No HCBs were harmed in the making of this video!
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
Benefits of HCB Technology

- Lighter Weight (reduces foundations)
- Reduced Carbon Footprint
- Optimization of every material used
- Sustainable (greater corrosion resistance)
- Simplicity in Design, Fabrication and Erection
- Provide the public with “SAFER” bridges
The Benefits of HCB

- Reduce the burden of infrastructure maintenance on future generations
From Concept - 1996

Original Sketches
To Reality - 2007

1st HCB Installation - TTCLI - Pueblo, CO
9.1m (30 ft.)
Laboratory Testing

- Inventory Rating = 2.68 (HS-54)
- Operating Rating = 3.47 (HS-69)
Ultimate Capacity of 30 ft. RR Bridge

2.6 x Union Pacific Big Boy
High Road Bridge - Lockport Township, IL
18m (57 ft.) Span - August, 2008
Route 23 Bridge, Cedar Grove, NJ
9.4m (31 ft.) Span - October 2009
Knickerbocker Bridge - Boothbay, ME
165m (540 ft.) - 8 spans @ 21.3m (70 ft) - Oct. 2010
B0410 - Lockwood, MO - July 2012
32.3m (106 ft.) span w/1524mm (60 in)
HCB Double Web Box
Standard Railroad Bridge Construction

1st HCB Railroad Revenue Service - Fernie, BC
10m (33 ft.) - Canadian Pacific Railway, Oct. 2014
I know the HCB works  But!

• How do I know the HCB is properly filled?
• What if the strands are damaged?
• What happens if a truck hits the bridge?
• How am I going to repair an HCB?
Standard HCB Construction
How do I know the HCB is properly filled?

Figure 4-10 (A) IR Picture of HCB Length in B0478 and (B) Diagram of Corresponding Camera Location

Figure 4-7 Mock-Up Beam (one day after pour)
Basic Structural Behavior of an HCB
HCB – Shear Behavior

Images courtesy of Virginia Tech

Tension Field Action - (TFA)
Experimental vs. ABAQUS
HCB – Bending Behavior

Strain Compatibility - Force Equilibrium
Solving for Neutral Axis

Once all of the horizontal force components in the HCB are known, the exact location of the plastic neutral axis can be found directly from force equilibrium on the section with the simple equation:

\[ \Sigma F = F_{CS} + F_{CB} + F_{TF} + F_{WT} + F_{WB} + F_{BF} + F_{R2} + F_{R11} + F_{R12} + F_s = 0 \]

Knowing all of the force equations for each component and normalizing each component to the properties of the FRP shell, it is now possible to return to the force equilibrium equation and solve directly for the plastic neutral axis using the following equation:

\[
\bar{y}_u = \frac{\left[b_{top}h + t_{web}h^2 + \frac{0.85h_c(f'_c t_s b_{eff} + f'_{CB}ab)}{E_w \varepsilon_c} + 3n_k t_{Reinf1}g^2 + n_s z_s A_s\right]}{\left[b_{top} + 2t_{web}h + \frac{0.85(f'_c t_s b_{eff} + f'_{CB}ab)}{E_w \varepsilon_c} + b_{bottom} + n_k b t_{Reinf2} + 2n_k t_{Reinf1}g + n_s A_s\right]}
\]
What if the strands are damaged?

Tides Mill - Colonial Beach, VA - Feb 2013
13.5m (44 ft.) span  45 degree Skew  21 in. HCB
C=T

C=0.85f'_ab

ΦM_n=ΦC(d-a/2)
What happens if a truck hits an HCB?

4.5 Ton concrete mass accelerated to produce no less than 100 kJoules of energy at impact
No HCBs were harmed in the making of this video!
Only damage to HCB was cosmetic
Same test apparatus – traditional building material
How am I going to repair an HCB?

FRP bonds to FRP better than to concrete
What do these 3 objects have in common?
What do these 3 objects have in common?
“Thomas Jefferson’s views on patents should not surprise those who are aware of his views about democracy and equality. He opposed patents strongly because he considered it an unfair monopoly. He would later become more in favor when he discovered the power they had to encourage invention.” Jefferson was subsequently instrumental in helping to pass the Patent Act of 1790.

Thomas O. Jewett
Almost every great paradigm shift in the evolution of bridge engineering resulted from a patented intellectual property, including:

- Trusses for Wooden Covered Bridges
- Iron & Steel Trusses (catalogue bridges)
- Drawn iron for wire ropes
- Spinning mechanisms for suspension bridges
- Reinforced concrete
- Almost every type of movable bridge
- Prestressing & Post-tensioning systems
“The bucolic covered bridge; the ethereal appearance of prefabricated metal trusses thrown across numerous streams; traditional arch and girder forms appearing in the garb of a new material, reinforced concrete – these altogether elicited more than eight hundred patents during the first century of the U.S. Patent Office.”

Kemp, Emory, L. *American Bridge Patents – The First Century* 1790-1890, West Virginia University Press, 2005
Some of the more Famous Patented Metal Trusses of Iron & Steel
“Catalogue Bridges”

- Howe
- Pratt
- Whipple
- Warren
- Murphy
- Fink
“These “catalogue bridges” appeared on the scene after the Civil War and became a ubiquitous feature on the American landscape. Arguably, they had a more profound effect on the development of the American highway system than the justly famous landmark bridges by luminaries such as John. A. Roebling, James B. Eads, Theodore Cooper, or James Finley.”

Emory L. Kemp
If you’re going to lose sight of land, which boat are you going to chose?
The Traditional “Least Cost” Materials
When it comes to Safety
Performance is more important than tradition!

They don’t build them like they used to!
Why do we?

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