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ANALISYS OF SHEAR BEHAVIOURS OF WOVEN FABRICS WITH IMAGE PROCESSING

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Abstract:

The main using areas of woven reinforcing structures are the aerospace and car industry through composite components. Those components frequently have complex surfaces. In plane shear behaviour of textile performs is the most studied mechanical property because this mode of deformation is necessary for forming double curvature surfaces. The examination of shear behaviour helps to understand better the properties of woven fabrics. Answering on the bias tensile stress the shear angle between the warp and weft yarns is change. The change of shear angle was examined during the bias tensile test with two different image processing method. General tensile tester equipment was used for the measurement and a video extensometer to determine the shear angle. According to the results it can be seen, which method is simpler and gives more precise results about the change of shear angle in a tensile loaded woven fabric.

Keywords:

deformation, shear behaviour, image processing, video extensometer

1 INTRODUCTION

The deformability of textile fabrics and its dependency on the fabric structure is an important issue for technical as well as for apparel textiles. Research work of the1950s–1970s has established theoretical understanding and methods of experimental characterisation of deformation of textiles, based on descriptions on the mesoscopic structural level. New challenges for textile mechanics were opened when different processes of draping of composite textile performs came in the order of the day in the 1990s. Deformability of textile preforms plays a key role in the quality of a composite part formed into a 3D shape. Comparing with the earlier apparel-oriented models, textile mechanics of composite performs must include a description of their behaviour under high loads, with deformations [1].

The shearing behaviour of a fabric determines its performance properties when subjected to a wide variety of complex deformations in use. The ability of a fabric to be deformed by shearing distinguishes it from other thin sheet materials such as paper or plastic films. This property enables fabric to undergo complex deformations and to conform to the shape of the body. Shearing influences draping, flexibility and also the handle of woven fabric. Shear properties are important not only for fabrics but for textile composites as well [2][3].

Optical full-field strain measurements start to being used in textile deformability research quite recently. Textile deformability testing mainly focuses on in-plane characteristics as shear resistance and biaxial tension. Unfortunately no standard test methods are available, although lately shear normalization exercises were performed and efforts were made to comprehend and compare shear test procedures, among others in a bench-mark exercise on deformability of woven composite reinforcements . Two shear test methods are in vogue: a bias tensile test(with principal directions at 45 with regard to the tensile load) and a dedicated test in a shear fixture, also called ‘picture frame’.

The bias test is easy to perform, but introduces an inhomogeneous deformation field, where the unconstrained fibres at the side edges may slip [4].

The main aim of this work is to compare the different methods of determining the shear angle during the uniaxial tension of a bias-cut fabric specimen.

2 EXPERIMENTS

A plain woven glass fabric was examined through out the experiments, the properties of the fabric is shown in table 1.

Table 1: Main properties of observed fabric

No.:	G220
Material:	glass fibre
Yarn density:	6 [1/mm]
Areal density:	220 [g/m^2]
Wave:	plain

The deformation of woven structures was measured under uniaxial tensile load. In the course of that the angle between the warp and weft yarns was determined. Specimens was cut out in angle of 45˚ according to the weft direction of fabric (Figure 1).

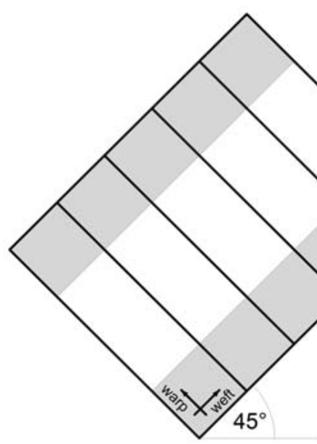


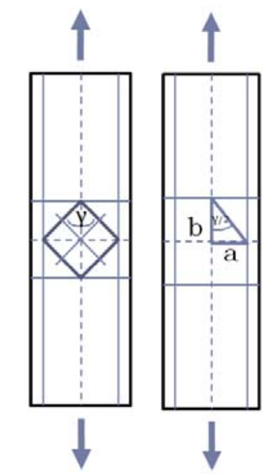
Figure 1: Arrangement of specimens

The yarns of reinforcement structures can slip easily during the cutting out the specimen. That is why it was cut out with special method. 5 pieces of 50x200 mm rectangles were cut out. The sizes was drown on a paper and the two side of that in 50 mm was fixed on the fabric (Figure 1). The specimen was cut out with the fabric along the lines. The stuck paper blocks the slipping of the yarns and that is why the structures did not deform. After cutting out the specimen with the paper it was gripped in the tensile tester and after that the paper was removed.

