"Bridge-in-a-Backpack" Inflatable Composite-Concrete Bridges

MaineDOT

AEWC Advanced Structures & Composites Center

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Outline

- UMaine Composites Center
- Governor’s Composites Initiative
- Bridge-in-a-Backpack
  - Why and how
  - 8 Years of R&D
  - 2 demonstration projects
- Benefits and next steps
- Video

UMaine Advanced Structures & Composites Center

Composites Industry

Construction Industry

- 70,000 ft^2 ISO 17025 Accredited Lab
- 140 personnel
- Analysis & Design + Prototyping+ Testing + Code Reports

UMaine Composites Center

- 200+ Clients Globally
- Prototyping/testing up to 230 ft spans
- Nanocomposites
- Global Impact
  - 3 ACMA ACE awards in last 2 years
  - 2009 Champion for Economic Development Award
  - Over 400 publications in last 10 years

Maine’s Composites Initiative

- Governor John Baldacci
- Up to 10% composites for bridges

Composite Bridge Drains

Maine DOT Collaboration

- Hillman Composite Beam
  - Static and fatigue testing
  - 500 ft bridge under contract

- Composite Culvert Lining
  - Composite liner repairs degraded metal culverts

Penobscot Narrows Bridge

- Maine DOT, FHWA, Figg Engineering Group, UMaine
- Steel strands replaced with carbon composite strands
- Long term performance monitoring

“Bridge in a Backpack”

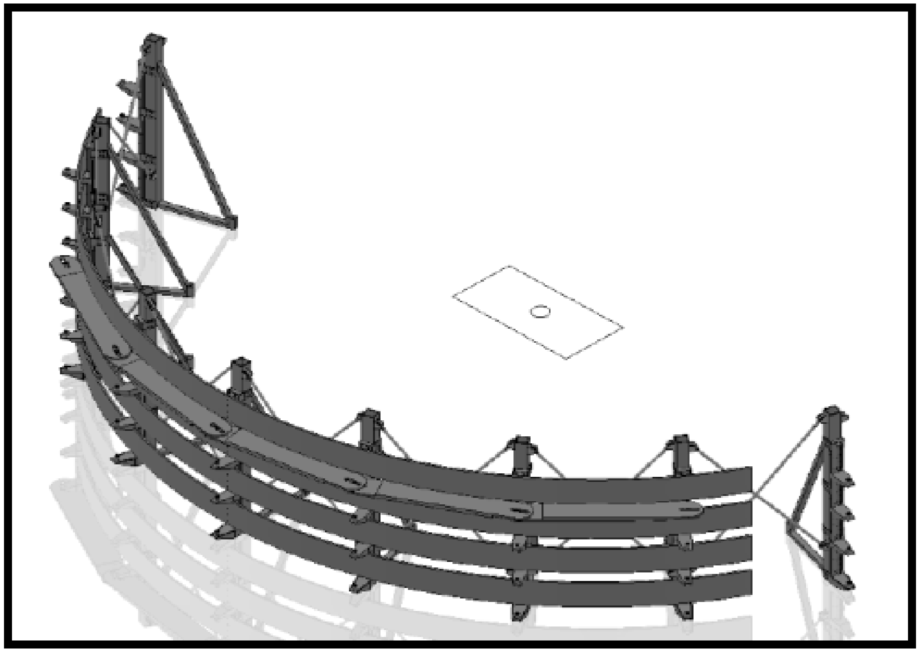
- Developed by UMaine over an 8 year period
- *Advanced Infrastructure Technologies, LLC*

Arch Placement

Decking Installation

Completed Bridge

On-Site Production:
Reduce shipping and handling logistics



- Geometries completely customizable for site requirements
- Spans made up to 90’, tube thickness up to ½”

A Faster, More Efficient Cast-in-Place Concrete Bridge

- Inflatable FRP tubes, made on site
- Tube weighs 200 lb for 70' span versus 50,000 lbs for Prestressed concrete girder
- Hand labor or light equipment

Arch Installation at UMaine

6 Arches Installed by 3 Laborers in 10 Minutes

Three Functions of FRP Tube:

1. Stay-in-place form for concrete

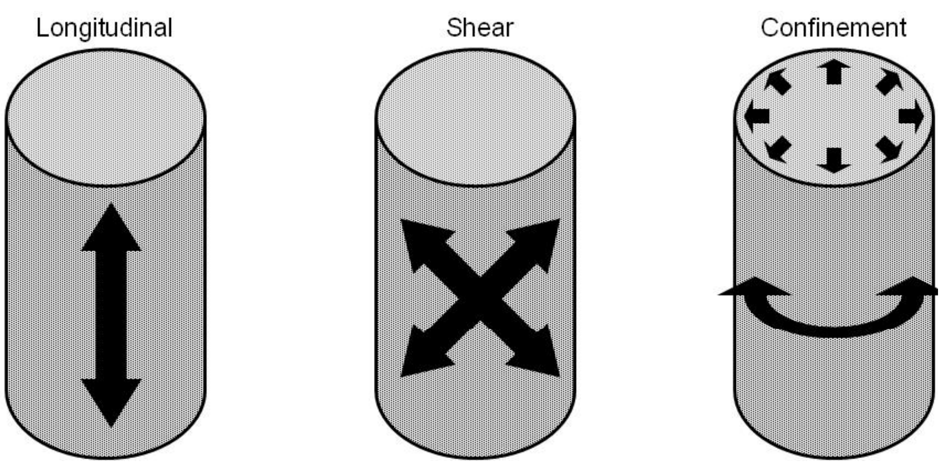
Filling Arches Using a Small Concrete Pump


