Identification of aeroelastic forces on twin bridge cables from full-scale measurements in skew winds

A. Acampora
Department of Civil Engineering, Technical University of Denmark
IPU, Building 404, 2800 Kgs. Lyngby, Denmark

J.H.G. Macdonald, N. Nikitas
Department of Civil Engineering, University of Bristol
Queen's Building, University Walk, Bristol, UK

C.T. Georgakis
Department of Civil Engineering, Technical University of Denmark

ABSTRACT

Despite much research in recent years, large amplitude vibrations of inclined bridge cables continue to be of concern. Various mechanisms for the excitation have been suggested, including rain-wind excitation, dry inclined cable galloping, high reduced-velocity vortex shedding and excitation from the deck and/or towers. Much of the research on these topics has been based on wind tunnel tests and theoretical modelling. Although cable vibrations have frequently been observed on actual bridges, there are still relatively few cases where extensive field measurements have been made.

Since 2010, the Danish Technical University has been monitoring the vibrations of the inclined twin cables of the Øresund Bridge, which connects Denmark and Sweden. Data have been collected in a wide range of environmental conditions. From the acquired data, Georgakis and Acampora [1] determined the aerodynamic damping for wind orthogonal to the twin cables, in both dry and wet conditions. Furthermore, Acampora et al. [2] analysed data for multiple modes of the same cables in dry conditions and showed that the aeroelastic forces appear to be a function of Reynolds number rather than reduced velocity and that there was reasonable agreement of the results with quasi-steady theory. Only cases of wind orthogonal to the cables in dry conditions were considered, giving uncoupled behaviour of in-plane and out-of-plane cable vibrations, as expected. Extending the previous work, the aim of this paper is to present the aeroelastic forces identified from the full-scale data on the twin bridge cables in skewed winds. This gives three-dimensional flow around the inclined cables and is expected to cause aeroelastic coupling of the in-plane and out-of-plane vibrations. An output-only system identification method employing the Eigenvalue Realisation Algorithm (ERA) has been applied to selected vibration events. From this, the effective stiffness and damping matrices, and hence the coupled aeroelastic forces have been identified from the measured cable vibrations. Of particular interest is evidence of aeroelastic coupling in skew winds, contrary to what has been found for wind orthogonal to the cables, and reductions in the aerodynamic damping in the vicinity of the critical Reynolds number range. Finally the identified aeroelastic forces are related to possible excitation mechanisms of the cables.

References

[1] Georgakis, C.T., Acampora, A., "Determination of the aerodynamic damping of dry and wet bridge cables from full-scale monitoring", International Symposium on Cable Dynamics 2011, Shanghai, China

[2] Acampora, A., Macdonald, J.H.G., Georgakis, C.T., "Identification of aeroelastic forces on bridge cables from full-scale measurements", EVACES 2011, Varenna, Italy