AUSTRALIAN NETWORK OF STRUCTURAL HEALTH MONITORING

Newsletter

Issue 8, June 2016

Contents

President Message

Tommy Chan

Professor in Civil Engineering, Queensland University of Technology

Dear All,

One of the important news that draws our attention this month should be the official opening of the Lonjiang Grand Bridge in southwest China's Yunnan Province. It is the longest and highest suspension bridges in Asia. It has a total length of 2,470m with a main span of 1,196m, connecting two mountains with its deck sitting 280 m above the river. After it passed a load test in early April it had its opening ceremony on 20 April 2016 and is officially opened to traffic on 1 May 2016. Same as many other important bridges, this longest and highest suspension bridge also has a sophisticated structural health monitoring system. According to the designer of this SHM system, Bridge Science Research Institute in China (www.brsi.com.cn), a total number of 278 sensors under 16 categories have been installed on the bridge, which could monitor the loading and responses of the bridge and could alert the bridge management team for any abnormal performance and behaviour of the bridge. It also uses the latest technologies in GIS, mobile network and electronic inspection. The SHM system helps a lot in the load test and the measurement at that time provides valuable bench mark data at its healthy state for its future comparison.

It can be seen again that the SHM system of the Lonjiang Grand Bridge, similar to other existing SHM systems installed all over the world, is mainly for the performance monitoring. As I always stressed that SHM should not be confined to damage detection only. SHM should have two

components: Structural Performance Monitoring (SPM) and Structural Safety Evaluation (SSE). As stated earlier,

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; whereas Structural Safety Evaluation refers to the evaluation of possible damage in 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, basing on its (their) designated performance limits at ultimate limit states (ULS).[1]

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 respectively, basing on the structural performance limits defined at ULS.

This month I had two important ANSHM meetings, one with the Executive Committee on 10 May for our EC meeting and the other with Saeed on SHMII-8 on 16 May 2016. There is so much to report but I will try myself to make it brief. Below are some updates of the month.

Research Collaboration

i. Linkage Opportunities

As proposed within the Australian Government's National Innovation and Science Agenda, the ARC is restructuring the Linkage Projects scheme to allow for continuous application submission. The ARC has advised that Linkage Projects application forms will be available in the ARC's Research Management System (RMS) when the scheme opens on 1 July 2016. In other words, this continuous application round will start from July 1, 2016 and they allow submissions of the applications every month. This important change will be very helpful for government organisations to participate a

1. Chan, T.H.T., Wong, K.Y., Li, Z.X. and Ni, Y.Q. (2011) "Structural Health Monitoring for Long Span Bridges – Hong Kong Experience & Continuing onto Australia" Chapter 1 in *Structural Health Monitoring in Australia*, edited by Chan, T.H.T. and Thambiratnam, D.P., Nova Publishers, New York.

particular project as they don't have to wait for a long period before they know that the project could be funded or not. It opens a great opportunity for ANSHM.

ARC recently sought stakeholder feedback through a consultation process and is yet to release the specific details on how the scheme will be changed from past rounds. Although the corresponding funding rules have not been released yet, we could start working on it. The *Funding Rules for schemes under the Linkage Programme, including Linkage Project commencing in 2016* could be used as a reference for the time being.

Therefore the Research Collaboration Task Force (RCTF) coordinated by Jianchun will look after that and he will work with Tuan, Alex, and myself to plan how ANSHM could make use of this golden opportunity. We could first explore how much we could secure from the Industry Partners. The Policy for Participating the Linkage Project could be as follows:

a. Try to include the all members
b. Priority in the directions of the project will be given to those who are able to secure cash contribution from the Partner Organisations
c. The regional factors of the confirmed Partner Organisations and/or the amount cash contribution from a Partner Organisation that could be secured by a particular institution will also determine the amount of support to a particular institution.

