Longitudinal response of a cable-stayed bridge to wind loads using fluid-structure interaction simulations

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Abstract

Cable-stayed bridges are highly susceptible to wind effects, both in the construction and service phases, due to their high flexibility, low damping, and the geometric shape of the deck and pylons. Their study, under the effect of the wind, is complicated if they are built-in mountainous regions since the winds can be subject to complex flow patterns (the wind speed is not constant in time and space). Normally, scale models are subjected to different tests in wind tunnels. However, with the improvement, in recent years, of the capacity of computers and the development of computational fluid dynamics algorithms, it has been possible to investigate the flow patterns of wind around civil structures prototypes. This paper presents the study of a long cable-stayed bridge through fluid-structure interaction (FSI) simulations to estimate its longitudinal structural response. The numerical model considers the topography of the bridge construction site. The response obtained is compared with the results of an aeroelastic model of the complete bridge in a wind tunnel

Keywords: cable-stayed bridges; computational fluid dynamics; fluid–structure interaction; computational wind engineering.

1 Introduction

Studying the effect of wind on bridges is complicated, especially if they are built in remote mountainous areas where the site's atmospheric boundary layer winds may be subject to highly complex flow patterns (air velocity is not constant in time and space) [1]. The current capabilities of computers and the development of numerical methods for computational wind engineering has made possible the simulation of the neutral boundary atmospheric layer (ABL) and the study of the effects of wind on civil structures. Over the past three decades, computational fluid dynamics (CFD), computational structural dynamics (CSD) and fluid–structure interaction (FSI) techniques have progressed rapidly and been used intensively for the study of wind effects on civil structures. In [2-7], several state-of-the-art summaries, recent advances and recommendations for good practices in the use of such techniques are presented. These numerical methods have the advantage over experimental tests (in wind tunnels or in full scale): allow the simulation of wind under well-controlled conditions; provide detailed information on important flow variables throughout the calculation domain; and may be used in the design phase of bridges.

However, to check the reliability of CFD simulations, verification and validation studies of the solution are desirable, hence high-quality

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