Evaluation of Shear Modulus of Thermoformed Glass Fibre Reinforced Polyester Thermoformed Composite

I. Černý [1,*], L. Remar [1]

[1] SVÚM a.s., Tovární 2053, 250 88 Čelákovice, Czech Republic
* Ivo.Cerny@seznam.cz

Abstract: The work described in the paper was aimed at an evaluation of shear modulus of multilayer glass reinforced polyester thermoformed composite material to be used for manufacture of 3D selected components in automotive industry. The methodology of the evaluation is described in detail. An effect of extensometer gauge length on final results is analysed and discussed. Shear modulus values of the material are presented.

Keywords: Glass Fibre Reinforced Polyester Composite; Shear Modulus; Experimental Methods.

1 Introduction

Use of polymer fibre reinforced composite materials in transport vehicles offers a solution, how to reduce overall vehicle mass, improve ride, reduce fuel consumption and emissions and consequently overall environmental impact. Therefore, research and development in the field has been recently intensively supported by different programmes of the European Union and numerous projects have been recently carried out with EU support.

Unlike metallic materials, polymer long fibre reinforced composites are characteristic by strong inhomogeneity and dependence of mechanical properties on direction related to the main fibre directions. That is why shear modulus and shear strength is one of the essential characteristics, besides tensile modulus and mechanical properties in tension or bending. Knowledge of such properties is an essential conditions for performing serious calculations of crucial stresses and strains in components.

This contribution deals with an experimental programme aimed at an evaluation of shear properties including shear modulus of new type of thermoformed material developed within the project 3D Light Trans of the 7$^{\text{th}}$ Framework Programme. Shear properties and modulus were urgently needed particularly by for modelling and calculations of one of the project demonstrators Fiat 500 L – tailgate.

2 Experimental Material

The investigated material was a high-tech polymer composite combining the superior properties of the reinforcement material (glass) with the ultra-light weight and low cost of polymer matrix (polyester). The material is characteristic by continuous fibre reinforcement in the form of woven multilayer fabric with Z reinforcement, showing enhanced performance compared to short fibre reinforced composites and allowing for a better control of the distribution of the reinforcement material. The material was developed in a collaboration of the project consortium partners, particularly Austrian Institute of Technology, University of Ghent and TU-Dresden.

3 Experimental Programme and Results

Measurement was performed in accordance with the EN ISO 14129 Standard – "Fibre-reinforced plastic composites". Determination of the in-plane shear stress/shear strain response. The experimental procedure contained the following steps:

- static tensile test in the direction ±45 deg with measurement of axial and lateral strains,
- evaluation of stress-strain curves (shear stress and shear strain),
- line crossing stress-strain curve at points of 0.001 and 0.005 strain (Fig. 2),
- evaluation of $G_{1,2}$ shear modulus given by direction of the line.

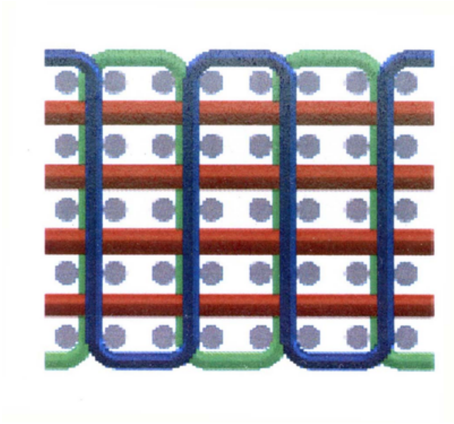

Fig. 1: Scheme of the material layout.

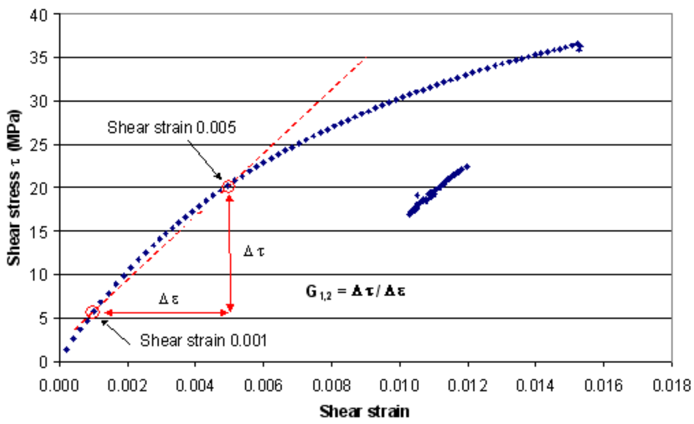

Fig. 2: Evaluation of sher modulus from diagram.

Axial strain was measured and recorded by fully computer controlled Videoextensometer ME46. The base distance (l_0) was 50 mm. Lateral strain was measured independently using Hottinger Baldwin Messtechnik (HBM) strain gauges (SGs), with 10 mm long measuring grid. Position of strain gauges is shown in Fig. 3. For a comparison, axial strain in some of the tested specimens was simultaneously measured by the SGs, complementarily to the videoextensometer. An example of differences between the axial strain measurements using the videoextensometer and SG is in Fig. 4. The results are discussed in the paper.

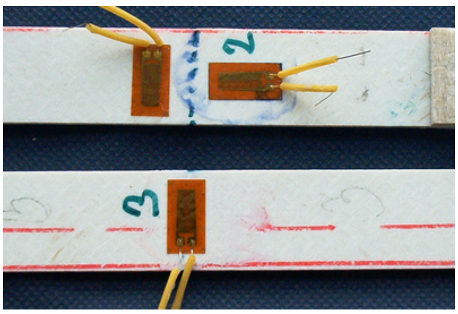

Fig. 3: Specimens with SGs before the test.

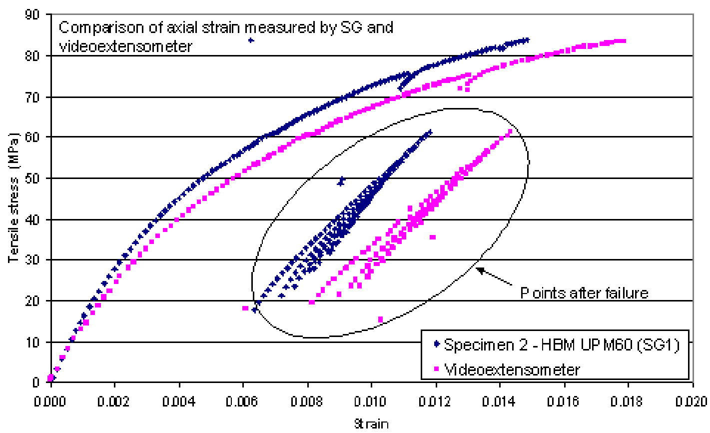

Fig. 4: Axial strain measured by the two methods.

4 Conclusion

The experimental methodology has been successfully applied and shear modulus values obtained. The average value was 3.63 GPa. The results were consistent, scatter was quite low. The results were further used for calculations of stresses and deformation of the car tailgate.

Acknowledgement

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