Concrete Filling of Stay-In-Place FRP Arch Forms

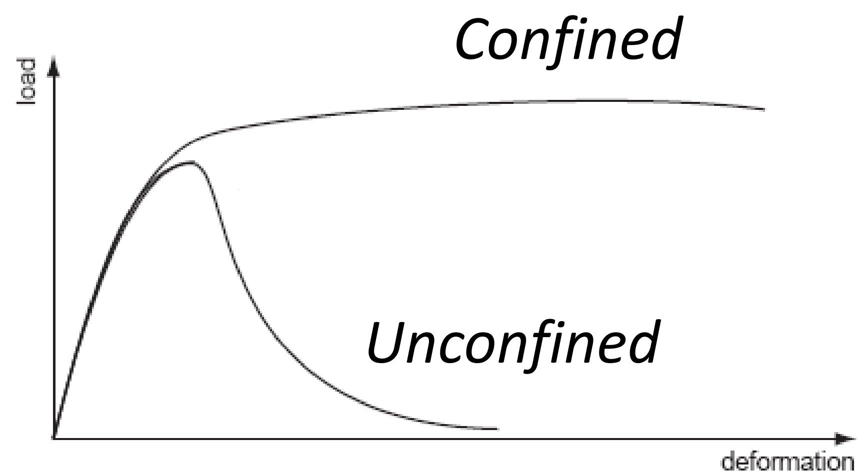
Eliminates need for temporary formwork

Three Functions of FRP Tube:

2. Structural reinforcement for concrete



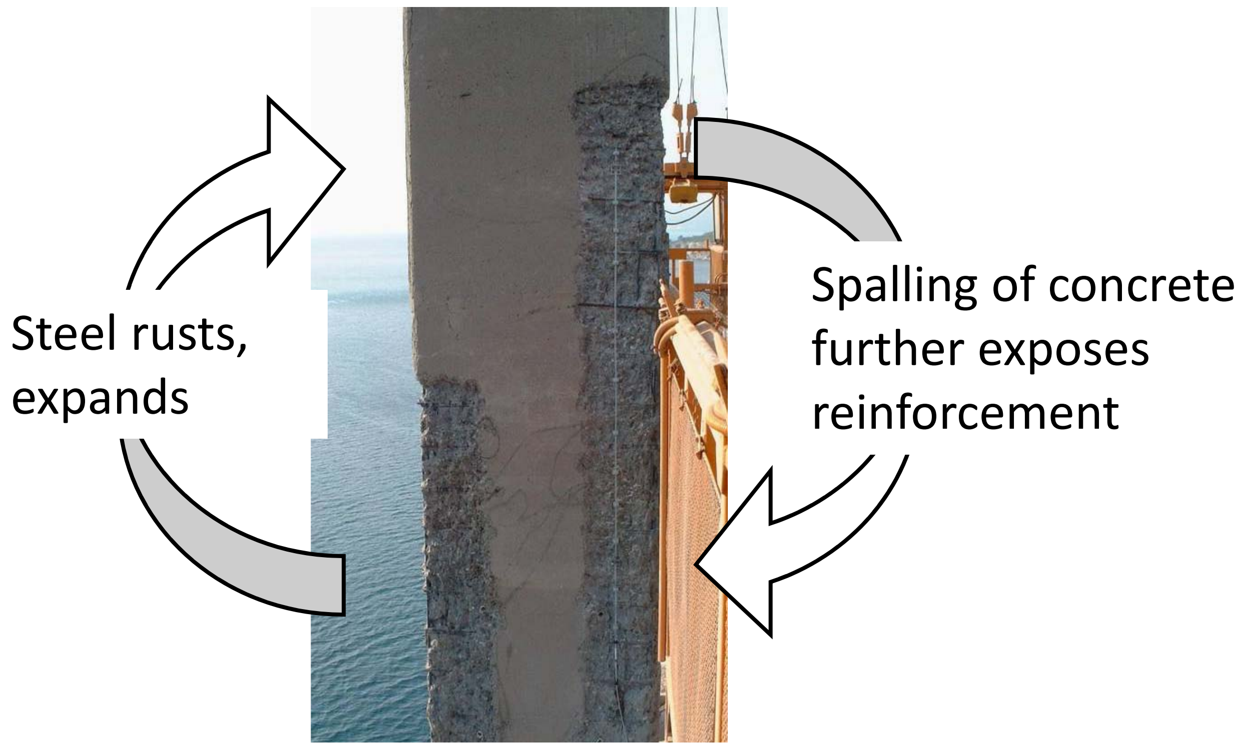
Three Components of FRP Reinforcement



Stress-Strain Relationship for Concrete

Eliminates rebars

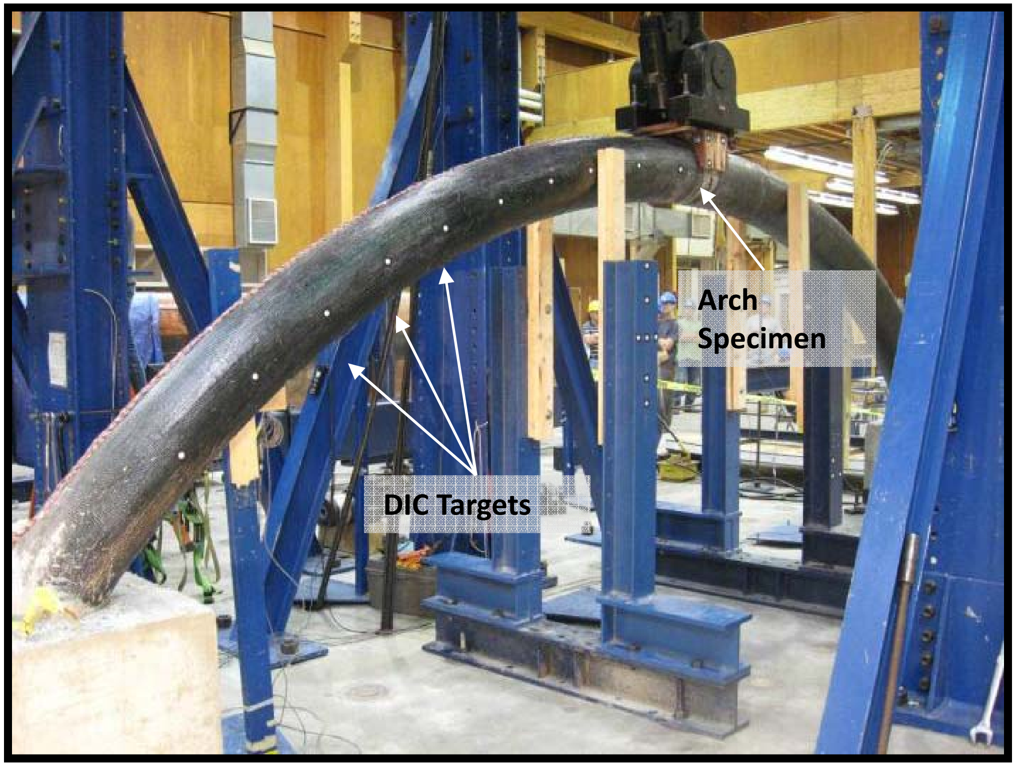
Three Functions of FRP Tube:
3. Protection for concrete