ii. SHM Projects from the Industry

Recently, I received a few calls for collaborations or EOIs from the industry for projects related to SHM. It is a good sign that it seems that SHM is getting more and more attention from the industry. One of the projects is a SHM related project conducted under the Curtin Advanced Technologies Research and Innovation Alliance (CATRINA) http://humanities.curtin.edu.au/research/centres/bim/catrina/. CATRINA is a newly established industry and research collaboration alliance at Curtin University, established by Curtin with foundation partners Shell Australia and Woodside Energy. They require an individual Express of Interest to Participate to be submitted by 15 June 2016. It will be good if some of the ANSHM members could participate the project as individuals. For those who are interested to participate this project, please contact me or other EC members for details.

iii.ARC Industrial Transformation Research Programme (ITRP)

ARC has just released their call for a Notice of Intent (NOI) for the two schemes of this programme:

- Industrial Transformation Research Hubs
- Industrial Transformation Training Centres

As mentioned earlier, ANSHM is very interested to participate in this programme. However unfortunately once again, none of the identified Industrial Transformation Priorities for this call could be related to SHM. However we will still keep ourselves prepared when the opportunity comes.

SHMII-8

It is really appreciated that Saeed came all the way from Armidale to my office in Brisbane to spend the whole afternoon of 16 May 2016 to plan for the SHMII-8. It is important that we need to use this event to showcase the world that this international top SHM conference series will be having its best in Australia. Below are some updates regarding the organisation of SHMII-8:

- It is good to know that QUT Conference has appointed Claire Vaz as the Event Manager in particular to SHMII-8, for general secretarial assistance including minutes taken, venues management, AV support etc., which is of great help to us.
- Although we have set up LOC and sub-Committees (Secretarial, Operational, publicity and financial) and tasks have been allocated, we will continue to invite more people to join us where necessary.
- Invitations to keynote speaker are currently ongoing. We plan to have two from US, one from Europe, one from Japan, one from the Mainland China and one from HK
- Industry partner, sponsorship, exhibition and show, etc. will need to be worked on and Jianchun with Jun, Lei and Ying. We are preparing a brochure to assist us approaching potential sponsors and exhibitors in this regards and these potential sponsors and exhibitors are being identified. It is suggested all EC members to approach their Heads of School, Deans, etc. for sponsorship.
- We need to report our progress to ISHMII at their Council meeting at CSHM-6 –Belfast (26-27 May 2016). Since we do not have anyone attending CSHM6, we could only send a PowerPoint presentation for this. With the help of Saeed and Claire, we have prepared the PowerPoint slides and sent to ISHMII.
- We are also exploring an effective way for the paper review process. Hong Guan, Lei and Xinqun have shared their similar experiences in that. Andy is comparing two paper review platforms, Open Conf and Easy Chair.

As mentioned earlier, there are many ANSHM members who have very rich experience in organising international conferences. Any advices, suggestions and volunteers of help will be much appreciated.

8th ANSHM Workshop

In our last Executive Meeting, we have confirmed to have the 8th ANSHM Workshop on 29-30 Nov 2016 (Tuesday to Wednesday). Make sure to pencil down the dates (29 to 30 November 2016) for the Workshop in your calendar. Please note that the IAPS (International Association of Protective Structures) Workshop is scheduled on 28 November 2016, the day before the ANSHM Workshop and also it will be free for all ANSHM members to attend. More details about these two workshops will be provided in due course. Besides, please keep an eye on my monthly updates. We believe the 8th ANHSM Workshop will be another successful event in the series.

ANSHM Special Issues

JCSHM

We are pleased to inform you that the special issue is going to be published as scheduled in the Journal of Civil Structural Health Monitoring Vol. 6, No. 3 in June. There are ten papers in this special issue with five papers from us and another five normal papers. It is a pity that there are still three papers under review and cannot be included in this special issue. I should thank Xinqun and Bijan for their efforts in editing this special with me. Finally, we would like to express our sincere gratitude to Prof. Farhad Ansari, the Editor-in-Chief of the Journal of Civil Structural Health Monitoring for his encouragement and support in helping us to put together this special issue.

Earthquake and Structures

We have received 12 papers for this special issue. The first round review of many of them has been finished.

