

Newsletter

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President Message
Tommy Chan

Professor in Civil Engineering, Queensland University of Technology

Dear All,

This month is really challenging for many of us. As we need to complete our ARC ITTC on SHM (ATCSHM) proposal for its submission in December as well as organising our special session at ACMMSM25 from 5-7 December 2018, our annual event of 10th ANSHM Workshop, the publication of this newsletter, etc. All that separately will already be not an easy task and in the past, it might take us to be in full gear to work on any of them but now we are able to deal with all that in the midst of preparing the ATCSHM submission. I am much indebted to the Executive Committee (EC) members.

We have a really strong proposal for this training centre and I am quite positive that we could get it awarded. We have 18 industry partners, which are government organisations including road authorities, national industry organisation and leading international companies with a considerable amount of cash contribution far exceeding our original target value. We also have Chief Investigators (CIs) with multi-disciplinary expertise from 11 universities across 5 states of Australia (Queensland, Victoria, New South Wales, South Australia and Western Australia). Also, regarding the alignment of the identified priorities of the ARC ITRP, we have been seeking advice from National Energy Resources Australia Growth Centre (Paul Hodgson, General Manager Innovation and Stakeholder Engagement (East Coast)) and Advanced Manufacturing Growth Centre (Michael Sharpe NSW/ACT Director) to ensure the Centre’s research activities match with the priorities of these two Growth Centres. In the last conversation, both of them were very happy with our proposal and considered that our proposal aligned well with their priorities. ARC keeps reminding the ITRP applicants to seek support from the growth centres of each of their six identified priorities and the proposed ITTC should be aligned with one of the identified priorities. We have support and confirmation from not only one but two identified growth centres. It is really encouraging!

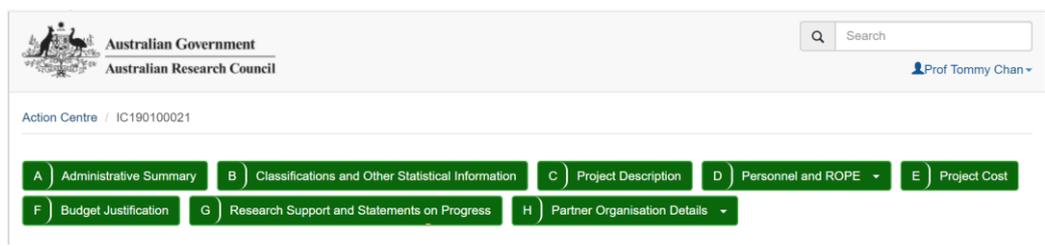
As mentioned earlier, preparing an ARC proposal for an ITTC is really a huge task. Just using our ACTSHM as an



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example, we have 23 CIs from 11 universities and 18 Partner Investigators (PIs) from the industry. Besides preparing the 15 page Project Descriptions and the Project Cost to budget that huge amount of cash contributions from the Industry Partners (IPs), each of the 11 universities and the asking amount of ARC (\$1M pa for five years) complying the requirements of ARC policies, e.g. ARC funding to be limited by \$1M per year without any year exceeding this amount, the travel amount could not exceed \$20k per year, we also need to collect information from them for their Research Opportunity and Performance Evidence (ROPE), the progress statements of their ARC projects, and help the partner industry with their final reports, without any of these, the project will become ineligible. One of the difficult tasks is to ask each of the PIs to set up an ARC RMS account so that QUT can invite them to the project. With the help of various CIs, all PIs have already set up their RMS accounts and supply all their relevant information.

Below shows the status of our application. It can be seen that we have all the buttons turned from red to green. The generated PDF of the proposal is of more than 470 pages! To me, I consider if we could complete all the details and submit the proposal for this ATCSHM, it is already a great achievement including the demonstration of our team capacity. Since all the EC members have joined the proposal as CIs, we consider the preparation of our ATCSHM should be not as difficult as other ITTCs. We have been working together for that many years and established the team spirit that any other ITTCs would not possess.



