# A Braided Composite Cable-stayed Walking Bridge

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## Introduction

- Walking bridges are typically made out of strong and heavy materials such as steel to withstand many different forces.
- It is difficult to transport and maneuver these heavy materials, creating a need to find alternative materials.
- In contrast to these heavy materials, braided composites are very lightweight materials with high strength-to-density ratio that may be able to serve as an alternative [1].

## Purpose

The purpose of this project was to determine the feasibility of constructing a cable-stayed bridge out of braided composite materials.

## Methods

### Design Process

The forces acting on a cable-stayed bridge were determined, as illustrated in Figure 1.

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Materials were selected based on the types of forces they would have to endure and the strength of the material.

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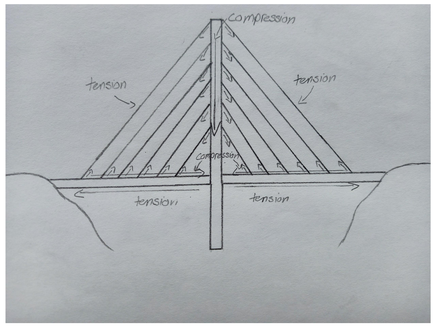


Figure 1: Sketch illustrating the forces being applied to the bridge

| Part of bridge | Fibrous material | Matrix (resin) material | Braid angle | Fiber volume fraction |
|---|---|---|---|---|
| **Pillars & top of bridge deck** | Carbon fiber (high compressive strength) [2] | Epoxy resin [3] | 30° | 60% fiber 40%matrix |
| **Cables** | Aramid fiber (high tensile strength) [2] | Silicon (leaves the cables flexible) | 30° | 60% fiber 40%matrix |
| **Bottom of bridge deck** | Aramid fiber (high tensile strength) [2] | Epoxy resin [3] | 30° | 60% fiber 40%matrix |

Using SOLIDWORKS®, a 3D modeling program, a model of the bridge was drafted to lay out the general desired structure. Illustrated in Figure 2.

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The connectors necessary for the bridge construction were designed as illustrated in Figure 3.

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The deck of the bridge is a sandwich of composite materials on the top and bottom and 3D printed plastic in the middle.

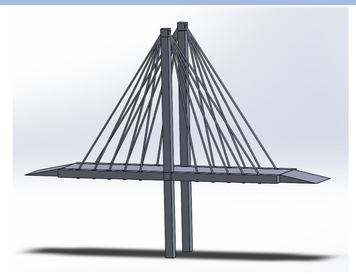

Figure 2: Solid model of bridge design

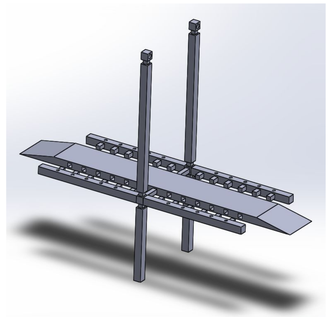

Figure 3: Bridge model with connecting pieces

### Prototyping Process

Connectors and center piece of the bridge deck were 3D printed. Shown in Figure 4.

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The dry preforms for the top and bottom of the deck, the top and bottom of the pillars and the supporting cables were manufactured using a maypole rotary braider. Shown in Figure 5 and 6.

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Braids performs for the composite parts were cured, by mixing a 4:1 ratio of resin and hardener and using it to cover the dry braid, letting it cure at room temperature. Shown in Figure 7.

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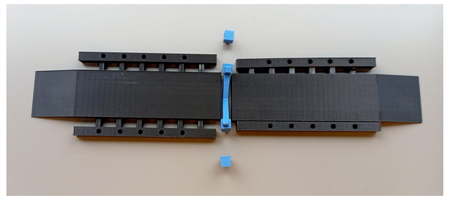

Figure 4: 3D printed connecting pieces

Figure 5: Maypole rotary braider

Using the 3D printed components and the braided composite components the bridge was constructed. Shown in Figure 8.

Figure 6: Dry preforms

Figure 7: Dry preforms being cured

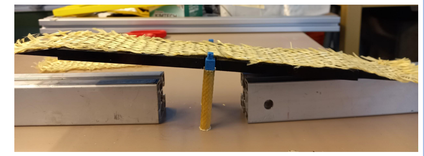

Figure 8: Assembly of the braided composite walking bridge

## Conclusions

- The braided composite cable-stayed bridge was designed using SOLIDWORKS®.
- All of the components except the connectors and the center layer of the bridge deck are braided composite.
- The bridge was assembled using the 3D printed parts and the composite parts.
- By using lighter materials for bridge construction, transportation of the materials would be easier and better for the environment.
- The braided composite cable-stayed bridge proved a viable alternative to typical materials used in bridge construction.

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## References

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