Research Article

Effect of Shape of Armoring Fibers on Strength of Composite Materials

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Abstract: In this work, experimental studies of the effect of fiber curvature on the strength and ultimate deformations of epoxy carbon plastic samples under loading are carried out. On the basis of the experimental studies carried out, the static characteristics of the composite layered material, which are promising for use in the structures under consideration, have been determined. Based on the test results, it was demonstrated that in the design calculations for the products under consideration, it is possible to use static characteristics, since an increase in the deformation rate of the material leads to an increase in strength and, therefore, the calculation results will provide an additional margin of safety.
Keywords: Strength, deformation, loading, static tests.

1 Introduction

Currently, a large number of studies have been carried out to obtain and study the strength of composite materials[1-9]. A large amount of experimental data dedicated to the synthesis and exploration of heterophase composites were obtained[10-26]. However, well-known studies were carried out mainly for the case of quasi-static loading of materials. The effects of strain rate influence on the strength of composites with bent fibers have been studied to a much lesser extent, although they have also been considered [27-35]. Analytical and numerical models are proposed to take into account the effects of curved stacking and the effect of fiber curvature. Some applied models, in particular, are used in standard software packages for finite element modeling[36-47]. The buckling effects of fibers, even in the case of ideal straight-line packing, leads to a decrease in the compressive strength in relation to the ultimate tensile strength of the fiber composite by more than 1.5 times. The presence of bends in the fibers can reduce this characteristic even more.

2 Study of the strength of composite materials

Samples of the composite material were made on the basis of ED-20 epoxy resin with Torey T800 reinforcing fibers. The volumetric content of fibers was 60%, the diameter of the fibers was 5 μm. Samples of three types were considered: 1) a quasi-homogeneous layered composite with a unidirectional reinforcement scheme, 2) a unidirectional composite with a wavelike layered structure, and 3) a pure matrix.

Mechanical tests were carried out on a universal electrical installation Instron 5969 (50kN) and Instron 5982 (100kN) (UK) with Bluehill 3 software. Compression tests were carried out. Test speed was 1 mm/min.

Photos of the samples after testing are shown in Figure 1. According to the test results, characteristic load-displacement and stress-strain diagrams were obtained, Fig. 1a for straight installation, Fig. 1b for wavy styling.

