Calculation of static deformation of membrane structures under the load of ponding water

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Abstract

Tensioned membrane structures are very efficient in carrying loads compared to the materials usage, but these structures undergo significant surface movement when loaded, making them vulnerable to the formation of a water pond. During rainfall, the water ponding can be initiated by a 'seed' event such as drifted snow settling on the surface of the structure causing a local depression of the membrane structure [1]. If the water accumulates, it will cause more depression and will lead to more water accumulation and so on. This cycle may give rise to a situation where the load increases too much resulting in structural collapse or failure.

In the present work, the static deformation of a membrane structure under water ponding is calculated by coupling a structural solver for the membrane and a volume-conserving solver for the water in the non-linear iterations. The volume-conserving solver contains 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. The speed of convergence is improved by adding the load tangent stiffness matrix of the ponding water to the tangent stiffness matrix of the structure [2, 3]. Using this method, the extent of ponding and the final deformation of the structure is calculated by applying loads in the form of an incremental water volume increase.

References

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