Doctoral Candidates' Day

Rupert Fisch

Towards the establishment of a numerical wind tunnel

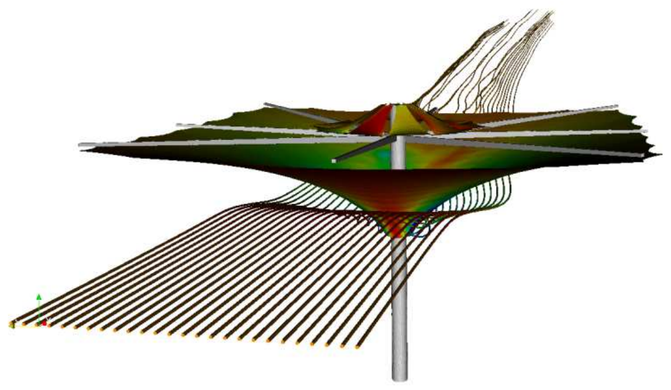
The ratio of self-weight to total load on lightweight and filigree structures is very low; therefore, these structures are sensitive to dynamic loading, for instance wind induced. In addition, flexible structures with large deformations are potentially interacting with the wind. One example is a foldable umbrella structure (cf. fig. 1 below). Presently, no standard is covering the described interactive scenario for complex geometries.
For the assessment of structural stability and serviceability of umbrella structures, a fluid-structure interaction analysis is required to cover all necessary effects. The experimental wind tunnel is not quite able to cover the interactive behaviour of the umbrella with the wind. Hence, a numerical wind tunnel should be set.

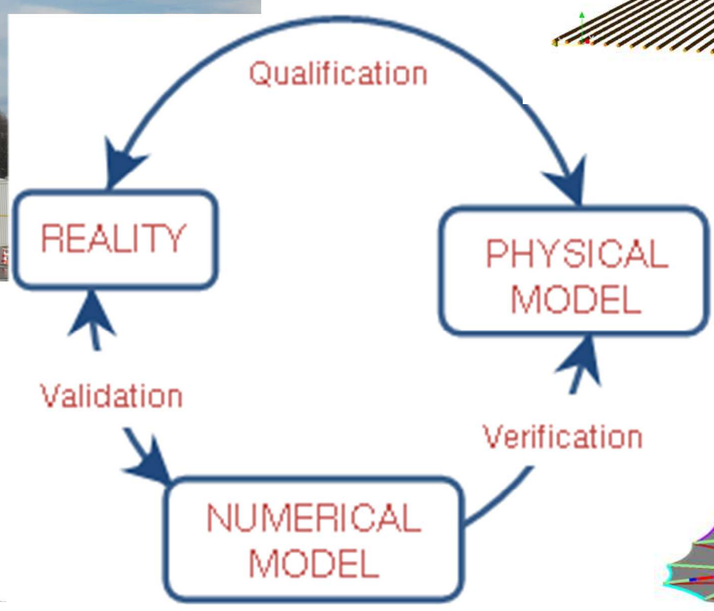
Wind tunnel challenges

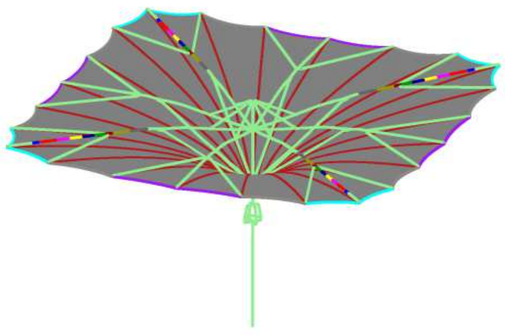
To design a numerical wind tunnel one has to care about a lot of aspects, like turbulence modelling and modelling of the atmospheric boundary layer in the flow simulation; creating geometric models resp. a mesh; solving the problem with all relevant influencing physical factors.

Besides that, there is justified skepticism in the relatively young field of computational wind engineering. Thus, only serious work on the predictive capability of computational wind engineering can generate trust in this approach.
Oberkampf and Roy named a list of influential factors for the predictive capability of simulations [1]. One factor is Verification and Validation (V&V). They provide evidence for the correctness of the code and results and contain a concept of quantitative accuracy assessment.

Source: SL Rasch, Stuttgart





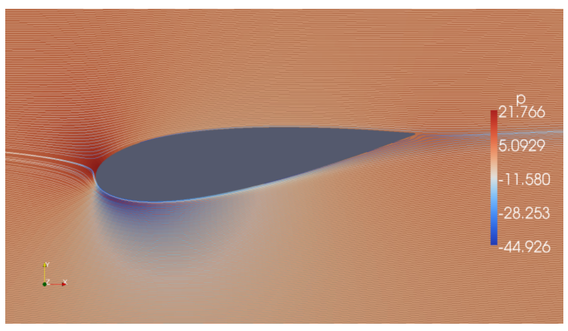


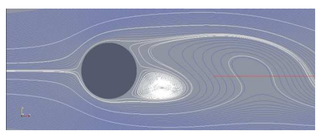
Verification & Validation

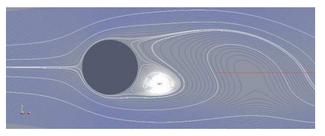
Verification means the "process of assessing software correctness and numerical accuracy of the solution to a given mathematical model" [1], or simpler spoken „Verification is solving the equations right" [2].