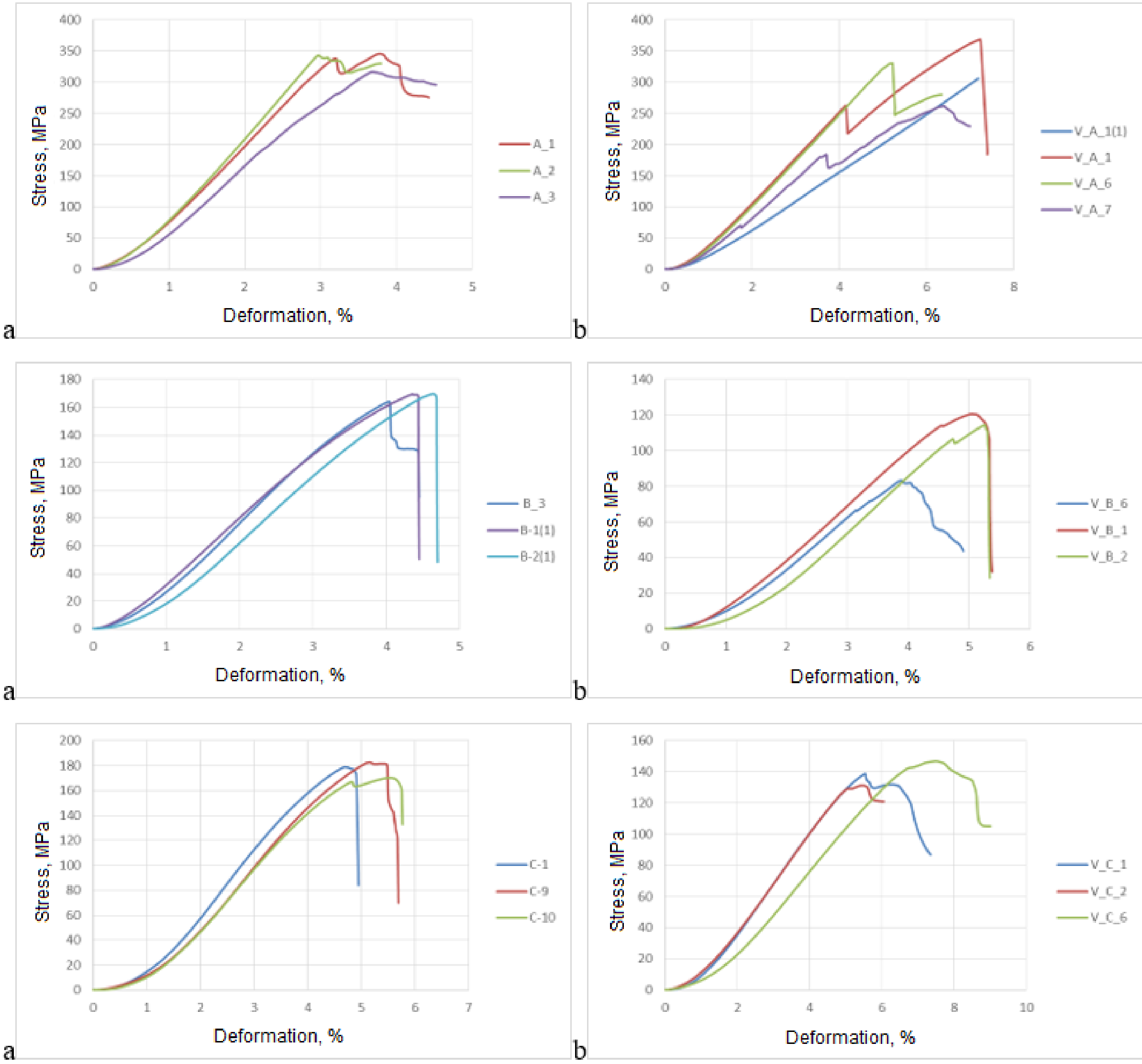

Figure: 1. Stress-strain diagrams obtained during static compression test of specimens with straight (a) and wavy packing (b).

For each batch, the resulting diagram was obtained as a result of averaging the experimental data for three samples of the same type (Figure 2). During the tests, the maximum load, ultimate strength and ultimate deformation were determined for each specimen. The results of static tests are presented in the Figure 2.

