HILLMAN COMPOSITE BEAMS

John Hillman, PE, SE
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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.
Fiberglass Box (FRP Shell)

- Balanced quad-weave fabric with fibers that are horizontal ($0^0$), vertical ($90^0$) and ($\pm 45^0$)
- Infused in an epoxy vinyl ester resin matrix
Tension Reinforcing

- Tension reinforcing consisting of 1,860 MPa (270 ksi) galvanized prestressing strand along bottom of beam
Work Cell - VARTM Fabrication
Staging Area and Top Flange Cell
Compression Reinforcing - SCC

- Compression reinforcing consisting of 41MPa (6,000 psi) Self-Consolidating Concrete (SCC) pumped into internal arch-shaped conduit
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
- “SAFER” bridges through better performance
The Benefits of HCB

- Reduce the burden of infrastructure maintenance on future generations through better performance.
From Concept - 1996
Stress History
Tension Field Action - (TFA)  
Experimental vs. ABAQUS (no bracing)
Shear Capacity Analysis

HCB Shear Strength Prediction
October 11, 2013
Virginia Tech

Strength prediction strategy:

\[ \phi V_{n,frp} \geq V_{u,frp} \]

The idea here is to check capacity versus demand for both the FRP shell and the concrete deck+fin+arch. If one component fails, then the beam fails in shear.

\[ \phi V_{n,concrete} \geq V_{u,concrete} \]
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:

\[
\bar{y}_u = \frac{bt_{\text{top}} h + t_{\text{web}} h^2 + \frac{0.85h_c (f'_{\text{CS}} t_s b_{\text{eff}} + f'_{\text{CB}} ab)}{E_w \varepsilon_c} + 3n_R t_{\text{Reinf1}} g^2 + n_s z_s A_s}{bt_{\text{top}} + 2t_{\text{web}} h + \frac{0.85 (f'_{\text{CS}} t_s b_{\text{eff}} + f'_{\text{CB}} ab)}{E_w \varepsilon_c} + bt_{\text{bottom}} + n_R bt_{\text{Reinf2}} + 2n_R t_{\text{Reinf1}} g + n_s A_s}
\]
\( C = T \)

\( C = 0.85f'_c'ab \)

\( \Phi M_n = \Phi C(d-a/2) \)
Laboratory Testing - 2009

- Inventory Rating = 2.68 (HS-54)
- Operating Rating = 3.47 (HS-69)
1st HCB Installation - TTCI - Pueblo, CO
9.1m (30 ft.) - Class 1 RR (320k), Nov. 2007
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
B0439 - Route 76 over Beaver Creek, MO (3-span) 55m (180 ft.) w/838mm (33 in) HCB - Nov 2011
B0410 - Lockwood, MO - July 2012
32.3m (106 ft.) span w/1524mm (60 in) HCB Double Box
Tides Mill - Colonial Beach, VA - Feb 2013
13.5m (44 ft.) span  45 deg Skew  21 in. HCB
Union Street - Bangor, ME - Nov 2014
27.4m (90 ft.) span w/1067mm (42 in) HCB Double Box
Revenue Service at Last

42 ft. HCB Span B. 218.83 - Boise City Sub, CO
CP Railway concluded that constructibility and overall cost favored replacement with HCB span!

1st HCB Railroad Revenue Service - Fernie, BC
10m (33 ft.) - Canadian Pacific Railway, Oct. 2014
University of Maine Research Pier, Machias, ME
30.5m (100 ft.) 3-span w/18 in. HCB - Sep 2011
HCB combined w/ FRP stay-in-place form
First HCB Bridge in Australia!
Wyndham Ridge Bridge 2, Greta NSW, Australia
15.0m (49 ft.) 3-span w/615mm HCB - Nov 2017
• 838mm Precast Box Beam
  • 1,168 kg/m
  • 21.3 m = 24.9 tonnes
  • 1 Beam/truck

• 838mm HCB
  • 115 kg/m – empty
  • 21.3 m = 2.4 tonnes
  • 6 Beams/truck

Big Crane vs. Little Crane
Dollies vs. Travel Lifts
I know the HCB works, but...

• How do I know if the HCB is properly filled?
• What if the strands are damaged?
• What happens if a truck hits the bridge?
• How do I repair an HCB bridge?
Basic HCB Bridge construction process.
The Show-Me-State believes us!

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)
Don’t worry about damaged strands!

- Damaged HCB w/12 of 22 strands cut
- Residual Capacity - 83,000 lbs
We know trucks hit bridges.

4.5 Ton concrete mass accelerated to produce no less than 100 kJoules of energy at impact.
We apologize for any damage to your truck.

No HCBs were harmed in the making of this video!
Any damage to HCB was cosmetic
Same impact force on precast concrete beam
HCB bridges easy to repair!
What do these 3 objects have in common?
They don’t build raquets like they used to!
They don’t build boats like they used to either!
Acknowledgements
The “Traditional” Least Cost Alternate
When it comes to Safety...
Performance is more important than tradition!

They don’t build them like they used to.
Neither do we!!!