Concrete Corrosion Cycle

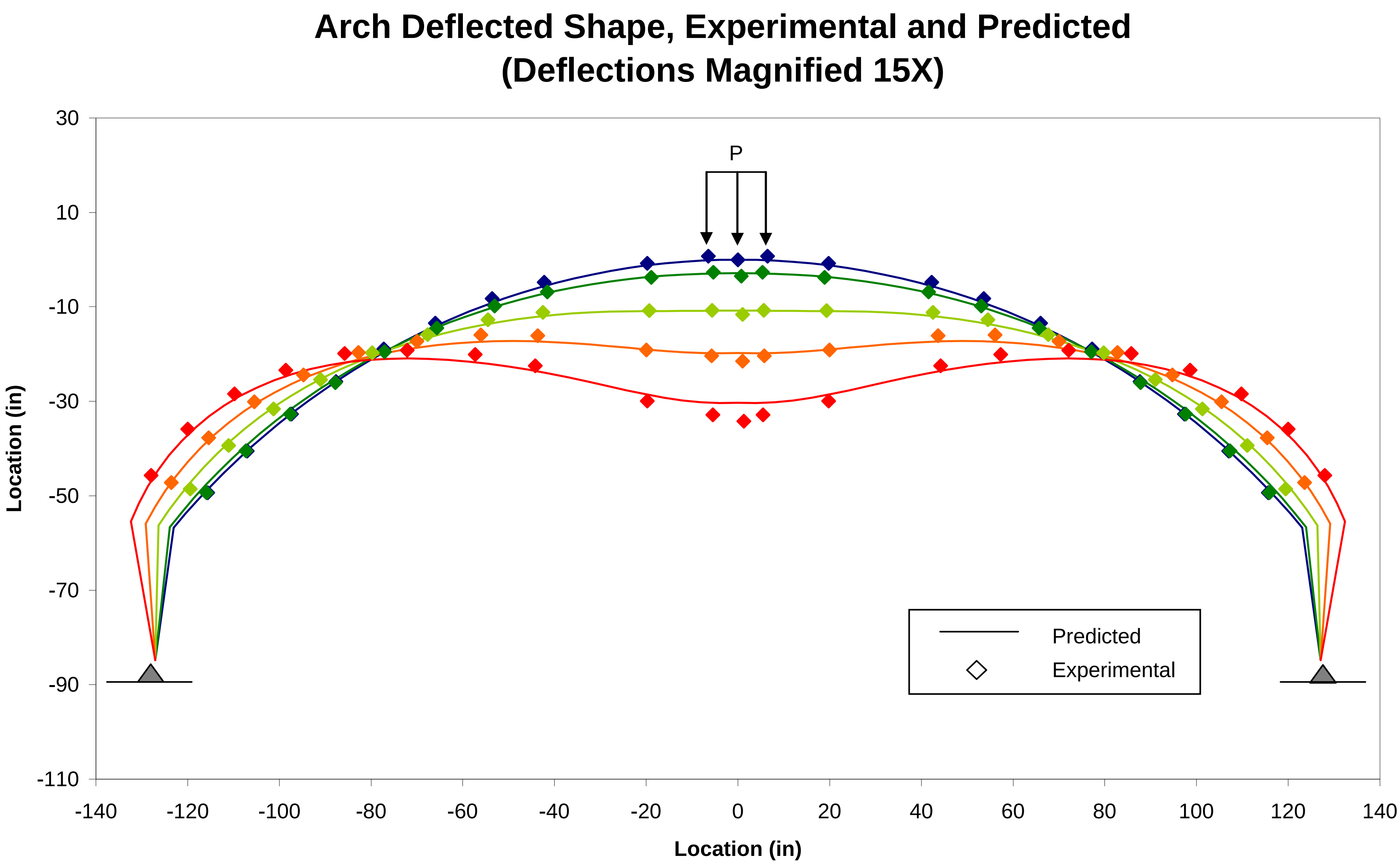
Protects against corrosion, prolongs life, reduces maintenance

8 Years of Design & Testing at UMaine



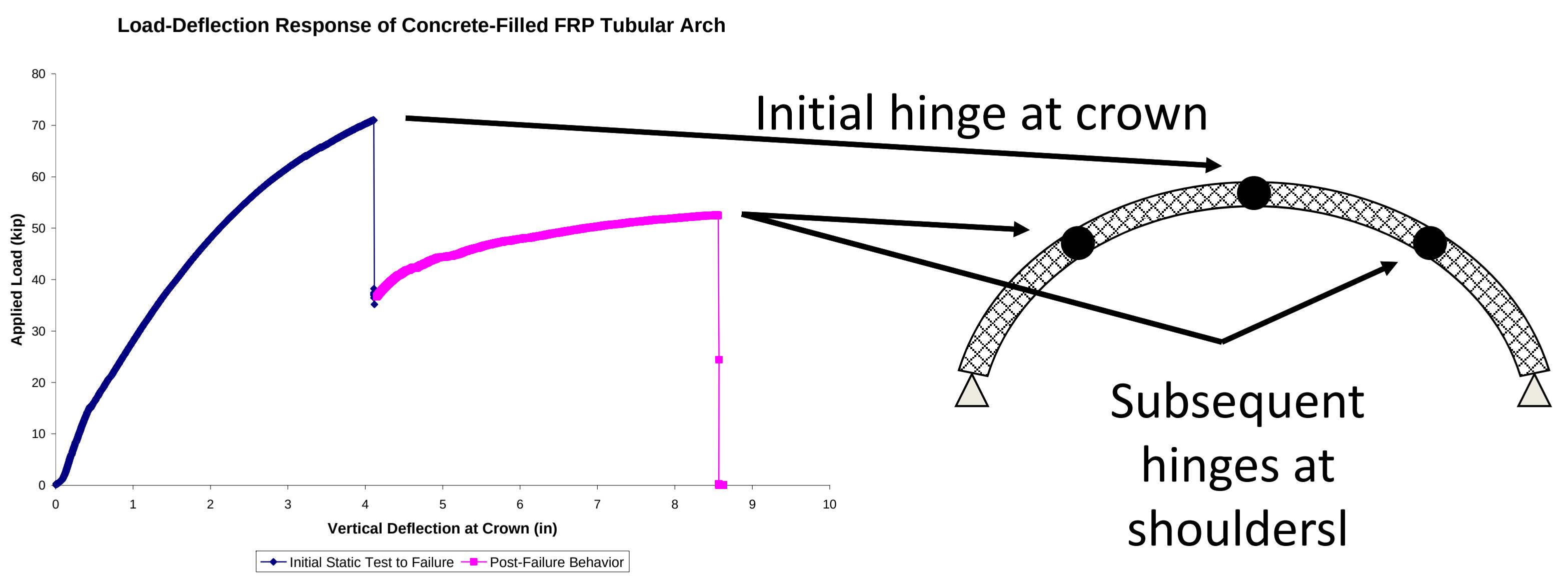
Static & fatigue testing
of over 40 specimens

