Engineering Recycled Plastic / Sawdust Composite Lumber

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ABSTRACT
The recycled composite lumber industry is growing by the rate of 40% each year. Over 32 million tons of plastic waste was made in 2012 alone. The goals of this project were, goal 1: create a mold to shape the recycled plastic / sawdust composite lumber, goal 2: engineer a recycled plastic / sawdust composite lumber plank goal 3: get the plank to have an equal or greater Young’s Modulus. A recycled plastic / sawdust composite lumber board was created with the components of, 92% PLA thermoplastic, 7.3% sawdust, and .7 % water and molded using a 3.81 cm x 8.89 cm x 2.54 cm mold. The recycled plastic / sawdust composite board was tested for its stress and strain to obtain its Young’s Modulus. The recycled plastic / sawdust composite board and the standard lumber were compared using a two-tailed t-test have no statistical difference. This data is good because one of the goals was to make the recycled plastic / sawdust composite lumber board have the same or greater Young’s Modulus as a standard lumber board. The future plan for this research is to test it with a higher standard than a standard lumber plank.

INTRODUCTION
The United States plastic lumber industry has advanced significantly from its early beginnings in the 1980’s by taking post-consumer plastics destined for a landfill, and turning them into planks [1]. The recycled composite lumber industry is growing by the rate of 40% each year [2]. Over 32 million tons of plastic waste was made in 2012 alone [3]. Recycled composite lumber, or RPL, printed out of a 3D printer would reduce the cost of framing thus reducing the cost of the project. A relatively new invention, the 3D printer, can take a computer file of an object and print in three dimensionally using various materials such as plastic or concrete.
The average cost to frame a house is over $16 per square foot ($52.50 per square meter) [4]. This research hopes to reduce the cost of this price. In 2001, wood-plastic composite lumber reached $22.80 per cubic foot [5]. Construction companies might never run out of lumber, they would just print more, and various other projects could be completed with relative ease.

Printing RPL would save money in the long run because it does not need to be refinished or maintained like industry standard lumber or even treated lumber would. Industry standard and treated lumber must be refinished or polished because of the weather and erosion especially in high humidity areas where the water will soak into the lumber causing it to rot. Because of this, lumber must be treated with a sealant to keep the water out costing more money. RPL does not need this treatment because it will not absorb water saving money the longer it is used.

Traditional house frames are made of different joints in the lumber. If those joints were removed by printing one piece instead of two, then the frame of the house would be stronger making it more resistant to storms with high winds saving money in repairs that would be needed with industry standard lumber.

The combination of these two ideas, a 3-D printer and composite, could revolutionize the construction and engineering industry. The engineering goal of this project was, if a new recycled plastic-composite board was created using a 3-D printer, then it will be able to handle more stress and strain less than the standard lumber because the two strong materials are being combined.

**MATERIALS AND METHODS**

89 mL of water were boiled at 100 degrees Celsius in a 250 mL beaker on a hot plate. The water was then removed from the hot plate and 1 ounce of unflavored gelatin was added to
the water. Once dissolved, 30 mL of white vinegar, and 9 mL of glycerin was added to the mixture. This mixture acted as the adhesive to the solid wood portion and the semi-solid plastic portion.

The entire adhesive mixture was added to 700 mL of sawdust in a 2000 mL beaker. Then 700 mL of plastic shavings were melted and added to the mixture. This plastic was obtained from milk cartons, water bottles, and other plastic items. The mixture was poured into a 7 cm by 13 cm by 4 cm metal mold and allowed to dry for 24 hours.

The RPL board was then tested for its elastic modulus using an extensometer. The extensometer was made by hanging the board from a metal sawhorse. A bolt was drilled into the bottom of the board to hang the weight platform. The board was measured for length then attached to the extensometer. Weight was added until the board stretched and measured again for its final length. (See Figure 1)

**RESULTS**

The average strain of the control group (Standard Lumber) trials was .0112 while the experimental group (Plastic / Sawdust Composite Lumber) trials average strain was .0093. The highest strain for the control group was .0169 while the lowest strain was .0056. The experimental group’s highest strain was .0112 while the lowest strain was .0056. The average strain of the control group was 120% greater then the average strain of the experimental group. The standard deviation for the controlled group was 704.58 while the standard deviation for the experimental group was 622.97.

The average stress of the control group was 18712.18 while the average stress of the experimental group trials was 16061.17. The control group stress was 109% greater then the experimental group stress. The control group’s lowest stress was18305.4 while the experimental group’s lowest stress was 16628.39. The control group’s highest stress was 19525.76 while the
The experimental group’s highest stress was 17775.17. The standard deviation for the controlled group was 0.57% while the standard deviation for the experimental group was 0.32%.

The average Young’s Modulus for the control group was 1.66 GPa. The average Young’s Modulus for the experimental group was 1.83 GPa. The lowest Young’s Modulus for the control group was 1.16 GPa while the lowest Young’s Modulus for the experimental group was 1.48 GPa. The highest Young’s Modulus for the control group was 3.27 GPa while the highest Young’s Modulus for the experimental group was 3.0 GPa. The average standard deviation of the controlled group was 1.11 GPa while the standard deviation of the experimental group was 0.84 GPa.

The data collected from the experimental group was compared to the controlled group using a two-tailed t-test, and there was no statistical difference between them (±0.02; df=3.7; p>0.1).

**DISCUSSION**

The standard lumber boards and the recycled plastic / sawdust composite lumber boards were compared using a two-tailed t-test. Both boards have no statistical difference. This is a good because the one of the goals of this project was to make the recycled plastic / sawdust composite lumber boards have the same or greater Young’s Modulus then the standard lumber boards.

The engineering goals of this project were accepted, a mold was created, a recycled plastic / sawdust composite lumber board was created, and both the standard lumber and recycled plastic / sawdust composite lumber board are statistically the same. One bad thing about the plastic / sawdust composite lumber board was it had a greater mass then the standard lumber.
In the future, trials will be run to test its ability to be cut by a saw or power tool. This is essential because carpenters need to be able to cut the board to their desired length. More trials will also be ran to test the recycled plastic / sawdust composite lumber board at a greater standard then the standard lumber to see if the engineered board is stronger then standard lumber boards.

REFERENCES
