Wind-Structure Interaction

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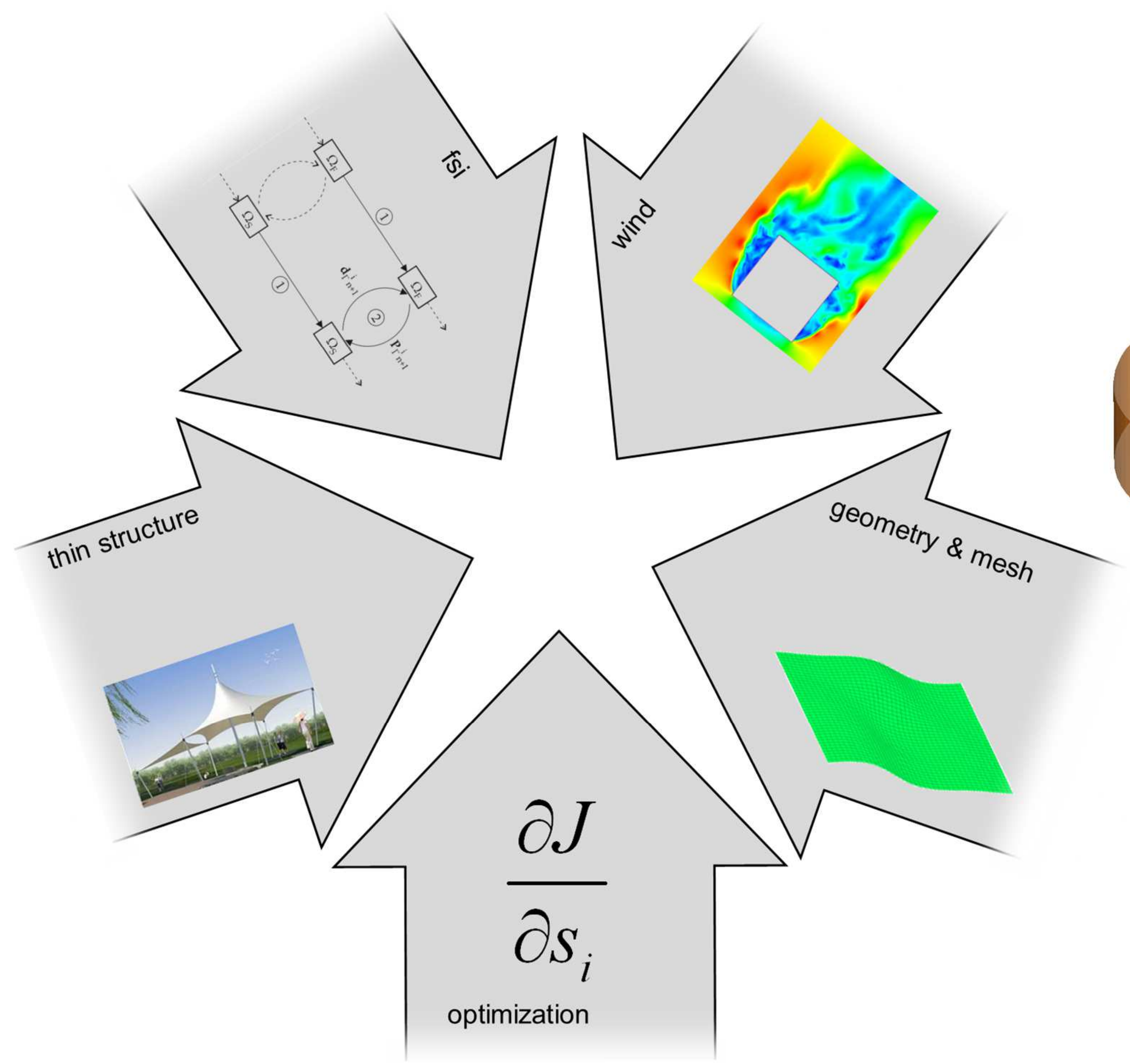
In design and simulation of light-weight structures, wind loads play a considerable role. For structures with simple shapes such as cube, cylinder, prism, etc., wind loads are well predictable through various existing standards and tables. However evaluation of these loads on complex geometries often requires extensive Computational Fluid Dynamic simulations of the wind flow. Moreover, since light-weight structures are generally slender and soft, they undergo large deformations due to wind loads, which indicates the importance of numerical solution of the coupled problem of Wind-Structure Interaction.

