Design of a Composite Roll Cage

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Project Inspiration

The intent of this project is to design and build a new composite roll cage for the next Blue Sky Solar Racing vehicle that will replace the steel design, in order to reduce the gross weight of the vehicle. This is expected to have positive effects upon the performance of the vehicle, such as higher efficiency, higher top speeds, and faster acceleration. Our roll cage is designed to fit the current vehicle, with some alterations.

Figure 1. Azure, the latest-generation Blue Sky Solar Racing vehicle, participating in the 2011 Veolia World Solar Challenge.

Key Mechanical Engineering Concepts

- **<u>Solid Mechanics</u> – estimating compressive loading and impact forces and their effects on the vehicle.**
- **<u>Composite Materials</u> – comparing their strengths and weaknesses, and selecting one based on the criteria.**
- **<u>Prototyping with Composites</u> – learning the basics of performing a wet layup, with curing in a vacuum bag.**

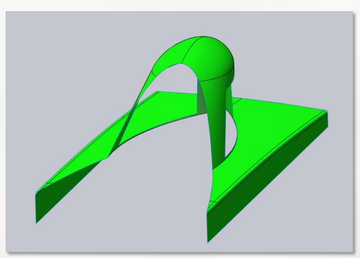

Figure 2: CAD Roll Cage Design.

Analysis and Results

Using a simplified approach, we were able to select a range of part thicknesses that would satisfy our design requirements. The resulting safety factors are shown below:

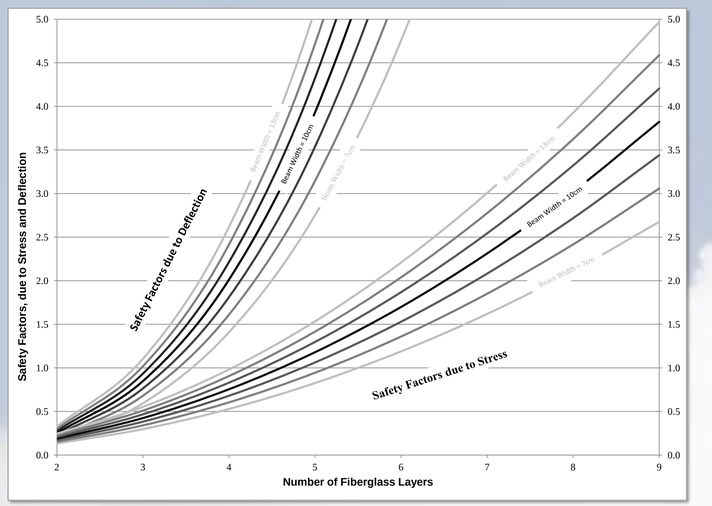

Figure 3: Safety Factors, Varying By Fiberglass Thickness

To estimate the primary loads on the vehicle in a frontal collision, we used the calculations below in our design:

Force of Shearing Solar Array:

$$F = ma = m_{shell} \cdot \frac{(v_1 - v_2)}{t_{collision}} = m_{shell} \cdot \frac{(42-0)}{0.1} = 45\ \text{kg} * 42/0.1 = 18900\ \text{N} = 18.9\ \text{kN}$$

Compressive Downwards Force:

$$F = ma = m_{total} \cdot 6 \cdot 9.81\ m/s^2 = 250\ \text{kg} * 6 * 9.81 = 14715\ \text{N} = 14.72\ \text{kN}$$

Note: Blue Sky Solar Racing requires the applied compressive load to be 6g, above the 4g minimum set by the WSC (World Solar Challenge).

We considered fiberglass, carbon fiber, and Kevlar®, and decided upon marine fiberglass for these reasons:

- **Reasonable cost, ease of fabrication compared to Kevlar®**
- **Strength in shear, as well as in tension and compression**
- **With additional layers, can be sufficiently stiff and strong**

Prototyping

1. **Created a thin full-size mock up to practice our wet layup techniques and for fitting to the vehicle.**
2. **Performed a multistage layup to achieve seven full layers of fiberglass on our positive mold.**
3. **Cut out appropriate sections to ensure adequate visibility while maintaining adequate strength.**

Figure 4. Roll Cage Prototype To Be Tested.

Future Work

1. **Mechanical Testing (Compressive loading)**
2. **Material Refinement (Carbon Fiber Prototype)**
3. **Refinement of Physical Geometry (Post-testing)**
4. **Improvement of Aesthetics (Paint, Coatings)**
5. **New Manufacturing Techniques (Pre-preg fabric)**

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