AUSTRALIAN NETWORK OF STRUCTURAL HEALTH MONITORING

Newsletter

Issue 3, March 2015

Contents

President Message

Tommy Chan

Professor in Civil Engineering, Queensland University of Technology

Dear All,

Frist of all, I would like to congratulate Dr. Saeed Mahini for being appointed as Director NSW/ACT of ASCE Australia Section. The ASCE Australia Section Board of Directors, has six members include the president (Prof Mark Bradford), Vice-President, secretary, treasurer and Director NSW/ACT. Saeed has been working hard for being our External Affairs Officers. I really appreciate his effort and contribution to ANSHM for that many years. He will continue to serve as our External Affairs Officer and with this new position, Saeed could help to strength the link between ANSHM and ASCE as well as obtain the ASCE's support for SHMII8.

As now is still within the first fifteen days of the Chinese New Year (according to Chinese customs, we celebrate the New Year for the first fifteen days), so I would also like to wish you all

A Blessed Chinese New Year!

Each year, we have an animal to represent the year. For this year, you may have seen that 2015 is the Year of the Sheep. But also, the Ram, or the Goat? It seems that there is no unique English name for the year. In Chinese, 2015 is the year of 羊 or “yang” and most often many Chinese New Year images show the animal with large horns. This can help to determine whether it is a sheep, or a goat, depending on how the word for the animal is translated from the Chinese language into English. It can be seen that just for a simple Chinese word will cause so many different English translations. Sometimes even for a simple term, it may have different definitions. Just like the term “Structural Health Monitoring”, there are different definitions given by different researchers, according to their understandings. As stated in our book “Structural Health Monitoring in Australia”, most often, researchers relate Structural Health Monitoring with damage detection that could be reflected by how they define Structural Health Monitoring. However, those who have experience in SHM for real structures will agree that SHM should not be confined to damage detection only. Actually out of the fifty odd installed sophisticated SHM systems for real civil structures, damage detection only play a minor part in the systems. Sometimes, one could even find that existing damage detection approaches will not be effective in the SHM of large complicated civil structures. However SHM has been found extremely useful in those systems for the asset managers and the authorities. Therefore in our book, the definition of Structural Health Monitoring is given as

> *Structural Health Monitoring is the use of an on-structure sensing system to monitor the performance of the structure and evaluate its health state.*

Hence, Structural Health Monitoring should be composed of two components: Structural Performance Monitoring (SPM) and Structural Safety Evaluation (SSE). Structural Performance Monitoring refers to the monitoring (observation) of structural performance in structure and its components under its (their) designated performance limits (or criteria) at serviceability limit states (SLS) by on-structure instrumentation system. In contrast, Structural Safety Evaluation refers to the evaluation of possible damage or deterioration in the structure or its components and/or the assessment of its health status by analytical tools, which are developed and calibrated in the course of structural health monitoring, based on its (their) designated performance limits at ultimate limit states (ULS).

Similarly, in the next edition of AS5100, which includes a section on SHM, SHM is defined as

> *Structural Health Monitoring (SHM) involves the use of various sensing devices and ancillary systems to monitor the insitu behaviour of a structure to assess the performance of the structure and evaluate its condition.*

The performance of the instrumentation system for structural health monitoring should be devised in accordance with the structural performance limits at SLS, and the analytical tools for structural safety evaluation should be developed and calibrated to identify and quantify the existence and cause of damage or deterioration respectively, based on the structural performance limits defined at ULS. Such approach makes structural health monitoring acceptable to bridge engineers because its design and operation comply with the codified requirements for structural design, construction and maintenance—the legal basis for monitoring and evaluation. Hence, other than structural safety evaluation, the key functions of development and deployment of a Structural Health Monitoring, are:

(i) to improve/enhance the current practice of structural inspection and maintenance from local and subjective condition to global and objective condition;

(ii) to provide data and information for updating/amending the contemporary structural design manuals, standards and codes which are the standards for future works of :

(a). design & construction of new structures

(b). maintenance & rehabilitation of old structures.

In order to perform such functions, an SHM system will involve sensory system that could monitor three different areas, namely: environment, traffic loads, bridge responses (including bridge features). In the monitoring of traffic loads, in this issue Colin gives a very good account of how the technologies of weigh-in-motion help in SHM. Besides, Xinqun gives a brief account of their Institute for Infrastructure Engineering and their research and development in SHM.

Special Session/Mini-Symposium in SHMII-7 2015

For our mini-symposium in SHMII 2015, we have received 10 papers and sent off the acceptance email to the authors. In terms of other interested participants, we will send an email to them individually to see when they could submit the full papers. It seems that we could showcase very well our Australian achievements in SHM in this important SHM conference.