Design of light-weight structures:

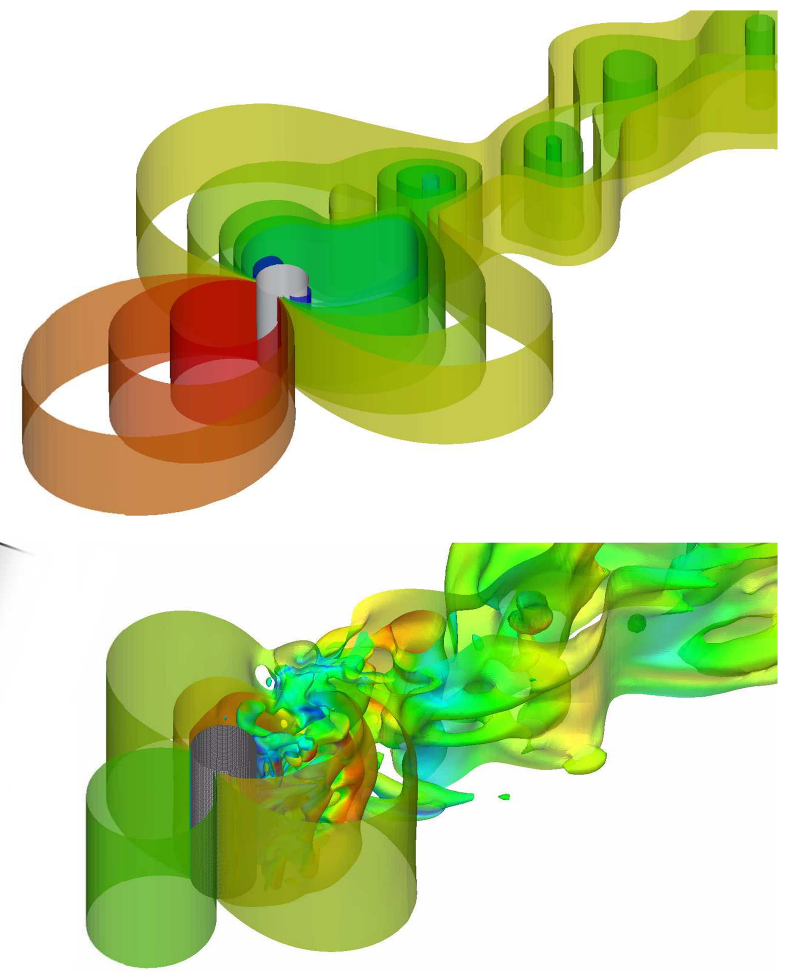
This procedure requires combining multiple disciplines ruling the physics and the design process. Both for the design and the FSI problem partitioned strategy is employed.

Basic validations of wind and FSI:

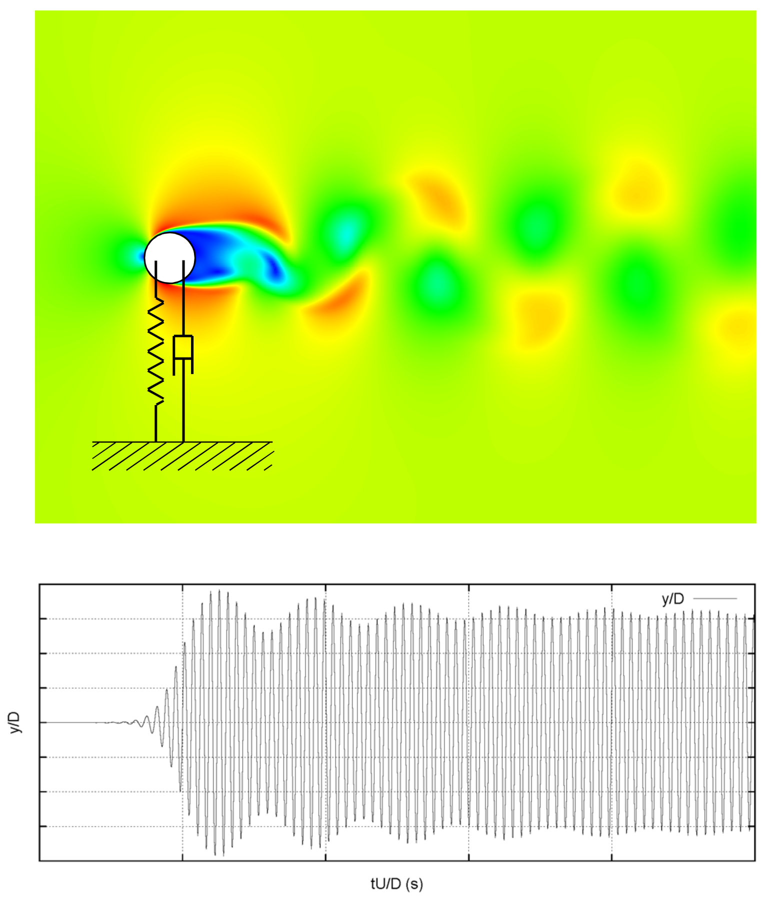
Different modules of the workflow are first tuned and validated with basic shapes and benchmarks, for which detailed reference results are available. In this steps various details are studied such as applicability of turbulence models, stability and accuracy of the FSI problem in different coupling techniques and time-integrations, etc.



disciplines involved in design and simulation of wind-structure interaction



Validating, tuning CFD, turbulence, flow parameters and models for a reliable simulations



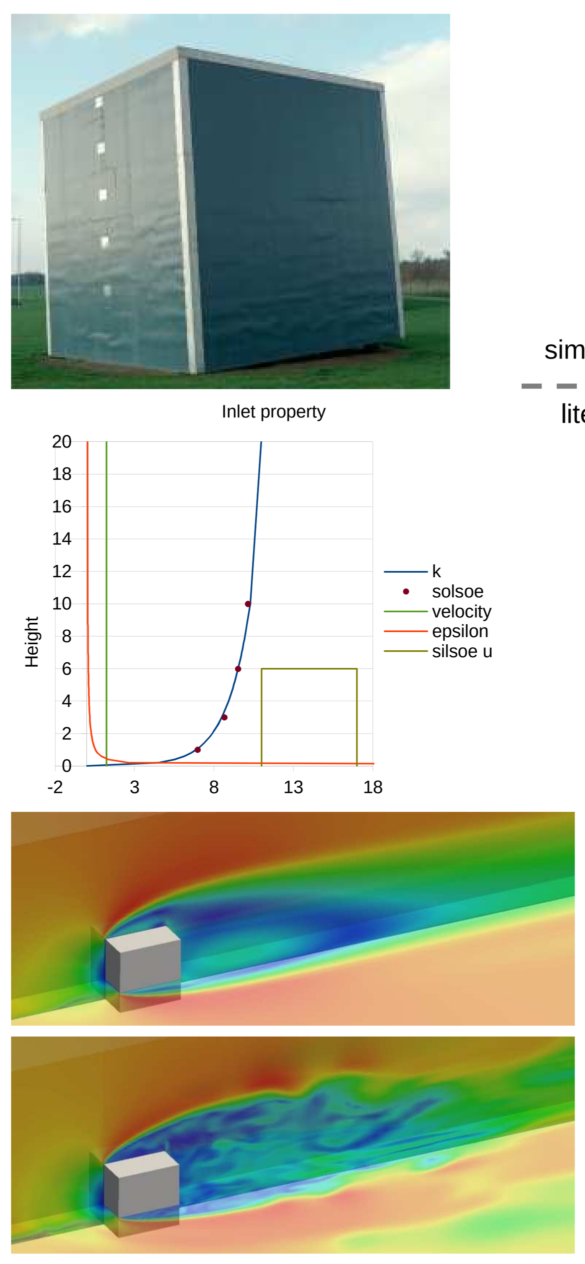
Flow-induced vibration of a circular cylinder with 1 degree of freedom. Despite the simple setup of the problem, it is a good challenge to study different techniques and parameters of an FSI problem

