The Institution of Structural Engineers

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2014/15 Undergraduate Research Grant Scheme

Project title: Prevention and control of vibration serviceability problems in footbridges

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Aims of research:
Modern slender footbridges are often prone to excessive vibration due to human-induced walking excitation. As a consequence, as-built lively structures often have to be retrofitted with vibration reduction devices. Traditionally tuned-mass-dampers have been used for this purpose. However, there is a potential to develop more cost effective techniques for vibration reduction that could utilise the existing structural features. For example rubber-like pavements could act as a medium for attenuating the force applied to the structure and consequently reduce the vibration response. In addition, they have potential to redirect pedestrian's attention from the sensation of excessive vibration to the tactile sensation of a flexible (non-rigid) pavement under the feet. This project aims to investigate innovative vibration mitigation measures and test their effectiveness on a lively footbridge. The project will result in a recommendation of an effective design approach for preventing incidence of lively footbridges.

Description of method:
The project consists of the following stages:
1. Research into materials that could be used for vibration attenuation will be conducted, building on the current knowledge about vibration isolation materials (e.g. from earthquake engineering) as well as materials used in sports science. Based on this research, two to three types of material will be selected for a detailed investigation.
2. Specimens made of chosen materials will be tested in the Materials Testing Laboratory to characterise their mechanical properties. Capability of the material to modify / attenuate a human induced force will then be tested in the Gait Laboratory. This will be done by measuring the force when walking over a bare force plate, and then repeating nominally the same tests with the force plate covered by the investigated material.
3. The effectiveness of the materials investigated will be tested in real-life conditions, i.e. on a lively steel-concrete composite bridge spanning 17m that is situated in the Structures Laboratory. Nominally the same tests that involve walking over: 1) bare deck and 2) deck covered by the flexible pavement will be performed. The measured acceleration response of the structure will be compared between the two scenarios. Ten test subjects will take part in the testing programme to provide statistical reliability of the results. The effectiveness of the tested materials in attenuating the vibration response will be evaluated and the most effective solution will be identified. FE models of the bridge (with and without pavement) for this solution will be developed and calibrated against the experimental data, resulting in recommendations for numerical modelling of the proposed pavement solution.

Benefits to structural engineering:
This project will result in an innovative solution for reducing/preventing excessive vibrations of low-frequency footbridge structures. The suggested solution will have potential to become a measure-of-choice for footbridge vibration reduction and control, and therefore overtake traditionally used vibration mitigation measures (such as viscous or tuned-mass dampers) due to its multi-functionality (i.e. being inherent part of the design, and having ability to alter dynamic loading induced by pedestrians as well as their sensitivity to vibration) and lower cost.

Proposed finish date: June 2015