Special Issue in SMM

Regarding the special issue in SMM, we have received 7 papers and one more is expected to be submitted soon. We are almost ready to trigger our review process and we will avoid too many papers being allocated to one reviewer. Thank Ying, Jun and Saeed, especially Ying, so much for their effort.

APWSHM 2016

The next Asia - Pacifica Workshop on Structural Health Monitoring (APWSHM) will be held in Hobert, Tasmania in 2016. This is the third time that APWSHM being held in Australia. We will discuss in the next Executive Committee about our involvement in this important SHM event in Australia.

Our Next Executive Committee Meeting

Our next executive committee meeting will be scheduled in early March 2015. This is an important meeting as it is our first meeting after our last AGM and ABM. We will try to consolidate what we have discussed in these two meetings. You are also welcome to send me by 4 March 2015, any suggested items for discussion.

With kind regards,

Tommy Chan

President, ANSHM

www.ANSHM.org.au

Institute for Infrastructure Engineering

University of Western Sydney

Institute for Infrastructure Engineering at UWS

Bijan Samali

Professor and Director, IIE at UWS

The Institute for Infrastructure Engineering (IIE) is one of four research institutes at University of Western Sydney (UWS) initiated by the Foundation Director Professor Brian Uy as part of the university's strategic plan to support selectivity and concentration. The Institute has four Program Themes:

Program 1: Infrastructure Systems is a central theme of the Institute. This program involves the analysis, assessment, design, maintenance and repair of infrastructure systems, an area of wide application. The research is concerned with the safety and reliability and mitigation strategies of infrastructure systems such as bridges, buildings, dams, hoppers and silos, roads, and water distribution systems (pipe networks).

Program Director: Professor Bijan Samali

Program 2: Infrastructure Computations. One of the research foci is on computational methods. Computational methods have played a major role in the advancement of many engineering disciplines over the last few decades. Computational methods can be used as efficient and reliable tools to solve challenging engineering problems when conventional experimental approaches become intractable or inefficient.

Program Director: Professor Kenny Kwok

Program 3: Infrastructure Materials. This program covers the development, application, characterisation, recycling, remediation, disposal, modelling and monitoring of engineering materials as part of infrastructure design, development and management. Engineering materials include both natural resources and man-made materials such as soil, water, cemented soil, geofoam, concrete, steel, composite materials and recycled concrete.

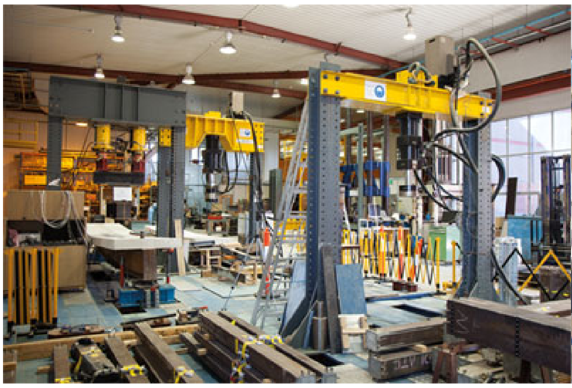
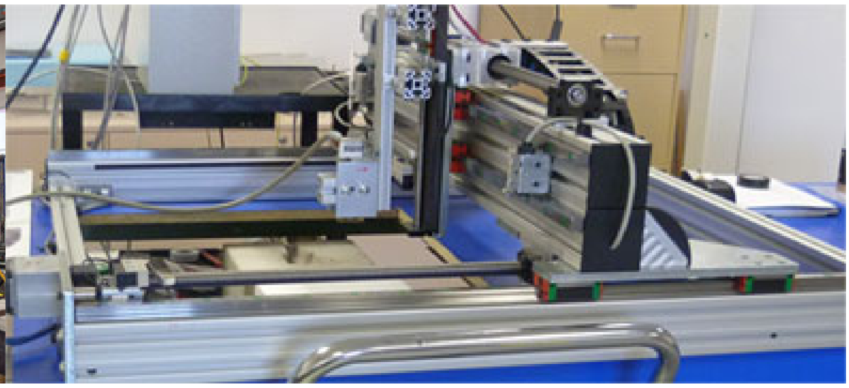
Program Director: Professor Zhong Tao

Program 4: Infrastructure Health Monitoring. This program includes two primary non-contact techniques for structural health monitoring. These include image processing and signal processing techniques. In addition this theme will incorporate smart structures and structural control methods.

