AUSTRALIAN NETWORK OF STRUCTURAL HEALTH MONITORING

Newsletter

Issue 6, December 2015

Contents

President Message

Tommy Chan

Professor in Civil Engineering, Queensland University of Technology

Dear All,

I prepare this President message on my way returning to Brisbane after the 7th ANSHM Workshop. I would like to express my sincere gratitude to Curtin University to host our 7th Annual Workshop. The effort of Jun Li and Hong Hao in organising the workshop is much appreciated. As I stated in the AGM, I considered this workshop is better than the best. For those who have attended this workshop will definitely agree with me that Jun and Hong have done a great job! Without their well planning and hard work, we could not have such a successful event.

This President message will mainly focus on the Workshop and what we have discussed in the workshop. We have a total of 18 presentations in the Workshop. We all shared our latest research and development in the area of SHM with one another. We have more than 60 delegates and many of them are from the industry.

Industry Forum

Same as previous years, a highlight of our Annual Workshop is the Industry Forum. I should acknowledge the effort of Govinda Pandey for being the facilitator. A lot of delegates from the industry shared their views on ANSHM and made suggestions on how it could help SHM to be developed to meet their needs and to practically apply SHM to solve their problems. They even suggested ANSHM to broaden the scope for monitoring not only civil infrastructures but also the

plants of the mining industry. We will consider whether this will be included in our areas of interests. We all agreed that the network should continue to establish/maintain/strengthen the relationship between the academics and the industry. This has been a task of ANSHM and we will continue to do it through publications, seminars/workshops, newsletters and web forums. We will also explore whether we need to have new means for such purpose. Actually, I am so pleased to notice that we now have more and more members from the industry to give us advice as well as taking significant roles in ANSHM.

Photos 1 & 2 – Industry Forum

New Advisory Board Member

I would like to express our warmest welcome to Mr Mahes Rajakaruna of Main Roads Western Australia to the Advisory Board. We are so pleased now we have members from the road authorities

of 4 states of Australia and of New Zealand. We believe they will help us align our work to meet better the needs of the road authorities to have more real life applications of SHM in Australia and New Zealand. Below I list again the ANSHM Advisory Board Members for your information and easy reference:

- Tommy Chan, President (QUT)
- Barry Wright (NZTA)
- Mark Bell (IDS)
- Bijan Samali (UWS)
- Brian Uy (UNSW)
- Craig Fuller (21c Infrastructure Solutions)
- David Thambiratnam (QUT)
- Govinda Pandey (Rockfield)
- Hong Hao (Curtin U/UWA)
- Mahes Rajakaruna (MRWA)
- Mark Stewart (U Newcastle)
- Nick Haritos (Melbourne U)
- Peter Prasad (ARTC)
- Peter Runcie (NICTA)
- Ross Pritchard (QDTMR)
- Wije W Ariyaratne (RMS)
- Xiaoming Wang (CSIRO)
- Yew-Chaye Loo (Griffith U)
- Yew-Chin Koay (Vic Roads)

Election of Executive Committee Officers

Alex Ng, Ulrike Dackermann and Jun Li were re-elected to serve in the committee for another 2 years of service (2016-2017). Because of the increasing tasks of ANSHM, we decided in the Advisory Board Meeting to add two more officers in the EC. I am very pleased Dr Andy Nguyen and Dr Lei Hou were elected to join the EC. Therefore the Executive Committee in 2016 will consist of the following officers:

- Tommy Chan (President)
- Jianchun Li (Deputy President)
- Alex Ng
- Andy Nguyen
- Hong Guan
- Jun Li
- Lei Hou
- Saeed Mahini
- Tuan Duc Ngo
- Ulrike Dackermann

- Xinqun Zhu
- Ying Wang

Roles of Member Representatives

In the Advisory Board Meeting, we have discussed about the importance of Member Representatives. It seems that some members are not aware of that and some Member Representatives are also not sure about their roles. I would like to explain about the Membership here. According to Cl 2.1 of our Rules,

"Member" means an individual or a group of individuals of an academic institution, university, industrial or research organisation, or a government body which has a serious interest in the Field and which agrees to become a member of the Association.

"Member Representative" means a representative who is nominated by the relevant Member as provided in rule 6.

"Core Member" means a Member, of which there is at least one individual who is prepared to attend most of the meetings of the Association, e.g. Annual General Meetings, Advisory Board Meetings, Executive Committee Meetings as provided in rule 5.