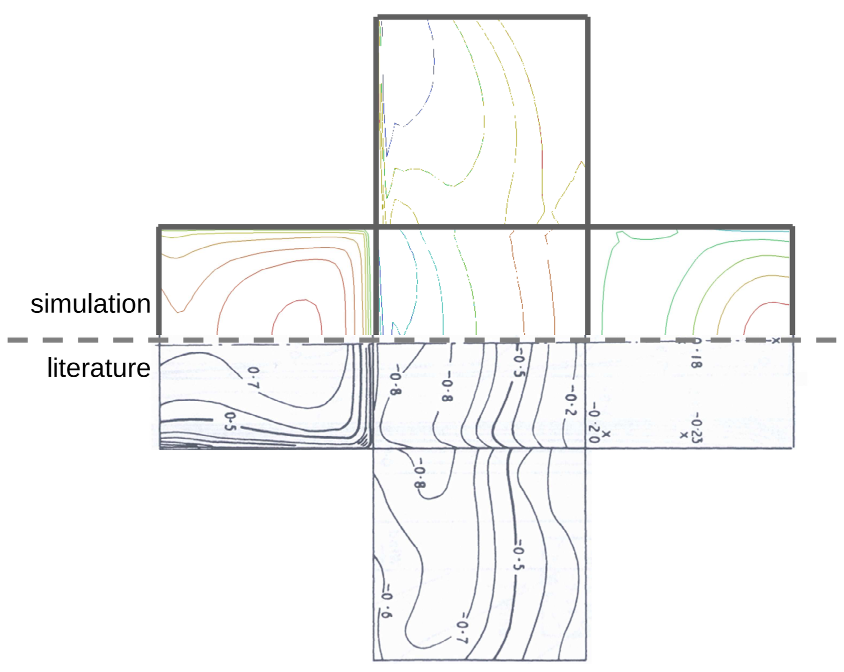
Structures in Atmospheric wind:

As the next step, the established framework presented above is further advanced and applied on real size wind problems.

For example, a detailed study on the wind around the Silsoe cube was performed. The flow parameters at the inlet were assigned based on the real atmospheric boundary layer. Results show good agreement with the experiment and other numerical and experimental studies.

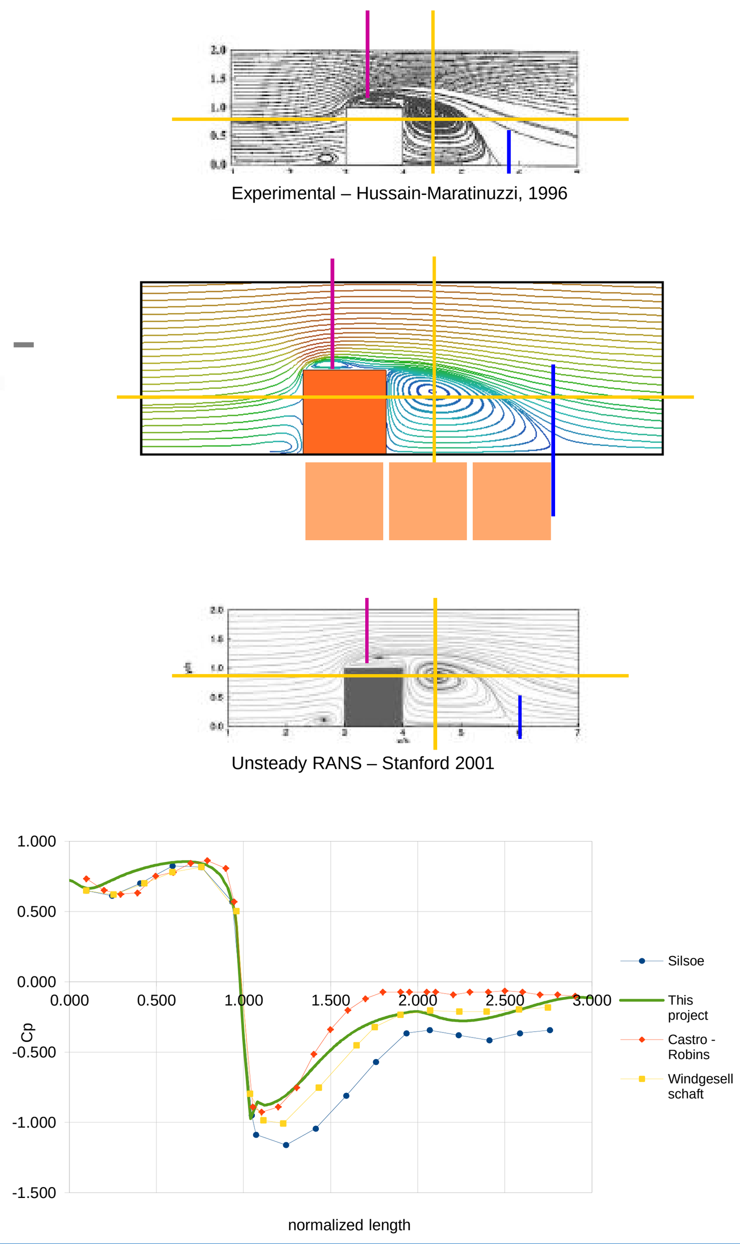
Furthermore, effect of flexibility and interaction of the structure and the wind was illustrated by assuming a side wall to be a membrane surface.

