Cable Aerodynamic Control: Wind tunnel studies

This dissertation investigates the possibility of preventing wind-induced cable vibrations on cable-stayed bridges using passive aerodynamic means in the form of cable surface modifications. Especially the phenomenon of rainwind induced vibrations, which is known as the most common type of these vibrations and capable of inducing severe vibrations. The recent increase in the number of cable stayed bridges continuously becoming longer and lighter have resulted in a high number of observations of cable vibrations.

A detailed literature review of the various types of passive means led to a categorization of the different control technics together with an identification of two key mechanisms for reduction of the design drag force. During this project extensive experimental work examining the aerodynamics of the currently used cable surface modifications together with new innovative proposals have been conducted.

The two current prevailing systems consisting of helically filleted cables and cables with a pattern-Indented surface were directly compared under the same conditions and both applications were found with attractive properties. The pattern-Indented surface maintained a low supercritical drag force due to the high intensity of streamwise vorticity, whereas the helical fillets resulted in a more gradual flow transition because of the spanwise variation. During yawed flow conditions, the asymmetrical appearance of the helical solution was found to induce a significant lift force with a sudden change in the lift during the flow transition, which could be the reason for a dry limited amplitude vibration observed only for cables with helical applications. Dry inclined galloping was only seen with the plain reference cable model, even though only the helically filleted cable was capable of reducing the intensity of the axial flow and disrupting the near wake flow structures. Similar studies during wet conditions with artificial simulation of light rain in the wind tunnel showed that the plain cable suffered from severe rain-wind induced vibrations. But despite the presence of both upper and lower rivulets on the surface modified systems, no significant rain-wind induced vibrations were successfully simulated.

Finally, by combining the understanding from the state of the art in the field and the experience from the currently applied solutions, several new innovative surface modified systems were tested. While a proper discrete helical arrangement of Cylindrical Vortex Generators resulted in a superior drag performance, only systems applying "mini-strakes" were capable of complete rivulet suppression. When the strakes was positioned in a staggered helical arrangement, the innovative system avoided all previous mentioned types of vibrations, had a supercritical drag similar to that of the patternindented surface, and a superior suppression of rivulets compared to any of the currently applied systems.

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