Membrane design with fabric of straight yarns

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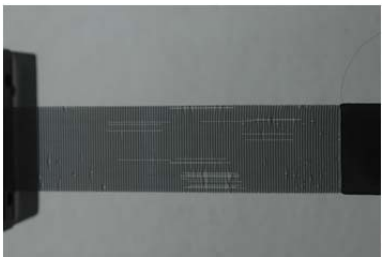
Abstract

Still today the behaviour of coated fabric is a topic of research in membrane structures, causes failure in existing building and determines the long term behaviour according to UV-resistance, aging and durability. Many designers, architects, engineers and manufacturing companies are in favour of fabric with straight yarns made of monofilaments. The behaviour is assumed to be easily controlled by the behaviour of one yarn, no influence of the twist in multifilament's and no change of geometries in the yarns caused by the interaction of warp and weft in a woven fabric.

There is a fabric on the market available made of straight monofilaments in warp and weft direction and the target is to use this fabric in pretensioned membrane structures for load carrying. The material has unique properties such as has total different behavior in warp and weft depending on the weaving technique. The uncoated fabric is translucent, has a high UV-resistance and to a certain amount water tight, see Fig 1.

Water tightness and translucency



statically distributed failure of single yarns in a tensile test

Test of a seam, sliding of yarns

Fig.1: Uncoated fabric with straight yarns

Research and development will be shown including the definition of the required material properties such as ultimate tensile strength and elastic constants under uniaxial and biaxial loads. It turned to be out the fabric is highly sensitive according to the clamping in the test machines. The load transfer between single yarns is only little. The fabric has no failure in a uniaxial tension test showing one crack, single yarns had been broken distributed in the whole test sample. This causes a new safety concept if the material will be used in load carrying structures. The development of seams turned out to be difficult avoiding sliding of the yarns in the welded seam. Several welding techniques had been tested to reach a tensile strength which is app. 80% of the uniaxial tensile strength.

Double curved surfaces made of this material with highly different tensile strength and elastic stiffness in both directions have to be designed. The question which needed to be answered is which ratio of curvature/span is feasible for this very anisotropy fabric. It is also necessary to know the shear deformation in relation to the curvature for this new material. Till now no free span and double curved structure of the new material is realized under environmental condition. Tests had been carried out defining the shear stiffness of the fabric and had been set in relation to the curvature of the tensioned surface to ensure a relative homogeneous stress distribution which is comparable with the tensions stresses in the shape of equilibrium. Finally the developments and test results ends up in a shading structure placed at the location of the producer to demonstrate the specific and unique properties of the fabric in a tensile structure.