
New Technologies in Bridges

The Hybrid Composite Beam

NIST – Advancing Infrastructure Delivery

May 19, 2010

Purpose and Need

- Infrastructure decaying at a rate outpacing rehabilitation.
- “40 Percent of all bridges are more than 40 years old. When these bridges were constructed, design life was often 50 years.”
- “Congestion Relief” is necessary to promote economic growth
- Safety of traveling public at risk

Inspiration for Optimization

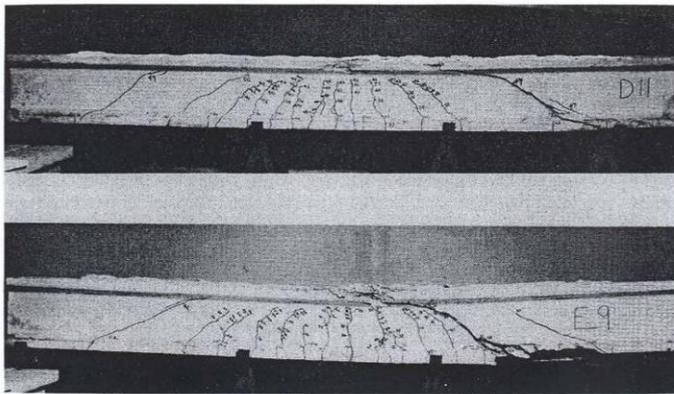
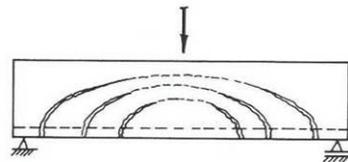
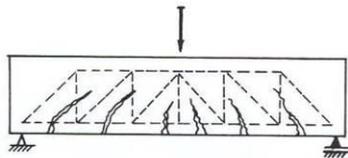


Figure 6.7 Typical shear failure in prestressed beams without web reinforcement. (Courtesy Prestressed Concrete Institute.)