An individual or group of individuals of an organisation (academic institution, university, industrial or research organisation) who is/are interested to join ANSHM could apply to become a member of ANSHM (Cl 5.1). If at start in this organisation, only 1 person becomes a member of ANSHM, s/he will be the Member Representative of this particular organisation. Later, if another person of this organisation would also like to join ANSHM, s/he will still need to lodge the application form of membership and, if applicable, his or her application will be approved in the next Executive Committee meetings. S/he will then receive a welcoming email (cc to the Member Representative) stating who the Member Representative of his/her organisation is. The Member Representative will represent the group of individuals of the organisation to vote in an AGM (Cl 7.7).

The Member Representative of an organisation serves as an important link between ANSHM and the group of persons of the organisation who joined ANSHM. We expect the Member Representative will ensure all the news, notices, updates received from ANSHM will be circulated within the group.

ANSHM Future Directions on Research

We had some discussions regarding ANSHM future directions on research. We have been striving to find an ANSHM project to establish an ARC Area of Excellence in SHM. However in reality because of the ARC Rules and the budget constraints of road authorities, it seems almost impossible to apply for that. Rather, we now see that the formation of an ARC Research Hub through the ARC's Industrial Transformation Research Programme (ITRP) may be more feasible for us to target. Although at the moment, infrastructure research has not been identified as a priority area for ITRP, we will make ourselves prepared for that once we have the opportunity. In the meantime, ANSHM will continue to facilitate and encourage members conducting collaborative research on SHM and applying for ARC

Discovery and Linkage projects. We will also provide a platform to help our members to apply for such funding individually or collaboratively. ANSHM will also provide a one point stop for one another to identify experts in various SHM areas to participate in different projects where necessary. Of course, we will continue to report the successful stories on our website. Jianchun will be the person in charge of leading a sub-committee to work on this. Tuan, Alex and I are also in this committee.

ANSHM Special Issues

Journal of Civil Structural Health Monitoring

The review process is progressing well. So far we have received 9 papers. Thank you for those who assist in the reviewing process. I believe you will provide your review timely. The successes on our previous special issues rely so much on your effort. We are always proud of having that many high quality papers published in our special issues in those high impact factor journals.

Journal of Earthquake and Structures

Jun and I are working on it. We have received 13 abstracts. It is a good number. The editor of the Journal appreciates so much our idea and effort. However they also raise their concern that a few SHM papers are not related to earthquake and they would like us to make sure the authors will cast their paper within the scope of the journal. They consider the special issue should be consistent with the journal mission. Jun, Jianchun and I will ensure all the submitted papers will be aligned with that.

SHMII 2017

Saeed reported the preparation of SHMII 2017 in the Advisory Board Meeting on its progress, venue, budget, sponsorship, conference dinner, local organisation committee (LOC), keynote speakers, etc. This will be the first international conference organised by ANSHM. I believe we could well demonstrate our team spirit to all the researchers of SHM field through this important event. In the next two years, the organisation of SHMII 2017 will be our main task. Saeed and I together with the Executive Committee and the Advisory Board will take the lead to work with the LOC and other sub-committees of this conference to make it to be the best of the series.

Subscription Fee

I am so pleased to inform you that we have decided the annual subscription fee for 2016 will continue to be null.

8th ANSHM Workshop

As informed in the last update, the 8th ANSHM Annual Workshop (in 2016) will be hosted by Monash University as coordinated by Dr Colin Caprani. We announced that officially in the Closing Section of the 7th ANSHM Workshop. Colin also gave us some background information about this forthcoming workshop. Our Executive Committee will closely work with Colin to organise this

important annual event of ANSHM. We will first seek the view of our members to find a date that best fit most of us. I believe the 8th ANSHM Workshop will also be as successful as others in the series.

Photo 3 –Dr Colin Caprani announcing our 8th ANSHM Workshop to be hosted by Monash University

ANSHM Mini-Symposium in PLSE 2015

As mentioned in the last update, there will be 20 presentations in this Mini-symposium – 10 on our side and 10 from Prof Y.Q. Ni's side. Look forward to seeing again our members participating this conference in less than 10 days.

In the next sections of this Newsletter, Hong Guan et al. report their research on enhancing Level 2 inspection for bridge condition assessment using different advance technologies including using a drone system. Colin et al. report their research on FRP structures to provide data that will inform the development of prediction models and give confidence in the proposed FRP bridges and flooring systems. Along with some pictures I embedded in this President Message, you will find more photos of the workshop in the 7th ANSHM Workshop Photo Gallery in this Newsletter. This newsletter also provides some information about the Australian reporting one of our SHM works at QUT. I hope this could help the public to be more aware of the importance of our technology.