The shear angle was measured with two different, image processing based method. The first method is described extensively by Domeskiené [2]. During the measurement in the centre of the specimen the warp and weft yarns were marked, with drawing four equal squares (Figure 2, a). The angles found in the upper point of the four created squares was determined with image processing program in different phase of the tensile process. After that the means of the four angle was calculated.

The searched shear angle can be determined by knowing the vertical and horizontal distance using the trigonometric function (1). In that case the distances was measured with video extensometer putting distinctly visible marks on the specimen in the two direction (Figure 2, b).

$$tg(\gamma/2) = \frac{a}{b} \rightarrow \gamma[\circ] \qquad (1)$$



a) b)

Figure 2: Shear angle measuring methods

a) Direct shear angle measurement b) Shear angle determination using trigonometric function

The measured specimen could be divided in three different zones [1]: zone A, B and C (Figure 3). Zone A is the centre of the stretched specimen there the shear is go off fully. In zone B the shear is go off in half. The zone C is the two ends of the specimen, there was no shear between the warp and weft yarn. That is why the measurement is only done in the central part of the specimen, where only the pure shear behaviour is measurable.

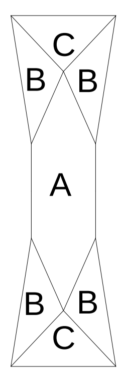


Figure 3: Shear zones on specimen

Figure 4 shows the measurement with the first method. The warp and weft yarns are marked with pen in the centre of the specimen.

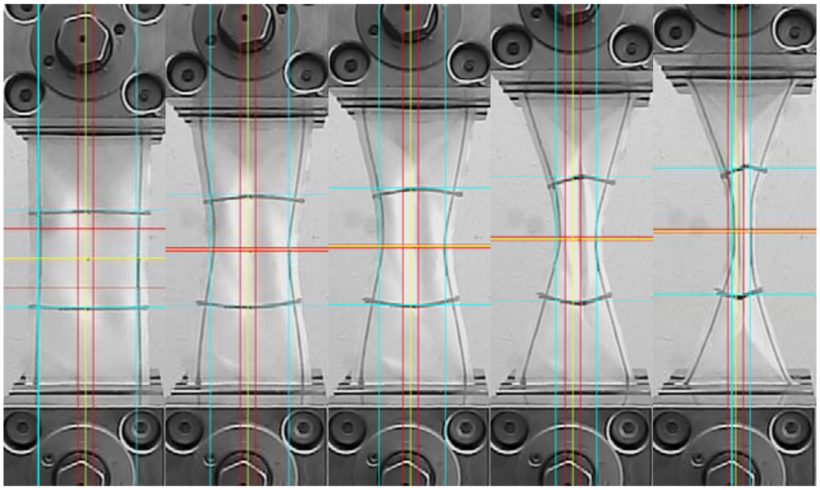


Figure 4: Measuring shear angle with second method

3 RESULTS AND DISCUSSION

The results of angle deformation given by the two methods were plotted in function of the strain (Figure 5).The difference is less than 2% between the results of the two methods. Plotting the specific shear angle against the specific strain shows that the results do not differ essentially, where the specific strain is the elongation of the fabric during the tensile load divided by the initial length in percentage. The specific shear angle is the change in angle during the tensile load divided by the initial angle between the warp and weft direction in percentage. Consequently both methods can be used well to determine the shear angle.

