IACMI and Team Integrating Composites into the Friendship Bell Park

The International Friendship Bell is an 8,000-pound bronze cast bell designed by an artist in Oak Ridge, Tenn. and cast by a family foundry in Kyoto, Japan. The bell symbolizes the spirit of the peace and friendship shared by the city of Oak Ridge, Tenn. and Naka, Japan, and offers a space for gathering and thoughtful reflection in our community.

The bell was created in 1996, and the park was renovated in 2018 with a goal to symbolize “a future being created by the ever increasing scientific and technological advances that benefit the world.” This renovation is a collaboration by many groups supporting the Oak Ridge community, including the City of Oak Ridge; Oak Ridge National Laboratory; the University of Tennessee, Knoxville; and IACMI – The Composites Institute.

This park signifies not only the strong relationship between Oak Ridge and Naka, but also the spirit of innovation and leadership that Oak Ridge offers internationally. This new park features state-of-the-art and futuristic technologies in materials and manufacturing, including 3D printed bench seatbacks, unique concrete architectures, and carbon fiber composite pavilion beams.

**Friendship Bell Pavilion Carbon Fiber Beams**

An innovative feature within the park are 17 free floating, 33-foot long, arched composite beams spaced that cantilever from a central concrete-steel superstructure surrounding the bell. The beams are made of a combination of low and high-density foam with a steel plate embedded in the center for assembly to the superstructure. The foam was overbraided with carbon fiber and vacuum infused to finalize the manufacturing.

IACMI – The Composites Institute; the U.S. Department of Energy’s Manufacturing Demonstration Facility (MDF) at Oak Ridge National Laboratory (ORNL); the University of Tennessee, Knoxville (UTK); and Highland Composites all worked together to create the 17 beams.

**Creating the Friendship Bell Beams**

Dr. Uday Vaidya, a professor at the University of Tennessee, Knoxville, the UT/ORNL Governor’s Chair in Advanced Composites Manufacturing, and the Chief Technology Officer of IACMI, led a team to create the composite beams manufacture over a period of three months.

The design was conceptualized to utilize several manufacturing technologies to build out the beam structures – manufacturing techniques included overbraiding carbon fiber and vacuum infusion molding. A sandwich design construction, similar to that used in aircraft and wind turbine blades, was
utilized for the beams. This sandwich design uses a polyurethane foam core overbraided by triaxial carbon fibers.

The foam core in the 33-ft long beams was seamed in three sections – the center section has a high-density foam with steel plate embedded for assembly to the superstructure. The left and right sections have lower density foam to maintain lightweight for the cantilever support. The machining of the foam to the arch geometry was performed on a Thermwood CNC machine at the Manufacturing Demonstration Facility (MDF) at ORNL by Dr. Lonnie Love's team.

Carbon fiber was utilized in these beams because of its lightweight, strong, and durable characteristics. Also, carbon fiber is of significance to the Oak Ridge area because of the concentration in advanced materials manufacturing research and growing composites industry in the area. The composite beams represent a unique innovation for a large-scale composite structure of this kind for infrastructure application.

The overbraiding was performed at Highland Composites, in Statesville, NC under the leadership of Dr. David Branscomb. During overbraiding, the seamed foam continuously advances through the braiding machine, where carbon fiber wraps the foam in a triaxial architecture (two angle plies and one unidirectional). The overbraided form was then vacuum infused with low viscosity epoxy resin.
The vacuum infusion process is similar to that used in construction of large boat hulls and wind turbine blades, where the dry fabric form and foam is placed under a vacuum bag and resin is infused under vacuum. The result of this process is a rigid structure when the fibers are wetted out with the resin which crosslinks and cures in 36 hours.

The UTK team who worked on the project was guided by Stephen Sheriff, Process Engineer at the UTK Fibers and Composites Manufacturing Facility (FCMF), and included team of 15 graduate and 10 undergraduates of the FCMF at the University of Tennessee, Knoxville. These students participated in hands-on learning on-site at Highland Composites to produce the beams.

Additive Manufactured Bench Seatbacks

Five bench seat backs were created at the U.S. Department of Energy’s Manufacturing Demonstration Facility (MDF) at Oak Ridge National Laboratory (RONL) through additive manufacturing (also known as “3D printing”). The seat backs were printed on Cincinnati Inc.’s Big Area Additive Manufacturing polymer system (BAAM). With the Cincinnati Inc. BAAM, researchers at ORNL were able to design the seatbacks in computer-aided design (CAD), then produce the seatbacks in nine hours – taking the seatbacks from design to completed production in less than one day. The seatbacks were printed with 700lbs of material, with a consistency of 20% carbon fiber, and 80% reinforced with acrylonitrile butadiene styrene (ABS) polymer, which is a common carbon fiber-ABS ratio used in additive manufacturing.

Additive manufacturing can have an advantage to traditional manufacturing practices by reducing the production time, number of parts needed, and overall cost. Additionally, oftentimes additive manufacturing opens opportunities for recycling the material, further creating a process than can be more environmentally sustainable when compared to traditional manufacturing methods.

The collaboration between UTK, IACMI, ORNL, the City of Oak Ridge, Highland Composites, and Cincinnati Inc. enabled the concept to final product of these large-scale composite beams and additive bench seatbacks for the Friendship Bell Park. Through the construction of these advanced manufacturing construction elements, the graduate and undergraduate student participants on these projects gained valuable learning of the process of concept design to manufacturing of a real world composite structure.

Additionally, the advanced manufacturing components in the Friendship Bell Park provide a lasting reflection of the spirit of innovation in Oak Ridge, as well as a recognition of the region’s resources to cultivate the leaders of tomorrow through fostering an innovative ecosystem in the Oak Ridge area.