I really look forward to having this ANSHM ARC ITTC on SHM (ATCSHM) established next year to celebrate our 10th ANSHM. As mentioned before, because of the administration purpose (I am glad that the EC made this right decision, otherwise we will be unable to prepare and submit this proposal just because of the administration difficulties), we could have only the EC and the AB who are interested to join this proposed centre as CIs, except those who could secure cash contribution from the industry. However its establishment will definitely benefit the whole ANSHM organisations and its members. In the forthcoming Advisory Board Meeting (ABM), we will discuss how this ATCSHM could bring benefits to ANSHM.

While I am writing this President message, ARC announced the funding Discovery Project (DP) grants, Discovery Early Career Researcher Awards (DECRA) and ARC Linkage Infrastructure, Equipment and Facilities (LIEF) grant. Congratulations to Hong Hao, Chun Wang and Kaiming Bi for their successes in DP grants! The low success rate (22% for DP overall yet even lower for Civil Engineering and Mechanical Engineering) indicated their significant achievement. It is a pity that once again none of the projects related to SHM has been awarded. I would like to re-state the following that I mentioned in the President Message in the last Newsletter, Issue No. 17.

Not sure how many more of this kind of accidents need to happen before the authorities could realise the importance of SHM and provide more funding to research, develop and implement SHM technologies to avoid this kind of tragedies to happen again. Our proposal of establishing ANSHM ARC ITTC on SHM is timely!



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Below are the updates of the month.

Executive Committee (EC) Meeting

We had a very fruitful EC meeting on 22 November 2018. We spent a lot of time on the discussion around the ITTC proposal submission. We also discussed on the preparation of the 10th ANSHM Workshop including the preparation for the ABM and the Annual General Meeting (AGM) and other matters. The minutes will be distributed in the forthcoming ABM.

ANSHM ARC ITTC on SHM (ATCSHM) Proposal Preparation

i. Submission

As mentioned above, the ARC official deadline for the proposal is 12 December 2018, which clashes with the last date of the 10th ANSHM Workshop. However we expect that we should have completed the proposal for the final submission prior to the 10th ANSHM Workshop, unless there is anything happened out of our control. Actually QUT requires us to submit the proposal to the ARC on 3 December 2018. As ITTC proposals are different from ARC DPs or LPs, which involve a lot of eligibility checks by the Office or Research of the corresponding Administration Organisation to ensure all the required documents are included. Missing any of those information or documents will make the proposal ineligible and all our months of effort will become in vain, so it is reasonable to have the internal deadline being 9 days earlier than the actual submission.

ii. Proofreading

The proposal at the moment is under the internal review. Also, since it is a huge proposal, the EC has set up a proofreading team to eliminate all the careless mistakes as coordinated by Hong Guan. There will be three rounds of proofreading to check the consistency in acronyms and styles for the whole proposal including section headings and section numbers, cross references, number matching, one part and the others, missing or including incorrect universities and/or partner organisations, etc.

ANSHM 10th Annual Workshop

You should have received the Tentative Program (from Dr Jun Li) of our annual important event, the 10th ANSHM Workshop, as a Joint Event with the 5th Workshop of the Australian Chapter of the International Association of Protective Structures (IAPS-AUS), which will be held at University of Wollongong from 10 – 12 Dec, 2018. The transportation, accommodation and tentative program, etc., are included in the Tentative Program. If you have not received it yet, please send an email to Jun (junli@curtin.edu.au). I suppose that you should have registered through its online registration. Thank Tao Yu and Alex Remennikov for hosting and organising this ANSHM Workshop.

There will be 14 presentations together with an Industry Forum, entitled as “Managing Assets in A Digital World: Role of Structural Health Monitoring (SHM) Techniques”. As our tradition, the Industry Forum will be a highlight of the Workshop, which will be facilitated by Govinda. Many thanks to him for taking up this role. I will also give some updates on our ATCSHM. Look forward to meeting you all in the workshop!

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Annual Membership Renewal

We need to renew our membership around the time of AGM, which could be done similarly as previous years. If you are going to attend the coming ANSHM workshop, Jun representing Alex will record your presence and ask directly whether you want to renew your (ordinary) Membership. However for the Core Membership, as such membership needs to be approved by demonstrating commitments to ANSHM, so Alex will send emails to you asking whether you wish to be core members. Your ordinary Membership will be renewed upon your request while your Core Membership request will be reviewed and approved by the EC based on your attendance of the ANSHM Workshops in the previous two years.

