AUSTRALIAN NETWORK OF STRUCTURAL HEALTH MONITORING

Newsletter

Issue 13, September 2017

Contents

President Message

Tommy Chan

Professor in Civil Engineering, Queensland University of Technology

Dear All,

One of the missions of ANSHM is to educate the industry to help them know better about Structural Health Monitoring (SHM). However nothing can be better than letting the engineering students, at least structural engineering students to be aware of this technology during their university training. As mentioned earlier we have been successful to include the topic on SHM in our undergraduate engineering course at QUT. At the moment, at QUT it is compulsory for students majoring in structural engineering and optional for other civil engineering students to do the unit (often in their second or third year of study). This first new engineering cohort using this new content began in 2015 and the first SHM lesson has just started in this month within the Advanced Structural Analysis unit. In this unit, I first introduced the definition of SHM and emphasized that a proper SHM system should include two main components, one on performance assessment and the other on structural health evaluation. Other topics include the followings.

i. Importance of SHM
ii. Performance assessment using Loads and Responses measurement
iii. SHM sensors for loads and responses
iv. Examples of SHM
v. Cost benefits of SHM

vi. Structural Dynamics
vii. Damage Detections
viii. Applications
...etc.

Basically I used our ANSHM 1st publication, “Structural Health Monitoring in Australia” as a textbook of the unit. Many of our ANSHM publications and special issues will also be helpful to the students’ understanding. We expect after the unit, they are able to describe the benefits of implementing SHM, to idenfy factors that influence the choice of sensors, to carry out simple damage detection using some vibration based methods and to identify the future directions for the research and development on SHM.

I was encouraged to see the responses of the students when they realised how this classic engineering could be blended with latest technolgies. They were excited to know how the traditional design concepts and assumptions could be kept improving when more and more SHM systems are installed. Since it was the first time that they were exposed to SHM, I tried to clarify them that SHM should not be confined to Damage Detection as many researchers in the area have mistaken. Also I tried to avoid giving them the imprssion that I am selling SHM without providing them examples and evidences. I showed them many successful examples in using SHM just for structural performance and health assessment.

As many of you may know that a project sponsored by the National Science Foundation of USA is exploring the introduction of the fundamentals and applications of SHM in the civil engineering curriculum there. They started the teaching of SHM in few universites for the academic year 2016-17. For the coming academic year (2017-18), more universites will be involved. I am so pleased to know that we Australian academics are at least walking with the same pace as universities overseas if not taking the lead.

Below are some updates of the month.

Pre-Conference Training Workshop

I am so pleased to let you know that to follow the tradition of SHMII series, we will arrange a Pre-Conference Training Workshop in the afternoon of 4th December 2017. In previous SHMII conferences, this kind of training workshops will be charged and we aim to make it free with RSVP. The workshop will be jointly organised by QUT, ASCE-Australia Section, ANSHM and SHMII-8. The schedule is tentatively from 14:00 to 17:00 on the date with refreshment. There will be two topics in the Workshop:

1. Bridge Inspection Techniques: Current Practices in QLD
2. SHM and Civionics Enhancing Evaluation of Ageing Bridges in Canada

Therefore the traditional bridge inspection and the latest SHM and Civionics techniques will be covered in one afternoon. The 2nd topic will be conducted by Prof Aftab Mufti, the former Scientific Director and President of the Innovative Structures with Intelligent Sensing Canada Research Network. He is a founder of ISHMII and its first President (2003-2008). I think many of us will be benefited by this training workshop. I will try to let you know earlier about this workshop so that you could arrive in Brisbane a day earlier, noting that SHMII-8 will be started from 5 – 8 Dec 2017 and 5 December is Welcoming Reception.

We have booked a room with a capacity of 220, but it is also open to QUT Graduate Students and graduate students of other universities, plus those from ASCE and other local engineers. The Bridge Asset Management group at the Department of Transport and Main Roads are willing to participate. We would expect many of SHMII delegates will also attend, so we hope the room size is good enough.

SHMII-8 (https://shmii2017.org/)

We are approaching the late stages of organising the conference. Many of us are working extremely hard in this month, especially those in the Editorial Subcommittee. Since we need to issue the letter of acceptance to most of the authors of the accepted papers so that they are able to apply the funding accordingly and timely, the Editorial Subcommittee members have been working extremely hard in the past few weeks. I am so pleased to know that although we have a very narrow timeframe for the review process, yet we do not sacrifice the quality of the papers because of that. Many of the reviewer comments are very constructive and helpful for the improvement of the quality of the paper. I am much indebted to the reviewers and the editorial subcommittee members for their effective and high quality services provided, especially Saeed who needs to lead the subcommittee on top of his Vice Chairman duties. We aim to deliver very high quality proceedings which will be extremely useful in your SHM personal library. Below are some updates which may be of your interest:

- Out of the papers received for possible presentations at the general sessions, 116 papers have been accepted and 11 will reach a decision soon. There will be around 75 papers to be presented at the Mini-Symposia/Special Sessions, of which two MS/SS session organisers have submitted their final papers to us. The other three MS/SS organisers to submit their final papers in next few days.
- In addition, we have recently received a few late submissions and they are under review.

