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Evaluation of the adhesion strength of linear filler fibers of composite polymer reinforcement

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Introduction

The creation of modern, competitive structures and products largely depends on the properties of the materials used in their production. The structural strength and mechanical characteristics affect the reliability and durability of structures made of polymer composite reinforcement (PCR). Strength is one of the important mechanical parameters. The normative regulation of the strength of PCR is currently carried out by the requirements of State Standard [1], in which the ultimate strength in axial tension [1,2] is determined as for reinforcing steel, and the ultimate strength in compression is determined [1,3], as for plastics. However, the use of normative test methods for PCR does not allow assessing the adhesion strength of linear filler fibers to control the established mechanical properties and strength characteristics, because the main feature of composite materials from plastics and steels is the presence of a component that connects substances of dissimilar chemical structure: matrix and filler. It is known that PCR is cured rods made of glass, basalt, carbon, or aramid fibers (linear fillers), impregnated with a thermosetting or thermoplastic polymer binder [4].The presence of a large number of processes (physical, chemical, etc.) acting on the rod in the production process creates certain difficulties in the theoretical analysis of product parameters. Therefore, it is extremely important to have effective means and methods for assessing the strength of PCR linear filler fibers as products withoutspoken discrete structures. The development of such methods and tools seems to be relevant.

2. The Method of test for PCR samples and assessment of the adhesion strength of linear filler fibers

The essence of the method under consideration consists in loading PCR samples on a tensile testing machine 2055-P -0.5 (figure 3) with an increasing load and recording the values of "load-displacement", and loading is performed on the axis-symmetric section of the bearing rod - a bead made with grooves , given the width and diameter along the axis of the reinforcement. The maximum load is used to estimate the adhesion strength of the adhesion of thefibers of the linear filler along the sample diameter [5-8]. To implement this method, specimens (figure 1) were prepared from glass composite reinforcement (GCR), the geometric dimensions of which are shown in figure 2.

Figure 1. *The PCR samples*

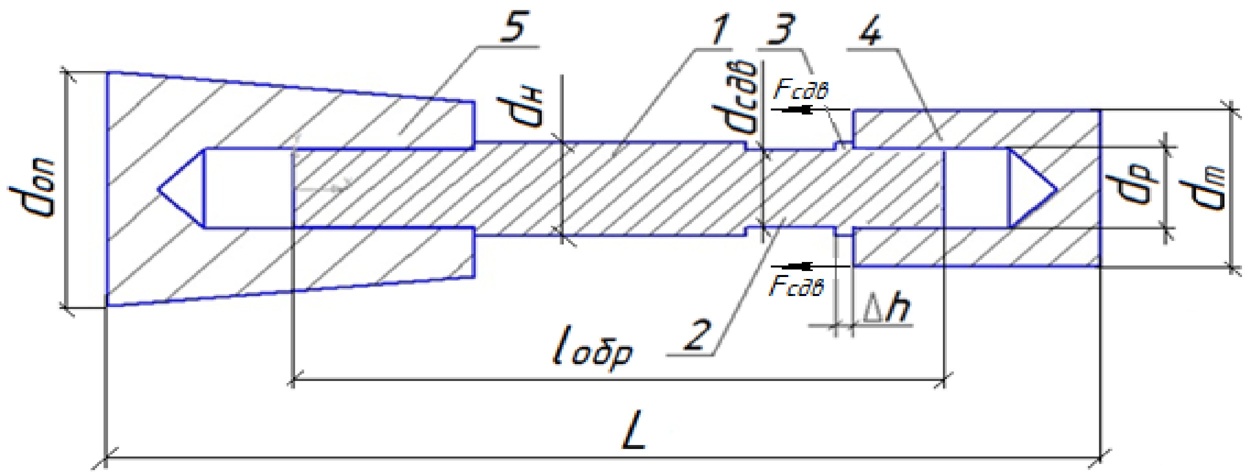

Figure 2. *The Scheme of shear test of the PCR rod to determine the adhesion strength of its fibers*

