"UHPC Overlays for Suspension Bridges – The Why & How?"

by Vic Perry

…using Next Generation Nano-engineered UHPC 2.0™

Our Purpose:

To improve society's quality of life by building more durable and resilient infrastructure with *UHPC 2.0™* – the infrastructure that provides clean water, food, sanitation, the movement of goods and the accommodation of people.

" We make a living by what we get, but we make a life by what we give." Winston Churchill

Outline:

Claiborne Pell Newport Suspension Bridge, RI

- *Suspension Bridges – The Rehab Problem (Challenges)*
- *'Key' Properties of UHPC*
- *How UHPC Addresses the Challenges of Rehab*
- *Example of UHPC Overlay on a Suspension Bridge*
- *Q&A*

Suspension Bridges – The Challenges:

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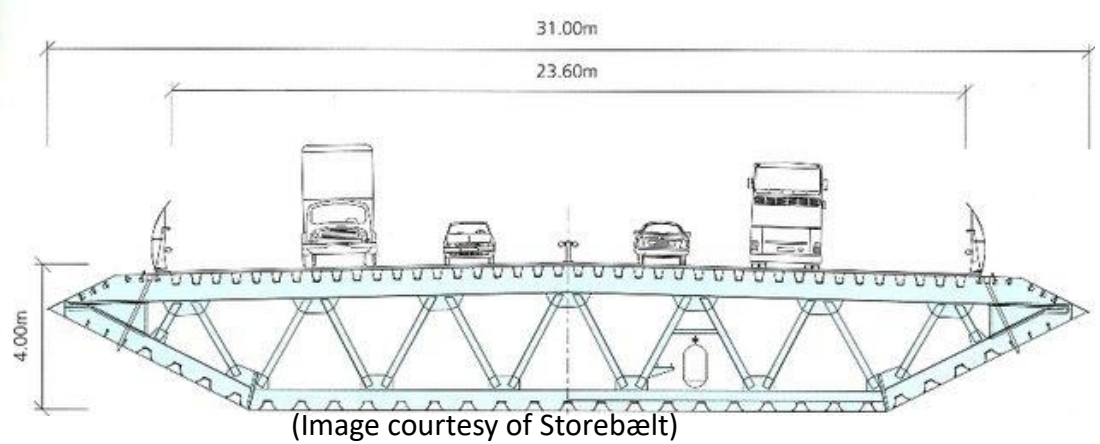
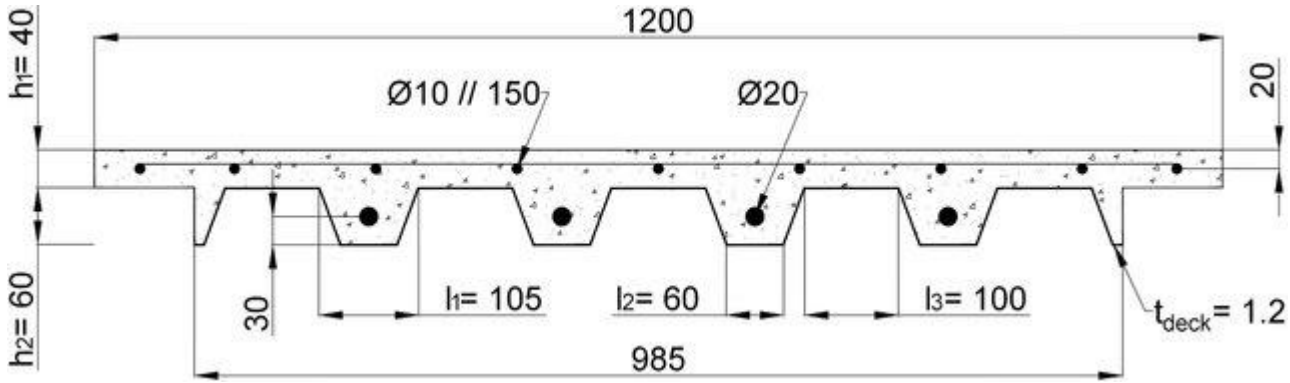


(Image courtesy of Storebælt)



Suspension bridge decks are designed to be light in weight to reduce deadload on the suspension cables and stiff to resist movement (bending & torsion) from wind and traffic. This results in very thin composite decks, with a potential for punch through if too much of the existing concrete material is removed during rehabilitation.