International Journal of Lifecycle Performance Engineering

So far we have received two papers for this special issue. We expect more will be coming around the deadline (31 May 2016) of the full paper submission. Please note that although this special issue is mainly for papers related to the 7th ANSHM Workshop, any papers reporting SHM research in Australia or related to SHM researchers in Australia are also welcome. All papers must be submitted online and please indicate clearly you are submitting to this Special Issue. Please go to the link (http://www.inderscience.com/info/ingeneral/cfp.php?id=3120) for details.

ANSHM mini-symposium at ACMSM24

We have received 13 abstracts. The ACMSM24 Conference secretary has sent the corresponding authors each a full paper acceptance letter and full paper template. Please contact Jun (junli@curtin.edu.au) if you have not received the full paper acceptance letter. Please note the deadline of full paper submission is 9 June 2016. You could visit conference website http://scieng.curtin.edu.au/acmsm24/ for more information and updates.

ANSHM Executive Committee Meeting

As mentioned earlier that we had our EC meeting on 10 May 2016. Many issues that we discussed have been reported in this President Message. The minutes will be forwarded to the EC and AB members in due course.

Regarding this issue of ANSHM Newsletter, we have two interesting articles related to SHM techniques used for construction. Dr. Yee Yan Lim of the Southern Cross University describes how wave propagation technique employing smart piezoelectric (Lead Zirconate Titanate, PZT) transducer could help effective concrete hydration and strength monitoring to ensure safety while maintaining cost effectiveness. Dr. Lei Hou of Griffith University also describes how advanced innovative visualisation technologies will help to improve efficiency and expedite the process of developing the complex procedural skills in operating and maintaining oil and gas facilities so as to improve the productivity and safety of its workforce.

With kind regards,

Tommy Chan

President, ANSHM

www.ANSHM.org.au

AUSTRALIAN NETWORK OF STRUCTURAL HEALTH MONITORING
Newsletter

Smart Piezoelectric based Concrete Strength Monitoring

Yee Yan Lim[1]

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Smart based Concrete Hydration Monitoring

In a competitive environment, intensive construction schedule prompted by financial constraint often poses great challenge to the construction industry. One of the key factors affecting the time frame is the waiting time for removal of formwork and shoring system in a staged construction project. This is especially critical if a project involves in-situ concrete construction. Safety consideration often prevents early removal because loading on concrete of insufficient strength can be catastrophic. As a result, an effective concrete hydration and strength monitoring technique is critical to ensure safety while maintaining cost effectiveness.

Conventional techniques such as ultrasonic pulse velocity and rebound hammer tests often suffer from drawbacks such as time-consuming, labor and cost-intensive, exposing inspectors to dangerous environment, and inapplicable to critical but inaccessible locations. Recent development of wave propagation (WP) technique employing smart piezoelectric (Lead Zirconate Titanate, PZT) transducer demonstrated its capability in overcoming the shortcomings of its conventional counterparts.

In the WP technique, two or more PZT transducers are permanently bonded onto the host structure using high strength adhesive at predetermined distances. One of the patches is assigned as an actuator and is excited by a transient voltage in the form of five-peak tone burst. The coupled mechanical vibration induced by the piezoelectric effect would generate a mechanical wave, travelling through the medium. Another patch, acting as sensor, would be triggered by the mechanical wave and converted it into electrical signatures. As the concrete hardens, it becomes stiffer and thus affecting the velocity of the propagating wave. Consequently, the amplitude and time of flight (TOF) of the wave packet are altered.

A study was conducted to investigate the feasibility of monitoring mortar curing process using the WP technique. Two concrete prisms (100 mm x 100 mm x 500 mm) of different strength were prepared. Water to cement ratios were set at 0.3 for H series (high strength) and 0.4 for L series (low strength). Three piezoelectric patches (15mm x 15mm x 0.5mm) were surface bonded onto each specimen. A Waveform Generator was used to generate a 10 V five-peak tone burst at 120 kHz and the signal of the sensor was measured by a Digital Oscilloscope, as schematically presented in Figure 1.