Experimental and Predicted Response



Experimental and Predicted Response

		Load (kip)	COV	specimens	Difference
Initial	Experimental	72.0	2.55%	3	4.14%
	Predicted	69.0	--------	--------	
Secondary	Experimental	57.6	7.75%	3	1.10%
	Predicted	57.0	--------	--------	

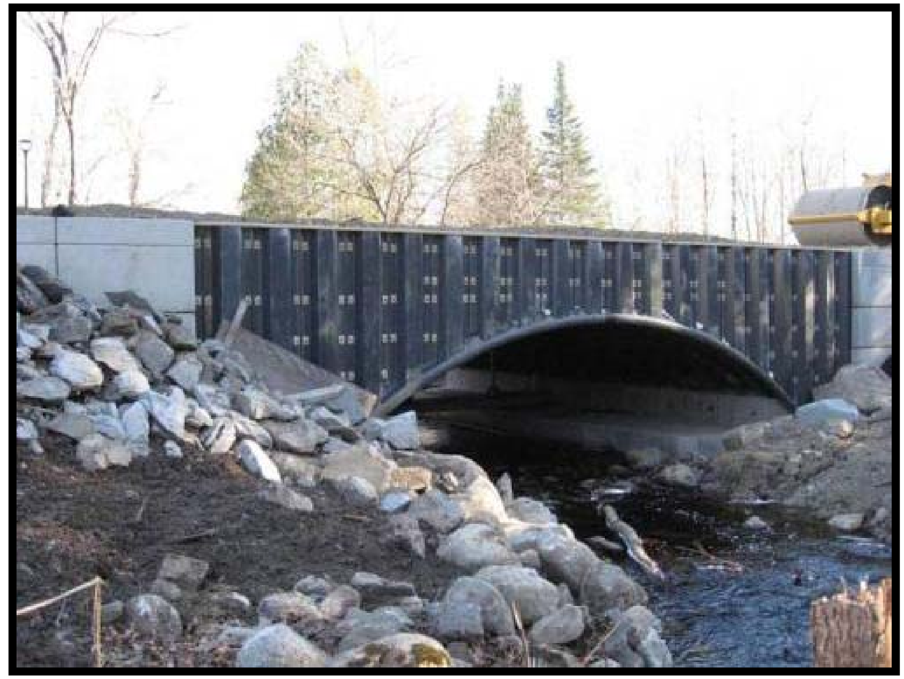


Neal Bridge Replacement – Fall 2008

- First Bridge-in-a-Backpack, 34’ span, 44’ wide
- 23 arches installed in one day
- Arches filled with concrete (1 hour)
- FRP decking