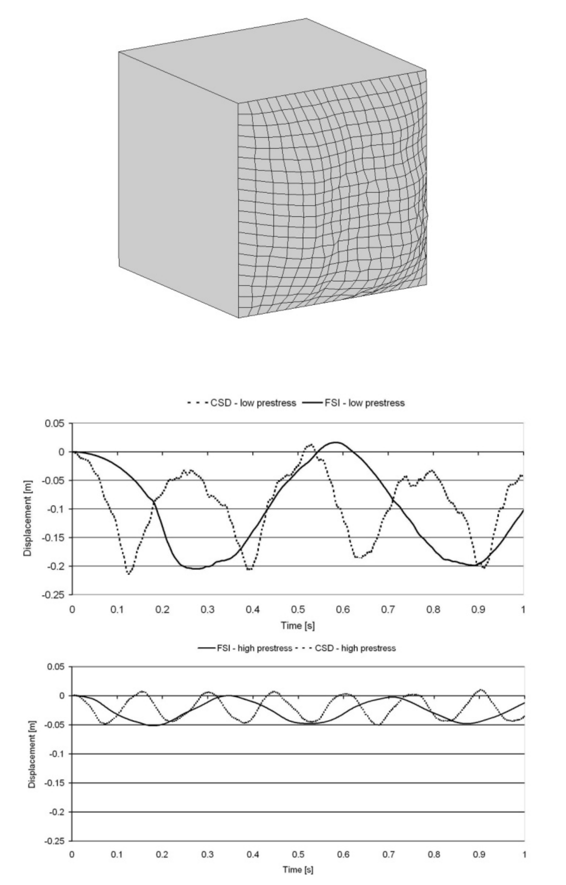




Specification of the relevant turbulent parameters at the inlet, consideration of different turbulent models (RANS/URANS/LES)

The Cp distribution on cube's surface is the main quantity of interest. Furthermore the flow around the cube is also validated





Assuming wind and structural problems to be decoupled leads to very poor calculation of structural dynamics.

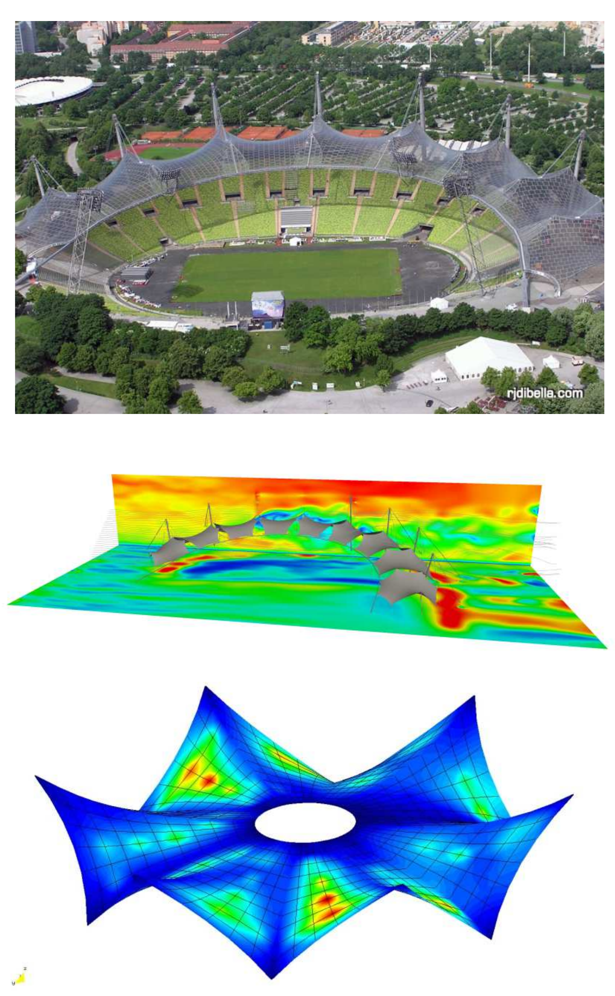
For structures with low stiffness, wind and structure problems are strongly coupled

