

Summary for the PhD Thesis of

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Nonlinear analyses of Tent Structure and Technical Textile by Numerical and Experimental Methods

The PhD thesis contain new results on the nonlinear analyses of tent structures. There are two main part: the numerical analyses of the structure and the experimental analyses of the technical textiles.

The tent structures are statically overdetermined structures, and they hold the external loads with large deformations and large elongations. The load-bearing material of the tent structures are textile composites with coating. The fibres of the textile are nonlinear on elastic and the behaviour of the woven textile is geometrically nonlinear. All over this the time dependent properties of the technical textiles has a significant effect on the deformations and internal forces of the structure. The thesis work on these topics and give methods to solve these them.

The first part of the thesis describe a new method for form-finding and analysis for external loads. The earlier methods use bars or flat 3-node surface elements for the discretization of the spatial surface of the tent structure. The new method use 8-node double curved spatial element to describe the surface. The calculation of the elongation is between the stress and elongation free (flat) cutting pattern and the actual deformed spatial surface. The changing of the curve-linear parametric coordinate system of the 8-node element is used to calculate the exact elongation. The dynamic relaxation is used to find the equilibrium state of the structure. According to the mechanical models used in the new calculation, the new method should be more accurate than the previous methods and less number of nodes and elements are enough to analyse a structure. The nonlinear elastic and viscous calculations are available as well.

The second part of the thesis contain a new phenomenology material law for the nonlinear elasticity. It can handle the geometric nonlinear behaviour of the textile micro structure and material nonlinear behaviour of the fibres. There were one- and bi-directional viscous elongation test on technical textiles with constant load. A new digital photographic method was worked out for measure the viscous elongations of textile specimens. Several heuristic creep model were tested on the experimental date. The viscous material law worked out from the experimental date was used for numerical analyses of tent structures. For the numerical analysis a new iterative method was used, which can handle the geometric nonlinearity of the structure and the time dependent behaviour.

The thesis integrate several fields of the nonlinear behaviour of the tent structures for a complex analysis.