FATIGUE BEHAVIOR OF 45^{O} FIBERGLASS BRAIDED COMPOSITES

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1 Introduction

Composites have become the leading material in diverse applications due to their superior mechanical properties as compare to their metallic counterparts. This study presents performance evaluation and modeling of biaxial braided fiberglass composites.

Commonly used forms are biaxial and tri-axial braided composite as shown in Figure 1. Braided fabric has greater specific strength. Their strength comes from intertwining three or more yarns without any two yarns being twisted around each other, continuously woven on the bias so that at least one axial yarn is not crimped. This arrangement distributes the load efficiently throughout the braid. Braids come in flat or tubular shapes. Illustrated below are biaxial and tri-axial braided architecture.

Two layers of 45^{O} braided fiberglass composites tubes were stacked together to achieve the desired thickness and then infused with resin using Vacuum Assisted Resin Transfer Molding (VARTM) processing.

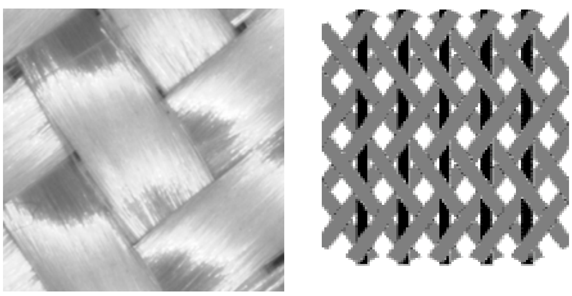

Figure 1 Biaxial and Triaxial Braid Patterns

2 Processing Methods

Numerous methods are currently being used to manufacture composites. Cost, time and quality of the composite laminates dictates the method that is employed. Resin transfer molding (RTM), hand lay-up and VARTM are widely used low cost manufacturing processes. Each of these fabrication processes has characteristics that suit the type of composites that can be fabricated. This is advantageous because the best solution process can be used for a specific material application.

2.1 Manufacturing of Braided Composites

VARTM is an infusion process where a vacuum pulls a resin into a one-sided mold. An overlay is placed over the top of the prepared composite lay-up mold to form a vacuum-tight seal. The pressure differential inside the vacuum or the vacuum itself is applied, drawing the resin into the mold. A schematic drawing of this process is shown in Figure 2.

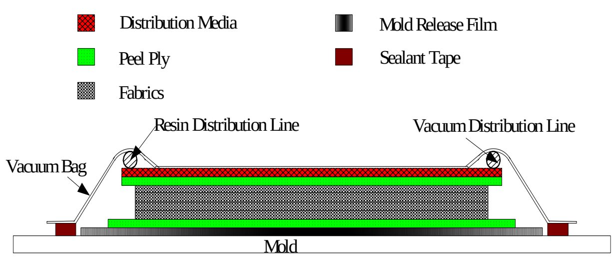

Figure 2. Schematic Drawing of VARTM[1]

3 Static Testing

Static testing also referred to as tensile testing is used to provide tensile strength and Poisson's ratio properties that is used in design calculations. This study was conducted according to ASTM 3039/D3039M titled 'Standard Test Method for Tensile Properties of Polymer Matrix Composite Materials.' A displacement control mode with a lead rate of 0.05 in/min (1.27 mm/min) was used. The test also provides information on stress-strain; yield point, elongation and reduction of area. The highest engineering stress that develops in the material before rupture is the tensile stress also known as the ultimate tensile strength (UTS).

The test was conducted using an Instron 5500R Static/Flexural testing system. The specimen's geometry composed of an 11 in length, 1 in width and a 0.1 in thickness. A two inch long 1-inch wide fiberglass epoxy tabs were used to avoid failure in the grips. The tensile results and stress strain curves are shown in the Table 1 and Figure 3 respectively.