Neal Bridge Replacement – Fall 2008

FRP Headwall



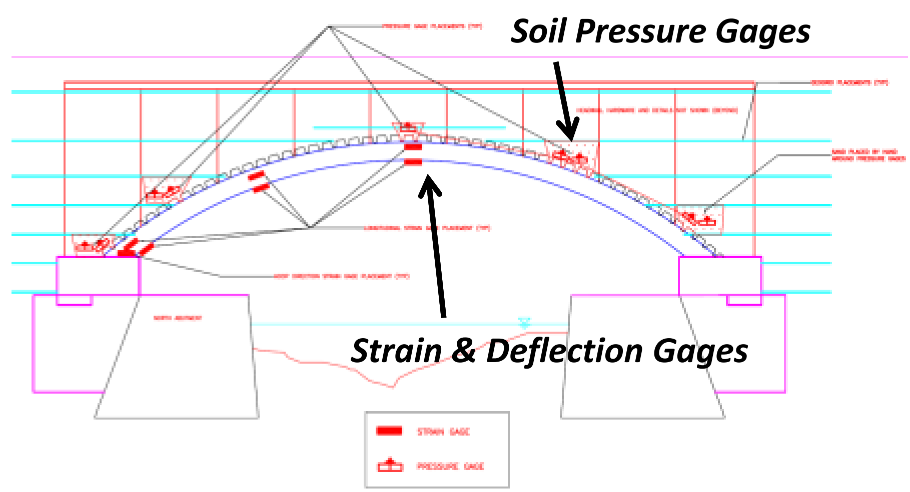
Backfill, Pave, Rail

Sensors monitor performance during backfill and service

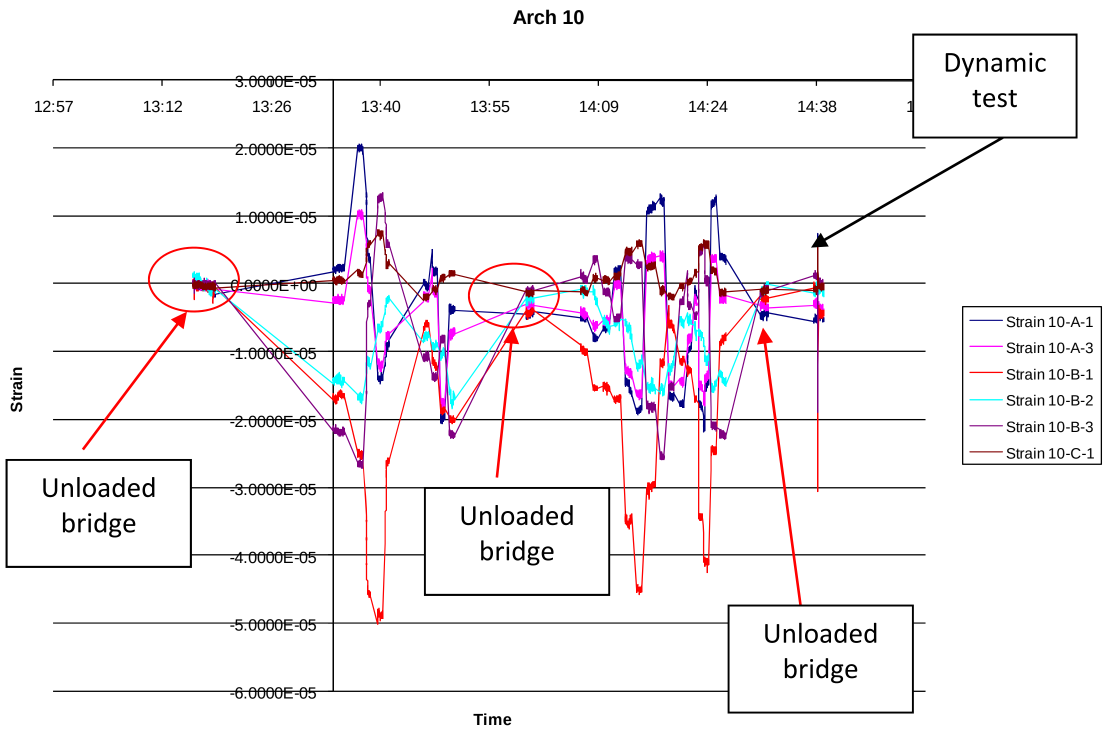
Low maintenance, joint-free, buried structure

Neal Bridge Field Load Testing

- Performed April 2009
- 2 fully loaded tandem axle dump trucks (66 kip total weight)
- Loading configurations in parallel and series, quasi-static and dynamic
- Instrumentation:
  - Arches – strain and deflection
  - Soil – vertical and radial soil pressure



Neal Bridge Field Load Testing



- Field measurements indicate structure significantly exceeds AASHTO requirements
- Analytical live load rating of 1.96 X AASHTO HL-93

McGee Bridge Replacement

- ***Composite low bid against Steel, Concrete, and Wood***
- August 2009: installation in North Anson, ME

Bid #	Bridge Type	% Over Low Bid
1	***Bridge-in-a-Backpack***	---
2	Steel on concrete	6.8%
3	Steel on concrete	18.4%
4	Steel on concrete	23.4%
5	Concrete	23.5%
6	Timber on concrete	30.0%

