Computational Wind Engineering of Large Umbrella Structures

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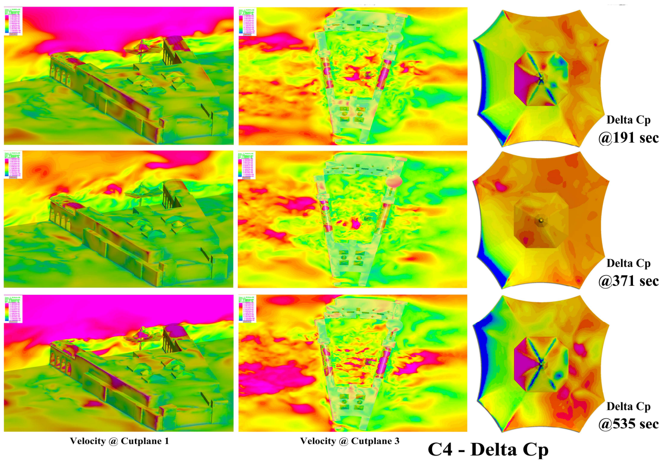
Summary

The sensitivity of membrane structures to transient wind loads becomes severe at wide spans and low pre-stress levels of the membrane. At stationary wind loads, the elastic behaviour of the flexible membrane leads to deformations with an associated change of the flow conditions and wind pressure distributions. This effect can be enhanced by time dependent fluid fluctuations such as atmospheric or building induced turbulences.

Common methods in wind engineering practice like small scale wind tunnel experiments do not fully cover non-linear structural behaviour, contact interaction between membrane and structural elements and the interaction of the flow field with the structural response. Therefore numerical tools - developed and validated during several scientific and applied engineering studies [1]- are used for structural engineering.

The objective of the presented work is to investigate the dynamic behaviour of large convertible funnel shaped umbrellas made of high strength steel and woven PTFE fabric, under turbulent wind loads, applying computational wind engineering tools. The task is to use a numerical software environment to detect aerodynamic instabilities and assess dynamic structural response. Results are used for the structural design of the load bearing members and for the development of the folding kinematics. Further studies cover the behaviour of partially opened membrane structures in turbulent wind conditions. The complete structural design process and the applied numerical methodology is sketched within this paper.

Furthermore, the validation of the FSI simulation environment on fully deformable 1:1 scale measured 29m umbrella prototype structure is presented.



[1] Michalski A. et al., 2011. "*Validation of the computational fluid–structure interaction simulation at real-scale tests of a flexible 29 m umbrella in natural wind flow*". J. Wind Eng. Ind. Aerodyn. 99 (2011) 400–413