Civil engineering applications:

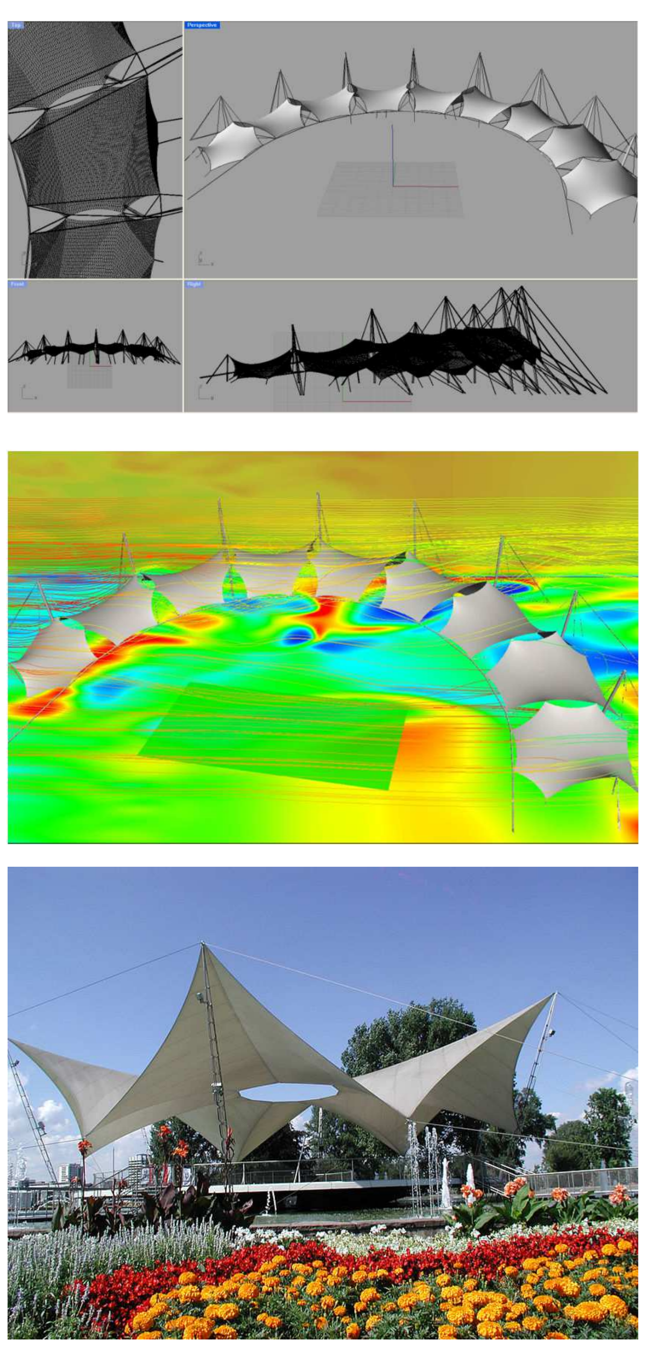
Having established a reliable and efficient frame for calculation of wind loads, one can step in to large size civil engineering problems.