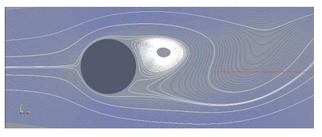
Validation means the "process of assessing the physical accuracy of the mathematical model based on comparison between computational results and experimental data" [1], or simpler spoken „Validation is solving the right equations" [2]. One part of verification is called Code Verification.

Once the confidence in the general environment of the numerical wind tunnel is established, one will be able to discuss specific issues of elastic membrane structures. As an example for these investigations one could think of: the capability to identify sensitivities and crucial parameters of the structure; the assessment of numerical and physical modelling aspects.





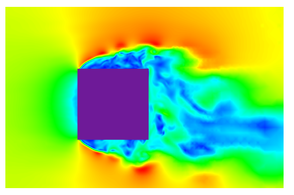


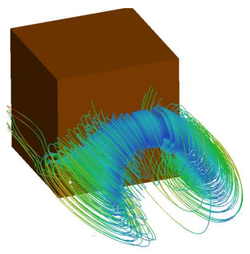


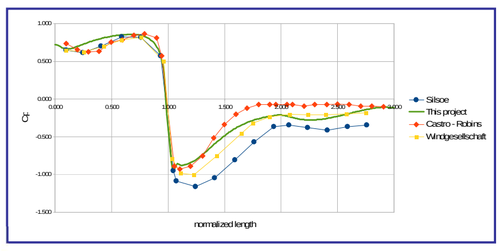
Re = 50

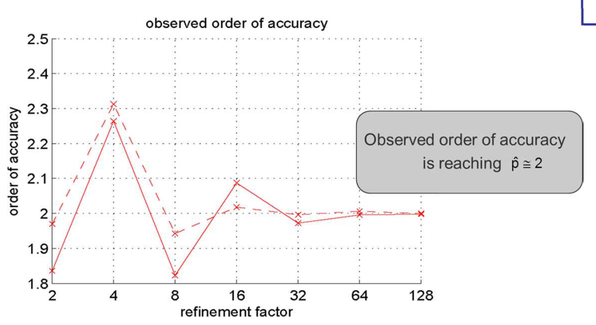
Re = 60

Re = 70

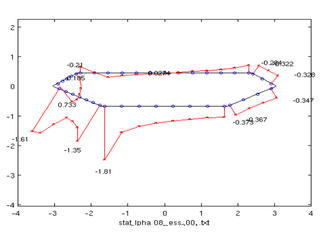


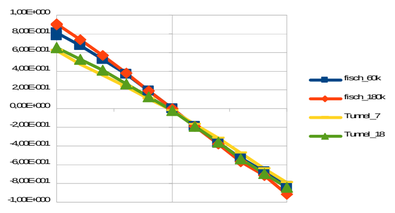


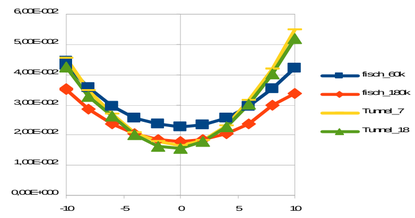


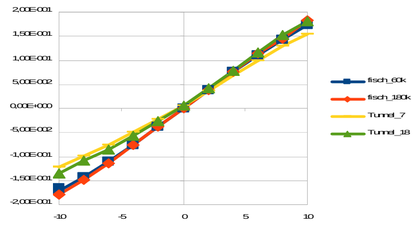


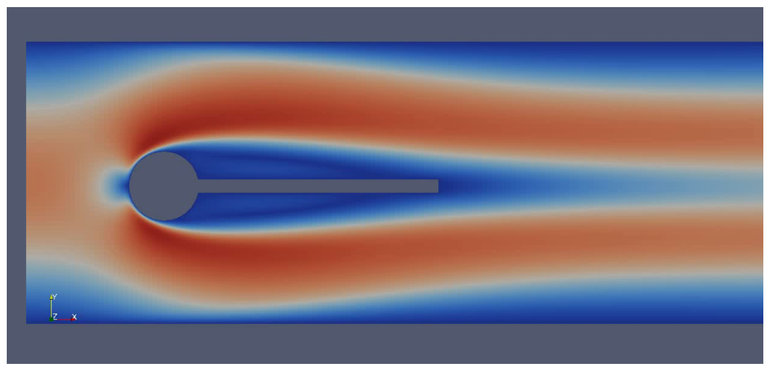
ARIES – mobile - © Gengnagel, 2006











Source: [1] Oberkampf, W.L. and Roy, C.J., Verification and Validation in Scientific Computing, Cambridge: Cambridge University Press (2010)
[2] Blottner, F.G., Accurate Navier-Stokes results for the hypersonic flow over a spherical nosetip, Sandia National Labs., Albuquerque, New Mexico (1989)

rupert.fisch@tum.de Lehrstuhl für Statik, Prof. Dr.-Ing. Kai-Uwe Bletzinger www.st.bv.tum.de