With kind regards,
Tommy Chan
President, ANSHM
www.ANSHM.org.au

Enhancing Level-2 Bridge Condition Assessment

Hong Guan[1], Jun Jo[2] and Michael Blumenstein[2]

[1]*Griffith School of Engineering, Griffith University Gold Coast Campus*

[2]*School of Information and Communication Technology, Griffith University Gold Coast Campus*

Bridge inspection practice

Level-2 bridge inspection is to assess and rate the condition of a structure (as a basis for assessing the effectiveness of past maintenance treatments, identifying current maintenance needs, modelling and forecasting future changes in condition and estimating future budget requirements). An intelligent Level-2 bridge inspection approach can minimise the shortcomings of current subjective, costly and unreliable inspection practices on condition rating assessment for Bridge Management System (BMS) and can provide a more cost effective solution for bridge agencies. It can also address the research problems identified in damage detection by using advanced techniques of data acquisition, image registration and image processing.

Griffith Infrastructure Asset Management Team and Griffith Robotics Lab

Having successfully completed an ARC Linkage Project (LP0883807) on artificial intelligence based deterioration model for development of bridge network maintenance strategy, the Griffith University Infrastructure Asset Management Team is currently undertaking a project aimed at overcoming the challenges associated with (a) crack detection in bridge images using advanced image processing techniques and (b) developing a revolutionary, automated robotic and sensor-based image acquisition approach to enhance bridge inspection practice. This will in turn lead to more reliable predictions of long-term bridge performance.

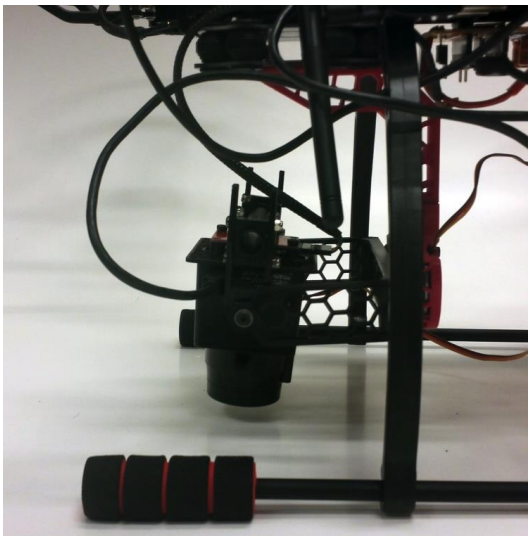
The Griffith Robotics Lab (http://ausrobotics.org/ara/web/jun.html) aims to research and develop innovative and integrated technologies and has been conducting various research activities in the areas of robotics, UAV, eHealth and sensor networks, since 2003. Through collaborations with many world-class institutes, the Griffith Robotics Lab has been involved in many research projects, including smart car systems, drone-based bridge inspection and sensor networks for surveillance, etc.

Drone-Based Bridge Inspection System

The Griffith Robotics Lab has been developing various drones and technologies (e.g. SLAM, control automation, computer vision and wireless communication) in order to operate the drones for various tasks (e.g. object chasing and gas pipeline surveillance and drone dancing). For bridge crack detection problems, the lab has researched on feature extraction, pattern recognition, autonomous control and

a high-precision gimbal system, etc. These techniques will be further developed and applied to complicated and large-scale bridge and building structures. The drone being developed at the Griffith Robotics Lab is controlled manually and (semi) autonomously (see Figure 1). The system contains two modules: a flight controller and a SLAM module. The flight controller uses a Pixhawk Autopilot Module that contains IMU to aid in keeping the drone stable during flight. An onboard barometer can be used to stabilise the height of the drone. With the addition of a GPS unit, the Pixhawk can even fly the drone autonomously; through GPS waypoints uploaded via a ground station computer. The drone has two existing communication links; one link to a 2.4GHz radio transmitter, used by an operator for manual control, and a 915MHz radio link that transmits telemetry data and commands to and from a ground station computer. A communication protocol called MAVLink is used for communication between the drone and the ground station computer.

