SEMINAR
Institute of Theoretical and Applied Mechanics
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Czech Society for Mechanics
and Institute of Theoretical and Applied Mechanics, CAS

invite you to

The Workshop on Vehicle-Induced Vibration on Bridges

on Friday, September 20, 2019, at 9:30AM in the building
of the Institute of Theoretical and Applied Mechanics, Prosecká 76, 190 00, Prague 9

Programme:

9:30 prof. Y.B. Yang (Chongqing University, China): *Resonance Mechanism of Train-Bridge Interaction for High-Speed Rails*

10:05 prof. M.S. Shih (National Chi Nan University, Taiwan): *Development of Multi-Virtual Pier Technique for Deformation Control of Disaster Relief Bridges*

10:30 prof. Judy P. Yang (National Chiao Tung University, Taiwan): *Investigation of Vehicle-Bridge Interaction by Different Vehicle Models*

10:55 prof. J.D. Yau (Tamkang University, Taiwan): *An additional damping method to assess VBI effects for HSR short bridges*

11:20 dr. J. Bayer (ITAM CAS, Czech Rep.): *Moving dynamic test loads for road bridges - a case study*

Abstracts:

Resonance Mechanism of Train-Bridge Interaction for High-Speed Rails

Yeong-Bin Yang
Chongqing University, China

A high-speed train consisting of identical cars of length D moving over a series of identical simple beams of length L is a practical and interesting problem in engineering. There exist two types of resonance for this problem: (1) The train-induced resonance on a bridge occurs at the resonant speed of $v_{br} = f_b D$, with f_b denoting the bridge frequency. (2) The bridge-induced resonance on a moving car occurs at the resonant speed of $v_{cr} = f_c L$, with f_c denoting the car frequency. In this study, in additional to the two resonant phenomena for the train-bridge system, the *dual resonance* phenomenon, i.e., with $f_c L = f_b D$, will be conducted. By the resonance conditions mentioned above and the dispersion relation derived, the key parameters affecting the critical stiffness of the couplers of the train are identified. Finally, the resonant effect on the moving linked cars will be investigated.

Development of Multi-Virtual Pier Technique for Deformation Control of Disaster Relief Bridges

Ming-Hsiang Shih
Distinguished Professor, Department of Civil Engineering, National Chi Nan University, Taiwan

High mobility and fast-to-establish are special requirement for the design of a disaster relief bridge. Therefore, the self-weight of the bridge should be as low as possible. The lightweight slender structure

leads to large deformation and the design is usually controlled by the deformation. In this study, to enhance and improve the serviceability of disaster relief bridge, a Neutral Equilibrium Mechanism (NEM) is proposed to adjust the internal force of the bridge and reduce the deformation of the bridge. A fixed length bridge, the more piers there are, the smaller the net span, so the deformation is almost inversely proportional to the third power of the number of piers. However, the control of multiple virtual piers may be unstable due to inter-system interaction effects. Therefore, this study verified the control effect and control stability by experimental methods. The experimental results show that the multiple virtual piers can achieve stable control with independent Single-Input-Single-Output control law, and the maximum displacement reduction rate can reach over 97%. The effective span of a bridge can be increased without increasing the depth of the cross-section. The feasibility and practicality of applying this proposed NEM to form a virtual pier of a bridge have been verified in this study.

Investigation of Vehicle-Bridge Interaction by Different Vehicle Models

Judy P. Yang

Department of Civil Engineering, National Chiao Tung University, Taiwan

The concept of vehicle-bridge interaction (VBI) was originated from the investigation of high-speed trains in 1990s. Later in 2004, the idea of extracting bridge frequencies from a passing vehicle was further applied to investigate the dynamic behavior of bridges in structural health monitoring. Traditionally, the test vehicle was modeled as a single-degree-of-freedom sprung mass moving over a simple beam in most previous studies, which suffers from the drawback that the sprung mass is largely affected by the vehicle motion and thus the bridge frequencies may not be identified clearly. As such, the Yang's group aims at effectively analyzing vehicle-bridge interaction and has proposed several vehicle models. In this presentation, four different vehicle models will be introduced, and the corresponding numerical results will be discussed accordingly. As there exist lots of factors affecting the results of identification of bridge frequencies, the key factors will be investigated through the parametric study. Finally, the discussion of the pros and cons of each model concludes the presentation.

An additional damping method to assess VBI effects for HSR short bridges

JD Yau

Tamkang University, Taiwan

As a train travels over a short railway bridge, the vehicle-bridge interaction (VBI) effects would become significant for train-induced vibration of simply-supported bridges. To account for the VBI effects by using constant load models, Eurocode 1 allows engineers to consider an additional amount of structural damping relating to the bridge span. This method is the so-called additional damping method (ADM). Nevertheless, the ADM may sometimes yield to an unsafe prediction of the bridge peak response. An alternative analytical approach based on an equivalent VBI model under resonant excitation is presented in this investigation, from which the key parameters dominating the additional damping problem are subsequently identified. From the numerical demonstrations, the proposed approach provides a concise prediction of the additional amount of damping to account for VBI effects on short simply-supported railway bridges.

Moving dynamic test loads for road bridges - a case study

J. Bayer and S. Urushadze

Institute of Theoretical and Applied Mechanics of the CAS, CZ

Two types of dynamic testing load for bridges - driving sprung mass and driving impulse load – are examined from the drive-by identification point of view. The numerical analysis carried out with ANSYS shows that the static deflections impose a non-negligible effect on the response of the sprung mass. The analysis and results of our initial laboratory experiments on a simple supported steel beam are discussed. The experiments confirmed that the driving impulse load is more efficient in exciting bridge vibrations. This, together with the fact that the impulse loading is not sensitive to surface roughness, leads to the conclusion that, as a method for bridge health monitoring, the impulse loading is more promising than the driving sprung mass.