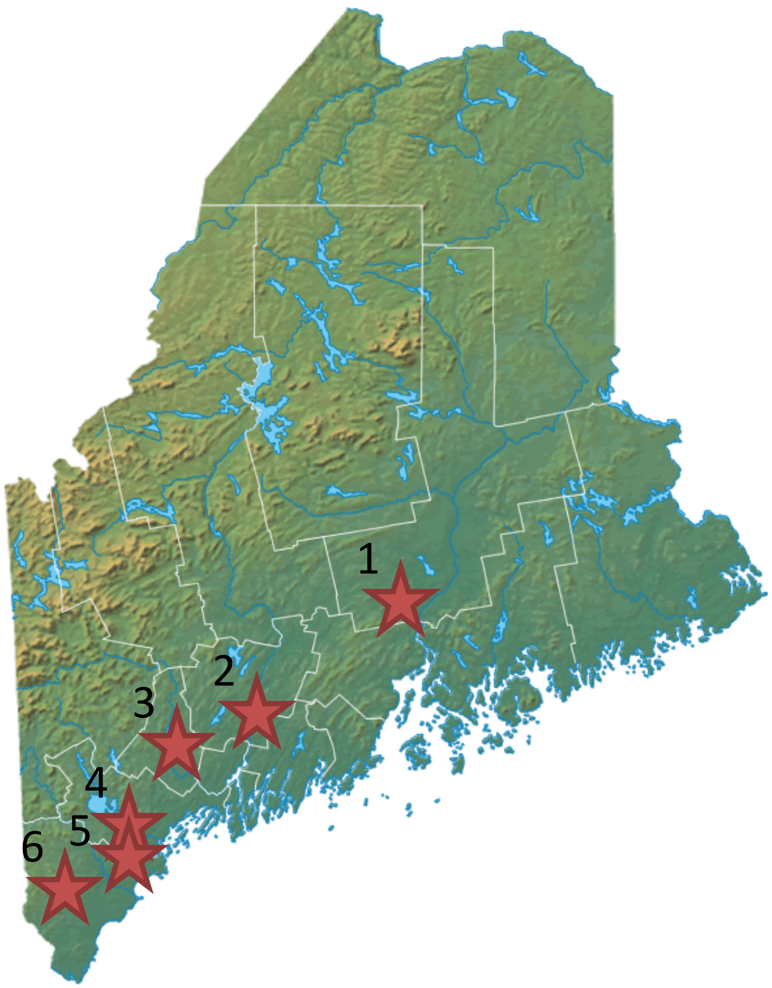
McGee Bridge Replacement: 12 Days

<u>CONSTRUCTION SEQUENCE</u>

1. *Demo. existing steel bridge*
2. *Drill bedrock, form footings*
3. *Arch installation (3 hrs)*
4. *Pour concrete footings*
5. *Install composite decking*
6. *Fill arches with concrete (1 hr)*
7. *Install composite headwalls*
8. *Backfill bridge*
9. *Grading, guardrails, cleanup*

Where we’re going…

2010-2011 Governor's Composite Bridge Construction



- 5 more Maine bridges in 2 years
- Spans from 24' – 72'
- Currently in design phase

Continuing R&D Plan

Expand Geometric Capabilities

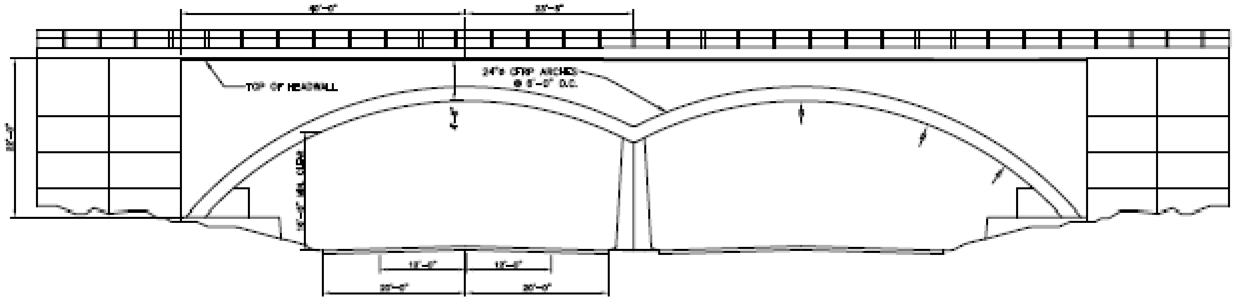
- Spans up to 90 ft
- Diameters up to 26”
- Rigid frame and girder designs

Expand Manufacturing Capabilities

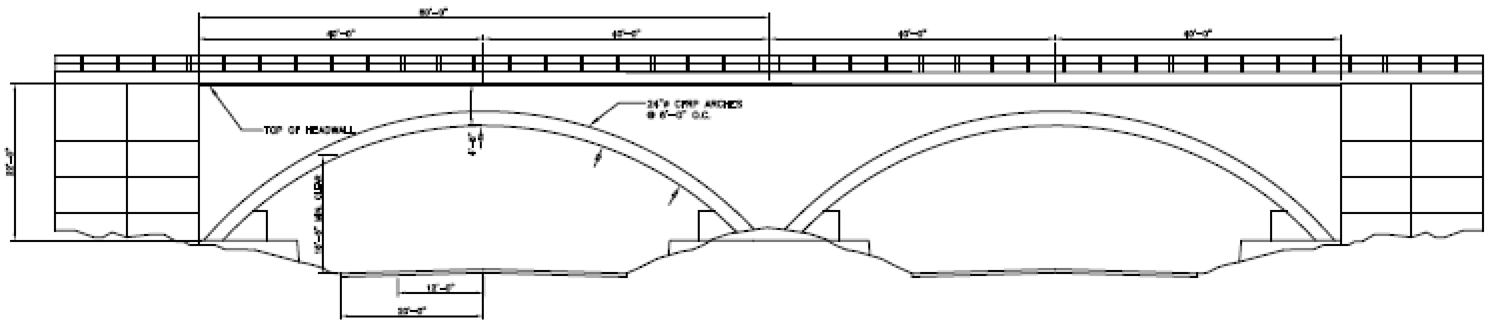
- Onsite manufacturing
- Versatile resin package
- Large scale production