(a) Eight-armed drone



(b) Gimbal for Lidar

Figure 1 Drone system developed at Griffith University

The SLAM module scans the environment using a light detection and ranging (Lidar) sensor and builds a 3D map for localisation. The localisation is an important task to identify the current location of the drone and the camera, as the GPS signal does not reach the drone when it is under the bridge. A Raspberry Pi B+ is used for the SLAM operation. It controls two gimbals: one for a camera and another for a Lidar, Hokuyo UTM-30LX. The Raspberry Pi stores images taken by the camera into an SD card and sends it to the ground station computer simultaneously. The computer builds the 3D map, identifies the current location of the drone without any GPS information and sends the instructions of the next movement to the flight controller. The images are analysed by the computer using the techniques of feature extraction and pattern recognition.

AUSTRALIAN NETWORK OF STRUCTURAL HEALTH MONITORING

Newsletter

Monash University Fibre Reinforced Polymer (FRP) Laboratory Footbridge

Colin Caprani, Yu Bai, Sindu Satasivam, Ehsan Ahmadi, Jun Wei Ngan, Shaohua Zhang, Chris Keys

In recent years, Fibre-reinforced polymers (FRPs) have attracted much attention from building construction. FRP are durable, sustainable, and cost-effective composite materials. They are light weight, simple, and can be manufactured in factory conditions, giving improved quality assurance. Structures that are constructed entirely of FRP offer advantages such as accelerated constructability, cost savings, and a low carbon footprint. However, structures made wholly from FRP present new problems because their characteristics, such as mass, stiffness, and damping, are significantly different from those of structures constructed using traditional materials like steel or concrete. Interestingly, a change in the dynamic properties of light FRP structures under human activity can occur - termed human-structure interaction. This is due to the higher mass ratio between the load and structure when compared against traditional structural forms. Furthermore, FRP-only structures remain rare and so there is insufficient data about their full-scale in-service structural performance. This in turn, impedes the widespread adoption of FRP in structural applications.

A team at Monash University, led by Dr Colin Caprani and Dr Yu Bai has conducted a research on FRP structures to provide data that will inform the development of prediction models and give confidence in the proposed FRP bridges and flooring systems. The team has constructed a full-scale laboratory footbridge (9 m in length) made entirely from pultruded FRP sections using epoxy bonding as shown in Figure 1. Pultruded FRP is formed by extruding glass fibres and resin through a die, and so has main strength in one direction, and secondary strength in the two remaining orthogonal directions - it is a tetratropic material. The built-up deck section which spans transversely consists of pultruded FRP SHS box sections integrated between two FRP flat panels forming an orthotropic sandwich structure for the bridge deck (Figure 2). In turn, this is supported on two bottom I-beams forming the footbridge structure (Figure 3). Throughout, the FRP fibres are orientated to maximize both longitudinal and transverse strength/stiffness. This FRP footbridge will serve as a benchmark structure for research into FRP floor and footbridge structures.

Figure 1 Bonded pultruded FRP footbridge

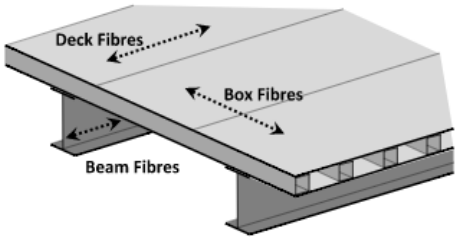


Figure 2 Fibre direction of pultruded FRP members

Alongside with the construction of the FRP footbridge, a significant quantity of specimens of FRP was tested for their strength properties. Tensile and shear tests were carried out for FRP specimens of different thickness, resembling the different FRP elements in the footbridge structure. Further, the adhesive bonding of specimens was also tested in the laboratory (Figures 4 & 5). Output from this testing characterizes the material and mechanical properties of the FRP footbridge.

Figure 3 FRP sandwich system as deck supported on FRP I-beams

Figure 4 Tensile testing of FRP specimens

Figure 5 Laboratory testing of bonded FRP plate specimens

The next stage of the project involves full-scale static and dynamic testing of the FRP footbridge. The footbridge is instrumented using strain gauges, load cells, transducers, and accelerometers (Figures 6 & 7). A finite element model of the footbridge was created to predict the static and modal parameters, which assists the planning process for static and dynamic testing. Some of the natural frequencies and mode shapes obtained from the finite element analysis are shown in Figure 8. These static and modal parameters are to be validated with the experimental results shortly.

Static testing of the footbridge will serve as a baseline demonstration of the capabilities of full-FRP structures under extreme loads. In the static tests, loads (up to 4.3 kPa) will be applied onto the deck of the FRP footbridge in loading increments and the strain readings from increment recorded. The performance of epoxy bonding for shear connection between FRP components and the shear lag behavior of the orthotropic FRP deck will then be fully characterized.