Therefore, it is expected that we will have around 200 to 220 presentations plus 8 keynote speeches. We are planning the programme of the conference based on this information.

- We are sending emails not only to the corresponding authors but to all the co-authors to encourage their participation of the conference.
- The ISHMII rule in case of multiple paper registration has been confirmed as follows: *If you plan to present more than two papers at the Conference with only one registration, i.e. only one person amongst all the co-authors to be attending the conference, you are required to add the multiple presentation fee of $300 per additional paper to your registration.*
- The LOC has approved a day pass policy to attend all the sessions of the day and the costs of day pass are $385 for ISHMII members and $450 for non-ISMHMII members.
- The proceedings are published in electronic (USB) format and include full papers. We will aim to index the proceedings as ISBN. The Abstracts will be published as a hardcopy (booklet).
- Some quotes for USB and delegate gift options have been received and we will make a decision in the next LOC.
- Next LOC meeting has been scheduled on 12 September 2017 and we will focus on the program arrangement and publicity for the conference.
- The last LOC meeting will be held on 9th or 10th November 2017, in which we will focus more on the operation and running of the conference and follow up work of the conference.
- Most of the information has been uploaded to the conference website, e.g. accommodation information, registration, our sponsors and keynote speakers (confirmed so far). Please visit https://shmii2017.org/ for details.
- Although it is more than 10 days (at the time of writing this message) before the Early Bird Registration closes, we have already received many registrations (about 13% of what we estimated of the total registrations) including even one 1 day pass registration. It is heartening! Nevertheless, please try your best to register before the Early Bird Registration, which **expires on 10 September 2017**, to not only enjoy the Early Bird Discount, but also help us have a more valid estimation of the number of delegates for organising the conference.

9th ANSHM Workshop (ANSHM mini-symposium/ MS1 in SHMII-8)

For the 9th ANSHM Workshop (ANSHM mini-symposium/ MS1 in SHMII-8), 15 papers were accepted and comments were sent to authors for revising their papers. There are two papers still being under review and we expect to receive the review report for these papers shortly.

Regarding the ABM most likely we will hold it in the afternoon of 5 December 2017, and finish it before the Welcoming Reception in the evening. For the AGM, we plan to have it during our Mini-symposium, maybe before or after one of the sessions for ANSHM MS. More details will be informed in due course.

ANSHM 3rd Special Issue in JCSHM

With the effort of Jun and Colin, now we have received 9 papers in total, 2 of which have completed the review process and the other 7 are under review. We expect two to three more papers coming shortly, so we could have potentially 11-12 papers for this special issue. I really thank Jun and Colin for their continuous effort in attracting papers for this special issue. If you are interested, you still have a chance to submit a full paper and are most welcome to submit ASAP. Please prepare your paper following "Introductions for Authors" (http://www.springer.com/engineering/civil+engineering/journal/13349) and submit online to this issue 'SI: Structural Identification and Evaluation for SHM Applications' through the official journal submission system.

For those who have been invited as a reviewer, please try your best to complete the review by the due date specified.

ANSHM Special Sessions

1. 7th World Conference on Structural Control and Monitoring, (7WCSCM), Qingdao, China, 22-25 July 2018

   The official conference website is live at http://smc.hit.edu.cn/wcscm2018/, and the abstract submission system is open now.
   Please note the following important dates:
   i. Abstract submission deadline: September 15, 2017
   ii. Acceptance/rejection notice: November 15, 2017
   iii. Full paper submission deadline: February 15, 2018
   iv. Early bird registration deadline: April 30, 2018
   v. Conference date: July 22-25, 2018

2. 9th International Conference on Bridge Maintenance, Safety and Management (IABMAS 2018) Melbourne, 9-13 July 2018

   Jun is organising a special session and 18 abstracts have been received and accepted.
   The conference website is http://iabmas2018.org/.
   Please note the following important dates:

   i. Full Paper Submission open: 1 September 2017
   ii. Full Paper Submission Deadline: 20 October 2017
   iii. Notification of Full Paper acceptance: December 2017
   iv. Final Paper Submission: January 2018

v.	Early bird Registration closes:	March 2018
vi.	Conference date:	9-13 July 2018

Conferences/Special Sessions/Mini-symposia of our interests

There is a special session focusing on SHM in the coming 6th ISRERM at National University of Singapore (http://cee.nus.edu.sg/ISRERM/index.html), on 31 May – 1 June 2018. It is organized by Prof. HF Lam and Prof. SK Au. Abstract submission deadline: 30 August 2017.

Regarding this issue of the Newsletter, we have two interesting research articles, one from University of Technology Sydney (UTS) and the other from Queensland University of Technology (QUT). Damage identification via finite element (FE) model updating using limited number of sensors has always been a great challenge. The article by Li et al. of UTS proposed a novel method based on a linkage modelling technique to locate and quantify structural damage. Instead of using the full FE model, the model updating problem herein is formulated using the linkage model which has a great potential for use when sensor deployment is limited. Focusing on bridge assessment, Jamali et al. of QUT used a comparative study to show a notable difference in the analysis results obtained when two most popular numerical modelling methods, Finite Element and Grillage Analogy, are applied for component-level analysis, rather than global analysis. Based on the analysis results, the study proposed a practical procedure to evaluate the performance of different modelling techniques. The need of using SHM data was also highlighted in this evaluation procedure. Please enjoy.

