SAMPE – Bridge Contest

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Abstract

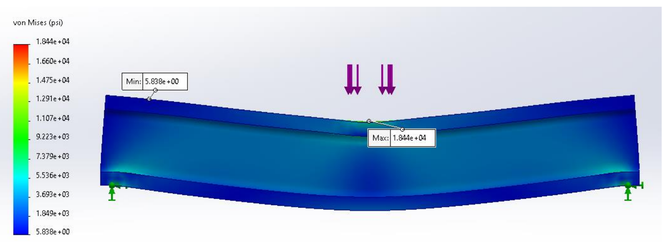
- This project focuses on designing and manufacturing a Carbon Fiber I-Beam for the SAMPE Bridge Contest. The primary aim is to optimize strength-to-weight ratios, enhance durability, tailor mechanical properties, and achieve precision in manufacturing..
- This project touches up on different manufacturing processes, different design interactions, design development and alternatives
- We use finite element analysis to simulate the beam's expected structural behavior when subjected to different types of forces and finally combine all this information with hours worth of background research data and multiple failed attempts to manufacture the most perfect, smooth and structurally impressive carbon fiber I-beam.

Introduction

- This project represents an ambitious endeavor to push the boundaries of composite engineering. By merging theoretical knowledge, advanced manufacturing techniques, and real-world testing, our aim was to create a carbon fiber I-Beam that not only meets but exceeds the expectations set by SAMPE Bridge Contest standards.
- Our project is centered on the meticulous fabrication of a carbon fiber I-beam using layered composites. This choice was made over several other options because it offers the most advantageous strength-to-weight ratio. Our main emphasis is to maximize that ratio, improving durability, customizing mechanical properties, and attaining precision in manufacturing. This is achieved through comprehensive research, 3D CAD Modeling, investigation into material selection and more.

Analysis

A simulation was conducted in order to analyze and predict the behavior of an I-beam under stress. A force of 7200 lbs was applied to the top of the I-beam as that is the design load of the selected category.



The above figure shows the result of the Standard I-beam stress test, which results in a maximum stress of 18 440 psi. This would be the most likely point of failure in the carbon fiber I-beam as this point would be experiencing the most compression. .

Discussion

- During the first stage, it was crucial to learn about the different uses of I-beams in construction and Engineering and therefore get a grasp about the required versatility and how we should proceed
- Next stage, we built a model of our design. Modeling helped us fine tune I-beam dimensions based on project requirements and not to mention, it was also crucial for running simulations and analysis.
- Next, we ran simulations and different analyses. Running simulations and Engineering analyses minimizes material waste, reduce costs, and even helps us simulate real world scenarios by giving us strong predictive capabilities.
- The final stage of our project after material testing was to carefully put all of our ideas and research together and bring our design to life.

Conclusions

The ultimate strength of a carbon fiber/epoxy composite material can be anywhere from 133-550000 psi depending on the layering and manufacturing, which causes some difficulties in predicting real-world events when simulating composite materials. The most significant factor of the strength of the I-beam is the quality of the production as any minor defects or voids in the epoxy will cause the overall strength of the beam to be lower than in the simulations. After running careful iterations, multiple prototypes and learning from previous mistakes, we have manufactured our final Carbon fiber I-beam iteration for this project.

Methods and Manufacturing

Our manufacturing plan for our carbon fiber I-beam was –

Create Mold:
Use our 3D model to develop an aluminum or steel mold that matches the shape and dimensions of the I-beam.

Prepare the Mold Surface:
Apply a mold release agent to prevent the cured composite from sticking to the mold and to ensure a smooth and clean surface.

Layup Process:
Cut carbon fiber fabric into the desired shapes and arrange the fibers in the mold, considering fiber orientation and layering.

Vacuum Bagging and infusing resin:
Infuse the resin into the fabric composite layers and consolidate it.

Curing:
Check the resin system's curing requirements and cure the composite layup at the specified temperature and pressure accordingly.

Demolding:
Once cured, we carefully demolded the carbon fiber I-beam from the mold and remove any mold release agent.

Post-Processing:
Finally, we Trimmed excess material and shape the I-beam to its final dimensions and sanding.

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