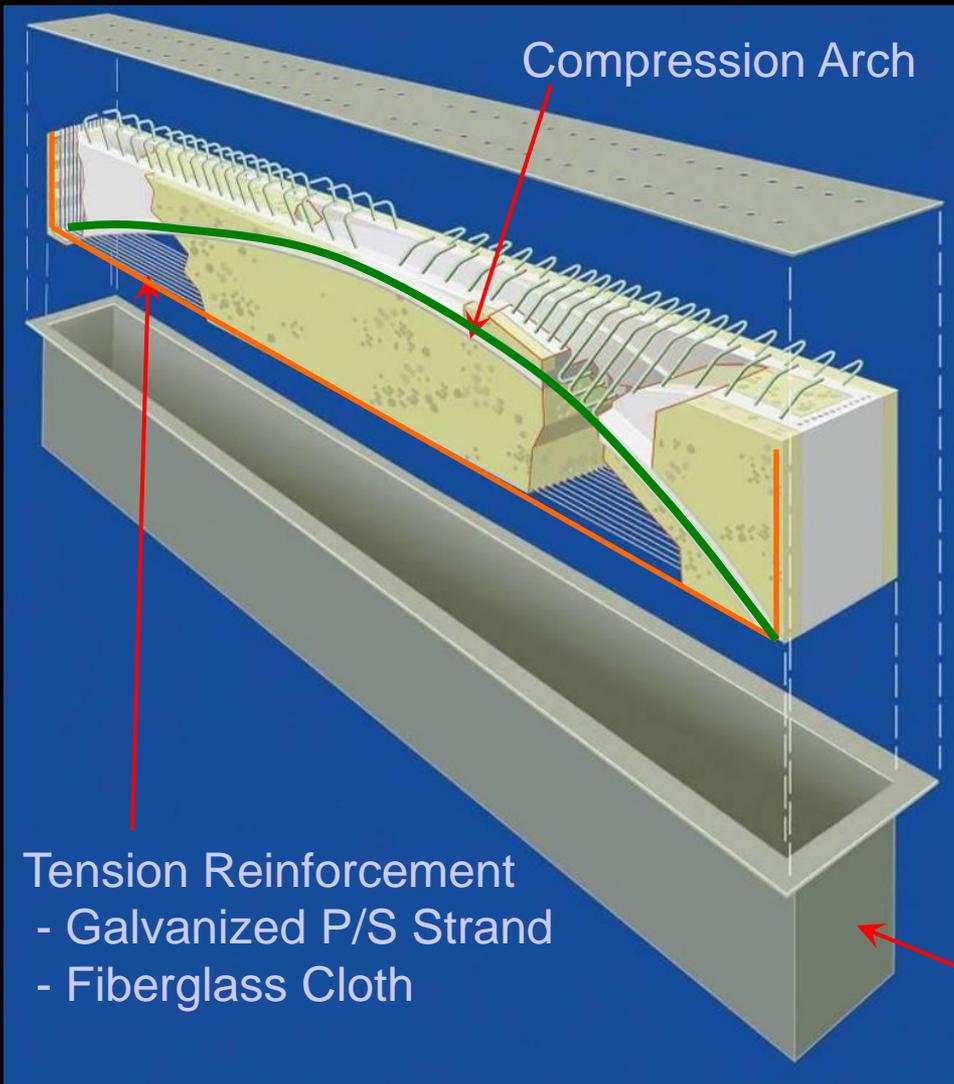
(a) Arch analogy



(b) Truss analogy

Figure 6.8 Typical analogies for shear failure mechanisms.

What is the HCB?



- A structural member using several different building materials resulting in a cost effective composite beam designed to be stronger, lighter, and more corrosion resistant
- Compression Arch
 - SCC Concrete
- Tension Reinforcement
 - Galvanized P/S Strand
 - Fiberglass Cloth
- FRP Shell

Fiberglass Box (FRP Shell)

- Quad weave fabric with fibers that are horizontal (0°), vertical (90°) and ($\pm 45^\circ$)
- infused in an epoxy vinyl ester resin matrix



Tension Reinforcing

- Tension reinforcing consisting of 270 ksi galvanized prestressing strand along bottom of beam



SCC - Compression Reinforcing

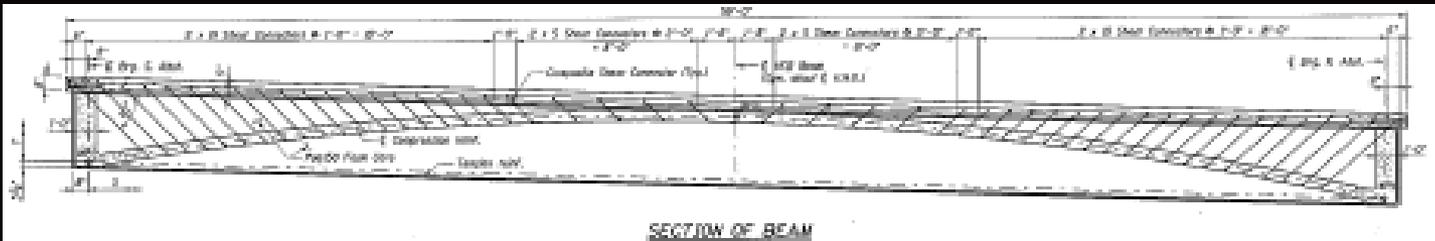
- Compression reinforcing consisting of 6,000 psi Self-Consolidating Concrete (SCC) pumped into internal arch-shaped conduit
- Modulus of Elasticity = 4.4 MSI



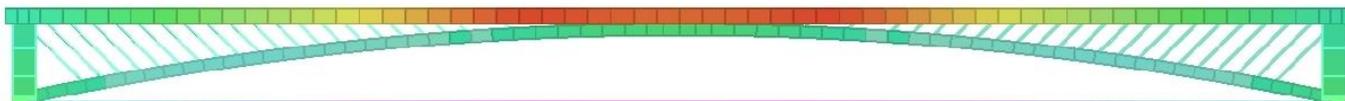
Benefits of the HCB

- Sustainability: (100+ year service life)
- Corrosion-Resistant
- Congestion Relief: (perfectly suited for modular bridge installation “ABC”)
- Lightweight: (10% of Concrete)
- Safer: (consistently exceeds code requirements for strength)
- Reduced Carbon Footprint: (uses 80% less cement than concrete structure)

Typical HCB Load Path



Force in Arch During Deck Casting



Forces in HCB Subject to Live Load

Simplified Bending Capacity

- $C=T$
- $C=0.85f_c'ab$
- $\Phi M_n = \Phi C(d-a/2)$

Use Simplified Approximate Method for Calculation of Ultimate Bending Capacity using Whitney's Equivalent Stress Block

