Advantages of Isogeometric B-Rep Analysis for the Design of Structural Membranes

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ABSTRACT

Structural membranes are wide-span lightweight textile structures that can be built in a variety of interesting and appealing shapes. Since textiles can only carry loads through tension, the combination of prestress and curvature is essential and necessitates the so-called design cycle including formfinding, structural analysis and cutting pattern generation. All three steps are highly nonlinear and iterative analyses with a result that influences the structural behaviour as well as the appearance. Formfinding needs to be perfomed to attain a functioning structure under prestress. Once a formfound shape is set, structural analysis ensures a structure's safety. Finally the cutting pattern generation provides the flat patterns, i.e. fabric stripes, which can be raised to the desired threedimensional shape. This presents a challenge since the double curved surfaces cannot be developed into plane ones without compromise.

Due to the interactive nature of the design cycle analyses, working with a single model holds a substantial advantage for the designer. With Isogeometric B-Rep Analysis (IBRA), it is possible to design and analyse these free-form shapes without leaving the CAD environment [1]. As IBRA uses the NURBS-based CAD models for analysis, the geometry can be represented in a far better way than is possible with classical FEM meshes. It thus leads to more accurate results with regard to both the shape and the stresses, because the curvature's influence on the structural behaviour is accounted for appropriately. IBRA accesses the full B-Rep description of a geometry. This means that CAD functionalities which are fundamental for the construction of geometries, e.g. trimming, can be used without compromising the analysis model. Especially with regard to the cutting pattern generation it is beneficial to model the pattern stripes by simply applying trimming operations to the formfound shape and performing the analysis on the trimmed patches.

The design cycle of membrane structures with IBRA will be presented in this paper on an exemplary structure. An emphasis will be put on the cutting pattern generation, where CAD-integrated analysis with IBRA holds the most advantages.

REFERENCES

[1] BREITENBERGER, M. et al. *Analysis in computer aided design: Nonlinear isogeometric B-Rep analysis of shell structures*. in: Computer Methods in Applied Mechanics and Engineering 284, pp. 401-457. doi 10.1016/j.cma.2014.09.033 (2015).