BRIDGE IN A BACKPACK

The University of Maine Advanced Engineered Wood Composite Center has developed a novel use of composite materials to simplify construction of short to medium span bridges and reduce their maintenance and life cycle costs. Lightweight carbon fiber arches are manufactured by inflating a tubular carbon composite shell and bending it to the proper bridge vertical profile. The arches cure on site within hours.

The process starts with flat, hollow tubes made of carbon fiber. Each tube can be rolled up and fit into a duffel bag, from which comes the name, "Bridge in a Backpack". When the bags arrive at the work site, the tubes are unrolled and placed on a steel formwork built to the length and curvature specifications required for the bridge arch. The tubes are inflated, taking on the shape of the formwork, and the carbon fiber material is infused, using a vacuum process, with a vinyl ester resin. The resin is allowed to dry overnight to a strength claimed to be two times stronger than steel, giving the tubes the strength and stiffness to carry the weight of the concrete. UMaine has patents pending on the technology.

The inflatable composite arches provide three simultaneous functions: They act as a stay-in-place form for the concrete, function as an external reinforcement for the concrete, and protect the concrete from corrosion and freeze-thaw damage. The arches can be erected by hand, reducing or eliminating the need for heavy equipment during bridge construction. The arches and corrugated decking can both be compactly stacked which reduces the staging area required during construction. These attributes make this technology ideal for tight or inaccessible construction sites, and they can reduce the total time of construction.

Since the concrete in the arches is protected from the elements by the composite shell and because of the non-corrosive performance of the composites materials themselves, this design should reduce the maintenance costs and increase the design lifespan of these types of structures. The net result should be a decrease in the total lifecycle costs.

An advantage of this system is that it is similar in configuration to standard construction, sharing many details at the foundation, head walls, wing walls, and backfill buildup. Therefore, it integrates easily with existing construction techniques. This technology should be scalable to longer span bridges, including spans longer than the competing metal plate arch and precast concrete buried bridges.

In the fall of 2008, MaineDOT built the first bridge, the Neal Bridge (below) in Pittsfield, Maine, a buried arch bridge constructed with composite materials. The arches were manufactured from 12-inch diameter rigidized inflatable hollow carbon fiber composite tubular arches that were put together at the AEWC lab in Orono, Maine and taken to Pittsfield. The arch-shaped tubes are light enough to be lowered into place with a simple boom and manual labor, spaced about 2-feet on center. A 4-inch deep corrugated fiber reinforced plastic (FRP) decking was installed on top of the arches. Arches were then filled with concrete through a hole at the top of the arch. It took about an hour to fill 23 arches at the Neal Bridge. As the concrete cures, the carbon-fiber tube becomes a skin around the concrete, and the arches can then carry bridge construction and traffic loads. The Neal Bridge head walls were constructed with a FRP sheet pile system and the wing walls were constructed from a prefabricated concrete T-Wall retaining wall system. Approximately 4 feet of dirt and sand fill was placed over the structure with typical MaineDOT subbase and hot mix asphalt pavement roadway section. The span of the arches is 27-feet, the guardrail to guardrail width is 30-feet, and the headwall to headwall width is 45-feet.

Five road bridges and one snowmobile bridge have been constructed as of 2010. The AEWC Center (http://www2.umaine.edu/aewc/) is under the direction of Dr. Habib Dagher, Professor of Civil and Structural Engneering.

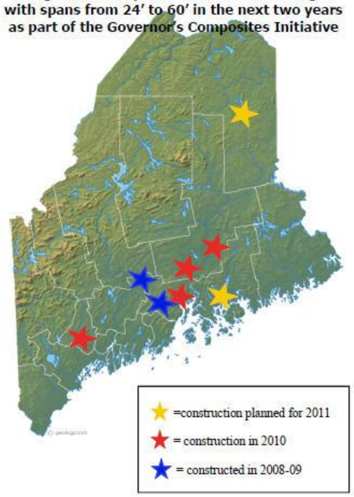
Neal Bridge, Pittsfield, Maine
Arch technology launched Nov 2008 with construction of low maintenance, joint-free, hybrid-composite buried structure