11th ANSHM Annual Workshop

I am pleased to announce our 11th ANSHM Annual Workshop celebrating ANSHM 10th Anniversary will be hosted by the Griffith University as coordinated by Prof Hong Guan. Thank Hong so much for taking the initiative to host this important event of ANSHM. Hong will give us some introduction on this Workshop during the Closing Session of 10th ANSHM Workshop on 11 December 2018.

ANSHM Advisory Board Meeting (ABM) and Annual General Meeting (AGM)

Please be kindly reminded that we will have our ABM and AGM during the 10th ANSHM Workshop. The details for the two meetings are as follows:

ABM (Only for the ANSHM ABM and EC Members):

Date: 10 December 2018

Time: 15:00 to 17:00 (AEDT)

Venue: Building 43, Room G02, University of Wollongong, Northfields Ave, Wollongong.

AGM (For any ANSHM Members):

Date: 11 December 2018

Time: 12:00 to 12:30 (AEDT)

Venue: Building 43, Room G01 or G02 (Same presentation venue for 10th ANSHM Workshop), University of Wollongong, Northfields Ave, Wollongong.

Election of Executive Committee Members

You may have received my message dated 23 November 2018 on the Call for Nominations for Election of Executive Committee Members According to the Rules of ANSHM, the Nominations shall be called at least 14 days prior to the election during the forthcoming AGM on 11 December 2018. For this time, the two-year term of the following EC members will be completed:

Tommy Chan (President)

Jianchun Li (Deputy President)

Hong Guan

Xinqun Zhu

Tuan Ngo

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All these five EC members are happy to continue their service and are willing to be re-elected. In the upcoming ABM, we will also review the EC including the number of members required.

ANSHM Special Issues

ANSHM 3rd Special Issue in JCSHM

I am pleased to inform you the Foreword for this special issue has been published on-line (https://link.springer.com/article/10.1007/s13349-018-0308-1?wt_mc=alerts.TOCjournals&utm_source=toc&utm_medium=email&utm_campaign=toc_13349_8_5). The papers included in this special issue are Papers 7 to 17 on the reference list.

ANSHM 2nd Special Issue in SHMIJ

I am pleased to inform you that all the review process for all the papers has been completed. The production team of SHMIJ has confirmed that the publication date for the special issue will be January 2019.

ANSHM Special Session in ACMSM25

Although eight papers are accepted for presentation in our special session, because of the arrangement of the organising committee, one of the papers has to be presented outside the special session. Thank so much for the authors of this paper for accepting this unexpected arrangement. We also understand the difficulty of the organising committee to accommodate this paper within the special session. The ANSHM special session has been arranged on 5 Dec 2018.

In the next sections, Ying Wang describes a research project funded by Engineering and Physical Sciences Research Council, UK Research and Innovation, which focuses on identifying the loosening of the bolts in steel structures using measured strain and accelerometer responses. It's great to receive some update about his recent research at Surrey University. In another article, Andy Nguyen and his co-workers give an interesting introduction about the Centre for Future Materials at USQ and the current civil and SHM research programmes that are undertaken there. Also as mentioned in my last monthly updates, in this Issue, we also include a photo gallery for the photos taken during the ANSHM ARC ITTC on SHM Workshop in Sydney.

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

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An integrated physics-based and data-driven approach to structural condition identification: Progress report

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Introduction

Bolted connections with high tensile clamping forces are widely used in steel structure industries. However, after repetitive external forces and vibrations during the long service life of the structures, the bolted connections experience loss of preloads. Identification of loss in pretension is thus essential to ensure the safety of bolted connections and prevent the catastrophic failures of the entire structure (Doyle et al., 2010). A review of various monitoring methodologies for structures with bolted connections is given in (Wang et al. 2013). Limitations and promise of out-put only vibration data are described in (Milanese et al. 2008). With the recent advancements in data driven techniques for structural Health monitoring (Wang and Hao, 2013), the recent focus is to integrate both physics-based modelling and data-driven algorithms to identify structural damage. The current research project “An integrated physics-based and data-driven approach to structural condition identification” (<https://gow.epsrc.ukri.org/NGBOViewGrant.aspx?GrantRef=EP/R021090/1>), funded by Engineering and Physical Sciences Research Council, UK Research and Innovation, focuses on identifying the loosening of the bolts in steel structures using measured strain and accelerometer responses.