With kind regards,

Tommy Chan

President, ANSHM

www.ANSHM.org.au

Structural damage identification using a frequency response functions-based model updating method

Jianchun Li, Yang Yu and Van Vu Nguyen*

Centre for Built Infrastructure Research, School of Civil and Environmental Engineering, University of Technology Sydney, Ultimo, NSW 2007, Australia

Introduction

This article introduces a novel method to localise and quantify structural damage via a linkage modelling technique to overcome issues caused by limited sensors in practice. The main strategy in the proposed method is to divide the whole structure into partitions. The Young's modulus of each partition is then updated to detect stiffness reduction caused by damage. The full finite element model is also reduced to a linkage model. The sensitivities of frequency response functions (FRFs) are then formulated using the linkage model for the synthesis of interpolated FRFs to iteratively calculate the values of updating parameters until the convergence is achieved. Finally, the proposed method is validated using numerical and experimental cases with satisfactory results. Successful implementation of this method has great potential to evaluate the location and severity of structural damage where sensor deployment is limited.

Methodology

The proposed method is based on the iterative formulation of the FRF sensitivities. In each iteration, linear least squares method is used to minimise the objective function, which is defined as the squared 2-norm of the residual, shown in Eq. (1):

$$\min_{\Delta p} \frac{1}{2} \left\| S\Delta p - \Delta\alpha \right\|_2^2 \tag{1}$$

where Δp denotes the vector of updating parameters and $\Delta\alpha$ denotes the vector of FRF residuals, calculated using Eq. (2):

$$\Delta\alpha = \begin{Bmatrix} \{\alpha_X(\omega_1)\}_j - \{\alpha_A(\omega_1)\}_j \\ \vdots \\ \{\alpha_X(\omega_n)\}_j - \{\alpha_A(\omega_n)\}_j \end{Bmatrix} \tag{2}$$

where $\{\alpha_X(\omega_i)\}_j$ refers to the vector of the experimentally obtained receptance FRFs at the ith measured frequency with each row of the vector corresponding to the degree of freedom (DoF) of the measured response with the input applied at coordinate j and $\{\alpha_A(\omega_i)\}_j$ being the analytical counterpart. S is the FRF sensitivity matrix and can be calculated using Eq. (3):

$$S=\begin{bmatrix} -[\alpha_A(\omega_1)]\left[\dfrac{\partial Z_A(\omega_1)}{\partial p_1}\right]\{\alpha_X(\omega_1)\}_j & \cdots & -[\alpha_A(\omega_1)]\left[\dfrac{\partial Z_A(\omega_1)}{\partial p_{N_p}}\right]\{\alpha_X(\omega_1)\}_j \\ \vdots & \ddots & \vdots \\ -[\alpha_A(\omega_n)]\left[\dfrac{\partial Z_A(\omega_n)}{\partial p_1}\right]\{\alpha_X(\omega_n)\}_j & \cdots & -[\alpha_A(\omega_n)]\left[\dfrac{\partial Z_A(\omega_n)}{\partial p_{N_p}}\right]\{\alpha_X(\omega_n)\}_j \end{bmatrix} \tag{3}$$

where $Z_A(\omega)$ is the dynamic stiffness matrix expressed in the frequency domain, shown in Eq. (4):

$$Z_A(\omega)=K+i\omega C-\omega^2 M \tag{4}$$

where K, C and M denote the stiffness, damping and mass matrices of the FE model, respectively. In Eq. (3), the derivatives of $Z_A(\omega)$ can be reduced to the linkage model, which is developed using system equivalent reduction expansion process. Also, numerical conditioning of objective function can be improved by normalising updating parameters so that current parameter estimate is unity. In this case, the parameters to be updated are Young's modulus of the partitions, which are separated from the full FE model. The decision of DoFs to retain after model reduction can be tailored around selected updating parameters. A novel damage index (DI) for each partition of the structure based on overall stiffness reduction of each partition, shown in Eq. (5):

$$DI=\frac{E_h-E_d}{E_h} \tag{5}$$

where E_h and E_d denote the Young's modulus of a partition of the FE model in its healthy and damaged states, respectively.

