Coupling of Structural Solver and Volume-Conserving Solver for Form-Finding of Membrane Structures Subjected to Ponding

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ABSTRACT

Tensioned membrane structures have a unique load carrying ability relative to their self weight due to their large deflection behavior. This at the same time makes them vulnerable to ponding, which is the formation of indentation filled with liquid. The ponding water coupled with wind excitation can be fatal for the structure. A real life example is the Pukkelpop accident (Kiewit, Belgium 2011), where a sudden severe storm along with a heavy rain led to the collapse of many large tent structures, resulting in several casualties.

Computational methods to investigate this phenomenon will typically involve a fluid-structure interaction simulation with a light weight structure, ponding water and wind loads. As a first step it is necessary to find the shape of the deformed structure for a given volume of ponding water. This has been calculated by coupling a structural solver and volume-conserving solver in a partitioned manner. The volume-conserving solver is a plane representing the free surface of the water. The solver updates its position based on the deformation of the underlying structure in order to conserve a given volume of water, which in turn applies hydrostatic loading on the structure. To improve the speed of convergence, the volume-conserving solver is coupled inside the non-linear iterations of the structural solver. The linearized contributions of the hydrostatic and volume-conserving behaviour [1, 2] are also added in the structural system to accelerate the convergence.

REFERENCES

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