Project goals

The goals of the project are to:

- Develop an integrated deep learning algorithm for structural condition identification
- Perform strain and acceleration monitoring tests on a physical archetype, namely a steel beam with end connections
- Calibrate finite element (FE) models of the physical archetype based on monitoring test results through model updating
- Simulate structural responses under different scenarios by using the calibrated FE model to create initial training data for the deep learning algorithm
- Apply the integrated algorithm to structural condition identification and assess its performance

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Experimental test set-up

A single bay single storey steel frame is considered in this study. The columns are welded to the base plate which is then bolted to the strong floor. The experimental test set-up is shown in Figure 1. The geometric details of the frame and bolted connection details are shown in Figure 2, with specified bolt numbers shown in Figure 3. The location of accelerometers and position of impulse hammer is shown in Figure 4. Measurements are taken under different damage scenarios mentioned in Table 1.



Figure 1. Experimental test set-up

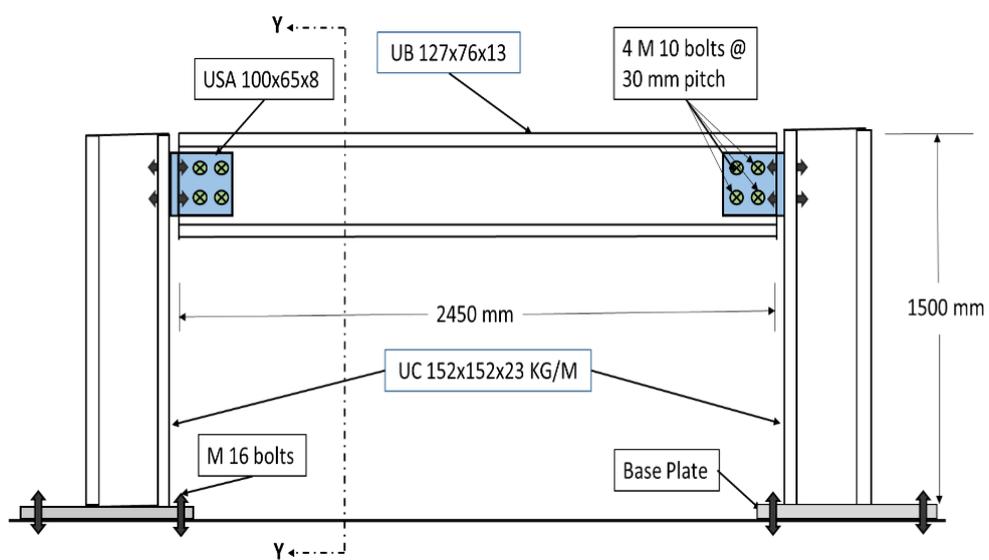


Figure 2. Frame components and connection details

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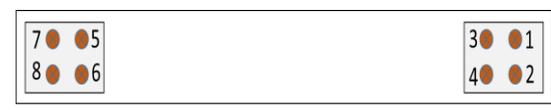


