LIGHTWEIGHT STRUCTURES in CIVIL ENGINEERING
CONTEMPORARY PROBLEMS
Monograph from Scientific Seminar
Organized by Polish Chapters of
International Association for Shell and Spatial Structures
Lodz University of Technology
Faculty of Civil Engineering, Architecture and Environmental Engineering
XXIV LSCE
Łódź, 7th of December 2018 (Friday)

TENSILE STRENGTH TESTING OF COMPOSITE RODS BASED ON GLASS FIBERS FROM PREFABRICATED REINFORCING GRIDS

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ABSTRACT: The article presents tests of composite reinforcing bars based on glass fibers and the results of these tests.
The rods were cut from prefabricated composite reinforcing meshes produced by a Polish producer.On the basis of the tests, it was found that rods of this type have a tensile strength comparable to that of AIIIN grade steel and half lower than the classic composite rods produced in the pultrusion process.

Keywords: tensile strength, composite bars, glass fibers

1. INTRODUCTION

Composite rods are increasingly used in construction indudtry. They not only have very high strength, but due to the use of different types of fibers and resins they can have different properties adapted to specific needs. Rods based on glass fibers also have a price comparable to steel bars. However, they also have several disadvantages, one of the main is the lack of the ability to join rods by welding in industrial reinforcement mesh, and thus prefabrication of reinforcing mesh. The solution to this problem is the production of reinforcing mesh by combining the fibers before hardening the resin with heat. One of the Polish entrepreneurs has developed and patented a method of manufacturing such grids on an industrial scale. The article presents the examination of the rods of such stretching grids and the results of these tests.

Fig. 1 Tested grids in two increase ranges

Fig. 2 Sample grid fragment for cutting.

2. RESEARCH SAMPLES

For the research, reinforcement meshes with dimensions of 1,0 x2,4 m were provided. In the shorter direction standard composite rods based on glass fibers with a diameter of 6 mm were used, spaced every 100 mm, perpendicularly made "braided" rods made of glass fibers entangling perpendicular rods made before curing of the resin with a nominal diameter of 5 mm in a spacing of 100 mm, Fig. 1. Samples for testing including one "braided" rod and three perpendicular rods were cut from the meshes. The length of such a sample was 40 cm. At the ends of the bars, holders are mounted to be fixed in the jaws of the testing machine.

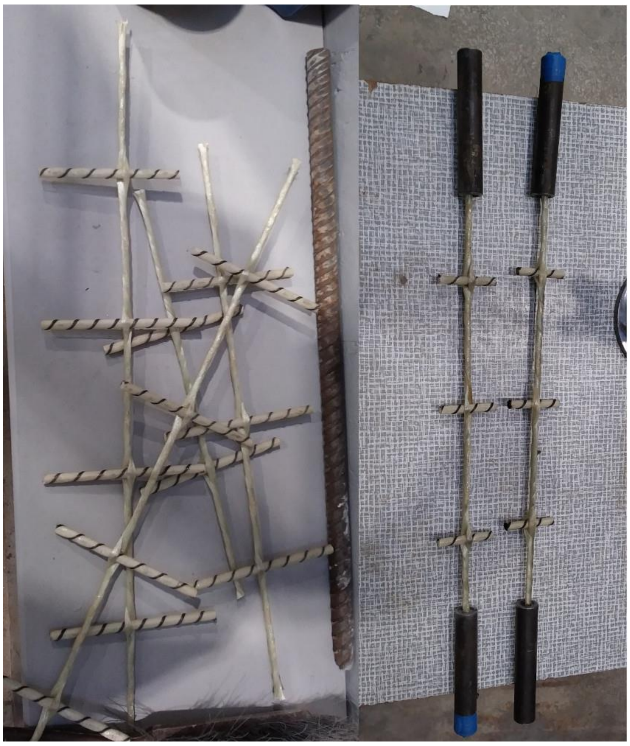

Fig. 3 Cutt-off bars from the grid before and after fixing the handles

2. PRELIMINARY EXAMINATION.

The cut rods were mounted in the jaws of the ZD100 testing machine and subjected to a tensile test, applying force until destruction. During the application of force, the rods began to unscrew, while reducing the acting force they twisted back. Adjacent transverse bars turned from each other alternately to the left and right by over 360 °.

Fig. 4 Rod in a testing machine after breaking.

As described above, one sample was stretched to break, labeled as "1". The following dependencies: force - elongation and after calculation stress-strain were obtained, Fig. 5 and 6. The maximum tensile force at break was 6.06 kN, the stress corresponding to this force was 307.1MPa. The maximum elongation at break was 13.3 mm.