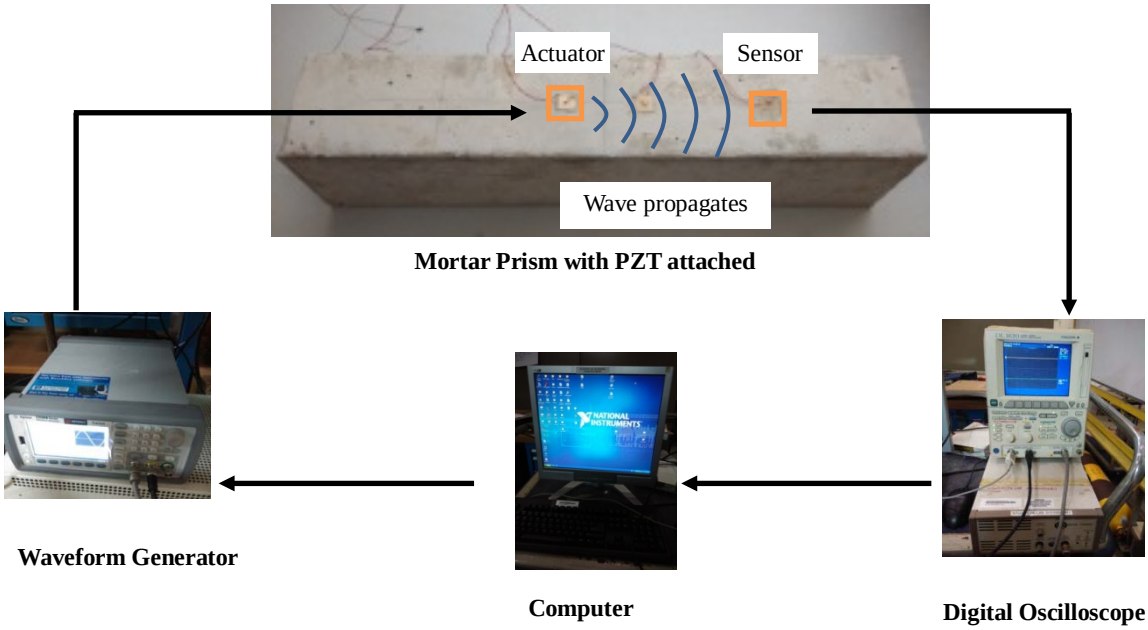

Figure 1: Experimental setup of WP technique

Velocity of surface wave can be calculated by measuring the TOF between actuator and sensor of known distance. TOF is the time difference between the wave packet of the actuator and the wave packet of the sensor (Figure 2). Multiple PZT transducer spaced at various spacing can be used to eliminate zero error of the instrument and to minimize the effect of heterogeneity. The pressure waves travel at higher speed than the surface waves. Thus, the first wave packet in the sensor's electrical signatures is induced by the pressure wave while the second wave packet is excited by the surface wave. Signal processing techniques such as cross-correlation and Hilbert transform were applied to achieve higher accuracy (Figure 3).

