The Institution of Structural Engineers

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2013/14 Undergraduate Research Grant Scheme

Project title: Using distributed temperature measurements to characterise thermal stress variations in highway bridges

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Student: tba

Aims of research:
This project is envisioned as a first step towards initiating research into characterizing the thermal stress variations in bridges due to daily and seasonal changes in ambient conditions, and consequently assessing their potential significance for bridge design and maintenance. The objectives of this project are as follows.

1. Evaluate the viability of capturing daily variations in temperature distributions using thermal imaging cameras.

2. Investigate methods of integrating thermo-mechanical behaviour models of bridges with measured temperature distributions to determine the thermal stress variations in these structures.

3. Analyse the impact of the predicted thermal stress variations on structural performance, especially, when combined with stresses due to live loads.

Description of method:
Temperature-induced stresses and deformations play an important role in bridge design. Real temperature distributions across bridges are often very complex and depend on several factors such as the bridge's geometry, material, surrounding environment and orientation. This study aims to fill the gaps in our understanding of thermal effects and to advance our knowledge in accurately estimating thermal stress variations in bridges. In particular, it focuses on the spatial (3-D) and temporal variations in temperatures in bridges and their impact on structural performance. The work programme for this project is as follows.
1. Review literature on measuring temperature distributions in full-scale bridges and in evaluating their thermal response.
2. Build numerical (thermo-mechanical) models of two bridges - a steel suspension footbridge and a concrete highway bridge, using available structural drawings and a finite element package (e.g. ANSYS). The two structures will form case studies for this project.
3. Use a thermal imaging camera, available within our research group, to collect images of the two bridges during three different times of the day such that measurements sufficiently capture the daily variations in temperature distributions. Process the images to generate data-sets representing temperature distributions across the two structures.
4. Use previous historical data on seasonal temperature variations and the measured temperature distributions to generate potential temperature scenarios that the structure could experience over the course of one year. Additionally, create temperature scenarios corresponding to simple linear temperature gradients in the longitudinal and vertical (gravity) directions of the bridge, as recommended by the design codes.
5. Feed the temperature scenarios as input into the developed numerical models to predict the thermal stress distributions in the structures.
6. Compare thermal stresses due to measured temperature distributions with those due to linear temperature gradients given in design codes. Examine their potential significance when combined with live load-induced stresses.

Benefits to structural engineering:
The project is expected to produce valuable evidence to support further research into the impacts of temperature-induced deformations and stresses on long-term structural performance of bridges.

Results are expected to show that steep temperature gradients exist in certain portions of bridges depending on their geometry and exposure to sun. Consequently, these could lead to thermal stresses that are much higher than those predicted by current design approaches for thermal effects. This project will also benefit ongoing research in structural health monitoring. Specifically, findings will help in developing methods to separate thermal effects from the effects of live loads in measurements collected from continuous structural monitoring.

Proposed finish date: June 2014

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