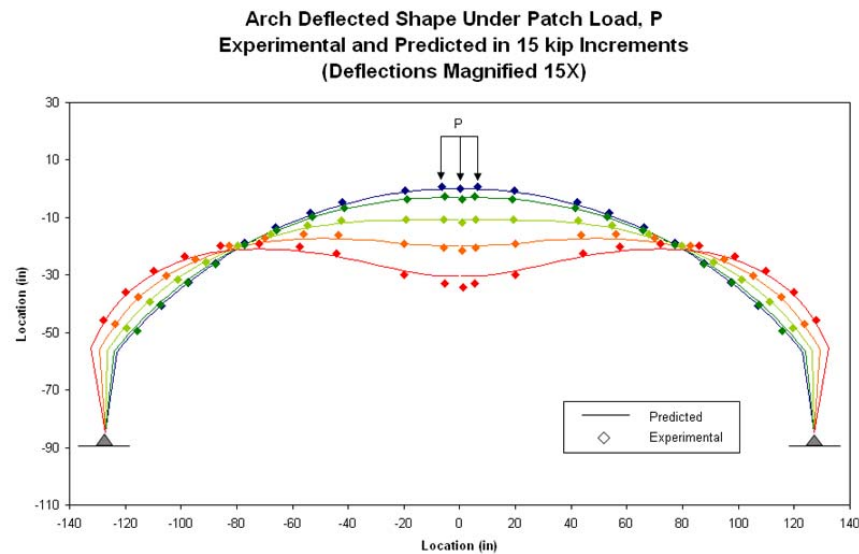


STRUCTURAL TESTING AND MODELING

In order to effectively carry out structural design using the arch members, AEWCC 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.



Fatigue Testing Verifies Long-Term Capacity



Capacity of Static & Fatigue Specimens

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

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

Progress to date

- Manufacture of 6" and 12" diameter 16, 40 and 60 ft arches of various wall thicknesses and geometries
- Tested load carrying capacity to 75,000 lbs over a 35' span
- Timeframe of less than two weeks to assemble and cast the support system for a bridge: infusion time, 20 minutes; specimen cure, 6 hours; concrete filling, 5 minutes; concrete cure, 10 days
- U.S. Patent application 20060174549 filed 8/10/06
- Construction of a short-span bridge by Maine Dept. of Transportation using arch technology completed Nov 2008.



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BRIDGE IN A BACKPACK

An innovative bridge technology using rigidified inflatable composite arches

- Simplifies construction
- Reduces life-cycle costs
- Increases the design life of bridges
- Decreases carbon footprint of bridge construction

Background

Highway bridges in the US are quickly becoming deficient due to increasing traffic volumes, rapid deterioration, extended service life, and increasing load requirements. 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 AEWCC Advanced Structures & Composites Center have developed 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. They are lightweight, easily transportable, rapidly deployable and require no 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



60' arch manufactured in AEWCC laboratories is light enough for two people to carry and place

Benefits over current state-of-the-art methods

- Acts as sole required reinforcement - no steel rebar needed
- Rapidly erectable, stay-in-place form
- Durability - Composite shell protects concrete from the environment, reducing maintenance costs and increasing the life-span of the structure.
- Simplicity of construction - formwork is simple to place, process is not complex, mitigates need for heavy equipment, cranes and large crews
- Cost competitive with alternative system
- Transportation efficiencies - compact, light-weight bridge kits can transported to the site with a single truck



Underside of Neal Bridge, first field application of Bridge in a Backpack

For more information about the AEWCC Advanced Structures & Composites Center's 48,000 ft² facilities, 10 integrated ISO 17025 accredited laboratories, expertise and product development, go to:
www.aewc.umaine.edu



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Reconstruction of the Neal Bridge in Pittsfield, Maine

The arch system was demonstrated in the replacement of the 90+ year old Neal Bridge, located on Rt. 100 in Pittsfield, ME. Twenty-three arch members were used in construction of the 34' span, 44' wide structure. The arches were installed in a single working day, covered with FRP decking, and filled with concrete. Next, headwalls and wingwalls were placSeed, and the bridge was backfilled, paved and opened to traffic .

Fabrication of Arches. 23 arches fabricated for bridge reconstruction. This process can easily be done at the construction site; in this first construction, arches were fabricated in the laboratory at UMaine.



Composite materials selected for geometry, cost, storage tolerance, and resin compatibility.

Reinforcement is placed over air bladder

The bladder is then inflated and the part is placed on a form of the desired geometry and infused with resin. Forming and infusion can be performed in a shop or in the field. The form developed in the AEWC lab is telescoping, adjustable and transportable.

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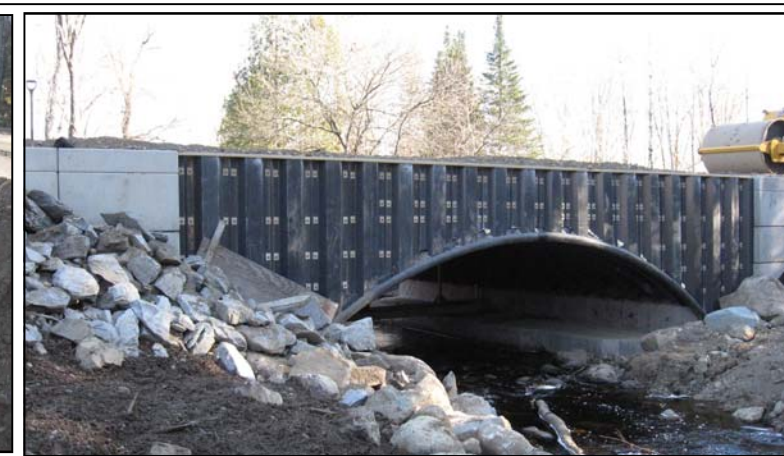
Neal Bridge before rehabilitation

Arch Installation. All 23 arches (34' span, 12" diameter, 0.10" wall thickness) were placed in a single day. They were lowered into place with a simple boom and placed by hand labor with no heavy equipment and no formwork. The base of the arches are encased in a shallow concrete footing.



Decking. The arches are covered with corrosion resistant FRP corrugated decking using attached screws which become concrete anchors once the arches are filled. Decking also assists soil retention.

Concrete Fill. Self-consolidating expansive concrete (26 cy total) was poured through individual holes in the top of each arch; fill time = 1 hr. Concrete was also spread on decking which with the concrete anchors form lateral force-resisting diaphragm.



Bridge Completion. The day after the concrete pour spandule headwalls and precast concrete wingwalls were installed. Granular sand backfill was placed over the concrete and compacted on top of the arch structure. The bridge was backfilled; and road surface paved.

Bridge Monitoring. Sensors were installed for continuing monitoring of the bridge. The monitoring program includes load testing with weighted vehicles, and the installation of instrumentation to measure arch strains and deflections. Load tests will document the change in the response of the structure over time (stiffness loss, deflections, cracking, etc.)

The development of this technology has been supported by the Natick U.S. Army Soldier RD&E Center, Maine DOT and the Federal Highway Administration. The goal is to construct as many as six bridges in Maine during 2009 and eventually design and kit bridges in Maine and ship them to installation sites across the country.