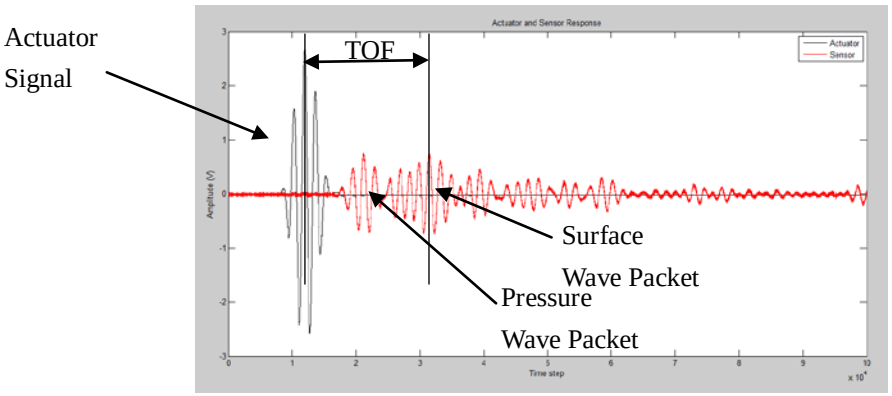

Figure 2. Wave packets and TOF of surface wave

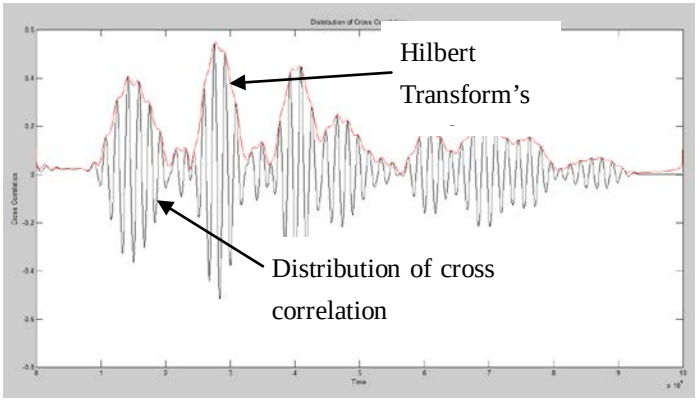

Figure 3. Distribution of cross correlation and Hilbert Transform's envelope against curing time

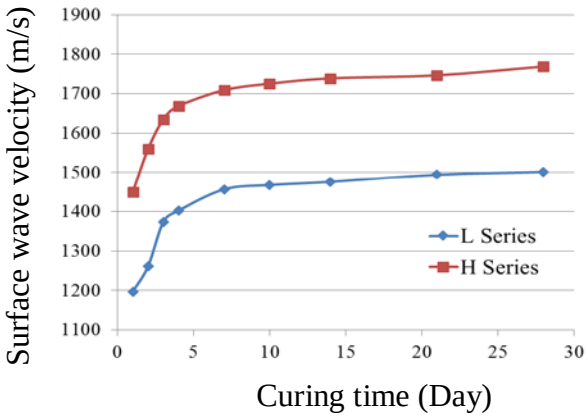

Figure 4. Surface wave velocity versus time

Figure 4 illustrates the relationship between the surface wave velocity, obtained from the electrical signatures and the curing time. As the concrete hardened with time, the velocity increased, implying an increase in stiffness and strength of the concrete. The wave velocities of H series were consistently higher than L series, indicating that the stiffness and the strength of H series were higher than the L series.

This preliminary result demonstrates the effectiveness of this technique in monitoring the concrete curing process. Further study is required to create a complete model that correlates the wave velocity and the concrete strength that enables accurate concrete strength prediction.

Smart Materials Research Team in Southern Cross University

The Smart Materials Research Team in Southern Cross University was established by Dr. Yee Yan Lim in 2014, one year after the launching of the engineering degree. The team is currently focusing on smart based structural health monitoring and vibration based micro-energy harvesting using piezoelectric materials.

An Advanced Materials Laboratory equipped with a wide variety of state-of-the-art engineering facilities was setup with the aid of a $28 million government grant awarded under the Education Investment Fund. Several international collaborations are established. There are currently two academic staffs and three PhD students working under the group.

Innovative Learning for Skill Development in Complex Procedural Operational Skills