Program Director: Associate Professor Sergiy Kharkivskiy

The Institute is committed to excellence and is home to world class research facilities including one of Australia's best laboratories for independent testing and monitoring for the construction and manufacturing industries. The Structural Research and Testing Laboratory at the UWS Kingswood campus holds NATA accreditation No. 14711 since 2003 and it complies with ISO/IEC 17025: 2005 for providing Mechanical and Structural Testing Services. These services include both static and dynamic testing of materials, structural components and assemblies at the research laboratory or on site. The 1000 tonne capacity multi-purpose structural testing facility for testing specimens and assemblies is up to 4m high with simultaneous loading from dual actuators at 500kN tilting load each at 3Hz synchronous or asynchronous loading. The 64-channel PXI data acquisition system for dynamic testing of structures and assemblies will be used for experimental program in this research. The CPU and one GPU based high performance computer cluster for the analytical program in this research has computational power of 2060 GigaFLOPS.

For more information on IIE, please visit: www.uws.edu.au/iie/home

Weigh-In-Motion for Structural Health Monitoring of Bridges

Colin Caprani

Lecturer, Department of Civil Engineering

Monash University

In a nutshell, structural health monitoring (SHM) aims to determine the state of an engineering system through its output (Figure 1). Changes in output are used to infer changes in the system, enabling condition monitoring and damage detection. The lack of focus on the input to the system is presumably because in most cases the inputs are extremely difficult if not impossible to measure accurately. As an example, it is not viable to measure the spatially-distributed wind loading on a building through time. However, when it comes to bridges, the major inputs to the system are readily measured, and should therefore not be overlooked when it comes to implementing SHM solutions for bridge health monitoring. Indeed, it is intuitively obvious, without recourse to frequency-domain mathematics, that measurement of both the input and output will yield better estimates of the system parameters, and hence more reliable estimates of bridge condition. Setting aside temperature effects, for highway bridges a major form of excitation to the system is the traffic loading. Through time, knowledge of both the input and output can yield ever-improving and adapting estimates of the system parameters. The challenge then, is suitable measurement of the traffic loading input to the system.

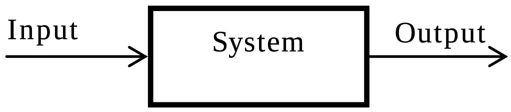


Figure 1: Basic representation of engineering system.

Weigh-In-Motion (WIM) is the technology that allows for unbiased measurement of traffic characteristics (in comparison to static weigh stations, for example). WIM has developed enormously over the last two decades, and although not quite accurate enough for legal metrology purposes (catching overweight vehicles akin to speed cameras), it has good accuracy for SHM purposes. WIM comes in roughly two forms: pavement-based systems, and bridge-based systems. In pavement-based systems (essentially) point sensors weigh individual axles and, along with timestamps, an algorithm infers gross vehicle weight (GVW), number of axles and axle spacings. Further algorithms can then identify vehicle class from this information. Pavement-WIM systems have good individual axle weight accuracy, but less so for overall GVW. On the other hand, Bridge WIM (B-WIM) systems use the bridge itself as a weighing scales, and so GVW estimates can be good, with lesser accuracy for axle weights. Typically strain readings at several locations are taken to establish axle spacings and the number of axles. What is particularly useful for bridge SHM, is that B-WIM systems are calibrated (using vehicles of known parameters) so that the actual influence lines for each of the sensors is determined, and this is used in the algorithm to weigh unknown vehicles. These measured site influence lines offer a window into the actual structural behaviour of the bridge, and are often significantly different to theoretical influence lines (Figure 2). Indeed, bearing friction, and other nonlinearities, can change the service load behaviour of the structure significantly. For SHM, the knowledge found in this way is invaluable for learning about the system (Figure 1).

