Bridge #:
SNN2TH93X72

Luminous Glass

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Category D

PROBLEM STATEMENT

Design an I-Beam to hold a 5,600 lbf distributive load using S2GL/8552 pre-impregnated unidirectional glass fiber.

BEAM DESIGN

The direction and placement of plies are the critical design features of this beam:

- **Web:** created with mostly 45° plies for shear stress and to distribute stresses throughout the entire beam.
- **Top flange:** created using mostly 0° plies for compressive stresses with 45° and 90° plies to distribute stress across beam, especially at the connection between the top and web. Includes tabs in the middle to distribute force from loading block (Figure 1a).
- **Bottom flange:** created using mostly 0° plies for tensile stresses and a few 45° tabs. Includes tabs at the ends for better reinforcement at lower contact points (Figure 1b).

(a) (b)

Figure 1: Side-view diagram of ply stacks with example tab placements. **(a)** Top flange of the beam. **(b)** Bottom flange of the beam

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MANUFACTURING

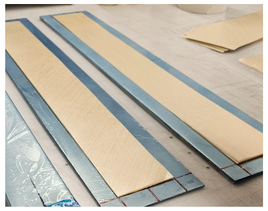


Figure 2: Top and bottom flanges laid up on tools.

Plies are cut using a CNC fabric cutting table. Next, the top and bottom flanges are laid up on steel caul plates, and the web sections are laid up on 2” x 3” aluminum tooling (Figure 2).

The biggest issue was the stiffness and dryness of the material utilized. The best method found was to lay up 3 - 4 plies by heating them up with a heat gun, and then debulking. Methods were also found to debulk the web on the tool (Figure 3). In this manner, better contact was achieved between the plies.

Figure 3: Vacuum-bagged web part for debulking.

Figure 4: Final cured and trimmed beam.

The beam is then assembled, joins packed with noodles, bagged, vacuumed, and placed in an autoclave to cure. The beam is trimmed with a wet-tile saw after curing.

TESTING

Iterations were tested with a testing frame (Instron) and resulted in the beam passing the designated load, but with extremely high deflection. Therefore, some plies were added to the top and bottom flanges to improve stiffness.

IMPROVEMENTS

During the manufacturing process, a significant issue was wrinkling in the web as plies were bent over the tooling (Figure 5).

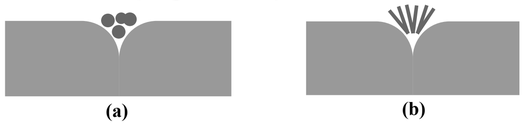
Figure 5: Wrinkage as plies are individually bent around web tooling.

Instead of bending plies one by one, plies were layed up flat and debulked. Then, each was carefully heated with a heat gun, bent around the tool and pressed down by steel weights (Figure 6). By using this method, wrinkling was reduced and there was better contact between the plies.

Figure 6: Pressing plies with steel weights.

Figure 7: Laid-up web created using new method.

This year, different noodle packing methods were also experimented with. Twisting strips of fiberglass and then placing into the gap caused several holes (Figure 8a).



(a) (b)

Figure 8: Cross-section diagrams of noodle packing methods. **(a)** Twisted strips. **(b)** Folded strips.

Folding strips of fiberglass and then wedging them into the gap served to help elminate the holes caused by the previous twisting method (Figure 8b).