1 -The PCR rod of the set diameter [1]; 2 - cylindrical section with diameter ; 3 - turned bead, width Δh; 4 - annular pusher with a working inner diameter, transmitting the shear force to the bead

For testing, 9 samples of various batches with a nominal diameter of 10 *mm* were selected, since the reinforcement of such diameters is the most demanded on the market. The equipment for the testing machine 2055-P -0,5 (figure 3) was also made: a pusher with an inner diameter (cutter) and a support (figure 4). All tests were carried out at Ltd "Independent Construction Laboratory" in Izhevsk. Applied equipment and measuring instruments: electronic laboratory scales VLG-MG4 head. No. 021 verification certificate No. 0-441-03 until 04.02.2020, vernier caliper VC-II, head. No. M671665, verification certificate No. 0-9990-01 until 02.08.2021

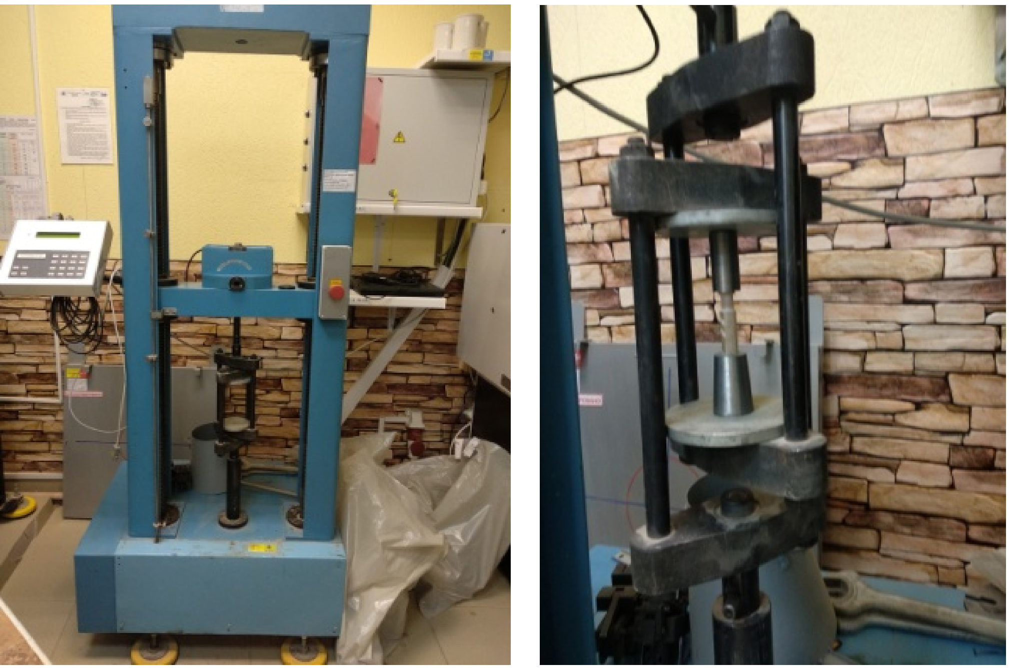

Figure 3. The tensile testing machine 2055-P -0,5

Figure 4. The equipment for the testing machine

The registration of the "load-displacement" value (figure 5) when shearing the beads is performed in the direction of their compression while maintaining the perpendicular position of the bead face to the direction of the shear force. The actual values of the maximum values of the adhesion forces of the linear filler of the rod F_{cc} with the same projection width Δh are equal to the maximum shear load $F_{cc} = F_{max}$. From the maximum load F_{max} applied to the samples, which resulted in the shearing of the protrusions, the tangential shear stresses of the fibers of the PCR linear filler τ_{shear} (figure 6), were determined as the ratio of the resistance force to the maximum load F_{max} to the area of its contact with the power rod S_{shear}:

