Stability optimisation of twin-box girders

Theoretical and experimental investigation of aerodynamic stability in twin-box girders

Background

Long cable supported bridges are often built with a single streamlined box girder deck as seen on the Great Belt Bridge. However, with the need to build even longer suspension bridges crossing wider bodies of deep water (main spans above 2,000m) the single box girder is not aerodynamic stable anymore. To obtain sufficient aerodynamic stability, it becomes necessary to split the deck into two streamlined boxes with an air gap in between. This design is also known as a twin-box girder. The gap width between the two boxes is a key parameter for achieving aerodynamic stability, together with the design of wind screens and the shape of the girder hulls.

The project's objectives

The objectives of the project are to establish in depth understanding of the physical phenomena and mechanisms that ensure aerodynamic stability of twin-box bridge girders, and to use these effects to optimise the design of the twin-deck configuration.

A commercial bridge project carried out by COWI has revealed that the aerodynamic stability of a twin-box deck can be increased beyond current theoretical predictions, if the girder assumes a certain "nose-up" twist relative to horizontal when exposed to high wind speeds. A feature of the twin-box bridge deck previously undiscovered by the general bridge engineering community. A desirable "nose-up" twist may be achieved by manipulating the cross-section shape of the bridge girder or by fitting of windscreens or other appendages, thereby ensuring a significant nose-up aerodynamic static moment coefficient.

The success criteria for the project are:

- Establishment of a fundamental understanding of the phenomena responsible for the enhanced aerodynamic stability of twin-box bridge girders displaying nose-up behaviour.
- Develop a design concept for twin-box girders for cable supported bridges based on this understanding.

In the design concept the effect of windscreens, the gap width and shape of the box-girder will be investigated in detail. The numerical simulation will be conducted, and verification will be done by wind tunnel testing of optimised deck models.

Project organisation and time plane

The industrial PhD project is a collaboration between DTU Mechanical Engineering department and COWI A/S with the PhD student Maja Rønne. The main supervisors for the project are Jens Walther (DTU) and Allan Larsen (COWI A/S). The project is expected to take place in the period from October 2019 to October 2022.