Design and evaluation of a simple Fluid-Structure Interaction framework for analysis of fabric structures under wind loading.

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Abstract
Tensile fabric structures pose -due to their inherent flexibility and complex forms- a particular challenge when it comes to deriving their response under complex load cases such as wind.

Aside from being a highly variable load case, the wind flow around these three-dimensionally curved, thin, and often open, structures leads to complicated distributions of pressure and suction zones which are influenced by the structure's displacements and its orientation with respect to the wind direction. Obtaining accurate pressure distributions for these structures is thus a complicated and often computationally-intensive which requires experience and expertise.

To facilitate the task of obtaining a more accurate structural behaviour of a fabric structure under wind load, a Python library was created where, rather than utilising custom analysis codes and algorithms, existing analysis tools are connected and data is exchanged using straightforward and easy-to-understand methods. The outcome provides a relatively intuitive and highly readable workflow tying together structural analysis and steady-state Computational Fluid Dynamics (CFD).

This paper discusses by means of a case study the foundations of the created framework, its possibilities as well as limitations.

Whereas the use of steady-state analysis provides the distinct disadvantage of not modelling temporal effects such as turbulence and the resulting fluttering, the conducted case study already shows the possibilities of this approach when it comes to deriving more accurate pressure distributions and their resulting displacements and stresses. Factors such as pretension, cable tension and overall curvature each affect the way the structure and wind flow interact with each other.

The proposed framework attempts to keep the middle ground between a simple structural analysis where pressure distributions are very roughly approximated and the high-end CFD calculations often requiring multiple days, if not weeks, of computation time. The preliminary results presented in this paper illustrate the framework's possibilities for obtaining a generalised pressure distribution pattern for different directions, investigate the effect certain structural parameters have on the behaviour under load and assess the effect of the constant interaction between the wind flow and the structure's displacements.