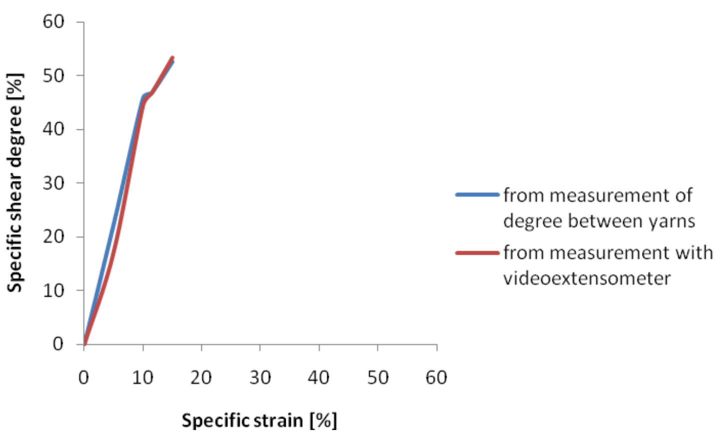


Figure 5: Comparison of two methods of shear angle measurement

Using the shear angle and the measured tensile force the shear force (2) awaken in the centre of the specimen can be determined:

$$F_{sh} = \frac{F}{2\cos(\gamma/2)}[N] \qquad (2)$$

where the F_{sh} shear force, F tensile force and γ is the shear angle between the warp and weft yarns.

The calculated shear force was plotted in function of the specific angle deformation (Figure 6). The shear force is change in a sudden rise at the maximum angle deformation, when the angle hardly do not change more. The graph is similar to the tensile force-strain graph (Figure 7), because the tensile and the shear force and the shear angle and the strain are proportional with each other. There was 9 measured specimen because generally that is written in the standard about woven fabric tension.

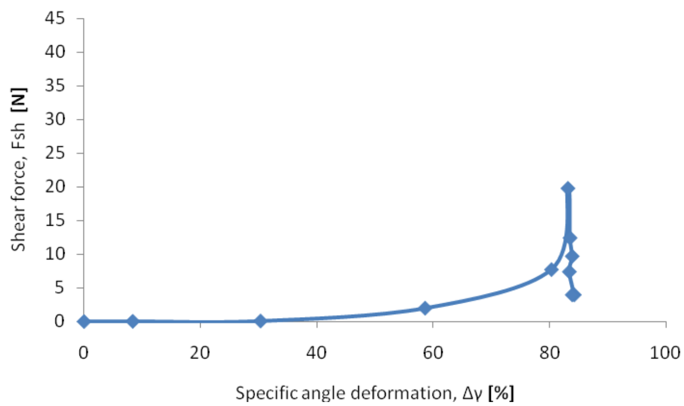


Figure 6: Shear force-specific shear deformation curve

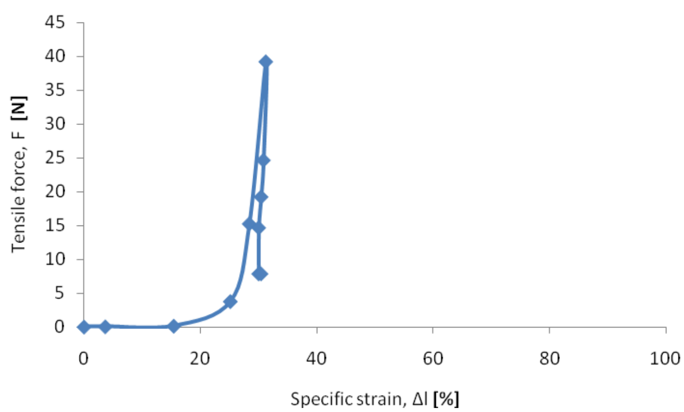


Figure 7: Tensile force-specific strain curve

The graph (Figure 6) shows that the specific angle deformation change 80% that is the decreasing of shear angle. The end of the graph show that the end of the sharing stops at 80% of deformation and after that there is only slipping between yarns.

4 CONCLUSIONS

The change of shear angle gives a good description about the textile deformation behaviour. Both of the used methods are determined well the pending angle between the warp and weft yarns. But the video extensometer method is an easier method to determine the deformation. The measured angles characterize well the deformation of woven fabric, it describes well the ability of fabric fitting on double curved shape.

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