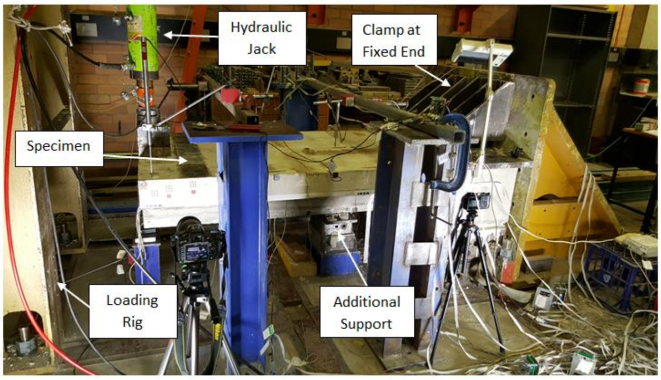


Figure 1. Specimen and experimental setup

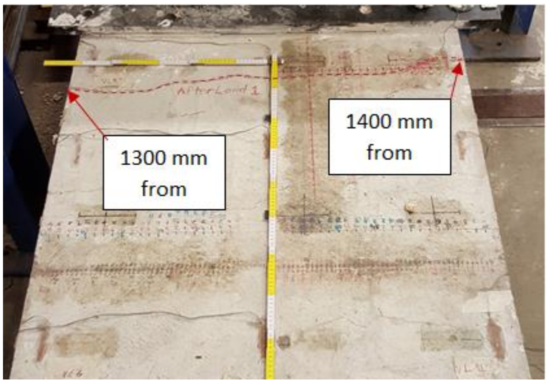


Figure 2. Crack from top view

Case study

A concrete specimen, as the replica of jack arch component from Sydney Harbour Bridge (SHB), is used to validate the proposed method. As shown in Figure 1, the specimen is 1m wide, 2m long with the height of 0.375m, and has a steel I-beam embedded along it. First, the modal test using an impact hammer is conducted to obtain dynamic characteristics of the specimen. 11 accelerometers are employed to measure vibration responses, which are used to calculate the receptance FRFs. The details of sensor deployment and test condition can be found in (Nguyen et al. 2015).

Then, the damage is introduced to the structure by applying a static load using a hydraulic jack. The loading is stopped when an obvious reduction of structural load carrying capacity is observed, and the modal testing is then carried out. At this stage a crack can be observed on the right of the specimen with 0.275m depth, shown in Figure 2.

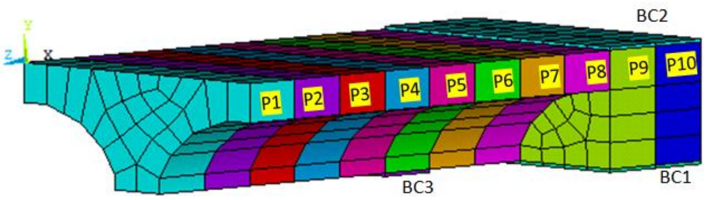


Figure 3. FE model of the specimen

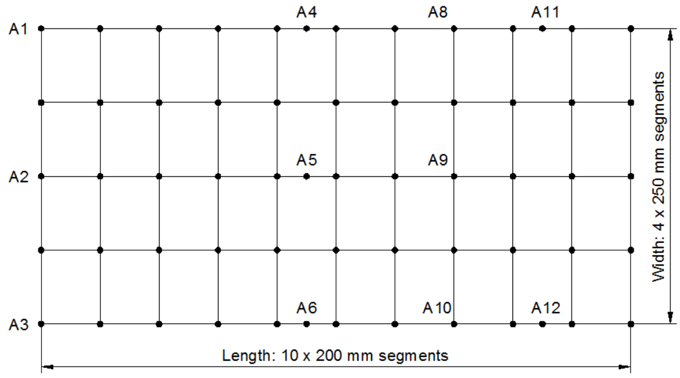


Figure 4. Linkage FE model

Furthermore, a FE model of the specimen is constructed with ANSYS using 20-node SOLID 186 elements to exhibit quadratic displacement behaviour in the model, shown in Figure 3. Updating parameters in the model are defined by dividing the model into ten partitions along the structure. Young's modulus values are defined for these partitions, denoted as P1 to P10 in Figure 4. Besides, Young's modulus of the adhesives connecting the specimen to the supports are considered as updating parameters, because they can directly affect the structural dynamic properties. They are denoted as BC1 to BC3 in Figure. Partial derivatives of the mass and stiffness matrices with respect to updating parameters are numerically determined by calculating the difference between perturbed and unperturbed system matrices.

In this study, it is assumed that the FE model has been updated in the healthy state. Smeared cracking is used to simulate damage which reduces the Young's modulus of P7. 11 receptance FRFs are synthesised based on experimental results. The choice of measured frequencies is considered in the updating process. Here, the frequency in the model updating ranges from zero to 1kHz with the frequency resolution of 1Hz. Figure 5 provides the comparison of FRFs before and after updating. It is clearly seen that the updated FRFs fit well with target FRFs within several updating iterations.

To further evaluate the performance of the proposed method, experimental validation is also conducted based on the data collected from the specimen. In this case, it is difficult to identify all modes using experimental results due to asymmetry of the structure and limited sensors. We just consider fours modes including a vertical bending, in-plane bending and two torsion modes for the model updating, the frequencies of which are in the range of [0 200]Hz and [800 1000]Hz, respectively. In each iteration, the model is reduced to the linkage model, which is used to expand the measured mode shapes. Figure 6 shows the driving point FRF before and after updating. It is noticeable that there is a closer agreement between the model FRF and measured FRF. Then, based on the updated information, the damage index is calculated, the result of which is shown in Table 1. It indicates that P7 has a stiffness reduction of 41.4%, which is significantly larger than other partitions of the specimen. This result also agrees with the crack visually in Figure 2, which is located between 1.3m and 1.4m from the front of the specimen and lies within the region covered by P7. Therefore, it can be concluded that the proposed method will be a practical approach to identify the structural damage for real SHM systems with limited measurement sensors.

