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Experimental Determination of Mechanical Properties of Textile Glass Reinforcement

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Abstract. Mechanical tests on samples of textile glass reinforcement were performed in the Klokner Institute. These tests will be used for the determination of elasticity modulus of textile glass reinforcement and the assessment of maximal stress at samples. Both mentioned quantities are necessary for the further modeling of structures and for the design of elements made from TRC (textile reinforced concrete). In total 10 samples made from one piece of 2D net (product of V. FRAAS, GmbH, Germany) were tested. The textile glass AR-glass reinforcement (alkali - resistant glass) with fineness 2400 TEX [g/km] that is commonly supplied in size of 1 x 2 m was tested. First 5 samples were prepared in direction of warp (direction of the load-bearing reinforcement) and then remaining 5 samples were made from the transverse direction (weft direction). These samples were loaded by s constant force increasing up to the collapse. Then the modulus of elasticity of textile glass reinforcement and stress at strength limit were determined from the monitored data.

Introduction

It was necessary to prepare the samples appropriately before an initiation of tests themselves. The preparation of the samples consists in cutting out of the testing specimens from 2D net into the longitudinal shape of a bar of the length of about 400 mm. So prepared samples were subsequently ended by the two-component Stado ResiFix 3E sealant. The final adjustment was carried out to the shape of the area that consequently after hardening facilitates a fixing into the testing jaws of a loading device. The plates of the jaws of a testing device were equipped by a nonslip modification mainly from the reason to prevent the sample from pulling out within tensile test itself. So prepared samples were put into the jaws of the loading device and fixed not to be pulled out during the test. A deformation sensor (refer to: Fig. 1) monitoring the change of the distance between two blunt edges of the sensor on the determined basis of 95 mm was put on so fixed samples. The course of the test itself was monitored using an automatic measuring unit where the dependence of the acted force on time and deformation course was monitored. The samples were loaded uniformly. The speed rate of the loading was 0.05 mm/s. The graphical outputs (refer to: Fig. 3) were subsequently worked out from the courses of the tests. For example the values measured on two samples are showed in the graph. The first of the samples is in the warp direction and the second is in the transverse (weft) direction. The way and the location of a disruption of the samples are important monitored factors. When is the disruption of the sample directly under the blunt edge of a sensor, it is possible to expect that the test could be effected and this sample should be excluded from an assessment. The way of the right disruption is shown in the picture (refer to: Fig. 2). The elasticity modulus of the textile glass reinforcement and the stress at the limit strength are consequently evaluated from the monitored data.

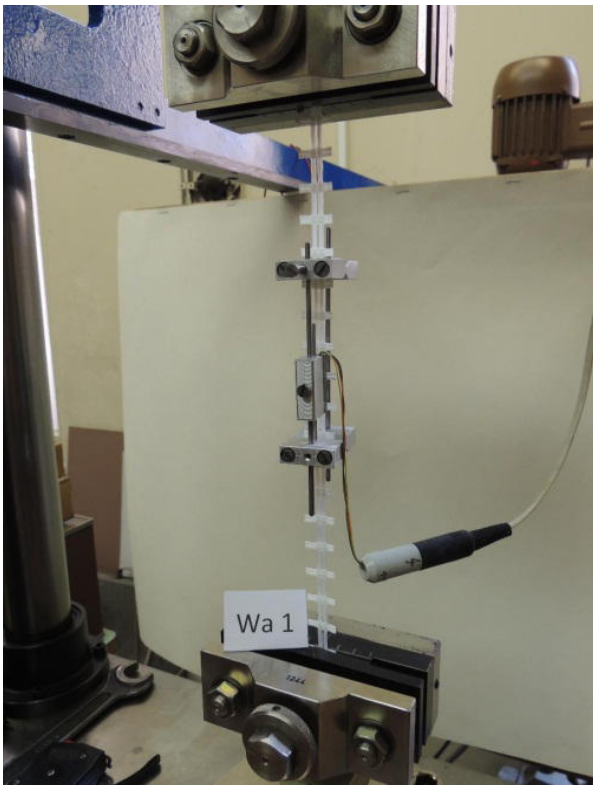

Fig. 1. Sample before test.

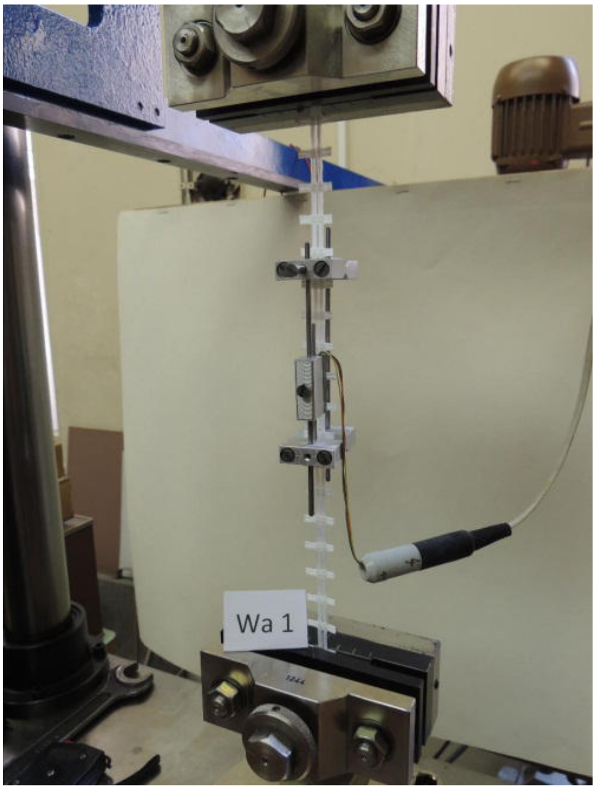

Fig. 2. Sample after test.