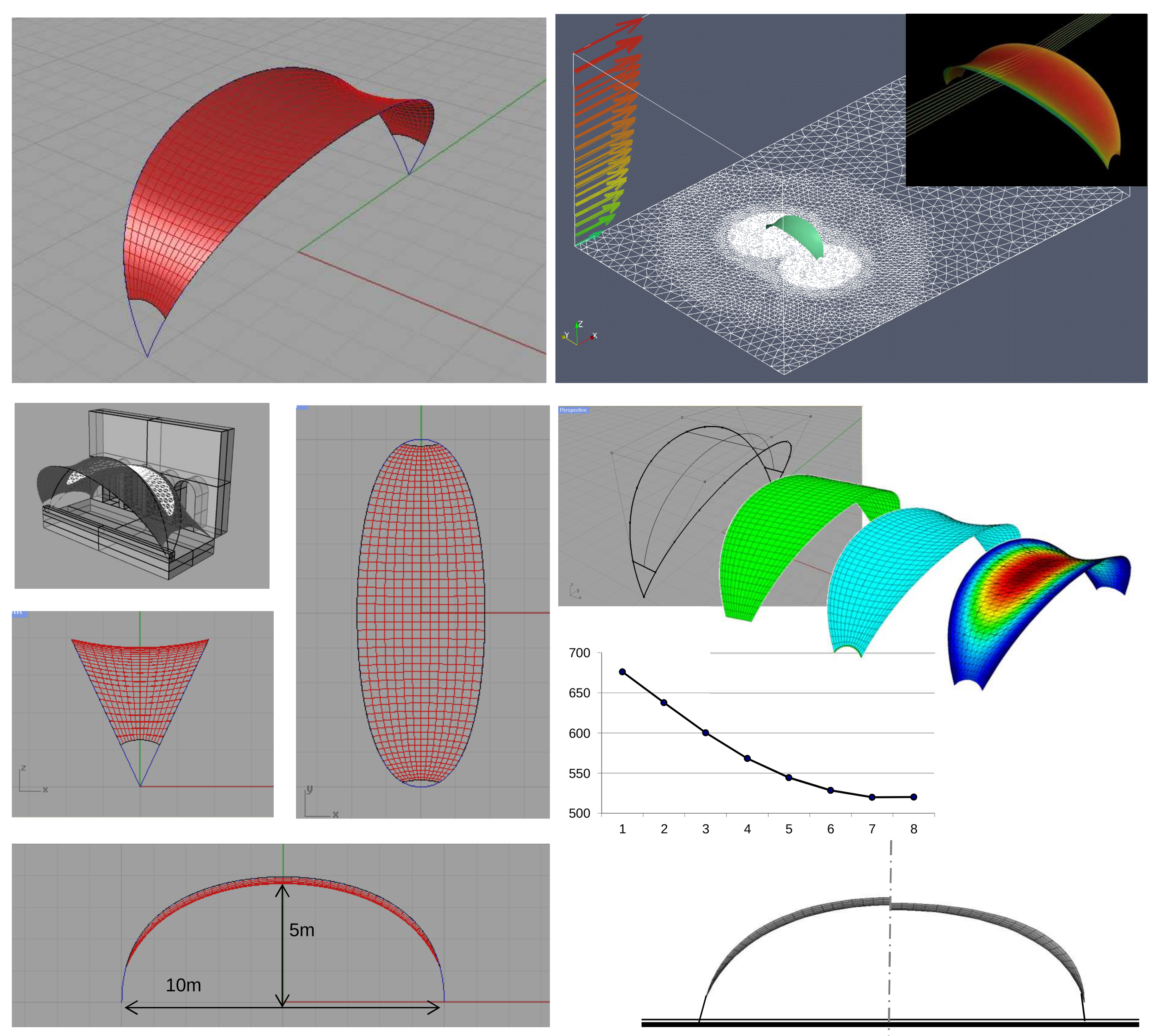
Design and optimization:

Optimization of the structure is done by use of gradient-based techniques and based on the chain rule of differentiation. In addition to a strong geometry parameterization, evaluation of the design sensitivities for the mentioned coupled problem is a big challenge in this class of problems.



Complex geometries are constructed by use of CAD and form-finding techniques, and then put in the numerical wind tunnel





Design chain of a membrane roof. The shape is parameterized by NURBS and form-finding. Optimization is done by a fully coupled sensitivity analysis