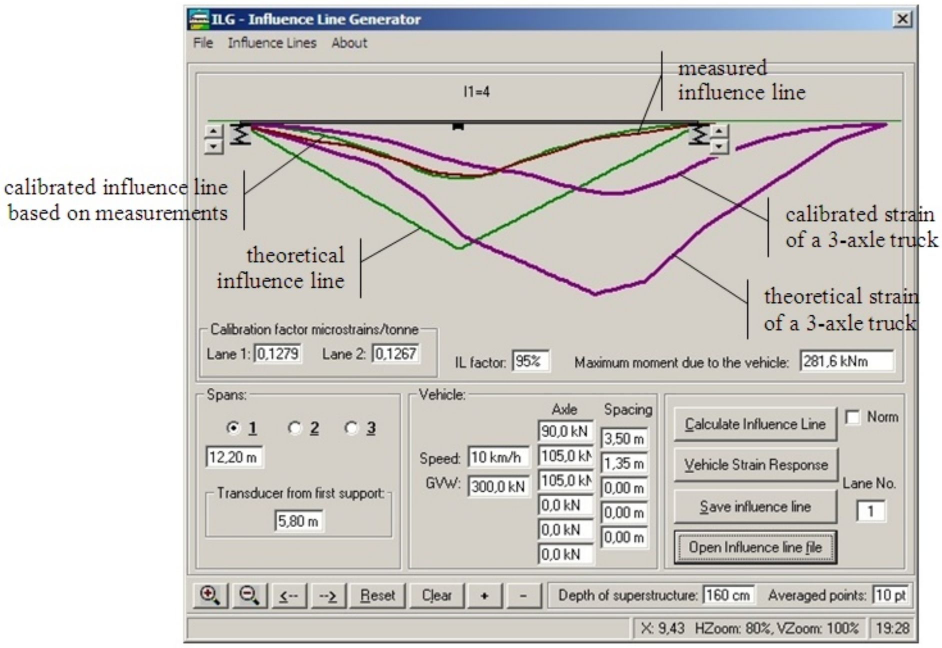


Figure 2: Comparison of theoretical and B-WIM measured influence lines (with strain responses from 2 3-axle trucks). The rating factor for the real influence line is 1.46 (safe), and for the theoretical is 0.68 (unsafe) thus verifying bridge safety. (SAMARIS Project, Deliverable D30, 2006)

Finally, for those involved in implementing WIM systems as part of bridge SHM, there are several aspects that are vital to consider. Unfortunately many installations fail to address some of these points, rendering the data usefulness less than optimum. It is important to capture vehicle arrivals to the nearest 0.01 seconds – many systems only measure to the nearest second, and for simulation and modelling purposes, this is not accurate enough. Some systems only output axle group weights, without identifying whole vehicles, as is required for back calculation of traffic loading (any load effect of interest). Some B-WIM system algorithms cannot distinguish multiple vehicle presences, which, ironically, are the critical events to capture. Lateral lane position is also important for localized effects, and for pavement condition monitoring and is not common in WIM systems. Even more challenging parameters for systems which could have applications, are the tread width for each axle, the number of tyres, and the front and rear bumper overhangs (to give full vehicle length).

Figure 3: Installation of a pavement WIM system sensor.

Figure 4: Example critical vehicle captured by WIM (courtesy Rijkswaterstaat, Netherlands).

In summary, WIM measurements should be an integral part of any bridge monitoring scheme. Knowledge of both the system input and output will allow better structural behaviour and condition assessment. Some characteristics of WIM systems for such purposes have been discussed.

The 6th Workshop of ANSHM

Xinqun Zhu

University of Western Sydney, Penrith, NSW2751, Australia

The 6th Annual Workshop for Australian Network of Structural Health Monitoring (ANSHM) was successfully held by School of Computing, Engineering and Mathematics (SCEM) and Institute for Infrastructure Engineering (IIE) at the University of Western Sydney (UWS) on 8-9 December 2014. About 50 participants from 13 different organizations attended the workshop and 12 presentations related to recent developments in structural health monitoring in Australia were given. The industry forum provided a platform for the industry to share their views on how structural health monitoring could help to meet industry needs. The workshop strengthened the collaboration with colleagues in the area of structural health monitoring in Australia, especially with the industries.

Conference Information

- Mini-symposium "***Research Advances in Structural Health Monitoring – Australian Experiences***" with the ***7th International Conference on Structural Health Monitoring of Intelligent Infrastructure (SHMII 7)***, 1-3 July 2015, Torino Italy. Organized by Prof. Hong Hao, Prof. Tommy Chan and Dr Jun Li.

  Full paper submission deadline: 15 Mar 2015. http://www.shmii2015.org/ Email: Hong.hao@curtin.edu.au, tommy.chan@qut.edu.au, junli@curtin.edu.au

- ***The 6th International Symposium on Innovation & Sustainability of Structures in Civil Engineering***, 26-27 July 2015, Beijing, China. Organized by Tsinghua University.

  Full paper submission deadline: 15 Mar 2015. http://www.isiss2015.org/ Email: isiss2015@163.com

- ***Special Session "Innovations in Reliability and Safety Evaluations of Civil Infrastructure"*** with **The Symposium on Reliability of Engineering System** (SRES 2015), 15-17 Oct 2015, Hangzhou, China. Organized by Prof. Shaofei Jiang, A/Prof. Yang Wang, Dr. Jun Li and Dr. Sheng-en Fang.

  Full paper submission deadline: 30 April 2015. http://www.sres2015.org/ Email: junli@curtin.edu.au

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  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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