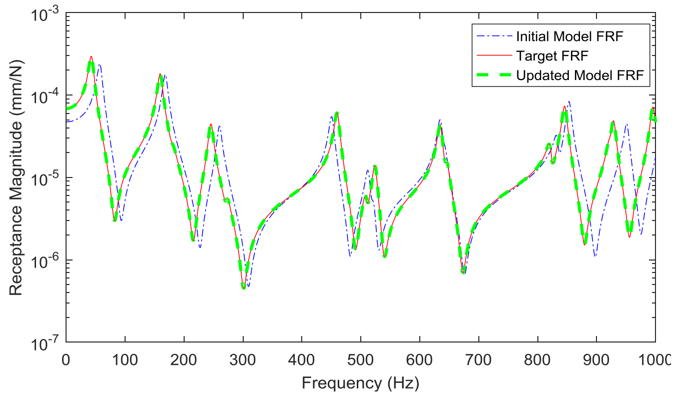
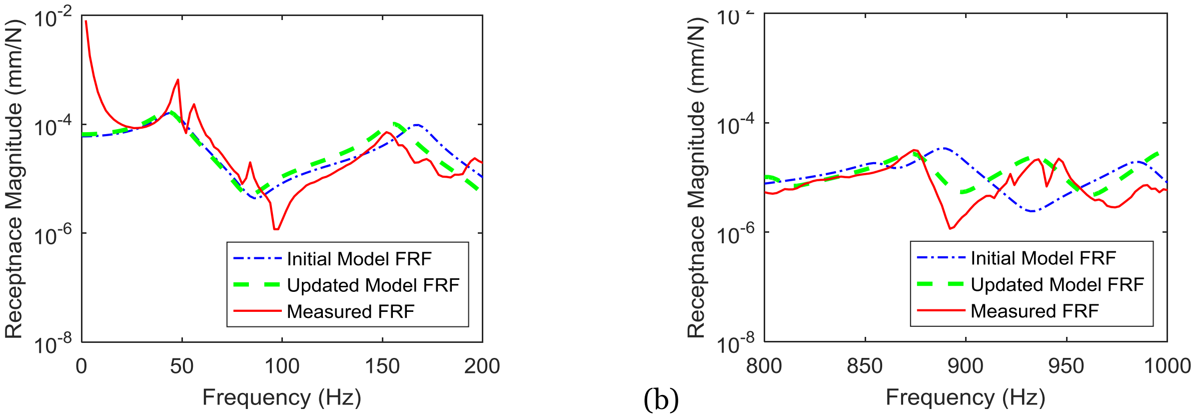


Figure 5. Driving point FRF before and after updating for numerical case

Table 1. Updating summary of damaged case

Parameter	Initial value	Updated value	Index
P1	32,721	32,720	0.0%
P2	32,721	32,716	0.0%
P3	32,721	32,721	0.0%
P4	32,721	32,714	0.0%
P5	32,721	32,721	0.0%
P6	32,721	32,381	1.0%
P7	32,721	19,177	41.4%
P8	32,721	31,482	3.8%
P9	32,721	32,711	0.0%
P10	32,721	32,446	0.8%



(a) (b)

Figure 6. FRF before and after updating at frequency range of (a) [0 200]Hz and (b) [800 1000]Hz

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AUSTRALIAN NETWORK OF STRUCTURAL HEALTH MONITORING
CIVIL ENGINEERS ANSHM
Newsletter

Heavy Load Assessment of Australian Bridges Using Grillage and Finite Element Methods

Shojaeddin Jamali, Tommy H.T. Chan, Andy Nguyen and David P. Thambiratnam*

School of Civil Engineering and Built Environment, Queensland University of Technology, Brisbane, Australia

Background

Enormous development in technology has occurred since the introduction of the first hand-held calculator in 1970. This advancement of technology had a revolutionary impact on engineering applications, owing to the fact that nowadays computer modelling has become an indivisible part of engineering design and analysis. For the purpose of bridge design, finite element (FE) analysis and grillage analogy (GA) have remained as valuable methods. In GA, the bridge superstructure is modelled by equivalent longitudinal and transverse beams, while FE analysis discretizes the deck into different elements connected together based on equilibrium and/or compatibility conditions. Detailed applications of FE analysis for bridge condition assessment can be found in the authors' previous publication (Jamali et al., 2016). GA idealizes the bridge as series of discrete longitudinal and transverse beam elements connected by nodal points. Recent proposed revisions to AS 5100.7 (Australian Standards, 2014) include introduction of road and rail assessment vehicles, fatigue, improved load factors, rating equations for combined actions and addition of structural health monitoring (SHM) as a part of bridge assessment approach. This major transition in national code implies the need for more rigorous analysis for assessment of aged bridges which are pillars of economic growth in Australia. Output of GA requires interpretations and cannot be applied directly to the structure (Hambly, 1991). Also, only vertical loads (concentrated or line loads) could be directly applied. Effect of construction sequence, reinforcement modelling, analysis of secondary effects, in-plane effects and nonlinear response of deck are a few other limitations of GA which are neglected in modelling. These downsides of GA makes it a weak solution for comprehensive bridge assessment which differs entirely from design philosophy. As a case study, various vehicular loading scenarios (see below) on a grillage model of a box girder bridge and its equivalent finite element model were investigated to study the influence of modelling approaches on bridge load assessment.