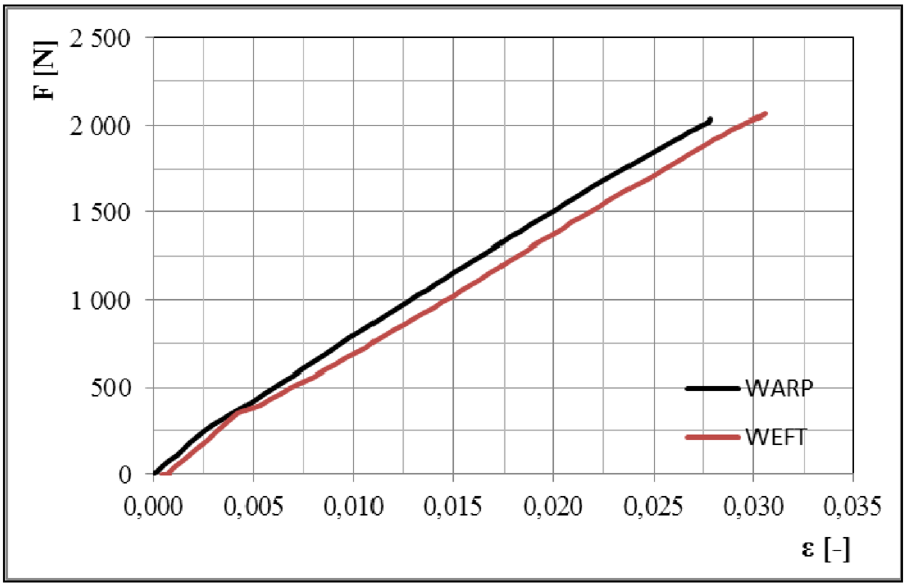

Fig. 3. Stress-strain diagram of textile glass reinforcement.

Results Evaluation

The textile glass reinforcement in the main (warp) direction and the transverse (weft) direction is evaluated from the results of the performed tests. The evaluation is performed from the point of the achieved elasticity modulus of the textile glass reinforcement and also from the point of the limit tensile stress that was reached at the time of the sample breaking. For the calculation of these quantities is going to be used the fineness of the tested textile glass reinforcement that is 2400 TEX [g/km]. The resulting values will be consequently utilized for a mathematical modelling of elements made from TRC (textile reinforced concrete). Because of the unknown area of the textile glass fibres but the known fineness is a recalculation carried out by the subsequent way. Firstly is the limit tensile stress at collapse expressed (refer with: Eq. 1) and then using this determined value of stress and measured deformations between the blunt edges of a sensor is elasticity modulus of textile glass reinforcement subsequently calculated (refer with: Eq. 2). The determined average quantities are showed in the table (refer to: Table 1, Table 2).

$$\sigma[kPa] = \frac{F\,[kN]}{TEX\left[\frac{kg}{m}\right]} \cdot \rho\left[\frac{kg}{m^3}\right] \qquad Eq.1$$

$$E[GPa] = \frac{\sigma[GPa]}{\varepsilon[-]} \qquad Eq.2$$

$\sigma = maximal\ stress[kPa]$

$F = extreme\ force[kN]$

$TEX = fineness\ of\ textile\ glass\ reinforcement\ \left[\frac{kg}{m}\right]$

$\rho = bulk\ density\ of\ glass\ \left[\frac{kg}{m^3}\right]$

$E = elasticity\ modules\ [GPa]$

$\varepsilon = srain, {}^{\Delta l}/_{l}\ [-]$

Table 1. Evaluation of maximal tensile stress at collapse and elasticity modulus for samples from warp direction (Wa1 – Wa5).

Marked samples	Force F [kN]	Stress σ [MPa]	Strain ε [-]	Elasticity Modulus E [GPa]
Wa1	2.081	2168.0	0.028	77.4
Wa2	2.086	2172.4	0.029	74.9
Wa3	2.234	2326.6	0.030	77.6
Wa4	2.288	2383.5	0.031	76.9
Wa5	2.013	2096.4	0.028	74.9
The average value of stress [MPa]				2229.4
The average value of elasticity modules [GPa]				76.3

Table 2. Evaluation of maximal tensile stress at collapse and elasticity modulus for samples from weft direction (We1 – We5).

Marked samples	Force F [kN]	Stress σ [MPa]	Strain ε [-]	Elasticity modulus E [GPa]
We1	2.234	2327.2	0.033	70.5
We2	2.161	2250.6	0.032	70.3
We3	2.086	2172.9	0.030	72.4
We4	2.028	2112.6	0.030	70.4
We5	2.054	2139.7	0.031	69.0
The average value of stress [MPa]				2200.6
The average value of elasticity modules [GPa]				70.5

Conclusion

On the basis of the published results it is possible to determine elasticity modulus and tensile strength of the textile glass reinforcement at both the warp and the transverse direction. Both directions have approximately the same tensile strength that reaches up to about 2200 MPa. The difference between the directions is very small what has been also expected because the both directions of 2D net have the same fineness, i.e. 2400 TEX. A noticeable difference is at evaluation of elasticity modules that is about 5.8 GPa. But this difference is not caused by material properties but by the way of a manufacturing of the 2D textile. The warp direction is made from stripes of textile that are straight whereas the weft direction is made from fibres alternately intertwined around the warp direction. This is the reason not only of a lengthening of fibres during the tensile test but also of a straightening of the weft into the direction of the test. The limit deformation of samples made from the textile glass reinforcement reaches for the warp direction approximately 2.9 % and for the weft direction about 3.1 %. The achieved results correspond to the theoretical values that can be generally expected for this type of reinforcement and they will be used for future tests of elements made from TRC and their consequent numerical modelling.

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