Composite Arch Bridge System
Reference FHWA Manual on ABC Construction:

**Accelerated Bridge Construction (ABC):** ABC is bridge construction that uses innovative planning, design, materials, and construction methods in a safe and cost-effective manner to reduce the onsite construction time that occurs when building new bridges or replacing and rehabilitating existing bridges.

ABC improves:
- Site Constructability
- Total project delivery time
- Material quality and product durability
- Work-zone safety for the traveling public and contractor personnel

ABC reduces:
- Traffic Impacts
- Onsite construction time
- Weather-related time delays

ABC can minimize:
- Environmental impacts
- Impacts to existing roadway alignment
- Utility relocations and right-of-way take

Common and viable reasons to use ABC deal with site constructability issues. Oftentimes long detours, costly use of a temporary structures, remote site locations, and limited construction periods present opportunities where the use of ABC methods can provide more practical and economical solutions than conventional construction methods.
A system for bridge construction that combines high-performance FRP materials and traditional concrete to create an efficient and economical three sided buried bridge.
Introduction to composites

- Advantages of FRP Composite Materials
  - Customized shapes
  - Customized mechanical properties
  - High strength-to-weight ratio
  - Corrosion resistance
  - High fatigue life
  - High stiffness-to-weight ratio
  - Wear resistance
  - Little or no maintenance
Introduction to composites

- Advanced Composite Materials - high strength fibers held together by a polymer matrix binder
- Ordered in layers called *lamina*
- Mechanical properties engineered into the composite based on fibers and matrix
Composite Arch Bridge System Arches

- uses glass and carbon fibers in a braided fabric oriented in the hoop and longitudinal directions
- uses an infusion grade vinyl ester resin which provides long term durability
Composite Arch Production Process

1. **Tubes assembled/packaged**
2. **Inflate tubes**
3. **Bend around arch form**
4. **Infuse with resin**

Within hours, arches can be removed from form for installation

Manufacturing of a 15” diameter 48’ span composite arch
1. Stay-in-place form for concrete

Eliminates need for temporary formwork

Temporary Formwork for Arches
Concrete Engineers Handbook,
McGraw-Hill, 1918
2. Structural reinforcement for concrete

Eliminates need for steel reinforcement  
Enhances concrete performance
3. Environmental protection for concrete

Reduces bridge maintenance costs

Concrete Corrosion Cycle

Steel rusts and expands causing concrete spalling

Spalling concrete exposes more reinforcement

Three Functions of the FRP Arch Tube
Arch Delivery and Unloading

For an international project all arches, decking, and headwalls arrived in a 40’ ISO container.

Components were lightweight enough to be unloaded with hand labor.

- arches arrive on site ready for installation
- Can be unloaded quickly with hand labor
- Minimizes trucking
- No heavy equipment
• A pultruded composite decking is used to distribute soil loads to the arches

• Decking is attached to arches with stainless screws
Arch Concrete Filling

- Filled with Self Consolidating Concrete (SCC)
- Simple procedure, no rodding/vibration required

Pumping concrete into arches

Funnel boxes direct flow, prevent overflow
Arch Headwall Options

Multiple options to meet the Engineering, Economic, and Aesthetic requirements of the site

- FRP Panel, Precast Concrete, or Cast in Place Concrete
- GRS, MSE, Gravity, Through-tied
Summary & Opportunities

**Where?**

*Versatile system can be applied to a wide range of bridge geometries/site conditions*

- Single-radius arches with rise/span from 15%-50%
- Variable radius arches in standard sizes up to 48’ span
- Skewed bridges reduce right of way requirements
- Single-span and multi-span structures
Design of Concrete-Filled FRP Tubular Arches

- **AASHTO LRFD Guide Specifications for Design of Concrete-Filled FRP Tubes for Flexural and Axial Members**
- Closed-form, simplified method for design of Concrete-Filled FRP Tubes (CFFT’s)
- Generic in nature – applies to all CFFT’s
- Final AASHTO approval Fall of 2012
Composite Arch Bridge System is faster than precast concrete

Example of 50’ span X 50’ width bridge

<table>
<thead>
<tr>
<th></th>
<th>CABS</th>
<th>Precast Concrete</th>
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<tbody>
<tr>
<td>Fabricate and Deliver</td>
<td>24 wd</td>
<td>39 wd</td>
</tr>
<tr>
<td>Installation</td>
<td>5 wd</td>
<td>4 wd</td>
</tr>
<tr>
<td>Total</td>
<td>29 wd</td>
<td>43 wd</td>
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</table>

SAVING 14 WORKING DAYS
**Actual contractor bid prices show major upfront savings**

<table>
<thead>
<tr>
<th>Owner / Location</th>
<th>Developer -- CA</th>
<th>Developer -- CA</th>
<th>County road -- MI</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>AIT Arch</td>
<td>PRECAST</td>
<td>AIT Arch</td>
</tr>
<tr>
<td>Span</td>
<td>50 ft.</td>
<td>50 ft.</td>
<td>53 ft.</td>
</tr>
<tr>
<td>Width</td>
<td>55 ft.</td>
<td>55 ft.</td>
<td>65 ft.</td>
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<tr>
<td>Bridge (Incl. Delivery)</td>
<td>$ 280,000</td>
<td>$ 270,000</td>
<td>$ 338,000</td>
</tr>
<tr>
<td>+ Foundations</td>
<td>$ 12,000</td>
<td>$ 32,000</td>
<td>$ 12,000</td>
</tr>
<tr>
<td>+ Walls</td>
<td>$ 49,000</td>
<td>$ 65,000</td>
<td>$ 40,000</td>
</tr>
<tr>
<td>+ Installation</td>
<td>$ 22,000</td>
<td>$ 64,000</td>
<td>$ 22,000</td>
</tr>
<tr>
<td>+ BackFill</td>
<td>$ 7,000</td>
<td>$ 2,000</td>
<td>$ 7,000</td>
</tr>
</tbody>
</table>

| Total Installed Cost | $ 370,000 | $ 433,000 | $ 419,000 | $ 559,000 | $ 276,000 | $ 315,000 |

**AIT Upfront Savings**

- $ 63,000
- $ 140,000
- $ 39,000

**** Savings areas: Foundation size, specialty equip & labor, wall cost, delivery (on smaller diameter)
Summary & Opportunities

- **Composite Arch Bridge System**
  - Innovative system for short- to medium-span bridge construction
  - *Fast and simple to construct*
  - *Minimal transportation and equipment needs*
  - *Durable - long life and minimal maintenance*
  - *Enhanced material performance makes for safe, efficient, economical structure*
Summary & Opportunities

- *Can use existing substructures or leave in place and span over*
- *Weighs less than precast - Uses less concrete*
- *Can be constructed out of the water - ease of permitting*
- *Minimal utility adjustments - no overhead work*
- *Fast assembly - Fast fabricate and deliver*
National Recognition for the Composite Arch Bridge System

2011 Charles Pankow Award for Innovation

2011 Engineering Excellence Grand Award

2010 Award for Composites Excellence Most Creative Application

Also recently featured in: ENR, Concrete International, Popular Science, Popular Mechanics, NY Times...
Thank you

Questions?

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