Testing and Characterization of Mycelium Composites
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Introduction

There is significant attention in the transportation industry on the development of technologies to bolster fuel efficiency. The use of polymer matrix composites (PMC) in products has grown and continues to grow steadily because of their high strength-to-weight and stiffness-to-weight ratios as compared to conventional engineering materials. Unfortunately, PMCs are notoriously unsustainable due to petroleum-based constituent materials, the wasteful and energy-intensive manufacturing processes used, and an inability to recycle at the end of life. Academic and industrial researchers have investigated encapsulating natural fibers with both petroleum-based polymers and biopolymers (e.g., cellulose plastic) to produce more biocompatible composites with varying degrees of experimental and commercial success, but all attempts have still fallen short of an ideal ‘bio-composite.’

Ecovative Design, LLC (Green Island, NY) has created an entirely new bio-composite material. The basic idea is to use mycelium as a matrix for binding natural fibers and core filler materials together in sustainable composite parts. First, the core bulk material is bound together over time by mycelium growing into and around common bulk agricultural waste such as cotton hulls. Then, reinforcing layers made from natural fibers (e.g., hemp) inoculated with fungal cells are applied to the core faces, allowed to infiltrate the laminate and bind to the core material, and then heated to inactivate the growth process to make a resilient composite sandwich structure.

Objectives

This research effort was designed to quantify the performance of two mycological bio-composites in relation to expanded polypropylene to meet specifications for the automotive industry. The samples tested will are also used to evaluate innovative material processing techniques.

Test Methods

Specimens supplied by Ecovative Design LLC were produced using Mycelium grown in Kenaf cores and Jute, Sisal, Flax, Hemp, and Muslin textile face sheets. All specimens were approximately 6.5 inches square and 1 inch thick. All specimens were subjected to 3 Point Bend and Compressive test evaluation.

The 3 Point Bend tests in this project were performed in the Mechanics Lab of the Mechanical Engineering Department at Union College. All tests were conducted on an Instrumet electro-mechanical load frame with a 1000 lb load cell (SN: 287). The load cell was spot calibrated each day prior to testing. The test fixture used during all tests was a 3 Point Bending Test Fixture manufactured by Wyoming Test Fixtures (SN: CU-FL-40). The load rollers are made of steel and are 0.5 inches in diameter and 6 inches in length. The end rollers were set a distance of 5 inches apart for the test performed; this left approximately 0.75 inches outside the span of the test specimens on both side of the fixture. Load was applied to the specimens in displacement control at a rate of 0.2 inches/minute.

The compression testing was conducted on specimens that were first tested in 3 point bending (the specimens that were reported on in the previous section). All tests were conducted on an Instrumet electro-mechanical load frame using an aluminum cage compression fixture manufactured by Innotech International, LLC that has an 8 inch square loading surface. The first three rounds of the Jute, Sisal, Flax, and Hemp Textile; and first two rounds of the Muslin Textile compression testing were conducted using a 1000 lb load cell (SN: 287). The testing on the remaining rounds, including all of the baseline testing was conducted using a 20,000lb load cell (SN: 202). Both load cells were spot calibrated each day prior to testing. Load was applied to the specimens in displacement control at a rate of 0.2 inches/minute.

Results

Data from both tests were evaluated using Excel spreadsheets. The apparent modulus of each specimen was calculated through a regression of a best fit line fitted between 10% to 40% of the maximum load (According to ASTM D1037, Section 9). The slope of this line was then compared with the other specimens using a normalized differential plot. A normalized residual plot of the modulus was made to check the deviation from the group average.

Conclusions and Future Work

From the residual plot it could be seen that some specimens had a large variance from the mean. A possible reason for this could be that the Mycelium did not completely grow through the face sheet for all specimens. In the future, the condition of the sample will be noted pre-test.

Once the data was organized it was sent to Ecovative for them to review. It will show how each variation performs under stress and will allow them to decide which specimen will be appropriate for certain products.

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