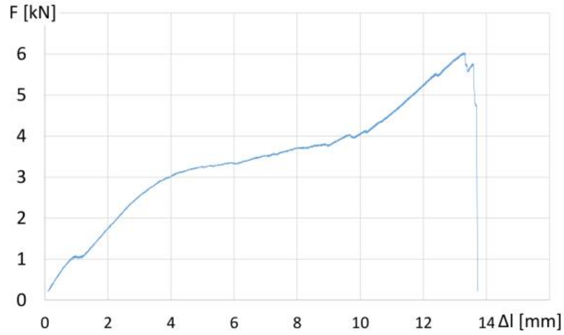

Fig. 5 Force - elongation graph for sample no. 1

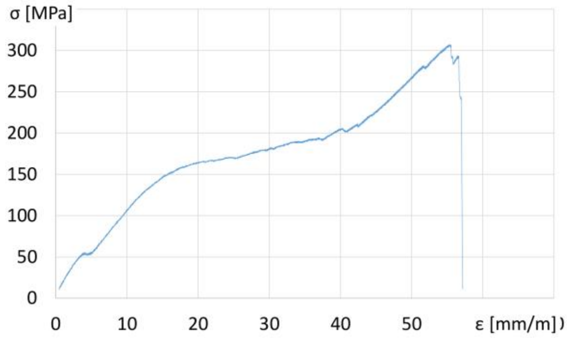

Fig. 6 Stress - strain diagram for sample No. 1

The course of the graph is very non-linear, the elongation increased rapidly after exceeding the stresses of about 150 MPa, after exceeding 200 MPa, the increase was again much slower. The Young's modulus calculated for the phase after exceeding 200 MPa is 8.13 GPa.

The maximum value of the tensile stress at break was 303 MPa.For comparison, the strength of classical composite rods based on glass fibers produced in the pultrusion process is about 1200 MPa, and the yield strength of AIIIN steel rods is about 600 MPa. Such low tensile strength would disqualify these rods to replace steel rods. The second sample was stretched in the same way, the results were analogous.

3. BARS TESTS WITH A BLOCKED POSSIBILITY OF ROTATION.

The previously presented results were obtained at high rod rotations. In the actual structure, the bars are fragments of embedded meshes, so it is not possible to rotate the bars so much. It was necessary to develop a method of stretching rods with the possibility of bar rotation blocked. The closest to the reality of the study would be to stretch the embeded grid, but it would be technically difficult to do. The type of jaws catching the stretched rods was designed and made, which hold the rods perpendicular to the tension rod and prevent its rotation.

As predicted, the jaws secured the rods against rotation, which significantly influenced their bearing capacity. Sample No. 2 was stretched until it ruptured. In sample No. 3 the force value was increased in stages, first up to 1kN and then reduced to almost zero, successively to 2 kN and again relieved, and so until reaching the value of the destructive force obtained in sample No. 1.Then the value of force was increased until the sample was destroyed. In subsequent samples, the value of force after 10% of the destructive value from the sample test no. 3 was increased. Six samples were tested in this way. The rods always broke in the place where the rods crossed, but not always in the place of the same rod - middle or extreme.

Fig. 7 On the left the jaws after painting in yellow, on the right the bar is fixed in the jaws in the testing machine before painting the jaws.

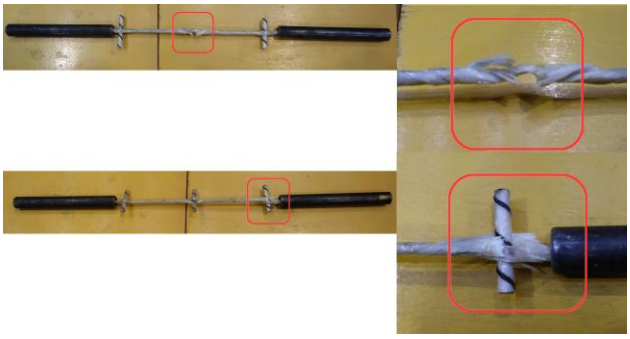

Fig. 8 Sample bars after breaking with the marked breaking point.

The graphs of force-elongation and strain-strain are presented below for samples No. 2, No. 3 and No. 4.The graphs for subsequent samples were analogous to sample No. 4.