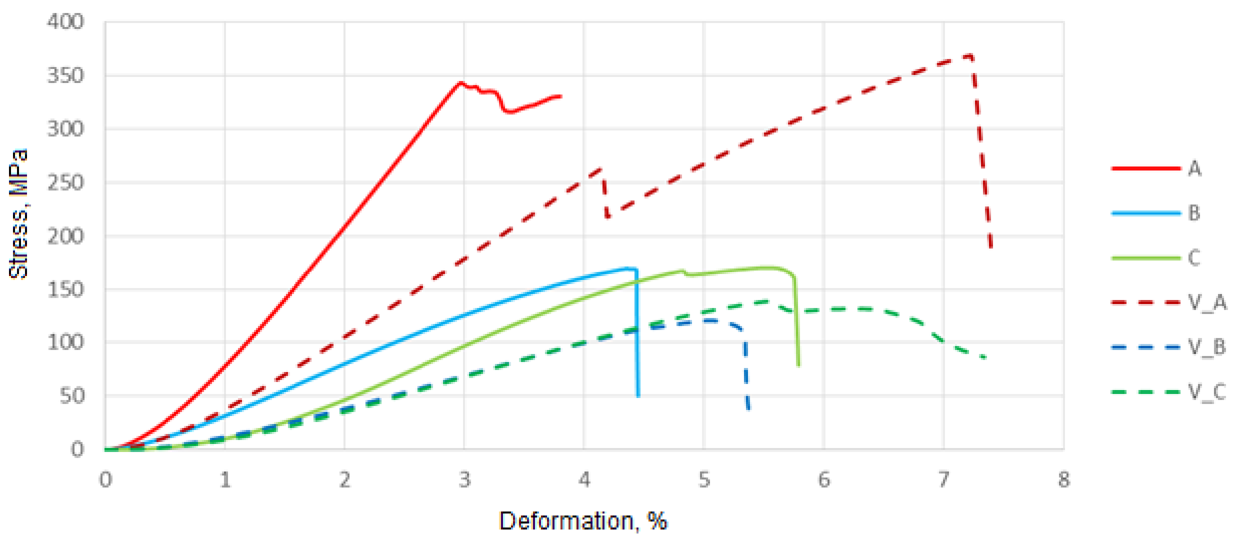

Figure: 2. The resulting stress-strain diagram obtained in a static compression test of specimens with straight (solid lines) and wavy packing (dashed lines).

The strength of the matrix was also tested. The tests were carried out on an Instron 5969 installation, with the maximum possible speed for this installation equal to 600 mm/min. The stress-strain graph is shown in Figure 3.

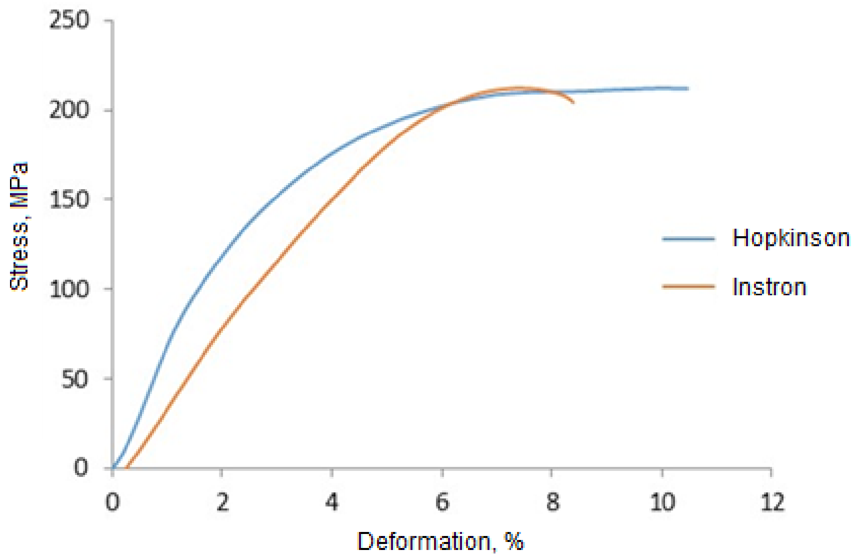

Figure: 3. The resulting stress-strain diagram obtained during static and dynamic compression tests of specimens made of epoxy resin ED 20.

From static tests it can be seen that the ultimate strength in unidirectional laying is higher than in wavy laying (in the direction A-5%, in the direction B-32%, in the direction C-23%), and the ultimate deformations in unidirectional laying are higher than in wavy styling.

From static tests it can be seen that the ultimate strength in direction A for unidirectional laying (335 MPa) is higher than for wavy (318 MPa), in direction B for unidirectional laying (168 MPa) it is higher than for wavy (114 MPa), in direction C for unidirectional laying (177 MPa) is higher than for wavy (137 MPa).

It is also seen from static tests that the ultimate deformations in the A direction for unidirectional laying (3,47%) are lower than for wavy (6,78%), in the B direction for unidirectional laying (4,34%) is lower than for wavy (5,16%), in the C direction for unidirectional styling (5,12%) is lower than for wavy (6,04 %).

3 Conclusions

Static tests of the strength of unidirectional CFRP specimens with rectilinear and wavy structure have been carried out. For the first time, a detailed study of the effect of fiber curvature on the properties of CFRP under static deformation has been carried out. As a result of static tests, it was found that the ultimate strength in unidirectional laying is higher than in wavy laying. The effect of increasing the ultimate deformations of specimens with bent fibers is established, which was noted earlier for the case of tensile tests.

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