Table 1 Tensile Test Results

Specimen	Tensile Strength		Young's Modulus		Tensile strain
	ksi	Mpa	Msi	Gpa	(%)
2	19.1	131.6	1.72	11.8	8.5
4	20.5	141.2	1.8	12.5	8.4
5	19.1	131.5	1.5	10.5	8.4
6	20.4	140.4	1.9	12.8	8.0
7	19.3	133.3	1.6	11.0	8.9
8	19.3	132.8	1.7	11.5	8.8
9	19.1	131.5	1.8	12.4	6.4
10	19.4	134.0	1.8	12.5	6.7
Mean	19.5	134.5	1.7	11.9	8.0
Std	0.57	3.9	1.2	8.1	0.9

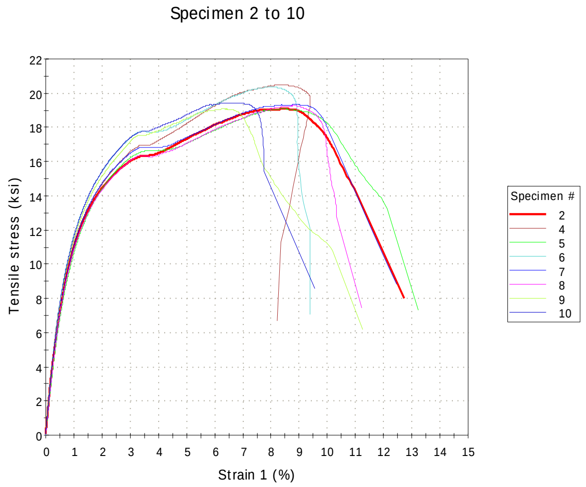

Figure 3 Tensile Stress Strain Response

4 Fatigue Testing

Tension-tension fatigue tests were conducted using a MTS Dynamic/Fatigue testing system. Tests were performed according to ASTMD3479/D3479M This test method determines the fatigue behavior of polymer matrix composite materials subjected to tensile cyclic loading. R = 0.1, 2 Hz frequency and UTS at 40%, 50%, 60%, 70%, 80% and 90% were the testing parameters. The test results and S-N diagram are shown in Table 2 and Figure 4 respectively.

Table 2 Fatigue Test Results

Fatigue Test Results		
90% of UTS	**80% of UTS**	**70% of UTS**
Cycles	Cycles	Cycles
170	408	736
160	580	844
240	628	820
60% of UTS	**50% of UTS**	**40% of UTS**
Cycles	Cycles	Cycles
4236	105,529	1,000,000
9927	99,632	1,000,000
14622	101,538	1,000,000

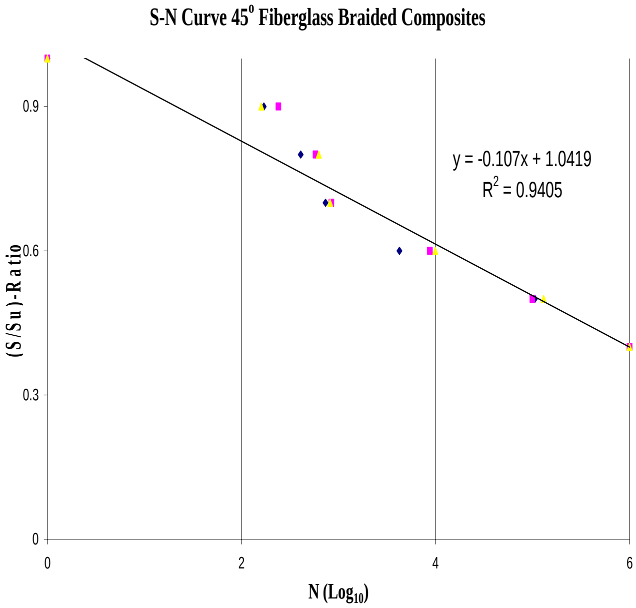

Figure 4 S-N Plot of 45^o Braided Composites

5 Conclusions

Tension-tension fatigue tests were performed on 45 degrees braided composites. Study indicated that the endurance limit is about 40%. The braided composites indicated classical three stage stiffness degradation behavior.

References

[1] Kelkar, Ajit D., Tate, Jitendra S. and Bolick, Ronnie; "Structural Integrity of Aerospace Textile Composites under Fatigue Loading", *Material Science and Engineering B*, 132 (2006) 126-128