Predictive Computational Analysis and Optimal Design of Wind-Excited Structures

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Abstract
The research project deals with the development of computational tools necessary to improve the response of wind-excited structures. It involves working with and extending a finite element based multiphysics tool which is used for wind flow simulations. Discrete adjoint shape sensitivity maps should aid the reduction of the alongwind load, whereas added devices will mitigate the crosswind vibrations caused by windload. Computational results are intended to be compared with experimental wind-tunnel data.

Motivation
Wind effects represent an important load case for many structures in civil engineering. In most cases a reduction of the structural response for this load case would be beneficial.

An automated computational workflow is proposed to help mitigate wind-induced strains and stresses of constructions. The developed and implemented code should aid and steer engineering experience based countermeasures.

Fig. 1: Aerodynamic modifications and added devices for the mitigation of wind-induced response of structures (adapted). [1]

Shape optimization using numerical
Numerical methods for flow-induced drag reduction and lift-to-drag ratio improvement have been used in the automotive[2] and aerospace industries.
These provide a starting point to the current research. Nonetheless, wind scenarios of civil engineering structures are characterized by significant fluctuations and turbulence. Neighbouring constructions and varying flow directions make the setup to be considered even harder to model. The method of choice is the discrete adjoint formulation for obtaining shape sensitivities. This is currently being developed, implemented and tested with the objective of providing valuable information for the mitigation of the effect of bulk wind load.

**Auxiliary devices for the crosswind response**

Vortex shedding and motion-induced aerodynamic forces should also be limited. The investigation involves the further enhancement of the aeroelastic components part of the numerical windtunnel with development related to the coupling of subparts in a multiphysics scenario as well as addition of devices for further control.

![Fig. 2: Possible shape modifications of a cross section.][1]

![Fig. 3: Shape sensitivities in normal direction for the drag reduction on a cube with an upstream prism.][2]

![Fig. 4: Mitigation of wind-induced vibrations with auxiliary devices.][3]

**References**


