Bridge-in-a-Backpack™
A hybrid composite-concrete bridge combining the advantages of advanced composite materials and concrete

Cost effective, greener and longer lasting

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™ 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 (CO₂e/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 CO₂ emissions reduction would equal taking 230,000 cars off the road.
**Arch manufacturing**
Inflatable composite tubes act as a stay-in-place form, structural reinforcement, and environmental protection for concrete fill.

**Arch installation**
**Arch placement:** All 23 arches for the Neal Bridge were placed in a single day. They were lowered into place with a boom truck and placed by hand labor with no heavy equipment. The base of the arches was encased in a concrete footing.

**Decking:** The arches were covered with corrosion resistant FRP corrugated decking using screws which became concrete anchors once the arches were filled. Decking also assists soil retention.

**Concrete fill:** Self-consolidating expansive concrete (26 cy total) was pumped into the top of each arch; aggregate fill time = 1 hr. Concrete was placed on decking forming a lateral force-resisting diaphragm.

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**Abrasion testing**
Testing was performed to quantify the relative effectiveness of various forms of abrasion resistance. It was found that the use of a low-cost abrasion layer provides nearly 30 times more abrasion resistance than unreinforced materials.

**Structural testing and modeling predicts strength, deflections, failure mode and location, and post-peak**

In order to effectively carry out structural design using the arch members, AEWC researchers have developed an analysis technique which has been validated through structural testing of arch specimens. The specimens were subjected to static testing to failure and their load-deflection response and ultimate strengths were studied. Excellent correlation has been seen between experimental and predicted results, providing a high level of confidence in the modeling technique.

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**Fatigue testing verifies long-term capacity**

| Capacity of Static & Fatigue Specimens |  
|---------------------------------------|----------------------------------------------------|
| **Average Failure Load (kip)**       |                                                   |
| Initial Static Tests                 | **71.1**                                           |
| After 2,000,000 Fatigue Cycles       | **68.9**                                           |
| Percent Difference                    | **3.0 %**                                          |

- 50+ years of truck traffic applied in 3 weeks
- Specimens subjected to 2,000,000 fatigue cycles