Figure 3. Bolt positions on the beam

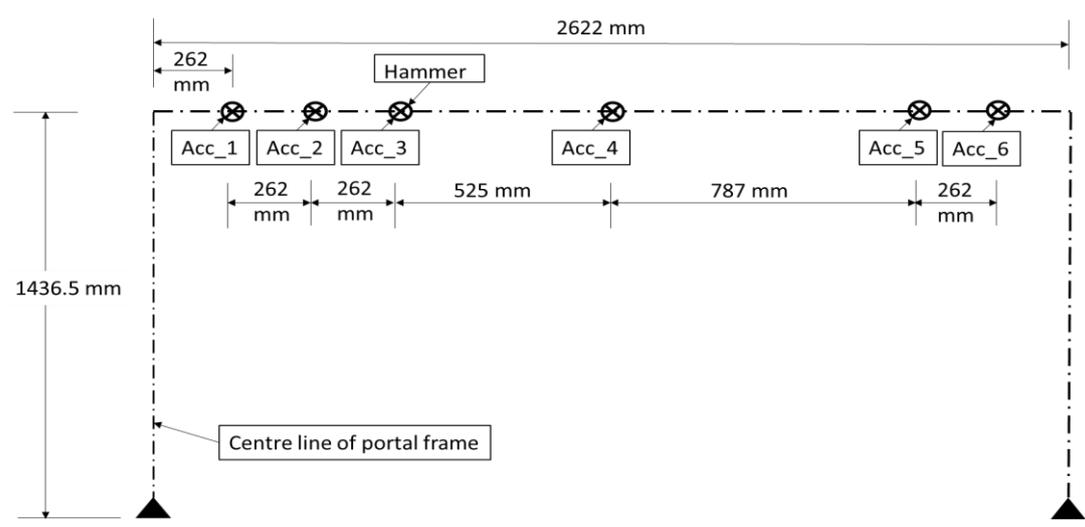


Figure 4. Location details of accelerometers and impulse hammer

Results and discussion

The measured frequencies and damping ratios for various damage scenarios are given in Table 1. From the results, it is clear that the change in frequencies and even the damping ratios is very small in most of the damage scenarios except damage scenario 6 when all the bolts are loosened. Most of the existing damage detection algorithms will be able to identify the damage scenario 6. However, the big challenge and the main objective of the project is to identify a few of the other damage scenarios, which are difficult using existing damage detection algorithms.

Table 1. Measured frequencies and damping ratios corresponding to different damage scenarios

Damage scenario	Bolt loosened	Percentage loosened	Measured frequencies, and damping ratio calculated by logarithmic decrement				
			1 st frequency (Hz)	2 nd frequency (Hz)	3 rd frequency (Hz)	4 th frequency (Hz)	Damping ratio
0	All tight	100	55.1	82.83	255	498	0.004
1	1	100	54.5	83	253	497	0.0044
2	3	100	55	83	254.5	498.5	0.0049
3	2	100	54.79	82.8	254	497	0.0052
4	1 & 2	100	54	81.5	251.5	494.4	0.0051



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5	1, 2 & 3	100	54.27	81.03	249.8	493.5	0.0054
6	1, 2, 3 & 4	100	53.8	78.6	248	485.5	0.0129
7	1, 2, 5 & 6	100	53.74	81.66	251	494.4	0.0045
8	1, 3, 5 & 7	100	53.54	82.6	254.3	495.3	0.0065
9	1 & 3	100	54.16	82.8	254.5	496.2	0.0056
10	1 & 4	100	54.68	83.22	254	497	0.0043

The steel frame is modelled using open source finite element software Opensees. The bolted connection is modelled using translational and rotational springs with varying stiffness. Modified Metropolis-Hastings algorithm (Zuev and Katafygiotis, 2011) is used in this study to update spring stiffness in the finite element model based on the measured responses. First four frequencies estimated from the updated finite element model of the frame with all bolts tightened are 58.18 Hz, 83.07 Hz, 256.09 Hz, and 497.17Hz respectively. The stiffness of the translational spring along the length of the beam, the stiffness of translational spring transverse to beam, and stiffness of rotational spring were estimated as 12×10^{11} N/m², 9×10^7 N/m² and 11×10^5 N/m² respectively.

High-frequency strain responses obtained using FBG sensors are also being considered in this study. The ongoing work focuses on developing an integrated data-driven and physics-based model for identifying the smallest possible damage (maybe loosening of a single bolt).

Acknowledgement

The authors would like to acknowledge Engineering and Physical Sciences Research Council, UK Research and Innovation, for the financial support to conduct experiments.

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Centre for Future Materials and Civil Engineering Research at USQ

Andy Nguyen, Allan Manalo & Peter Schubel*

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The Centre for Future Materials (CFM) at the University of Southern Queensland (USQ) is one of the leading research centres in Australia for engineered fibre composites and delivering R&D to reality. Established in 2016, CFM derived from its predecessor the Centre of Excellence in Engineered Fibre Composites, which was well known to be the only institutional contributor to the great success of the first Australian fibre composite bridge installed in 2002 by industry partner Wagners CFT. Since its establishment, a new USQ investment of \$1.2M has been directed towards the key competencies and associated unique equipment. CFM research grants have reached the total of \$5.7M, with the leveraged industrial funding of \$5.4M. CFM currently holds one CRC-P project, engaging in the Bushfire & Natural Hazards CRC, and nine research grants from Australia Research Council. Strong industry links have been established alongside over 1000 industrial test clients and more than 20 active collaborative partners.

