The Institution of Structural Engineers

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Project title: Aeroelastic performance of inclined stranded cables; Testing and verification

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Aims of research: Large scale wind-induced vibrations of cables have lately become of great concern for cable-stayed bridges. Namely smooth inclined circular stays, contrary to expectations, were found to respond with galloping-like motions both under the combined action of rain and wind and the sole action of wind. Stranded cables, which are very popular on small to medium span footbridges, are actually believed to be more prone to similar instabilities though little has been done on assessing their wind behaviour.
The aim of this project is to scrutinise observed ambient responses from inclined stranded stays and size the usually mishandled aerodynamic damping contribution.

Description of method: A recent vortex-induced fatigue collapse of an inclined stranded cable in the Sabo footbridge in the US (http://tinyurl.com/nut9tln) has posed questions in design understanding. Vortex shedding from stranded cables was always thought to be minimal, especially when combined with the vortex mitigating action caused by the inclination. Still, the proofs from the Sabo case support the opposite. As a matter of fact, monitoring of structures has always served engineering well in updating modelling approximations and providing us with further knowledge. Specifically for stranded cables, which can be found in many applications other than the bridge stays, full scale response has rarely been recorded and studied.

The plan of the proposed research is to first design a cost-efficient monitoring system based on MEMs devices that will be used for monitoring the cable vibrations of the Centenary Bridge over the river Aire in Leeds. Such a monitoring solution would have cost thousands of pounds per monitored channel in the past though now it can be realised in a fraction of the cost using USB-accelerometers and even mobile phones. Results will be calibrated against state-of-the-art measurements (e.g. Digital Image Correlation system and expensive wired seismic-accelerometers)

Continuous dynamic motion measurements of the cables will give a range of wind speed conditions that will allow sizing the variation of aerodynamic damping and indicate whether any propensity for instability exists. Actually this analytical part of the project will attempt to add further details on which of the Reynolds number or reduced wind speed is more critical in slender bridge design.

Detailed wind tunnel testing from the bridge design/construction era will allow the development of a quasi-steady aerodynamic model, which will serve as comparative measure to the recorded response. This will highlight, if any, limitations and shortcomings of quasi-steady aerodynamic theory and their critical addressing.

Benefits to structural engineering: Cable-stayed bridges are signature structures of today's cost effective, visually slender engineering. The experimental campaign proposed will support our understanding in what is still considered to be a weak link in modern bridge design. Aerodynamic influences are very complicate to assess on real-scale structures and monitoring studies remain limited although resources have evolved and become more affordable. The direct output of this research will be valuable data to act as benchmark in future computational and wind tunnel studies that will attempt to influence modern design guidelines.

Proposed finish date: 09/2014