$$\tau_{shear} = \frac{F_{max}}{S_{shear}}$$

$$S_{shear} = \pi \cdot d_{shear} \cdot \Delta h$$

Test results

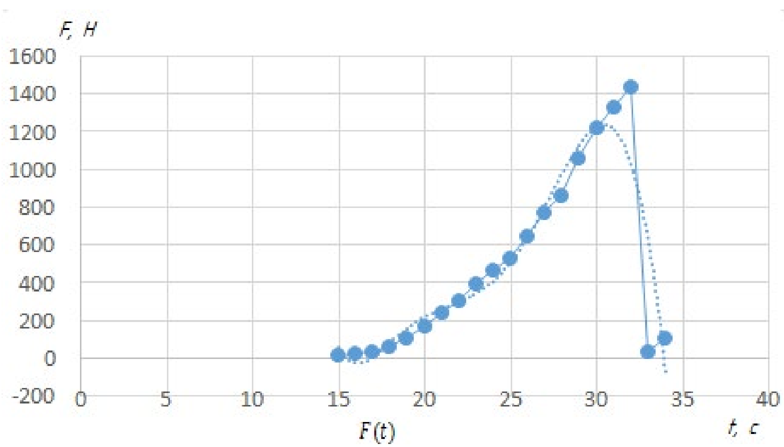

Figure 5.Loading curve *F (t)* of the sample№1

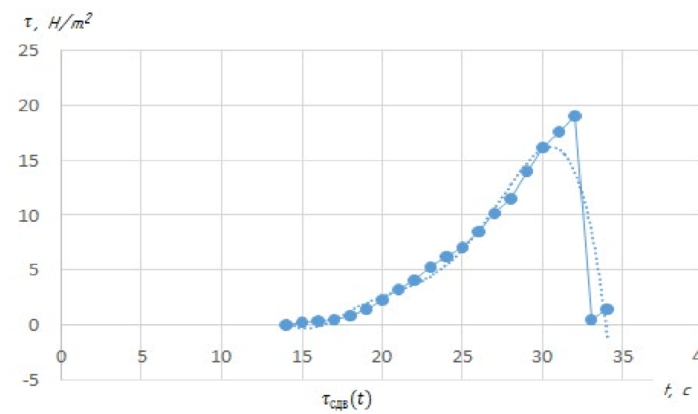

Figure6. Graph of values of tangential shear stresses $\tau_{shear}(t)$, MPa over time t,c for sample №1