Live load assessment

Due to page limitations, detailed analysis of each moving case is not presented which can be accessed in the full paper (Jamali et al., 2017). From the transient analysis, it was found that load effects (i.e. bending moment) differs between GA and FE when the corresponding response is considered as per component-based, whereby response of each structural element in bridge such as longitudinal girders is studied separately for the external load.

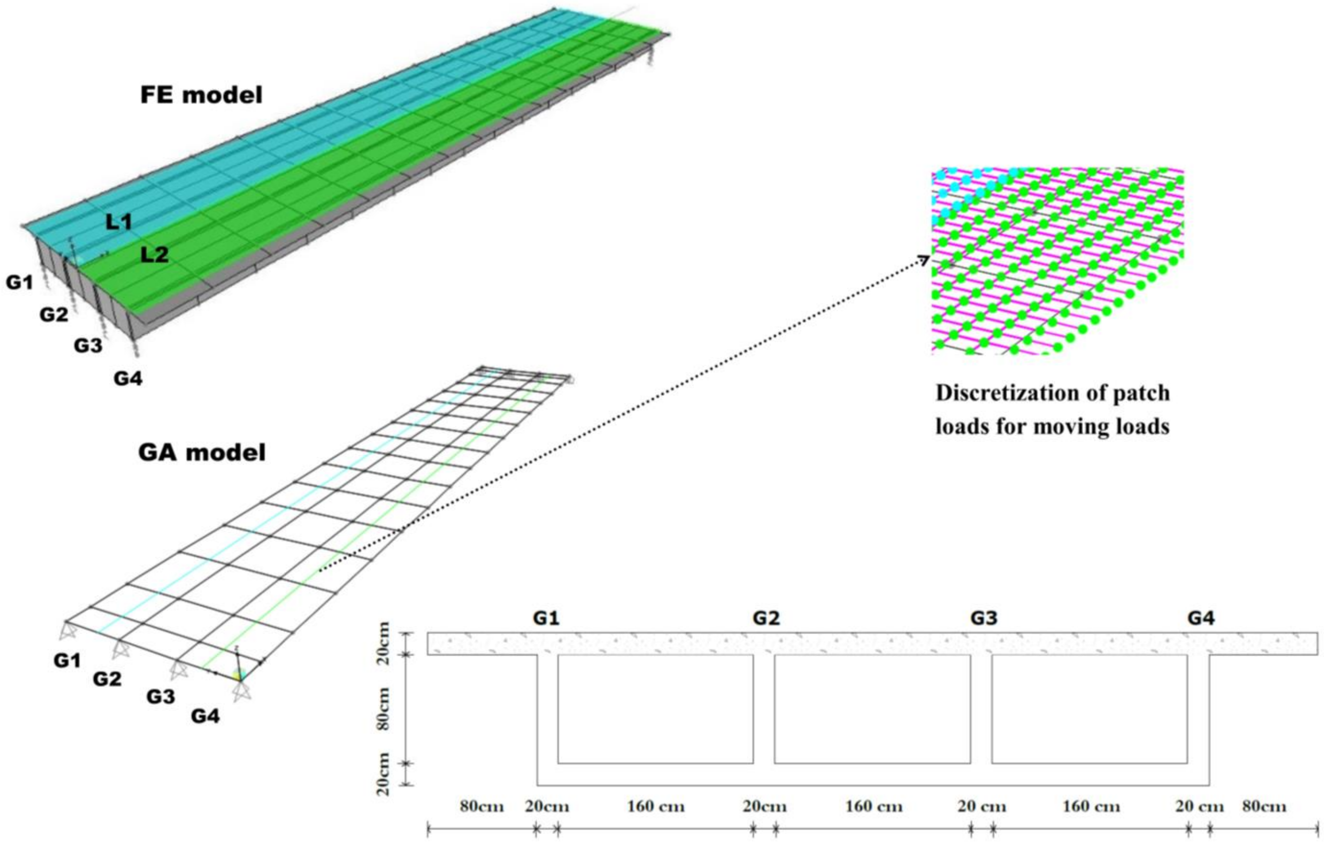

Figure 1: Analytical models of box girder

Table 1: Vehicular loading scenarios

Load case	Vehicle class	Vehicle Position (L#1*)	Speed (km/hr)	Coexisting vehicle	Coexisting vehicle position (L#2*)	Speed (km/hr)
1	-	Static loads	-	-	Static loads as	-
2	45.5t	LCL*	50	42.5t	LCL	70
3	48t	Adjacent to BCL	40	42.5t	Adjacent to BCL	60
4	48t	Adjacent to kerb	20	42.5t	LCL	25
5	79.5t	LCL	35	42.5t	LCL	35
6	79.5t	LCL	8	42.5t	LCL	8
7	95.5t	0.3m away from kerb*	11	42.5t	LCL	15
8	320t	1m offset from BCL	10	-	-	-

