Abstract:
The goal of this project was to design and build a composite bridge structure for the purpose of entering the 2007 SAMPE Super Lightweight Bridge competition. Entries are judged based on load to weight ratio. Utilizing successes of teams in the past, attention was brought to previous modes of failure. Through testing and analysis, design iterations were made. The primary goal of exceeding a load to weight ratio of 10.0 was achieved in the test of the second prototype.

Design
This year’s competition rules were very similar to those in the past. Benchmarking of previous efforts yielded a design consisting of several components. The final design was composed of only carbon fiber.

Subcomponents
Cross Members
- Prevent buckling without adding significant weight

Load Plate
- New design incorporated ± 45° carbon fiber cloth
- Saved 100 grams over aluminum design
- Analysis shows where material can be spared

Plugs
- Previous year’s bridge failed in plugs
- Using a majority of cloth over tape reduces preloading from thermal strain
- Applying a force during the curing process improves bond strength

Straps
- Unidirectional carbon fiber is strongest in tension
- Minimal weight with high strength

Top Caps
- Absorb the load of the top straps and distribute it into the trusses

Trusses
- Hollow unidirectional carbon fiber tubes
- Light and strong in compression

Testing and Analysis
Load plate
Using finite element analysis, it was confirmed that an all carbon fiber plate would be sufficient. Further analysis determined the optimal design would have a circular cutout in the center.

Plugs, Straps, Trusses
Both truss and plug coupons were tested under compression. Two types of plug tests were performed. One in which a vice clamped down the plug and the other in which no force was applied. Several strap designs were tested. The best one proved to be an overlapped continuous laminate made of unidirectional tape.

Prototype
A full model analysis was performed. The failure predicted was found to be in the corner of the bottom strap.

In the first prototype this is where failure occurred. In the second prototype, the top caps failed due to fatigue from the first test.

Prototype I / II
| Load(L) | 3070/3850 lbs |
| Weight(W) | 360/383 g |
| L:W | 8.52/10.05 |

Conclusion and Recommendations
Through the process of benchmarking and iteration, the main goal of improving performance over previous designs was achieved. Despite surpassing the load to weight ratio of 10.0, there is still room for improvement. Future considerations should focus on manufacturing techniques and optimizing material distribution.

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