Test results

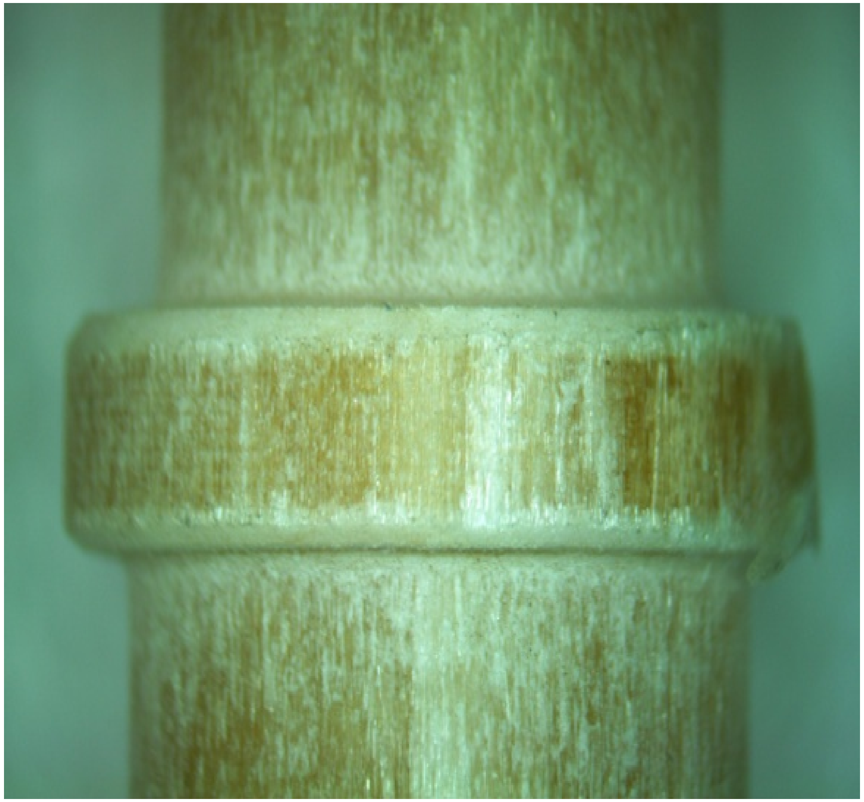

Figure 7. Sample before testing

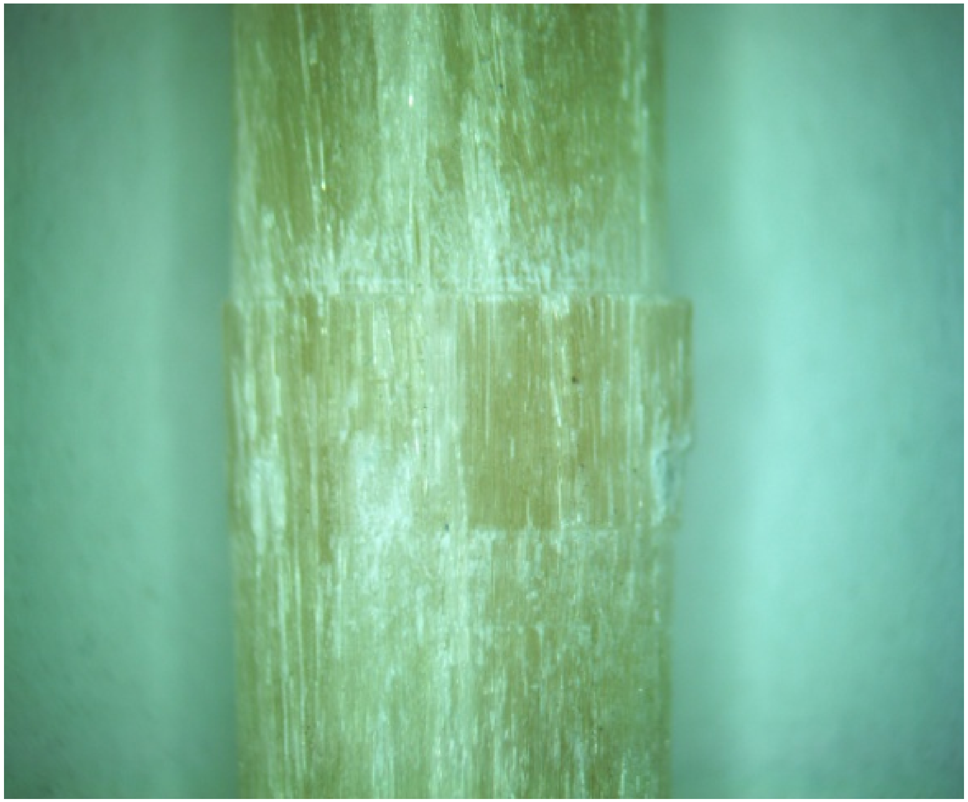

Figure 8. Sample after testing

Conclusions

The considered method of testing for shear of beads, performed on samples of composite polymer reinforcement, makes it possible to monitor the picture of the strength state of the bar in depth for various nominal diameters of the reinforcement.

The strength of the transverse links of longitudinally oriented fibers is an indirect indicator of the breaking strength of the reinforcing bar and is informative enough to judge the quality of the reinforcing bar and its tensile strength. In this case, not only the absolute value of the obtained values of the adhesion forces of the fibers of the linear filler is assessed, but also the deviation from the specified (reference or certification) values of the strength parameters of the reinforcement.

Literature

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Acknowledgments

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