*LCL: lane centerline, BCL: bridge centerline, L#: lane number, Kerb: measured from outer face of wheel

In existing practice, usually global-based response of components are taken as resistance to load, whereby bridge is considered as an integral system and global-level response is taken. To better assess the difference between global-level and component-level response, following modelling ratios were developed. Figure 2 clearly displays that the difference in modelling techniques reduces notably when global-response of structure is considered rather than each individual element.

$$\text{FE model comparison ratio} = \frac{\text{Load case}_{\text{load effect}}}{\text{Reference vehicle}_{\text{load effect}}}$$

$$\text{FE model comparison ratio} = \frac{\text{Load case}_{\text{load effect}}}{\text{Re ference vehicle}_{\text{load effect}}}$$

$$\text{Modelling comparison ratio} = \frac{\text{GA model comparison ratio}}{\text{FE model comparison ratio}}$$

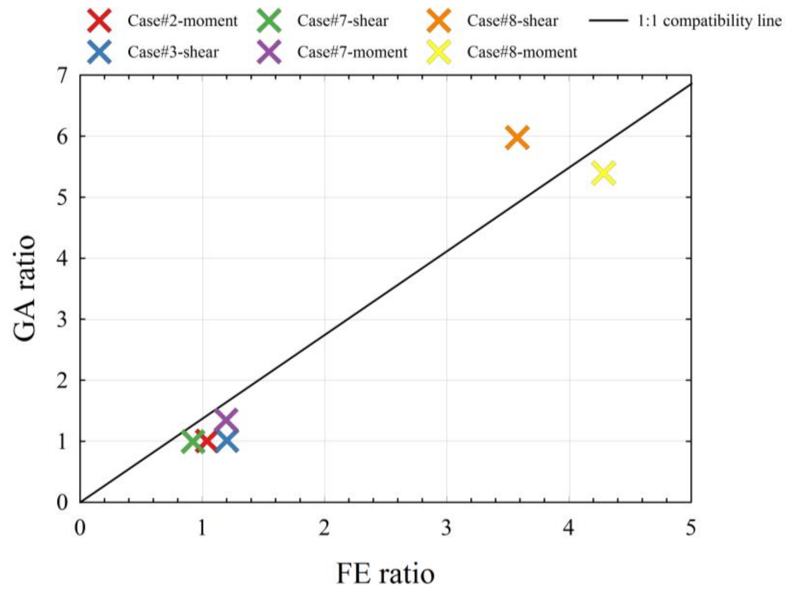

Figure 2: Modelling ratios: closer to compatibility lines indicates less difference between two models

An advantage of proposed modelling ratios is for checking analytical models against a validated model. For instance, if FE model was validated using field measurements and a corresponding grillage model was required or vice versa, then any point falling in the FE model region (i.e., below compatibility line), it would be regarded as non-conservative result for that particular load case and analytical model. Likewise, any point above compatibility line needs further refinement to match the validated numerical model. Another use of modelling ratios is for comparison of peak effects (global-based analysis) induced by vehicular loading against design load which could be either previous or existing designed vehicle class. This comparison highlights the fact that the level of accuracy in modelling is essential for bridge assessment, particularly when component analysis rather than global analysis is involved. Proposed flowchart for validation of numerical modelling is shown in Figure 3. This process is applicable for any type of bridge profiles and load assessment. It can also be extended to a range of vehicles for various load effects of structural components (superstructure and substructure) for serviceability and strength limit states using load factors and other provisions prescribed by state department of transportation. Moreover, similar concept can be adopted for comparison between other modelling techniques used for bridge assessment. For rapid comparison, only specific elements from both models can be compared to spot any incompatibility in the modelling to avoid misjudgment on existing capacity of load bearing elements to withstand live load effects. For instance, results of numerical analysis in this study can be refined to have more compatibility. For that purpose, at least some data from existing conditions are needed to validate either numerical model, and then calibrate other computer models. This is a very important consideration because merely using design documents for assessment may not give reliable results. Although the existing assessment approaches in Australia are helpful for quantifying the risks associated with heavy freight vehicles, yet the traditional design-based methods are used for structural capacity check and usually the maximum load response is considered for any live load analysis instead of component-based analysis. Current best practice is to use simplified numerical model for bridge load assessment. The nominal capacities of bridge components are determined from design drawings if no severe damage exists (which is verified by visual inspection or previous records), then analytical load effects due to different truck loadings are evaluated and subsequently, bridge is rated.