Lei Hou

Griffith School of Engineering, Griffith University

As today's oil and gas projects are becoming larger and more complex, project managers are constantly faced with a number of concerns about schedules, budgets, productivity and safety. Operating an oil and gas facility is a process where workers refer to technical specifications to obtain the right information, identify the components, and then make a decision as to the adjustment or correctness. This entire process is iterative and triggers a learning process which may lead to improved proficiency as the cycle is repeated. The inability to find the right information or sequence within a cycle can contribute to efficiency losses. Jobsite training offered by qualified organisations and associations for the oil and gas industry is very limited, and the relevant training facilities and centres that have been established or considered in the construction agenda are far from sufficient to the growing standard of operators and industry expansion. This project, underpinned by advanced innovative visualisation technologies, will propose a framework to improve efficiency and expedite the process of developing the complex procedural skills in operating and maintaining oil and gas facilities, through identifying scientific principles of enabling complex procedural learning approaches, developing proficiency-based learning approaches and corresponding learning curricula, and appraising learning outcomes according to developed skillset taxonomy. The proposed framework is envisaged to have broad research and pragmatic benefits. On the one hand, it will provide paradigms of transformative learning process of pedagogically adopting Information Commination Technologies (ICT) in curricula development and assessment regimes, while on the other, it will help the oil and gas industry significantly improve the productivity and safety of its workforce.

Framework Development Outline

1. Development of a learning model and performance metrics in problem-solving and decision-making

A particular set of human factors will be taken into account in addressing the scale of complexity inherent in oil and gas operation and maintenance, and these factors typically deal with a diverse range of human performance related to operational errors, productivity, and workplace health and safety. This task will use the PEAR (People, Environment, Actions and Resources) model (Johnson and Maddox 2007) as an instructive framework to identify human factors related to the tasks and

conditions in the maintenance environment. Pilot work has started in developing the learning model at the "*people tier*", and developing a skillset taxonomy that concerns physical, cognitive and other human factors (e.g., fatigue, stress and motivations).

2. Development of a mix-reality coaching and learning system, and testing of learning scenarios tied directly to realistic scenario events

At present, this system has been tentative prototyped (Figure 1) and will be functioned to generate varied task-specific scenarios under Objective C, an iOS programming language, and integrate various software development kits (SDK): e.g., mobile AR SDK, sensing/tracking SDK and real-time communication SDK.

