10-90850

UCRL-ID-104835

Three Point Bend Creep Testing of Carbon/Epoxy

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June 27, 1990

Lawrence
Livermore
National
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Work performed under the auspices of the U.S. Department of Energy by the Lawrence Livermore National Laboratory under Contract W-7405-Eng-48.

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Abstract

This study provides data to verify theoretical models for predicting and characterizing viscoelastic behavior of fiber composites. Since performing uninterrupted creep tests for years at a time was not feasible, creep behavior was accelerated with elevated temperatures.

An improved method was developed and implemented for measuring specimen deflection within the tight confines of an environmental chamber. This proved to be critical to make this experiment a success.

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Introduction

Dimensional stability of materials is critical for structural applications. Many new applications for fiber composite materials, i.e., carbon/epoxy, are being implemented in high technology industries. As the need for these materials grow more data will be required to predict long-term behavior. This study, funded by the Mechanical Engineering Research, supplies data to verify theoretical models for predicting viscoelastic (creep) behavior.

Test Specimens

Carbon/epoxy panels were fabricated by the Composites Fabrication Group of Materials Fabrication Division. The material used for this study is a carbon fiber tape, TC2145, pre-impregnated with epoxy resin, Hexcel F263 (also termed as pre-preg). F263 resin was chosen because of the extensive data available to help verify theoretical models.

Coupons were cut to approximately 4.50" long, .500" wide, and approximately .080" thick.

Fiber Orientation

Panel 1 - All 0° or 90°

Panel 2 - (+45°/-45°) 8 symmetrical

Panel 3 - (0, -45, 90, +45) 4 symmetrical (termed Quasi-Isotropic)

Each panel had 16 total plies and an average thickness of approximately .080".

Test Apparatus and Procedure

Environmental chambers with elevated temperature capability and controlled loading were used for the experiment. Hallikainen temperature controllers were used to maintain temperatures up to 250°F at $\pm 1^\circ$. Elevated temperatures were used to accelerate creep behavior and see trends which would otherwise take months or years at ambient temperatures.

Because of their thermal stability, portability, and resistance to air turbulence, Bourn's potentiometers were used to measure specimen deflection for three point bend tests.

Test fixturing for three point bend creep tests was designed by the author (Figure 1). The loading of specimens was controlled by a motor driven cross head (which supported dead weights) to assure uniformity of tests (Figure 2). Most tests lasted five to seven days.

An IBM PC coupled with a HP3497A Data Acquisition control unit were used to take the data from potentiometers and thermocouples. Once these tests were completed, data was converted to Apple Macintosh format and plotted using Kaleidagraph software.

Results/Summary

Results in the table (shown in figure 3) show the test I.D. number, the orientation of fibers in each specimen, test temperature, and load. Specimen dimensions, span, and approximate deflection measured 1.0" off center are also listed.

Initially, the same test fixturing was used to measure deflection, but using an indirect measurement technique. This tended to lack repeatability, and modification of measuring technique seemed to be the answer. Instead of measuring indirectly and using crosshead as a reference, the transducer (Bourn's potentiometer) was moved inside the horizontal beam of the fixture and (lightly) spring loaded to be in direct contact with the 3 point bend specimens. Repeatability and accuracy were significantly improved and made the experiment a success.

Ideally, higher temperatures would have been used to increase acceleration of creep except 250°F was the maximum our Bourn's potentiometers could handle. However, sufficient creep was noted to verify theoretical models for predicting creep behavior.

Acknowledgement

I would like to thank Dr. William W. Feng for his valuable contributions to make these tests a success.

Figures

1. Three Point Bend Fixture.
2. Environmental Chamber, Loading Apparatus, and Data Acquisition System.
3. Three point Bend Creep Test summary.

Figure 1. Three Point Bend Fixture.

Figure 2. Environmental Chamber, Loading Apparatus, and Data Acquisition System.

3 POINT BEND
CREEP TEST SUMMARY

TEST I.D.	FIBER ORIENTATION	OVEN #	TEMP. F.	LOAD (LBS.)	SPECIMEN DIMENSIONS	SPAN	DEFL'N (MILS) 1" OFF CENTER
3PTBNDA3	90 DEGREES	11	250	4	.085" X .498" X 4.5"	4.00"	14
	90 DEGREES	12	250	3.5	.085" X .499" X 4.5"	4.00"	11
3PTBNDB	(+/-)45 DEG.	11	250	4	.087" X .500" X 4.5"	4.00"	23
	(+/-)45 DEG.	12	250	4	.086" X .499" X 4.5"	4.00"	22
3PTBNDB2	QUASI-ISOTROPIC	8	225	15	.084" X .501" X 4.5"	4.00"	3
	QUASI-ISOTROPIC	11	250	15	.083" X .498" X 4.5"	4.00"	4
3PTBNDB3	QUASI-ISOTROPIC	8	225	21	.084" X .501" X 4.5"	4.00"	4
	QUASI-ISOTROPIC	11	250	21	.083" X .498" X 4.5"	4.00"	4.5
3PTBNDC1	90 DEGREES	11	250	3.5	.085" X .498" X 4.5"	4.00"	10.5
	90 DEGREES	12	250	3.5	.085" X .499" X 4.5"	4.00"	10
3PTBNDC2	90 DEGREES	8	200	2.5	.085" X .498" X 4.5"	4.00"	4
	90 DEGREES	12	200	2.5	.085" X .499" X 4.5"	4.00"	3.5

Figure 3. Three Point Bend Creep Test Summary.

— #111-MILS

90 DEGREES, 4 LB, 250 F.

3PTBND A3.EDT

— #12-MILS

90 DEGREES, 3.5 LB, 250 F.

3PTBND A3.EDT

#12-MILS **+/-45 DEGREES, 4LB, 250 F.**

3PTBNDB.EDT

— #111-MILS

+/-45 DEGREES, 4 LB, 250 F.

3PTBNDB.EDT

— #8-MILS

QUASI, 15 LB, 225 F.

3PTBNDB2.EDT

— #11-MILS

QUASI, 15 LB, 250 F.

3PTBNDB2.EDT

— #8-MILS

QUASI, 21 LB, 225 F.

3PTBNDB3.EDT

— #111-MILS

QUASI, 21 LB, 250 F.

3PTBNDDB3.EDT

— #11 (MILS)

90 DEGREES, 3.5 LB, 250 F.

3PTBND C1.EDT

— #12 (MILS) 90 DEGREES, 3.5 LB, 250 F.

3PTBNDC1.EDT

— #8-MILS

90 DEGREES, 2.5 LB, 200 F.

3PTBNDC2.EDT

— #12-MILS

90 DEGREES, 2.5 LB, 200 F.

3PTBND C2.EDT

END

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11 / 27 / 90