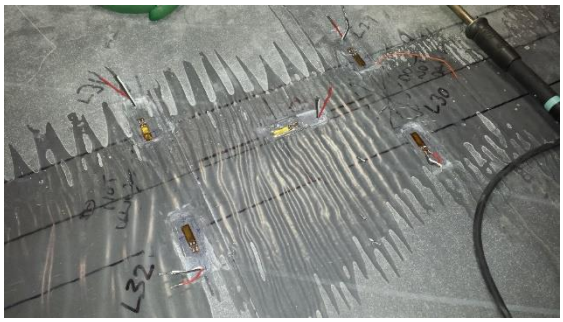


Figure 6 Strain gauges and wiring on deck surface

Dynamic properties of the FRP footbridge such as stiffness and damping properties along with other modal parameters such as natural frequencies and mode shapes will be obtained through experimental modal testing. The human-induced vibration response of the structure will also be measured. The FRP footbridge offers a more flexible surface which will enable the quantification of human-structure interaction.

In summary, full-FRP structure is explored as a potential system with many significant advantages over conventional construction materials. The constructed FRP footbridge serves as a benchmark structure for research into FRP floor and footbridge structures, fostering the growing adoption of FRP in civil structures. The outputs enabled by this project will provide calibration and validation information for both static and dynamic mathematical models, giving confidence in future proposed bridge and flooring system design.

Figure 7 Electrodynamic shaker operating in vertical mode

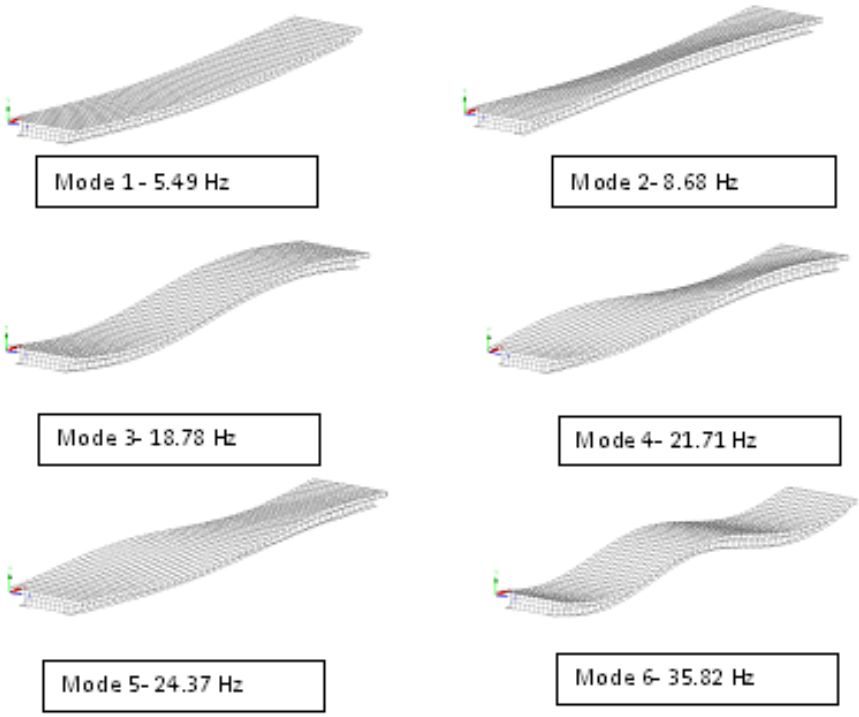


Figure 8 Footbridge mode shapes from FEM

Photo Gallery 7th ANSHM Workshop

Opening Speech by Prof Tony Lucey, Dean of Engineering, Curtin

Oral Presentations I (26 November 2015)

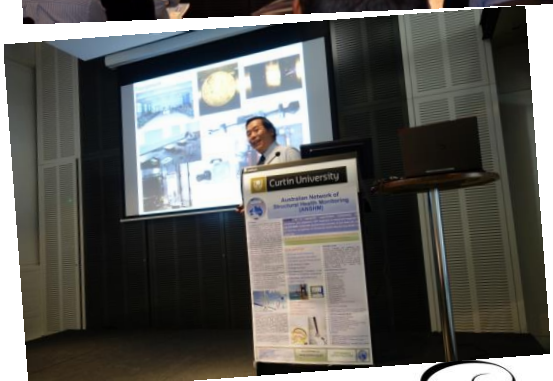


Photo Gallery 7th ANSHM Workshop Ctnd..