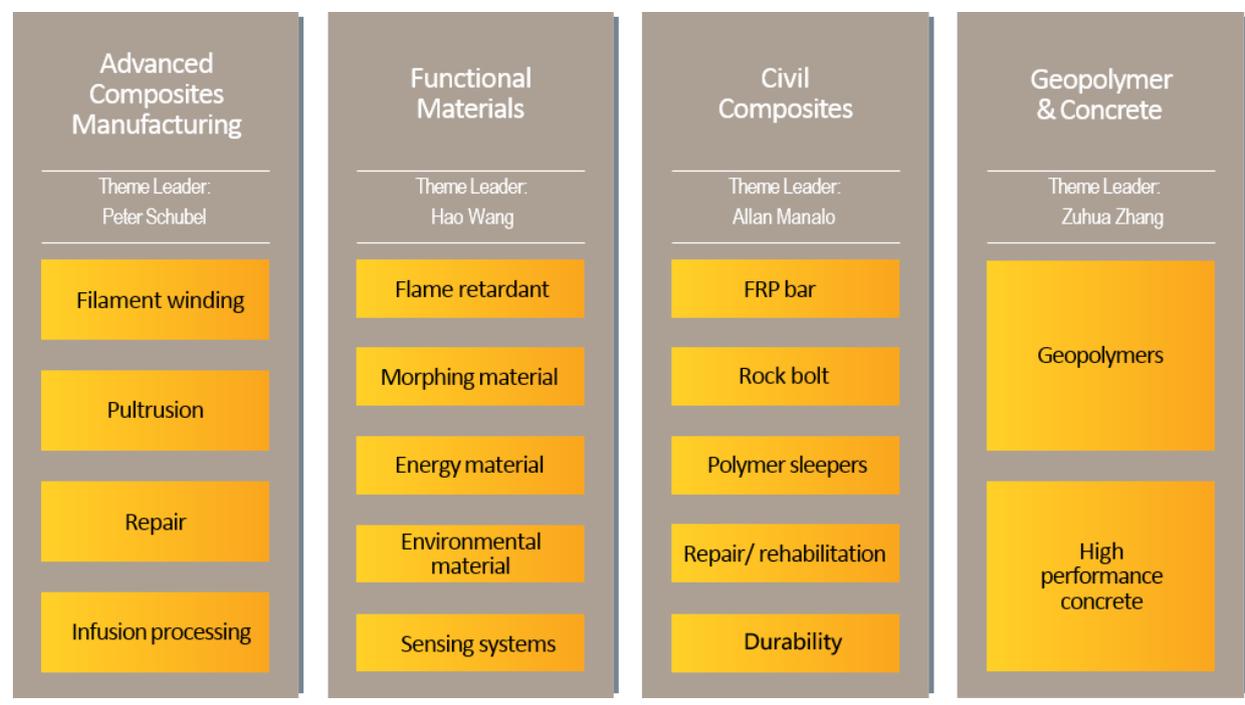


Figure 1. Research themes at CFM

Led by Centre Director, Prof Peter Schubel, CFM focuses its research engagement activities in four main research themes as shown in Figure 1. Advanced composites manufacturing research is focussed on automated manufacturing, process development, advanced infusion processing, and process



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modelling for the aerospace, space, defence and civil engineering sectors. The functional materials group aims to develop functional composites and composites for special applications including in-situ structural health monitoring (SHM) systems, nano material for high-efficiency energy conversion, and shape memory composites. Geopolymers and concrete group focus on the development of green cement and concrete, including geopolymer concrete and permeable concrete.

The civil composites group, led by A/Prof Allan Manalo, is revolutionising the Australian infrastructure industry, providing an alternative solution for civil engineering and construction through the use of fibre reinforced polymer composites and sustainable concrete. In collaboration with various industry partners and asset owners, this group has developed and applied novel composite technologies in an array of construction and through the repair of bridges, roads, railways and marine structures, to future-proof Australian infrastructure.

