BRIEF POPULAR SCIENTIFIC ABSTRACT

The possibility of preventing dynamic instability in terms of bridge deck flutter by deliberately designing the bridge deck of suspension bridges with a lower torsional frequency than vertical is investigated in the present PhD thesis.

Aerodynamic stability is a major design constraint for the shape of the suspended bridge deck and the mechanical properties of long span suspension bridges. The self-excited forces occurring due to the mutual interaction between the bridge decks inertia and elastic properties and the incoming wind are expressed by using mathematical functions obtained from experimentally estimated flutter derivatives.

The focus of the work has been on the development of a novel triple-box girder for very long span and on the estimation of flutter derivatives from wind tunnel section model tests.

Wind tunnel tests of nine differently shaped section models have been conducted. Flutter was avoided in all tests where the torsional frequency was lower than the vertical. The aeroelastic design of bridges is, however, more complex than the torsional-to-vertical frequency ratio. If the torsional stiffness is too low, static rotations followed by steady-state oscillations may occur. Torsional flutter, divergence, dynamic stall or aerodynamic hysteresis are severe frequency ratio independent aeroelastic phenomena that must be avoided. The wind tunnel tests conducted indicates that this is possible by means of a novel triple-box girder design presented in the thesis.

An improved system identification method for the estimation of coupled free decay flutter derivatives has been developed. Enhanced accuracy of the experimentally estimated flutter derivatives could increase the accuracy of the prediction of the stability limit in full scale. The method has been used to show that torsional flutter can be avoided for a sharp-edged rectangular section with a width-to-depth ratio, B/D=10 and to identify non-linear pitching motion amplitude effects on the flutter derivatives.

The bridge deck section model of the novel triple-box girder is tested to be aerodynamically stable at full scale equivalent wind speeds up to 88 m/s despite that the equivalent mass per unit length is lower than that of for example the Great Belt Bridge. Even in very lightweight setups, the free vibration section model tests were aerodynamically stable at high wind speeds.

It is thus shown, that it is possible to design very long span bridges with aerodynamically stable and lightweight girders, which may plausibly be used in future bridge projects.