Technical University of Denmark

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Popular science summary of the PhD thesis

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Title of the PhD thesis	Aerodynamics and icing of bridge cables with concave fillets
PhD school/Department	Departement of Civil Engineering – BYG DTU

Science summary

The dissertation investigates the efficiency of two new innovative cable surfaces fitted with concave fillet of preventing wind-induced vibrations on cable-stayed bridges. Focus was directed in particular to the phenomenon of rain-wind induced vibrations (RWIV), which is known as the most common type and damaging type of vibration. The recent increase in the number of cable stayed bridges, becoming increasingly longer and lighter resulted in a higher number of observation of these vibrations, requiring for external active method of damping (i.e. external dampers between bridge girder and cables). Furthermore, due to the subsequent increase of the aerodynamic static loading induced by the wind action on the bridge cable due to their increase in number and length, an optimal level of aerodynamic forces should be maintained when introducing passive aerodynamic means of vibration suppression on bridge cables.

A detailed literature review, lead to an understanding and a basic background into bridge cable aerodynamics, wind and cables interaction in terms of instabilities, and a categorization of different passive means of control techniques with an identification key mechanisms for reduction of design drag force.

During this project, an extensive experimental wind-tunnel campaign has been undertaken examining the aerodynamics of the currently used cable modifications together with the two innovative cable surfaces fitted with concave fillet. The two currently prevailing system consisting of helically filleted cables and cables with pattern-indented surface were directly compared under same conditions and both cable configurations fitted with helically concave fillets were found with attractive properties. Furthermore, a parametric investigation on the concave fillet shape in order to evaluate its influence on aerodynamic coefficients, structure of the flow's near-wake and rain-rivulet suppression. The results show a complete suppression of the rain-rivulet and an early suppression of vortex-shedding in the sub-critical regime both for the helically concave (HC) and the helically staggered concave (HSC) filleted surface modification. In particular, HSC filleted surface show a low drag force in the post-critical regime, similar to the pattern-indented surface despite an increase of the fillet height of 100% compared to a traditional helically filleted surface.

Finally, particle image velocimetry (PIV) tests were performed in a wind tunnel in a cross-flow set-up on scaled sample of the helically concave and helically staggered concave filleted cable surfaces. Both two-dimensional and stereo PIV measurements in order to have a complete quantitative and qualitative overview and understanding of the development of the near-wake structures both in the streamwise and spanwise directions compared to a plain surface cylinder. The HC filleted surface exhibit a more stable near wake region, compared to the plain surface, which results in a weaker interaction and early suppression of vortex shedding, a smooth transition of drag force in the critical regime and a constant zero lift force. On the other hand, the HSC filleted surface creates high turbulence at separation, weakening a further development of large scale vortices inside the wake with an increased base pressure behind the cylinder. These facts prove that the presence of the staggered concave fillet is able to control the flow and prevent the interaction between shear layers to create vortices, resulting in a strong weakening of vortex shedding, a more stable near wake turbulent region. It can be seen as an indication for the reduction of drag force acting on the cylinder, suppression of vortex shedding and smooth transition from the subcritical to the critical regime, with a constant zero lift force.

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