Current HCB Installations



- High Road Bridge – Lockport Township, IL – 57 ft span, Aug 2008

Current HCB Installations



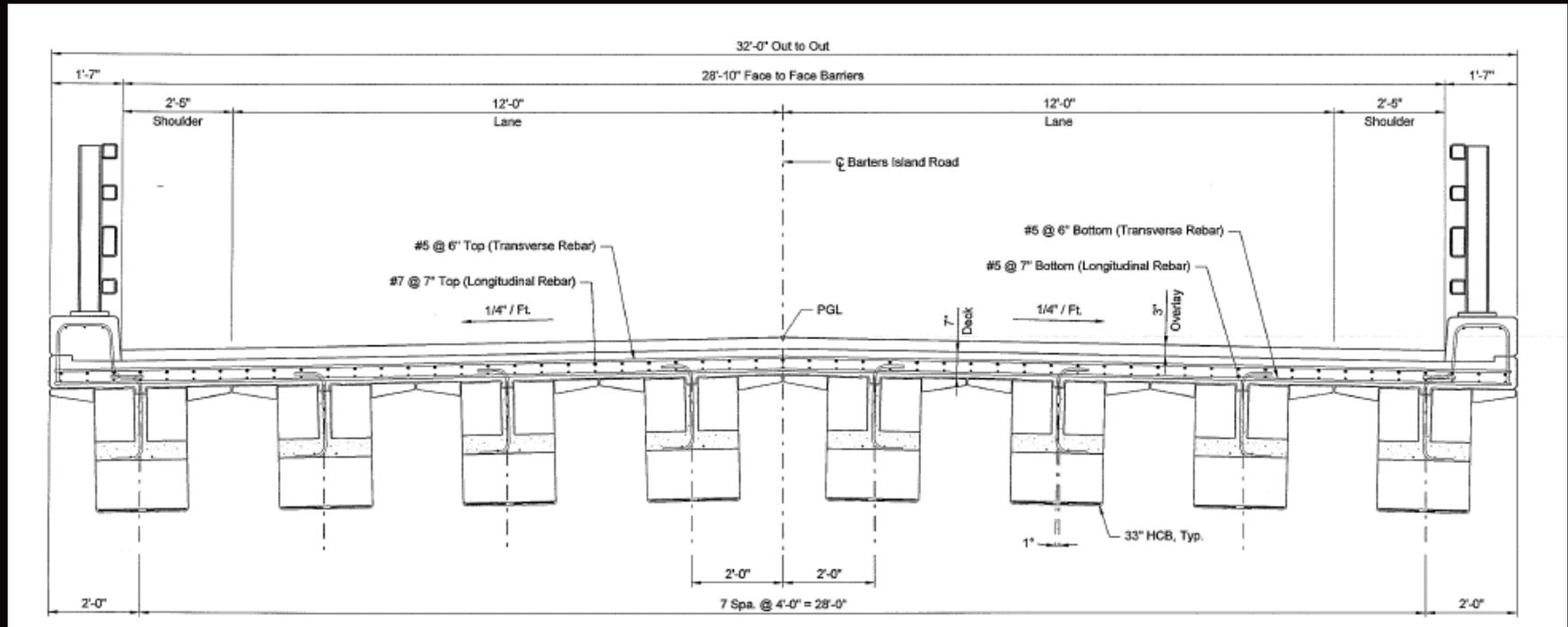
- Route 23 – Cedar Grove, NJ – 31 ft span, July 2009 and October 2009

Current HCB Installations



- TTCI-Pueblo, CO – 30 ft span designed for Class 1 RR loads (320,000 lbs), Nov 2007

2010 HCB Installations



- Knickerbocker Bridge – Boothbay, ME, 8-span, 540-ft bridge continuous for Live Load
- Bridge over Little Spring River – MO, 3-span

Fully Assembled HCB



Dollies vs. Travelifts



TENG

HC BRIDGE COMPANY, LLC

Weight Comparison

- 33" Precast Box Beam
 - 784 lbs/ft
 - 70 ft = 27.4 Ton
 - 1 Beam/truck
- 33" HCB
 - 77 lbs/ft – empty
 - 70 ft = 2.7 Tons
 - 6 Beams/truck



HCB Validation



- Route 23 & Knickerbocker Load Ratings
- Operating = 2.68 (HS-54)
- Inventory = 3.47 (HS-69)

HCB - Uses

- Bridges - 100 feet spans and beyond
- Piers and Wharves
 - Caps
 - Beams and Planks
 - High Capacity is Perfect for Craneways
- Roofs
 - Ideal for Green Roofs
- Virtually Anywhere Steel or Concrete Beams are used

The Objective

- To create a paradigm shift in bridge construction through the deployment of safe, sustainable structures that can withstand extreme environmental conditions at a better value through the deployment of advanced composite materials.
- **“Build Better Bridges”**

The Benefits

- Provide the traveling public with safer bridges
- Reduce the burden of infrastructure maintenance and reconstruction for our grandchildren and generations beyond

Measurement Science Challenges

- Quantify inefficiencies in NEPA process
- Study performance based specifications for components of projects
- Establish “Best Value” procurement models for Design/Bid/Build lettings
- Review 23 CFR 635.411 as it relates to obstacles to innovation
- Consider funding models combining, construction, health monitoring and maintenance costs.

Questions?



■ www.hcbridge.com

TENG

HC BRIDGE COMPANY, LLC