Pseudo three-dimensional simulation of buffeting response under turbulent wind

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Summary

The aeroelastic response of bluff bodies is strongly influenced by atmospheric turbulence contained in the wind. The accurate prediction of wind-induced dynamic response of line-like structures such as bridges and towers requires modelling of the cross sectional aerodynamic behaviour, the structural dynamics and the wind characteristics. This study aims to integrate all these aspects by performing CFD analyses in slices that are coupled to a three-dimensional structural model and performing fluid-structure interaction analyses that are able to account for turbulent inflow conditions. The method is applied to the study of a cable-stayed bridge and the results are verified against wind tunnel measurements.

Keywords: Buffeting response, bluff body aerodynamics, correlated turbulent wind, vortex particle method, numerical simulations, computational wind engineering.

1. Introduction

Aeroelastic phenomena are complex interactions between the fluid flow originating from wind and the dynamic characteristics of the structure. For a thorough analysis of long span bridges and high structures an assessment of wind induced dynamic effects is required. The characteristics of real wind are influenced by global climatic effects as well as those of the local terrain which have significant influence on the atmospheric turbulence. Fluid flow around typical structures is determined by the aerodynamic behaviour of the bluff cross section and forces induced give rise to dynamic structural response. These effects all need to be modelled, as has been pointed out by Davenport, cf. Fig. 1.

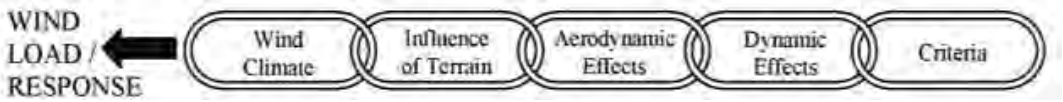

Figure 1: Wind chain by Davenport [1].

The Vortex Particle Method (VPM) is used here as the numerical method to study the aeroelastic phenomena. The VPM method has the computational advantage for two dimensional simulations of Navier-Stokes equation of slightly viscous flows. For that reason, the method proposes itself as an efficient numerical technique in the context of wind engineering, e.g. wind structure interaction for cross sections of complex geometry. The challenge of studying a structure with varying cross section along its axis, however requires an extension of the sectional analysis concept.

The pseudo three-dimensional simulation is proposed here as a numerical approach within which multiple two dimensional simulations are carried out. Two dimensional sections are linked together

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