Morning Tea (26 November 2015)

Oral Presentations II (26 November 2015)

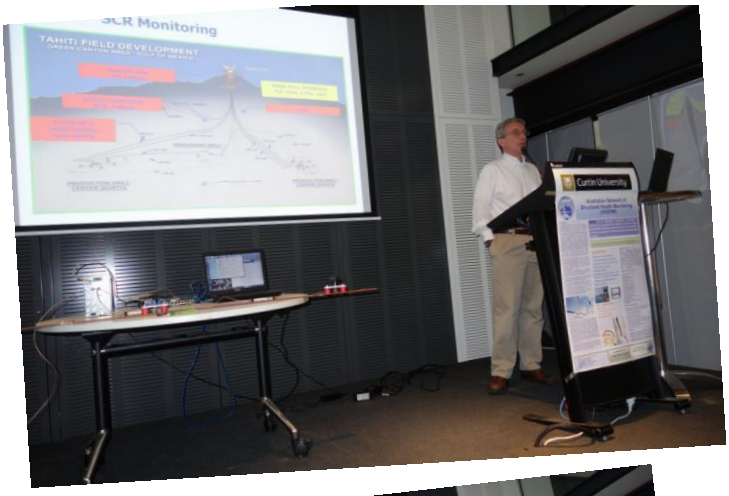
Oral Presentations III (26 November 2015)

Photo Gallery 7th ANSHM Workshop Ctnd..

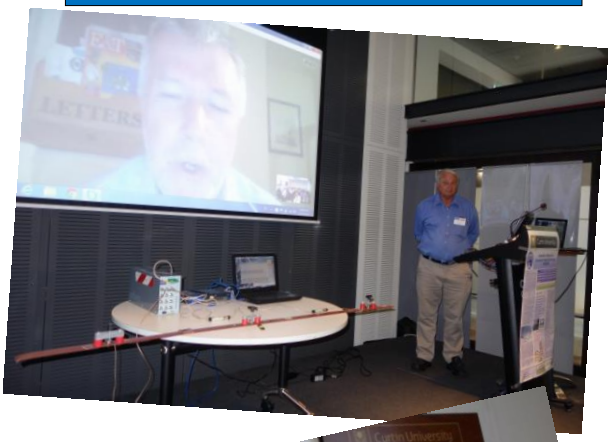
Afternoon Tea (26 November 2015)

Advisory Board Meeting

Photo Gallery 7th ANSHM Workshop Ctnd..



Industry Presentations III (27 November 2015)



Industry Forum (27 November 2015)

More photos of 7th ANSHM workshop can be viewed and downloaded from the following dropbox link
https://www.dropbox.com/sh/2j83nztgafbpayv/AAAN0pn1y0vII7NjChVZoipCa?dl=0

Research Achievement and Conference News

QUT makes structural advances

THE AUSTRALIAN | NOVEMBER 5, 2015 1:01PM SAVE

Jennifer Foreshew
Technology reporter
Sydney

Professor tommy Chan is looking at the structural health monitoring system in QUT's P Block and its successful detection of the two recent earthquakes.

- **"QUT makes structural advances"** is the title of the interview that the Australian recently made with Professor Tommy Chan (pictured) about the cutting-edge SHM technologies used in the Science and Engineering Centre (P block building) of QUT. During this interview, Professor Chan also talked about the possible benefits of having such an SHM system in comparison with the traditional inspection approach. Details about this interview could be retrieved online from the following link: http://www.theaustralian.com.au/business/technology/qut-makes-structural-advances/story-e6frgakx-1227597299419

- Mini-symposium "***Structural Health Monitoring for Performance Assessment & Recent Research by Australian Network of Structural Health Monitoring***" in the ***Second International Conference on Performance-based and Life-cycle Structural Engineering (PLSE 2015)***, 9-11 Dec 2015, Brisbane, Australia. Organized by Prof. Yi-qing Ni, Prof. Tommy Chan, and Dr. Saeed Mahini.
- ANSHM mini-symposium in the ***24th Australasian Conference on the Mechanics of Structures and Materials (ACMSM24)*** (http://civil.eng.curtin.edu.au/ACMSM24/), 6-9 Dec 2016, Perth, Australia. Organized by Prof. Tommy Chan, Prof. Jianchun Li, and Dr. Jun Li

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

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Welcome your any comments and suggestions, please contact

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