Bauhaus-Universität Weimar

Institut für Konstruktiven Ingenieurbau
Professur Modellierung und Simulation – Konstruktion
Prof. Dr. Guido Morgenthal

Optimierung winderregter Tragstrukturen unter Berücksichtigung stochastischer Einwirkungen und verschiedenartiger Grenzzustände

Optimization of structures under wind-induced loads taking into account stochastic influences and different limit states

Motivation

Wind engineering deals with the interaction between wind in the atmospheric boundary layer and structures. The evaluation of wind loading and its effect on structures depends on various interconnected considerations. The fluctuating nature of the wind in the atmosphere caused by terrain effects produce complex flow fields which interact with structures in high-Reynolds-Number flow regimes. Pressure fields are generated as a result of flow separation and reattachment, leading to severely unsteady loading on the structure. Structural vibrations may also cause complex fluid–structure interaction effects and phenomena such as vortex-induced vibrations and flutter. These effects are strongly dependent upon the geometry and the mechanical properties of the structure.

The characteristic of the natural wind field results in a problem with stochastic input parameters. Additionally, aerodynamics and structural dynamics affect the structural response which can be influenced by changing properties such as shape or stiffness. However, in practical engineering, coupled analyses and structural optimizations are usually not carried out and only deterministic studies are performed which makes the planning process more challenging and generally leads to non-optimal structures.

Goals and Methods

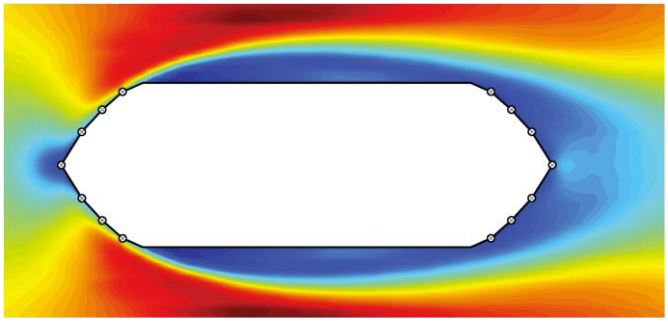
The fundamental goal of this project is to develop a generally applicable methodological framework, which makes it possible to evaluate the forces in structures due to complex dynamic wind-induced phenomena. This shall be carried out by means of numerical simulations considering defined limit states and to optimize the structure on the basis of probability of occurrence or degree of utilization.

The analysis will be based on numerical simulations of critical wind phenomena considering linear structures and using appropriate mathematical optimization strategies to ensure compliance with all design requirements and, if necessary, the optimization of other criteria such as material costs. In the context of practical application to structures, it must be demonstrated that such methods are suitable for resolving complex optimization problems using the available computational resources.

Optimization and sensitivity analyses are usually time-consuming, therefore meta-models can be used to replace the complex numerical simulations with simple mathematical functions to make this process more efficient. Various regression and interpolation approaches differ in their complexity and flexibility which can be applied directly. The simulation methods and optimization strategies shall be selected, tested and adapted. Also the interfaces and evaluation algorithms shall be developed and tested for an efficient computational implementation.

Innovation and Perspective

The outcome of this project is to develop a numerical framework of optimization of line-like structures such as bridges, skyscrapers, towers, masts or chimneys. Utilizing optimal shapes, the design of these structures can be made more cost-efficient, reliable and environmental-friendly.



Optimized shape of a wind nose to minimize the wind drag forces, taking into account the flow from both directions. Modelling the shape as a polygon, where the coordinates of the points (o) served as design variables.

Bauhaus-Universität Weimar

Institut für Konstruktiven Ingenieurbau
Professur Modellierung und Simulation – Konstruktion
Prof. Dr. Guido Morgenthal

Projektträger

Deutschen Forschungsgemeinschaft (DFG)

Gesamtzuwendung

XX Mio. €

Projektlaufzeit

09/2017 – 11/2020

Projektpartner

MSK, ISM
Bauhaus-Universität Weimar

Contakt

Prof. Dr. Guido Morgenthal‘
Tel.: +49 3643 584418
E-Mail: guido.morgenthal@uni-weimar.de

Webseite

https://www.uni-weimar.de/de/bauingenieurwesen/forschung/