Structural Health Monitoring (SHM) research at CFM has two components (1) civil SHM located within the civil composites group, and (2) mechanical and aerospace SHM sitting in the functional materials theme. Coordinated by Dr Andy Nguyen, civil SHM research focuses on developing and applying cutting-edge monitoring and assessment technologies onto key civil engineering materials and structures such as large-scale buildings and major bridges. Alongside using contact measurement methods such as accelerometers, strain meters or FBG sensors, the Centre has recently acquired a state-of-the-art portable digital imaging correlation (DIC) system for non-contact deflection-strain measurement. Figure 2 shows a recent lab trial of the system and further developments are currently underway to demonstrate the capability of the full system particularly for field applications.

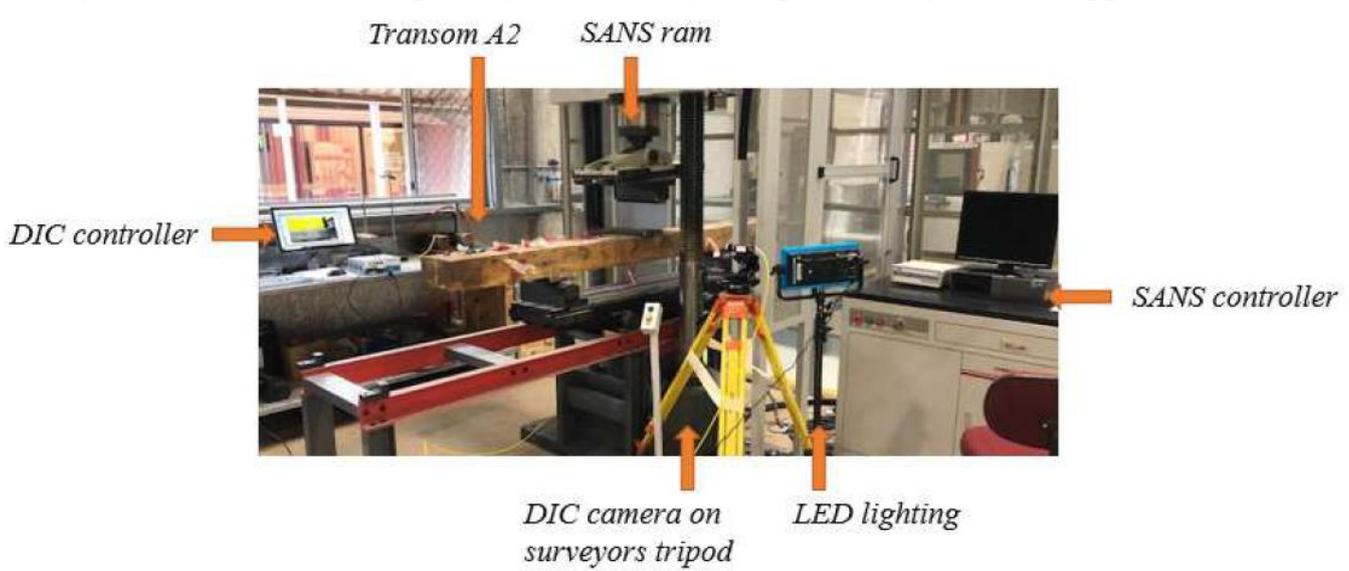


Figure 2. Lab trial of CFM's DIC system

For constant updates of CFM activities, please visit our dedicated LinkedIn page <https://www.linkedin.com/company/centre-for-future-materials/>



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Photo Gallery of Sydney

ANSHM ARC ITTC Workshop

on 11 October 2018



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*Photo Gallery of Sydney
ANSHM ARC ITTC Workshop
on 11 October 2018*



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Conference News

- **ANSHM special session “Latest advances on Structural Health Monitoring in Australia” in the 25th Australasian Conference on the Mechanics of Structures and Materials (ACMSM25), 4-7 Dec 2018, Brisbane, Australia. Organized by Prof Tommy Chan and Dr Andy Nguyen. <https://acmsm25.com.au/>**
- **9th International Conference on Structural Health Monitoring of Intelligent Infrastructure, 4-7 August 2019, St Louis, Missouri, USA. <https://shmii-9.mst.edu/>**
- **12th International Workshop on Structural Health Monitoring, 10-12 September 2019, Stanford, California, USA. <http://web.stanford.edu/group/sacl/workshop/IWSHM2019/index.html>**

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

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