Benefits and Challenges of the Twin-box Bridge Girder

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Abstract

The aerodynamics of the twin-box bridge is considered to highlight the reasons for making this type of bridge deck superior to the conventional trapezoidal mono-box for suspension bridges having span lengths longer than 1800 m. The paper proposes a simple theoretical model yielding physical insight into the flutter stability and presents a design example comparing the flutter performance of a 2000 m main span suspension bridge designed with either a mono-box or a twin-box bridge girder. Experience from vortex induced vibration of twin-box bridges is discussed to demonstrate that a twin-box girder can be designed to avoid vortex induced for practical damping levels.

Keywords: flutter instability; suspension bridge dynamics; mono-box bridge girder; twin-box bridge girder; vortex induced vibrations; cross girder connection.

1 Introduction

As the technologies advance and the demands for longer bridge connections arise, additional challenges meet the bridge designer. One being the structural performance of the bridge girder particularly for long span cable supported bridges in areas where the wind climate is harsh and weather extremes will become more frequent and intense because of global warming.

The wind performance of the conventional mono-box girder layout, as used for some of the longest bridges in the world such as the Great Belt bridge in Denmark and the Osmangazi bridge in Turkey, may have reached its limit once the spans approach the 1800 - 2000m mark. The alternative: A twin-box girder.

From the perspective of aerodynamic performance, the twin-box has some merits, as it reduces the self-excited aeroelastic loads in torsion leading to higher wind speeds for onset of flutter. The downside of the twin-box is that vortices shed rhythmically from the upwind girder hull may impact on the downwind girder hull and lead vortex induced vibrations at low wind speeds commonly encountered for every day operation.

From a structural point of view separating the two boxes increasing the lateral stiffness around a vertical axis will naturally be beneficial to some extent, however in doing so cross girders are required to connect the girders to achieve this effect. Herein lies a challenge, since the Vierendell effect of the girder system may impose some localised effects at the connection between the longitudinal girders and the cross beams. This connection will require special attention, and the knowledge of this effect shall be considered in the early phases of the design, since it may have direct impact on the general layout of the bridge girder system.

2 Flutter instability

Aerodynamic instability of long span suspension and cable stayed bridges manifests itself as flutter

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