- Bridge superstructure built in less than 2 weeks
- Composites utilized for all major components in superstructure
- Structure expected to provide 100+ years of service with very little maintenance
- Natural stream bed maintained, no disruption to hydraulics
- Composite structure cost-competitive with precast concrete and steel alternatives
- Engineers continue to monitor the bridge

McGee Bridge, Anson, Maine
Second generation arch bridge built Sept 2009; Cost Competitive

- Thinner arch walls
- Lighter weight headwall
- Improved headwall details
- New concrete filling technique
- Improved construction materials
- Superstructure construction reduced
- Fewer arches—increased arch spacing

Advanced Infrastructure Technologies, LLC - a private company commercializing the *Bridge-in-a-Backpack™* - will build 5 bridges with spans from 24' to 60' in the next two years as part of the Governor's Composites Initiative



Bridge-in-a-Backpack™

A hybrid composite-concrete bridge combining the advantages of advanced composite materials and concrete

Cost effective, greener and longer lasting

Auburn Bridge, built in the summer of 2010. This bridge is an example of the successful commercialization of the technology by Advanced Infrastructure Technologies (AIT).

Due to increasing traffic volumes, rapid deterioration, delayed maintenance and/or replacement, and increasing load requirements, U.S. highway infrastructure is decaying at a rate outpacing rehabilitation. Typical bridge design life is 50 years; 40% of all U.S. bridges are more than 40 years old. Repair or replacement of deficient structures is expensive, time and labor intensive, and typically results in lengthy road closures during construction.

Researchers at the University of Maine's AEWC Advanced Structures & Composites Center have developed the *Bridge-in-a-Backpack™*, a lightweight, corrosion resistant system for short to medium span bridge construction using FRP composite arch tubes that act as reinforcement and formwork for cast-in-place concrete. *Bridge-in-a-Backpack™* arches are lightweight, easily transportable and do not require the heavy equipment or large crews needed to handle the weight of traditional construction materials.

These arches capitalize on their inherent properties to transform vertical loads to internal axial forces, the superiority of concrete in sustaining compression loads, and the versatility and strength of composite materials.

Bridge-in-a-Backpack™

A strategy for successful infrastructure upgrade

- **Lightweight.** *Bridge-in-a-Backpack™* tubes are 1/250th the weight of a 70 ft concrete girder.
- **Longer lasting.** No painting, rusting, cracking or spalling. 100+ Year Service Life.
- **Safe.** Extensive laboratory testing demonstrates that Bridge-in-a-Backpack™ exceeds code requirements.
- **Congestion relief.** Lighter, modular bridges allow for "Accelerated Bridge Construction" which reduces traffic congestion during construction and mitigates the effect of lengthy construction schedules on economic vitality.

Bridge-in-a-Backpack™ Carbon Footprint Analysis

- *Bridge-in-a-Backpack™* superstructure has 50% of the carbon footprint of a typical concrete bridge.
- The total carbon footprint of the *Bridge-in-a-Backpack™* is 45.71 kg (CO_2e/year)/sq m. This is one third less than the carbon footprint of a comparable concrete bridge and one fourth less than that of a steel bridge.
- A recent report by the Federal Highway Administration concluded that 25.4% (152,316) of all bridges are either structurally deficient, in need of repair, or functionally obsolete. If *Bridge-in-a-Backpack™* replaced just 20% of these bridges, the equivalent amount of CO_2 emissions reduction would equal taking 230,000 cars off the road.

1865 THE UNIVERSITY OF MAINE

1/12/10

CONTACT:
Brit E. Svoboda, President and CEO
Advanced Infrastructure Technologies
207-866-6526
Brit@aitbridges.com

ADVANCED INFRASTRUCTURE TECHNOLOGIES

1865 THE UNIVERSITY OF MAINE

CONTACT:
H. J. Dagher, Director
AEWC Advanced Structures & Composites Center
207 - 581 - 2138
hd@umit.maine.edu

AEWC Advanced Structures & Composites Center