Sustainable Structures in Space
Braedon Bellamy, Jack Dryden, Jordan McDuffie, and Henry Jenkins

Introduction

This study examines various materials and design concepts to create educational satellite structures that are more environmentally conscious in an effort to reduce wasteeful consumption. Materials such as durable papers, various types of wood, post-consumer recycled foam board, cork, and organic sealants were put through a series of tests in order to determine their viability in harsh environments found at high altitude. These materials were used to build a number of payload designs and were tested in multiple ways to determine functionality, practicality, weight efficiency, and insulation capabilities in extreme temperatures. The majority of the testing related to the rigidity and insular capabilities required for the DemoSat payload created by ACC students. The conditions for the testing were designed to replicate the possible conditions a satellite may endure during a five mission. Results were collected and the data was analyzed.

Background

Enthusiasm for universities to become involved in the Space Grant Research has grown over the past few years as interest in aerospace technologies has become more popular. There is a negative implication to this as well due to the payloads often being made of materials that are not sustainable, nor environmentally conscious, therefore creating unnecessary landfill waste. Currently, petroleum foam based materials appear to be the standard for constructing a balloon satellite for DemoSat payloads. These materials offer many structural benefits for high altitude testing including: durability, lightweight, insulation, and impact resistant; however they are not yet readily recyclable.

To find alternative environmentally conscious materials, our team considered both more natural based and recycled products to build our payload structure. All materials chosen in this study were considered based on their structural integrity to create a working satellite that could receive and transmit NAM radio signals. The only constraint for our payload designs was to not have features that would affect the functionality of the electrical components that were housed inside, like sensors, batteries, and antennas. Based on these conditions, the parameters were determined for the ideal materials and structure needed to accomplish all desired results.

Materials

<table>
<thead>
<tr>
<th>Woods</th>
<th>Made Paper Products</th>
<th>Sealers</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Birch</td>
<td>- Poster Board</td>
<td>- Mineral oil</td>
</tr>
<tr>
<td>- Bassa</td>
<td>- Recycled Foam</td>
<td>- Polycrylic</td>
</tr>
<tr>
<td>- Cork</td>
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</tbody>
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Materials Test

The goal of the materials test was to compare multiple materials/finishes quantitatively. Qualities such as water-resistance and durability in building materials was researched by ACC students, specifically for the purpose of establishing alternative to conventional non-environmental conscious materials. The list of materials for the test include: birch wood, recyclable foam, cork, blank finish, mineral spirits, and polycrylic. The tests were conducted in accordance with the following procedures. 1. First 3" rectangular cross-sections were cut for every material. 2. Finishes were applied to every cross-section such that all possible combinations were created. 3. Every sample’s initial mass was recorded. 4. Then all samples were submerged for 20 minutes in a beaker filled with water. 5. Following submersion, final masses were recorded, and their mass differences were calculated. The difference in mass was then divided by the square cross-sectional surface area of each sample, and the results were presented graphically (see Data/Results).

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Structures

Wood Based

- Birch
- Poster Board
- Mineral oil
- Polycrylic

Paper Based

- Bassa
- Recycled Foam
- Polycrylic

Hybrid

- Birch
- Recycled Foam
- Mineral oil
- Polycrylic

Vertical Drop Tests

- Drop Test: 20 ft
- Weight: 0.173466 N
- Density: 159.99 kg/m³
- Volume: 0.000110636 m³
- Mass: 0.0177006 kg

Data/Results

Thermal Tests

- Temperature: 31.5°C
- Humidity: 50%
- Weight: 0.1684 N
- Mass: 0.0177006 kg
- Density: 159.99 kg/m³
- Volume: 0.000110636 m³

Conclusion

The conclusion reached after analysis of the data collected is that the results of the materials test show the most effective material for water repulsion was birch wood with a value of 0.707 (g/ml®2), and the most effective finish for water repulsion was found to be a polycrylic coating with a value of 0.707 (g/ml®2). For the structures tests, we found that both the wood and paper made structures had benefits, such as weight efficiency and ease of use. The wood structure was very durable and was ultimately selected to be launched in for this year’s (2018) Demo-Sat project. Furthermore, it was determined that the wooden structure was more environmentally conscious based on it being made from raw natural materials. The paper recycled foam board performed extremely well, but the secondary structure created for rigidity increased the mass of the payload. The exterior ribed structures did an excellent job in cushioning impact and showed that ribbed structures disperse energy more efficiently.

Photos