Comparison of Reduction in Elastic Modulus and Poisson's Ratio for GFRPs

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ABSTRACT

Carbon fiber and glass fiber reinforced polymeric materials have different elastic modulus and major Poisson's ratio values depending on their fiber type and stacking sequences. When the number of off-axis plies increases, a notable change in the values of Poisson's ratio and elastic modulus is observed. In this research, we examined the percent change of Poisson ratio and elastic modulus for different stacking sequences.

Keywords: Poisson's ratio; elastic modulus; glass fiber; damage accumulation

1. INTRODUCTION

Compared to carbon fiber reinforced polymeric materials, glass fiber reinforced polymeric (GFRP) materials possess lower mechanical properties but affordable prices. It is crucial to understand the damage mechanism in GFRP under the applied strain. When GFRP is subjected to a tensile loading, damage is inevitably created inside the materials in the form of transverse cracking, delamination and fiber rupture depending on the amount of applied strain [1, 2]. The stacking sequence is also an important parameter that influence the damage formation and accumulation in GFRP as the level of the applied strain.

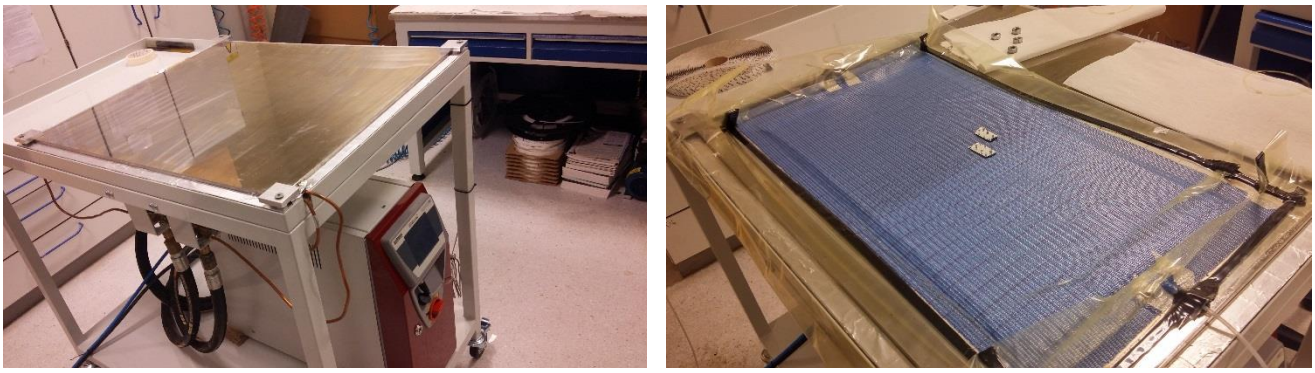
2. MATERIALS and METHOD

2.1. Composite Materials

As a reinforcement, 330 gsm unidirectional (0^o) E-glass stitched fabric (Metyx, Turkey) was used. As a matrix material, Araldite LY 564 epoxy and XB3403 hardener system (Hunstman) was used. Composite laminates with two different stacking sequences, namely, $(0)_6$ and $[90/90/0]_s$, were manufactured by vacuum infusion method as shown in Figure 1 (a)-(b). Figures 1(a) and (b) respectively show the water-heated metal curing table and the vacuum bagging setup. Composite plates were cured at 75^oC for 15 hours. Having completed the curing process, laminates were cut into the test specimen according to ASTM D3039 standard using water-cooled diamond circular saw.

2.2. Equipment and Test

Specimens were subjected to the quasi-static cyclic tensile test using Zwick Z100 universal testing machine with a load cell of $\pm 100\ kN$ under the constant rate of crosshead displacement (2 mm/min). The quasi-static cyclic tensile test is performed through loading-unloading cycles with 50 MPa increment in stress with respect to previous maximum stress. Epsilon 3542 with fixed gage length of 25 mm and Epsilon 3575 with a controllable gauge length were respectively used as axial and transverse extensometers. The extensometers were excited at 10 V constant voltage and their signals were collected by National Instruments NI SCXI-1000 main chassis with NI SCXI-1520 card at a sampling frequency of 1000 Hz.



(a) (b)

Figure 1: a) water-heated curing table, and b) vacuum bagging process

3. Results and Discussions

Collected data were processed to be able to calculate major Poisson's ratio (υ_{xy}) and longitudinal elastic modulus (E_{xx}). Figure 2 shows the normalized values of Poisson's ratio and elastic modulus for the stacking sequence of $(0)_6$ and $[90/90/0]_s$. It is clear that change in the Poisson's ratio is much higher than that in elastic modulus with respect to applied strain for two different stacking sequences. This result also clearly indicate that stacking configuration notably affects the evolution of Poisson's ratio and the elastic modulus trend. When the number of off-axis plies increase, the level of the reduction in Poisson's ratio and elastic modulus raises.

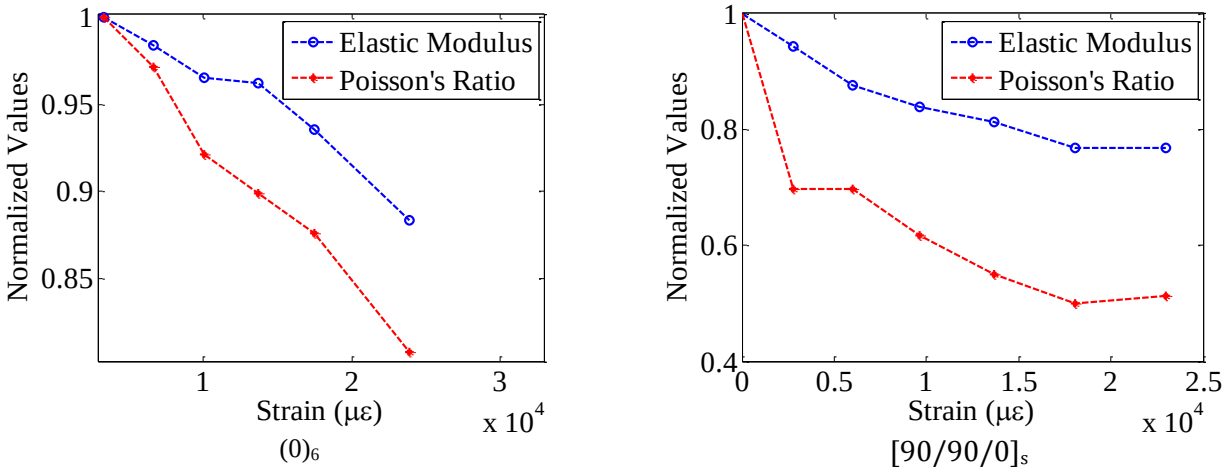


Figure 2: Normalized elastic modulus and Poisson's ratio with respect to applied strain for unidirectional and biaxial composites

4. Conclusion

We investigated the effect of stacking sequence on the evolution of elastic modulus and Poisson's ratio. When the number of off-axis plies increase, a higher reduction in both elastic modulus and Poisson's ratio is observed. Furthermore, referring to the results of the quasi-static cyclic test on two different stacking sequences, one can note that the reduction in Poisson's ratio is higher than that in elastic modulus. It is also observed that the change in the Poisson's ratio is greater than that of elastic modulus for that stacking sequence indicating that the Poisson's ratio can be used a more sensitive damage index.

5. References

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