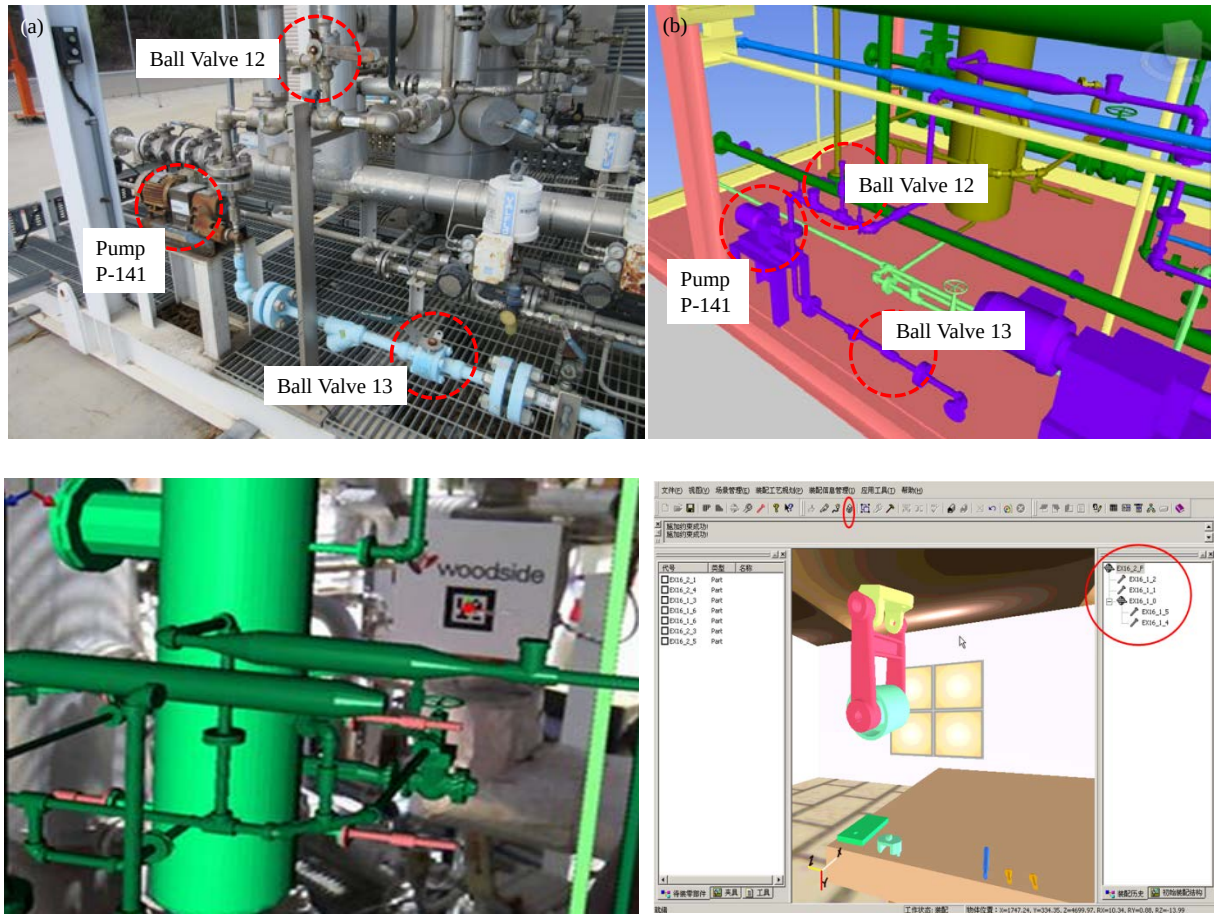

Figure 1. Augmented Reality (AR), Virtual Reality (VR), and mix-reality coaching and learning system interface for maintaining LNG pipelines and equipment

3. Establishment of pedagogical curricula

To foster domain-specific knowledge, the trainees need to learn how to perform procedural tasks under particular curricula. Within these curricula, the research inspectors can make explicit

statement about learning effects. To this end, the proposed curricula will incorporate activities from which a learner's knowledge or skills can possibly be constructed and acknowledged based on the performance index developed from the Task (Figure 2).

