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SIMULATION OF WIND INDUCED EXCITATION OF A MEMBRANE STRUCTURE WITH PONDING WATER

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Membrane structures undergo large deformation to carry loads and consequently they can be vulnerable to ponding. When coupled with a strong wind gust, this can lead to violent excitation of the tent structure. One example of this phenomenon was observed during the 2011 Pukkelpop festival held in Kiewit, where the sudden onset of a storm along with heavy rainfall [1] damaged many tents and also resulted in casualties. This is clearly a fluid-structure interaction phenomenon (FSI) involving coupling of a membrane structure, ponding water and the wind. In our previous work [2], we developed partitioned and monolithic algorithms to calculate the static deformation of a membrane structure due to a given volume of ponding water, which will serve as an initial condition for the time varying FSI simulation.

One way to simulate this interaction is to couple a structural solver modelling the membrane behaviour and a two-phase solver such as a Volume of Fluid solver that simulates the wind and water. However, this will be computationally expensive as simulation of wind generally requires a large domain and a large number of cells. In the present work, we use the observation that the added mass from the air on the combined structure and water is negligible; therefore, we can either use a staggered coupling between the wind and the membrane-water system or small number of Gauss-Seidel iterations for convergence, where the membrane-water system is simulated using strong partitioned coupling. The computation domain for simulating the water will be much smaller as the water occupies only a fraction of the volume compared to the wind domain. One of the key assumptions in this approach is that the interaction of the ponding water and the wind is negligible which can be justified by considering that the typical fetch of the ponding water is relatively small. The main advantage of this strategy is that the simulation will be much faster as this involves fewer wind solver executions.

REFERENCES

[1] P. D. Meutter, L. Gerard, G. Smet, K. Hamid, R. Hamdi, D. Degrauwe and P. Termonia, Predicting Small-Scale, Short-Lived Downbursts: Case Study with the NWP Limited-Area ALARO Model for the Pukkelpop Thunderstorm, *Monthly Weather Review, American Meteorological Society*, Vol. **143**, pp. 742-756, 2015.

[2] N.K. Narayanan, R. Wüchner and J. Degroote, Monolithic and partitioned approaches to determine static deformation of membrane structures due to ponding, *Computers & Structures*, Vol. **244**, pp. 106419, 2021.