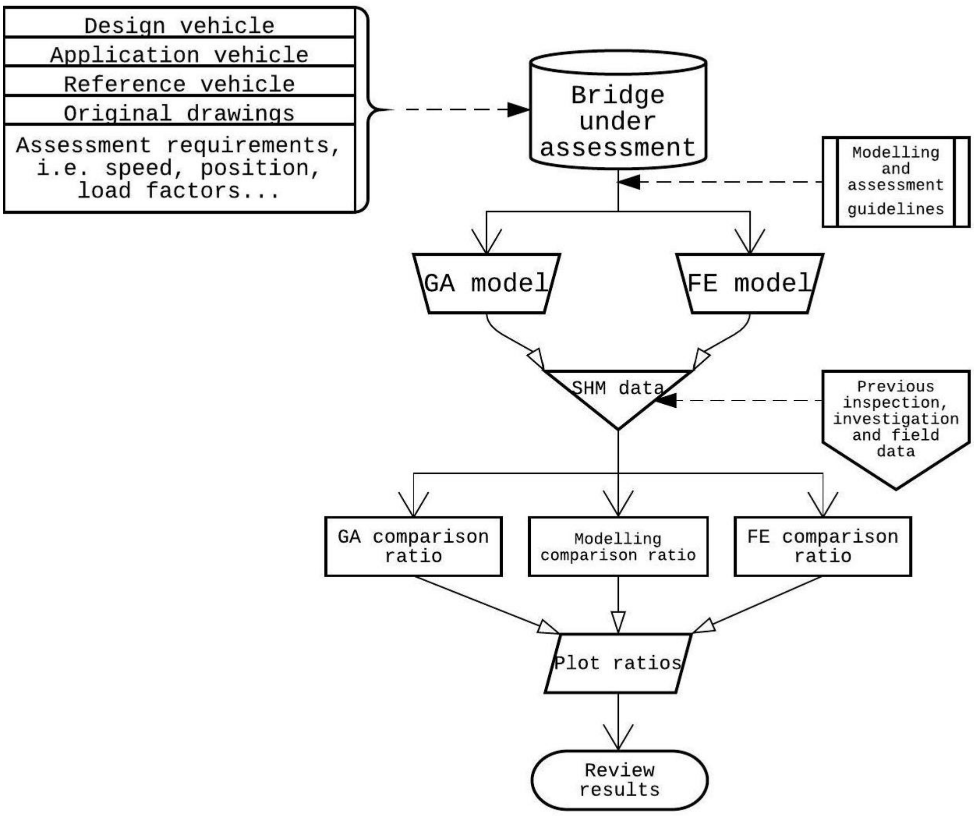

Figure 3: Concept map of developing and validating numerical models for bridge assessment

A drawback of this approach is that truck loading is not always feasible due to fiscal constrain, traffic interruption and structural deficiency of bridge to take heavy truck loading. Besides, critical modelling information such as boundary conditions and material properties are presumed from design blueprints. By using the flowchart, less conservative assessment could be achieved because a baseline model can be made much easier since numerical model is calibrated; which is applicable to a family of similar bridges that needs load assessment or analytical model for field test planning. Also, calibrated model may be used for permit access, change to configurations of as-of-right vehicles, future assessments and will enable asset managers to check the structural integrity of their bridges after extreme events. In an event where an old bridge has no design plan, using on-site geometrical measurement and ambient traffic as source of excitation with no traffic closure; operational modal analysis can be implemented. Such approach massively reduces the cost of testing and uncertainty since analytical model is coupled with in-service conditions for global and component-based analysis.

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Conference News

- ***8th Structural Health Monitoring of Intelligent Infrastructure Conference (SHMII-8),*** 5-8 Dec 2017, Brisbane, Australia. Organized by ANSHM and QUT. (http://shmii2017.org/)
- ANSHM mini-symposium "Recent SHM advances in Australia" in the ***8th Structural Health Monitoring of Intelligent Infrastructure Conference (SHMII-8)***, 5-8 Dec 2016, Brisbane, Australia. Organized by Prof. Tommy Chan and Dr. Andy Nguyen.
- Mini-symposium ***"Recent Research Advances on Structural Control and Health Monitoring in Australia"*** in the ***7th World Conference on Structural Control and Monitoring (7WCSCM)***, in Qingdao, China, 22-25 July 2018. Organized by Prof. Hong Hao, Dr. Kaiming Bi, and Dr. Jun Li (http://smc.hit.edu.cn/wcscm2018/)
- ***"SS11 - Structural Health Monitoring for Infrastructure Asset Management"*** in the **9th International Conference on Bridge Maintenance, Safety and Management**, Melbourne, 9-13 July 2018. (http://iabmas2018.org)
- ***Special Session on SHM in the 6th The International Symposium on Reliability Engineering and Risk Management (ISRERM)*** *at National University of Singapore, 31 May – 1 June 2018. Organized by Prof. HF Lam and Prof. SK Au.* (http://cee.nus.edu.sg/ISRERM/index.html)

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If you have any comments and suggestions, please contact

Newsletter Editor: Jun Li, Curtin University, Perth.

Email: junli@curtin.edu.au, Tel: +61 8 9266 5140.

Co-Editor: Andy Nguyen, Queensland University of Technology, Brisbane.

Email: a68.nguyen@qut.edu.au, Tel: +61 7 3138 0741.