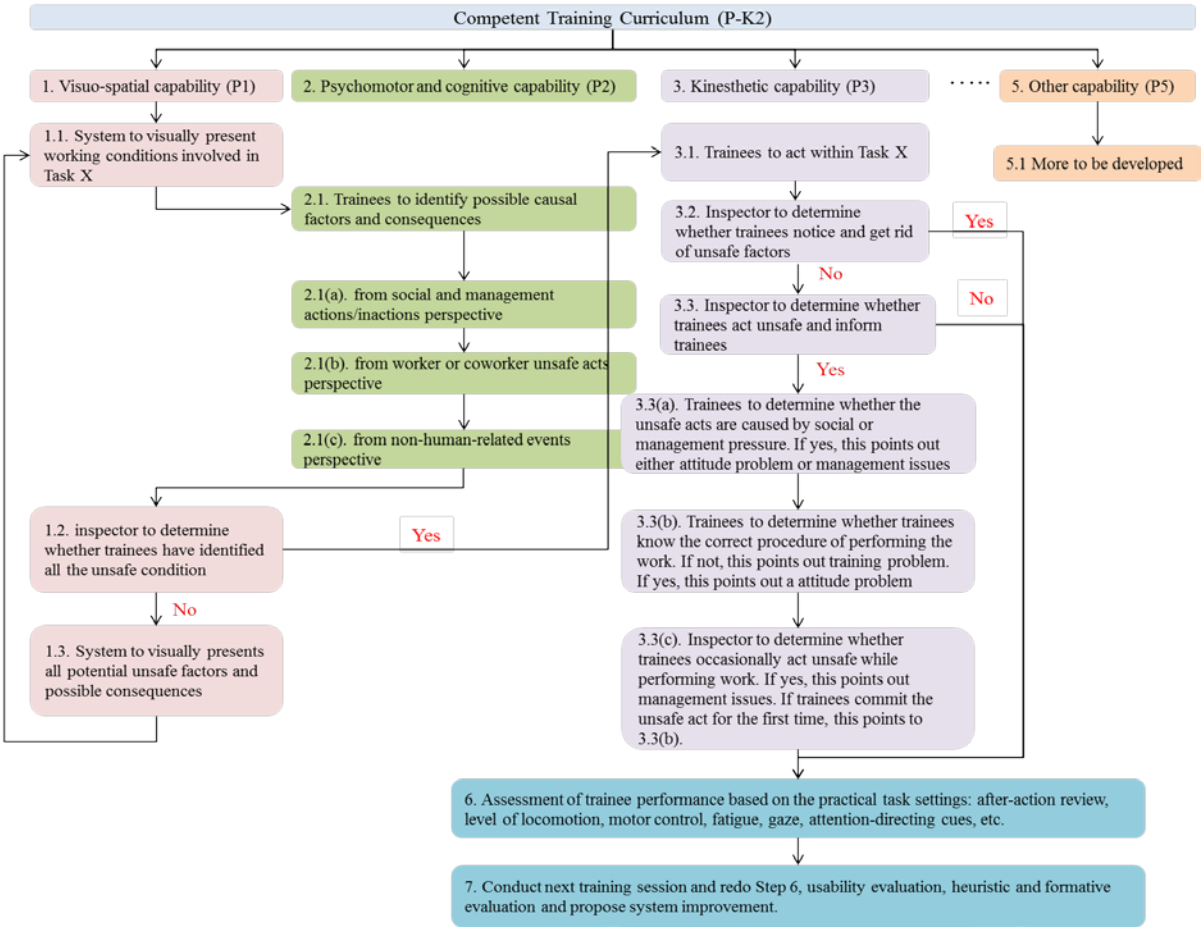

Figure 2. A sample curriculum for the Skill Level of Competent in Operation in terms of Safety Compliance (K2)

4. Implementation of coaching and learning curricula and longitudinal experimentation to validate learning effects

The framework will also validate the hypothetical development that concerns the effectiveness of the visual platforms for different learning styles, the characteristic of skills to be learned, and proficiency levels. The learner in this task will demonstrate knowledge acquired from curricula based training by solving authentic problems. First of all, a pool of trainees will be assembled. The immediate design is to have a number of learners of each proficiency level (novice, advanced beginner, competent, proficient and expert). Secondly, following a standard instruction, the trainees will be introduced to the mixed-reality system and allowed to familiarize themselves hands-on with pre-training session.

Thirdly, the training at each level will be organized in sessions with sufficient time between sessions for the learners to process what has been learned (Figure 3).

Figure 3. Simulated pump P-141 blocked-out and removal training procedure: (a) switch off the ball valve 13 and (b) 12; (c) unbolt connections of the pump and related flanges, and (d) the pump removal

Project Expected Outcomes

The project outcomes will have broad industrial and research benefits. On the one hand, it will help the Australian oil and gas industry to significantly improve the productivity and safety of its workforce, while on the other, provide paradigms of transformative learning process of pedagogically adopting ICT in national curricula and assessment regimes. Explicitly, this project will benefit the nation in several areas:

- Contributing to National Occupational Health and Safety Commission's vision of a "workplace free from death, injury, and disease"
- Enabling a cost-effective and highly efficient way of training future workforce
- Establishing an easily-customizable coaching and learning environment for varied task requirements
- Expediting the process of "the uptake of ICT" in education practice

- Providing important new knowledge about learning/education
- Preparing a basis for a wider field of use (e.g., mining and other resources sectors)

Conference News

- ANSHM mini-symposium in the ***24th Australasian Conference on the Mechanics of Structures and Materials (ACMSM24)*** (http://scieng.curtin.edu.au/acmsm24/), 6-9 Dec 2016, Perth, Australia. Organized by Prof. Tommy Chan, Prof. Jianchun Li, and Dr. Jun Li
- ***The 8th ANSHM Annual Workshop***, 29-30 Nov 2016, Monash University, Melbourne, Australia. Organized by Dr Colin Caprani.
- ***Structural Health Monitoring of Intelligent Infrastructure Conference 2017,*** 6-8 Dec 2017, Brisbane, Australia. Organized by ANSHM.

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