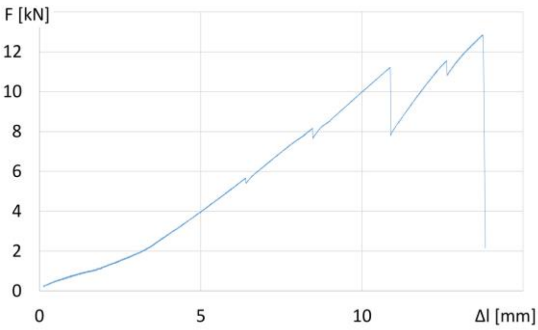

Fig. 9 Force - elongation graph for sample no. 2

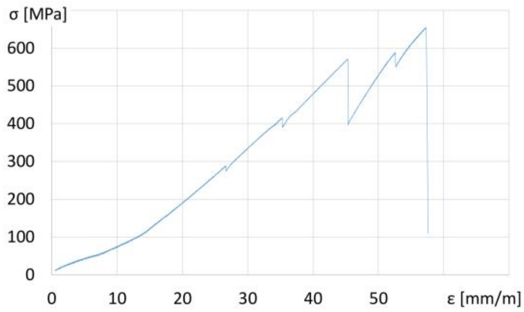

Fig. 10 Stress-strain relationship diagram for sample No. 2

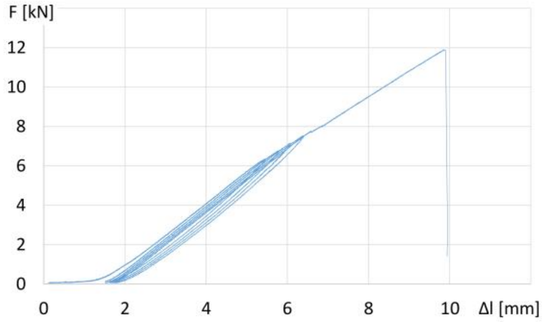

Fig. 11 Force - elongation graph for sample no. 3

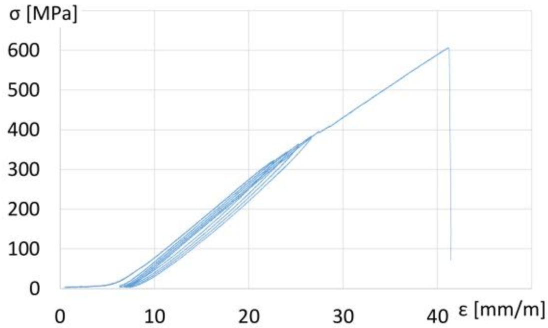

Fig. 12 Stress-strain relationship diagram for sample No. 3

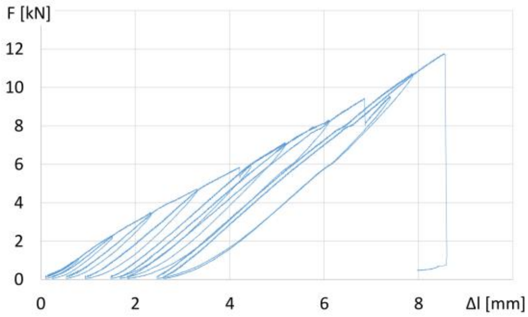

Fig. 13 Force - elongation graph for sample no. 4

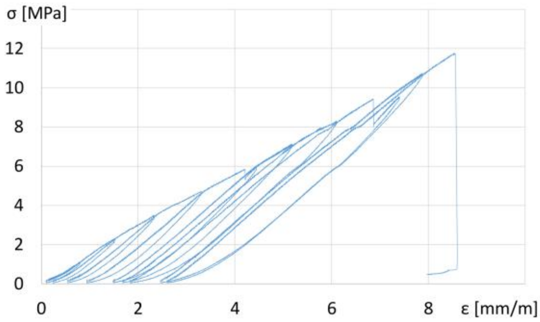

Fig. 14 Stress-strain relationship diagram for sample No. 4

The average tensile strength was 604,2MPa, which is comparable to the yield stress of AIIIN steel rods, however it is still lower by half than for composite rods based on glass fibers produced in the pultrusion process.

Twice the lower strength of bars with the freedom of rotation can be caused by an uneven increase in stresses in individual fibers during the increase of tensile force and rotation angle. Part of the fibers reaches the limit stress values faster and ruptures, the internal forces are distributed to the remaining fibers, however, there are too few of them to transfer these forces, with a smaller amount of fibers they are higher in them with the same tensile force.

Young's modulus is much lower than for steel, it is on average 23.0GPa, steel has a module at the level of 200GPa, and classic composite rods at the level of 50GPa.The table below shows the maximum values of the tensile force at failure, the maximum stresses and the Young's modulus for the last cycle of load in cyclically loaded samples.

Table 1. Values of maximum forces and stressesas well as Young's modulus for individual samples

sample no	force [kN]	strain [MPa]	E [Gpa]
1	5,96	303,83	-
2	12,85	654,88	-
3	11,91	606,84	-
4	11,78	600,08	24,42
5	11,60	591,25	25,26
6	11,25	573,13	23,95
7	10,76	548,26	20,29
8	11,76	599,27	22,33
9	13,40	682,72	21,61

4. SUMMARY

The article presents the results of research on composite rods based on glass fibers cut from reinforcement mesh for concrete reinforcement.

The strength of these rods is comparable to the yield stress of AIIIN steel rods, however, it is lower by half than for composite rods based on glass fibers produced in the pultrusion process.The rods produced by the fiber weave do not show plasticity like in the case of classic composite rods, the break occurs in a rapid manner.Young's modulus is ten times lower than for reinforcing steel and twice lower than for conventional composite rods. The introductory research of reinforcing bars is followed with investigation of the concrete slabs reinforced with them. It will be shown in further publications.

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