Bridge-in-a-Backpack Capabilities: Interstate Overpass

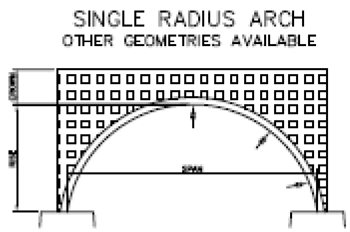
INTERSTATE OVERPASS
NORTH AND SOUTH DIRECTIONS
MINIMAL MEDIAN



INTERSTATE OVERPASS
NORTH AND SOUTH DIRECTIONS
40' MEDIAN

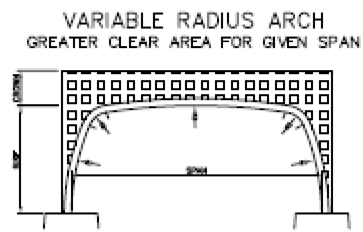


Bridge-in-a-Backpack Capabilities: Stream Crossings/Railway Crossings

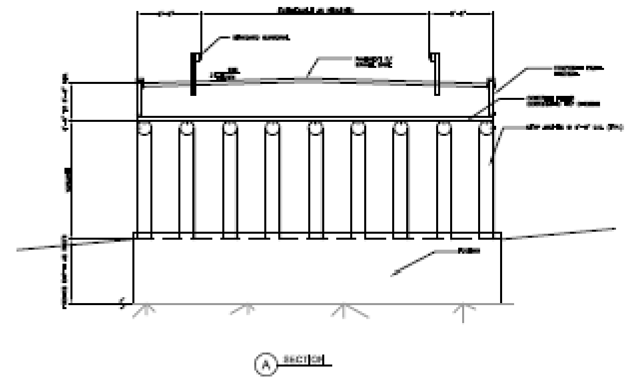


SPAN	RISE	CROWN
30'	7'–15'	3'8"+
45'	10'–24'	4'4"+
60'	14'–30'	4'10"+
70'	15'–35'	4'10"+
MAX SKEW APPROX. 30 DEG.		
NO MAX OR MIN WIDTH		
ANY ROAD SLOPE/VERT. CURVE		

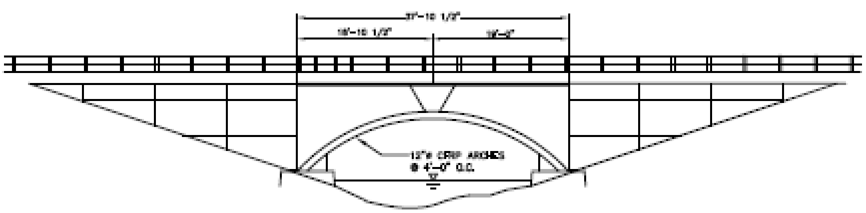
NOTE: TUBE DIAMETER MAY VARY THROUGHOUT LENGTH OF ARCH



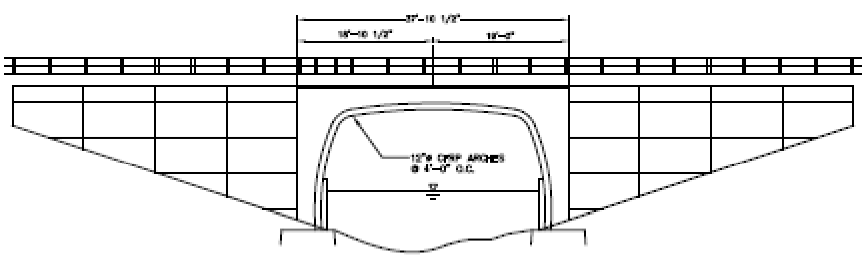
NOTE: ALL RADII INFINITELY VARIABLE FOR ARBITRARY ARCH GEOMETRY



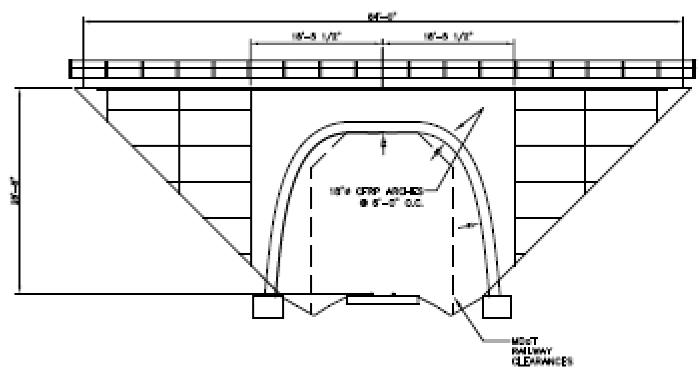
SHALLOW STREAM CROSSING



DEEP STREAM CROSSING



SINGLE TRACK RAILWAY CROSSING



Summary and next steps

- Composites can compete on first-cost basis!
- 50% reduction in carbon footprint
- Public interest finding from FHWA for Maine
- TIG Application
- 20% of US bridges candidates
- 15 projects in multiple states, International projects
- Expand geometries and spans (800 ft bridge)
- Recent value bidding by contractors
- Beyond bridges

Thank you!

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