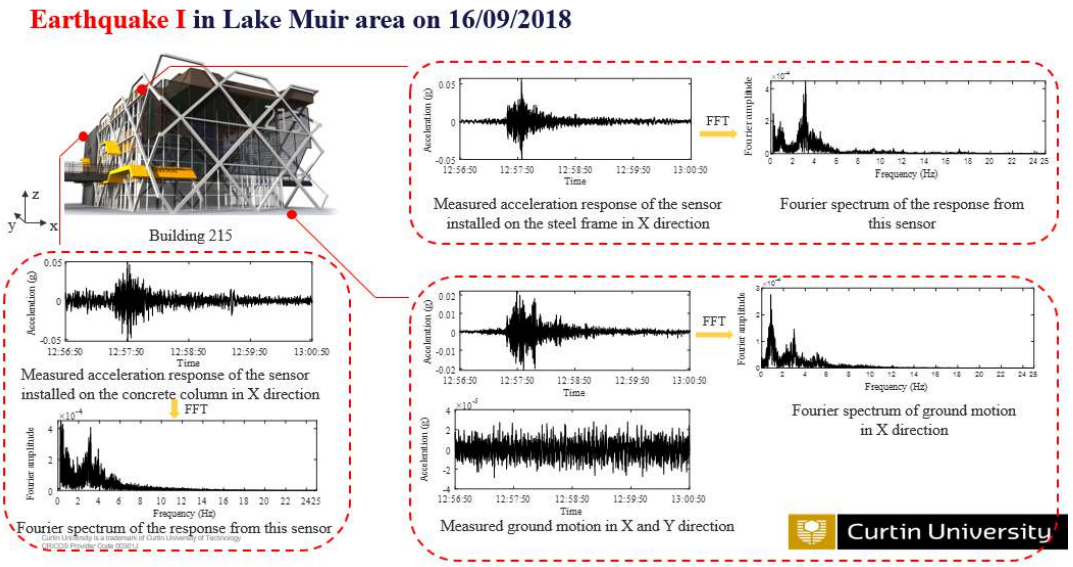


Fig. 8. Monitored earthquake I and the responses of Building 215

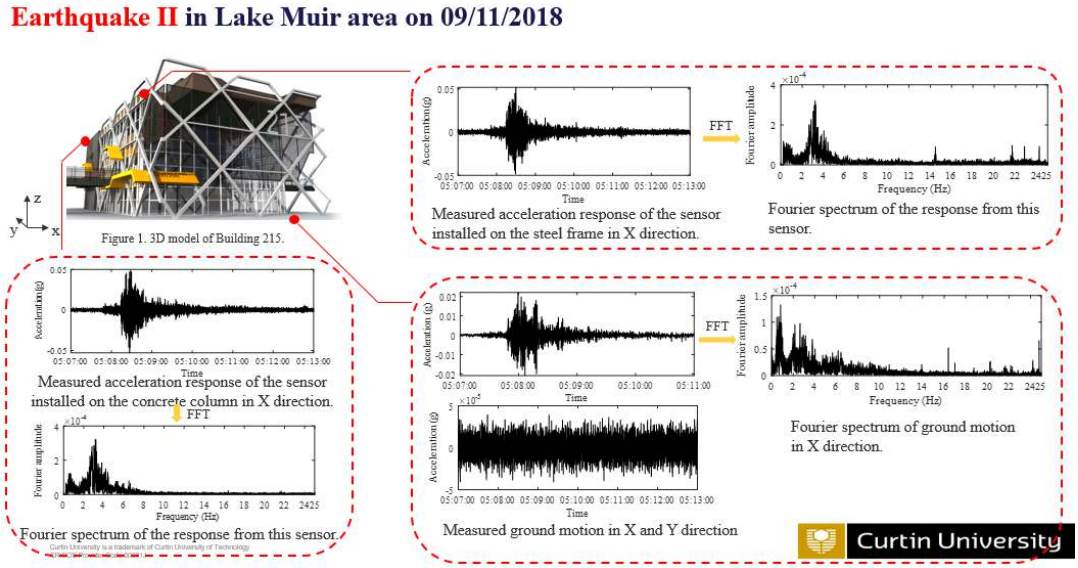


Fig. 9. Monitored earthquake II and the responses of Building 215

'Living laboratory project' at Curtin University can be served as a benchmark platform nationally and internationally for long-term and continuously monitoring of the structural vibration and environmental conditions to demonstrate the values of SHM to engineering community. This exclusive benchmark platform can be used to validate the design, conduct the continuous structural vibration measurements and condition monitoring, monitor structural performance, predict structural responses under various dynamic events, and provide real-time information for safety assessment immediately after disasters and extreme events, etc.

Conference News

- The 10th Australasian Congress on Applied Mechanics (ACAM10), to be held at The University of Adelaide, Adelaide, Australia, from 25-27 November 2020. Chair: Assoc. Prof. Alex Ng. Webpage: https://acamconference.com.au/
  Abstract submission due: 27 April 2020

  Full paper due: 20 July 2020

- Mini Symposium "Latest advances on SHM and smart structures in Australia/Oceania" in the Tenth International Conference on Structural Health Monitoring of Intelligent Infrastructure, Porto, Portugal, from 30 June to 2 July 2021. Organized by Dr Andy Nguyen, Assoc. Prof. Alex Ng, Prof. Tommy Chan.

  Webpage: https://web.fe.up.pt/~shmii10/conference/mini-symposia/

  Abstract submission due: 30 June 2020

  Full paper due: 10 Jan 2021

- Mini Symposium " Innovative data-driven techniques for Structural Health Monitoring" in the Tenth International Conference on Structural Health Monitoring of Intelligent Infrastructure, Porto, Portugal, from 30 June to 2 July 2021. Organized by Assoc. Prof. Jun Li, Prof. Ting-Hua Yi.

  Webpage: https://web.fe.up.pt/~shmii10/conference/mini-symposia/

  Abstract submission due: 30 June 2020

  Full paper due: 10 Jan 2021

Social Media

Follow us at the next social media and webpages

- ANSHM Facebook webpage: www.facebook.com/ANSHMAU
- ANSHM Facebook group: www.facebook.com/groups/ANSHM
- ANSHM LinkedIn group:

www.linkedin.com/groups/ANSHM-Australian-Network-Structural-Health-4965305

Call for Articles

Interested in publishing an article in ANSHM newsletter, please register here

https://docs.google.com/document/d/1XJX9qhxEfIkXSVluWDV5rvROuYySM-hWn-q9n80-Tzw/edit?usp=sharing

Edition	Submission Deadline	Distribution
Spring	15 Feb	Early March
Summer	15 May	Early June
Fall	15 Aug	Early Sep
Winter	15 Nov	Early Dec

If you have any comments and suggestions, please contact

Newsletter Editors:

Dr. Jun Li, Curtin University.

Email: junli@curtin.edu.au

Dr Andy Nguyen, University of Southern Queensland

Email: Andy.Nguyen@usq.edu.au

Prof. Richard Yang, Western Sydney University.

Email: R.Yang@westernsydney.edu.au

Dr. Mehrisadat Makki Alamdari, University of New South Wales.

Email: m.makkialamdari@unsw.edu.au