MECHANICAL PROPERTIES CHARACTERIZATION OF COMPOSITES REINFORCED BY KNITTED FABRICS

Andrejs Krasnikovs[1(*)], Olga Kononova[2], Galina Kharkova[3], Jevgeny Zalesskis[4], Vitalijs Lusis[5], Vitalijs Zaharevskis[6] and Sandris Ruchevskis[7]

[1, 2, 3, 4, 6] Institute of Mechanics, Riga Technical University, Riga, Latvia

[1, 5] Concrete Mechanics laboratory, Riga Technical University, Riga, Latvia

[7] Institute of Materials and Constructions, Riga Technical University, Riga, Latvia

[(*)]*Email:* ***akrasn@latnet.lv***

ABSTRACT

Polymer and concrete matrix composites reinforced by knitted fabric were investigated. Such materials are mechanically non-linear with a high dynamic energy absorption possibility. Precise mechanical properties appreciation and prediction are important for materials use in novel structures. Three different approaches were executed - numerical (FEM, using Solid Works software) structural modeling based on reinforcement and matrix mechanical and geometrical properties (were measured experimentally), direct experimental mechanical properties measurements and inverse method approach for mechanical properties appreciation, based on vibrations modal analysis. All tree approaches results (for polymer matrix composites) were compared and comparison results were discussed. For concrete matrix composites only first two approaches were executed and were discussed.

INTRODUCTION

Cotton and glass yarns were used for knitted fabric preparation. Cotton knitted fabric was prepared by enterprise “Juglas manufaktūra”, glass knitted fabric was prepared by ourselves in Riga Technical University (using knitting machine Neva-5). Yarns were mechanically tested. Knitted fabric samples were tested according to the procedure described in ASTM D 5083-02. Tensile tests were executed using electromechanical testing machine Zwick Z150. The stress–strain curves were obtained for yarns and cotton fabrics. Thermoset matrix composite plates (5 layers, 2.2 x 10^{-3} m thick), reinforced by the cotton (and glass) fabric, were manufactured using acrylic resin. Rectangular specimens were cut out of the plates for tensile tests under different directions to knitted fabric orientation (angles 0°, 45°, 90°) Mechanical tests were performed on composites with fiber weight fraction 27% for cotton fabric and 11% for glass fabric. Tensile tests were executed using electromechanical testing machine Zwick Z150. The 3D geometrical modeling of the knitted fabric was based on the Leaf and Glaskin approach, FEM 3D unit cell (of the cotton and glass fabric reinforced composite) model was elaborated (see Fig. 1.a) and materials elastic properties were numerically calculated on the base of yarn’s and matrix experimentally measured mechanical properties data. The computer simulation data was compared with experimental results for samples cut under different directions (for 45 deg is shown in Fig. 1.b). Finally the numerical-experimental method [1] was used to composite plates, consisting of few steps. In the beginning the physical experiments have been performed. Second step is to identify, the domain of search and choice the criterion containing experimental data. Then finite element method has been used in order to model the frequency response of the structure. The FEM eigenvalue problem results were employed as numerical experimental data. Then experimental design points were been determined. In the next step the numerical data were

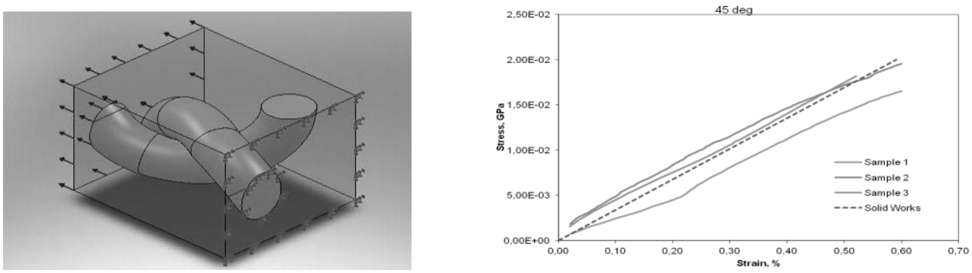

Fig. 1. a) CM unit cell; b) the stress-strain curve for cotton knitted fabric polymer matrix composite cut under 45 deg;.

obtained by FEM in the reference points, was used with the goal to determine simple functions are using response surface method for calculation of the eigenfrequencies. After that using simple models and experimental data of the measured eigenfrequencies the identification of the material properties is performed minimizing corresponding functional (using method of non-linear programming). The test panel has been excited by an piezoelectric actuator (PZT), placed in the bottom of the composite plate. As a result of this excitation the plate starts to vibrate within the frequency band of the input signal. After the measurement if performed in one point, the vibrometer automatically moves the laser beam to another point at the scan grid measures the response using the Doppler principle and validates the measurement with the signal-to-noise ratio. The procedure is repeated until all scan points have been measured. The frequency spectrum of the panel is then obtained by taking the Fast Fourier Transform of the response signal.

Similar ways were elaborated knitted fabric reinforced composites with concrete matrix. Three different strength and elastic properties concrete matrix were investigated. Thin (1.5cm, 3 layers) plates as well as 10cmx10cmx40cm prisms (with 5 layers) were elaborated and experimentally investigated. Experimental results were compared with performed numerical simulations.

RESULTS AND CONCLUSIONS

Three different approaches were successfully executed: a) numerical (FEM, using Solid Works software) structural modeling based on reinforcement and matrix mechanical and geometrical properties (were measured experimentally); b) direct experimental mechanical properties measurement approach; c)inverse method approach with the goal to predict mechanical properties of weft knitted fabric reinforced multilayered composite. Inverse method was predicted higher elastic properties in comparison with direct experiment and performed structural numerical modeling. Was demonstrated effectiveness of modeling approach and inverse method application to materials with high damping facilities such as textile reinforced polymer composite.

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REFERENCES

1. A.Krasnikovs, O.Kononova, A.Machanovskis, V.Zaharevskis, P.Akishins and S.Ruchevskis Mechanical Properties Characterization for Composite Reinforced by Knitted Fabric using Inverse Technique. Part 2. Mechanical properties experimental evaluation by frequency eigenvalues method// Journal of Vibroengineering, (Submitted in 2011).