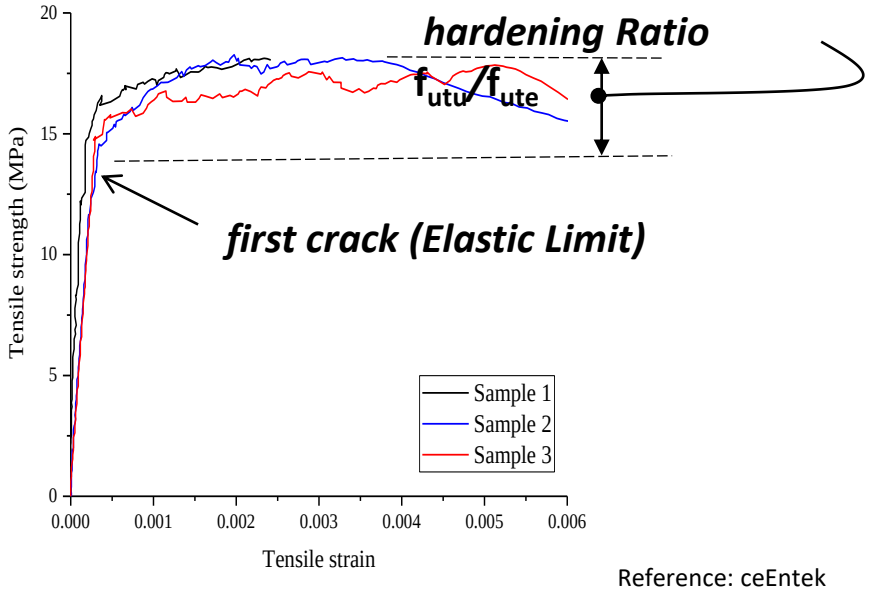
Suspension Bridges – The Challenges:

Conducting a rehabilitation on a deck that is 200 ft in the air with slopes and cross-grades that are continuously moving (bending and twisting) from truck traffic, wind and equipment.

'Key' Important* Properties of UHPC for Overlays:

Superior Strength!

Material Characteristic	Conventional Concrete	UHPC
Compressive Strength	20 to 40 MPa (2.9 to 5.8 ksi)	120 to 250 MPa (17 to 36 ksi)
Direct Tensile Strength	1 to 3 MPa (0.15 to 0.44 ksi)	6 to 12 MPa (0.9 to 1.7 ksi)
Bond Strength (ASTM C1583)	-	> 300 psi Failure in Substrate
Elastic Modulus (ASTM C469)	25 to 30 GPa (3600 to 4400 ksi)	40 to 50 GPa (6000 to 7200 ksi)



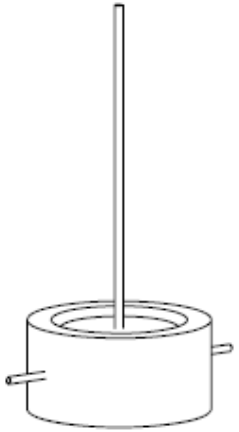
Reference: ceEntek

Ultra-high performance concrete (UHPC) — a cementitious composite material with enhanced strength, durability, and ductility compared to high performance concretes.

Note: *UHPC may contain fibres for post-cracking ductility, have a specified compressive strength of at least 120 MPa at 28 days, and are formulated with a modified multi-scale particle packing of inorganic materials of less than 0.6 mm diameter (larger sizes may be used).*

Reference: CSA A23.1 Annex U- UHPC

'Key' Important* Properties of UHPC for Overlays:



SCHEMATIC – CYLINDERS WITH REBAR

Enhanced Bond!

Bar Rupture with 4 d_b in UHPC @ 14,000 psi.

UHPC Interface Bond to Normal Concrete.

'Key' Important* Properties of UHPC for Overlays:

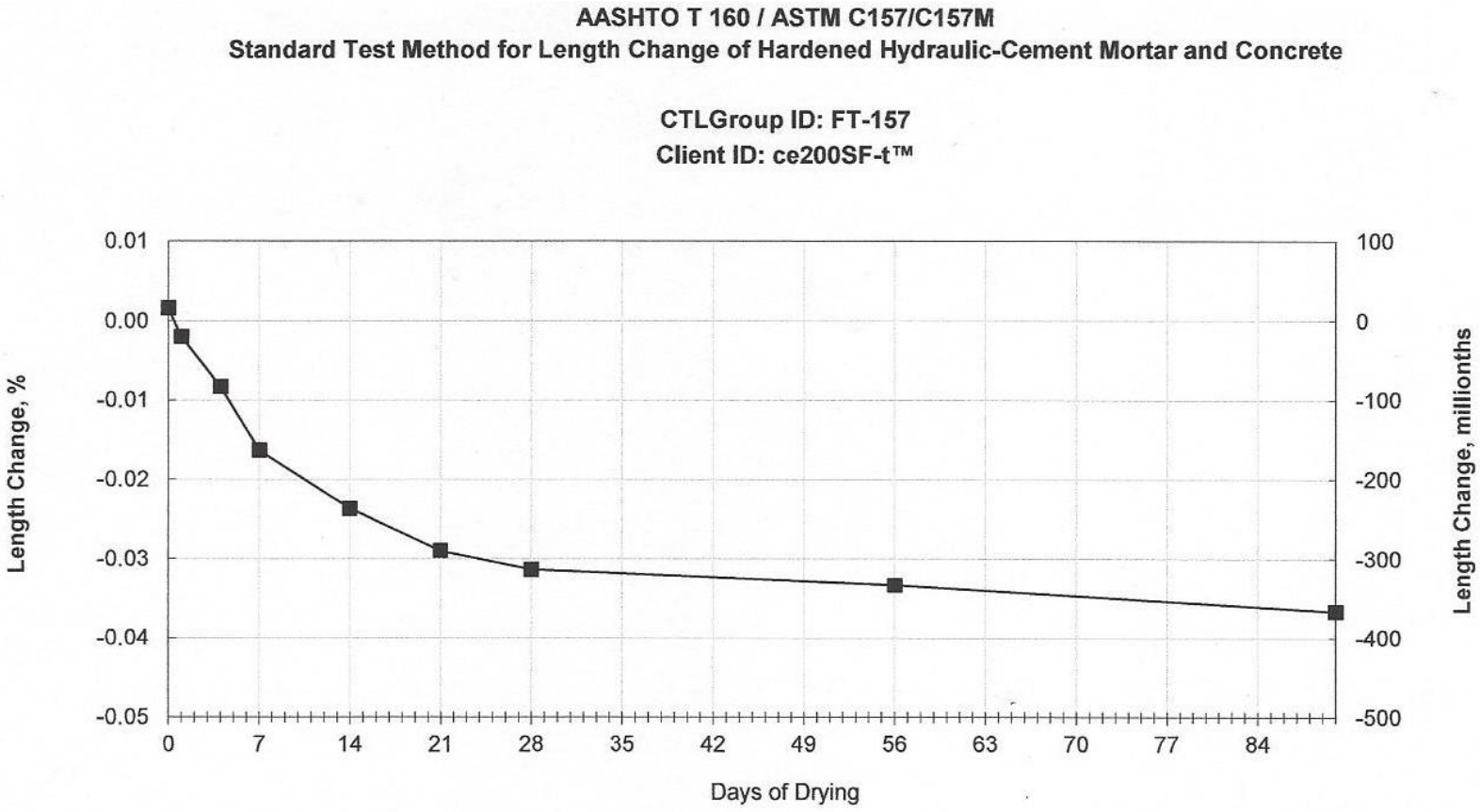
Superior Durability!

Material Characteristic	Conventional Concrete	HPC	UHPC
Freeze/thaw (ASTM C666) RDM	70 (%)	90 (%)	> 95 (%)
Abrasion Resistance (ASTM C944 Modified -Mass loss)	30+ grams	5 -10 grams	< 1 gram
Permeability in water K_{water}	$10^{-10} – 10^{-11}$ (ft/s) $10^{-11} – 10^{-12}$ (m/s)	10^{-12} (ft/s) 10^{-13} (m/s)	$< 2 \times 10^{-13}$ (ft/s) $< 5 \times 10^{-14}$ (m/s)
Absorption, A	0.002 – 0.006 ($lb/ft^2/s^{1/2}$) 0.01 – 0.03 ($kg/m^2/s^{1/2}$)	0.0006 – 0.002 ($lb/ft^2/s^{1/2}$) 0.003 – 0.01 ($kg/m^2/s^{1/2}$)	0.00006 ($lb/ft^2/s^{1/2}$) 0.0003 ($kg/m^2/s^{1/2}$)

UHPCs are typically an order of magnitude superior to HPC!

'Key' Important* Properties of UHPC for Overlays:

Low Shrinkage!



ASTM C1107/C1107M-20 specifies that a Nonshrink Hydraulic Cement Grout shall not have a change in length of more than 0.3% at 28 days.

'Key' Important* Properties of UHPC for Overlays:

Thixotropic Workability!

Photos Courtesy of FHWA

UHPC can be self-leveling, self-consolidating or thixotropic

Example Application of UHPC Overlay

Claiborne Pell Newport Suspension Bridge, RI

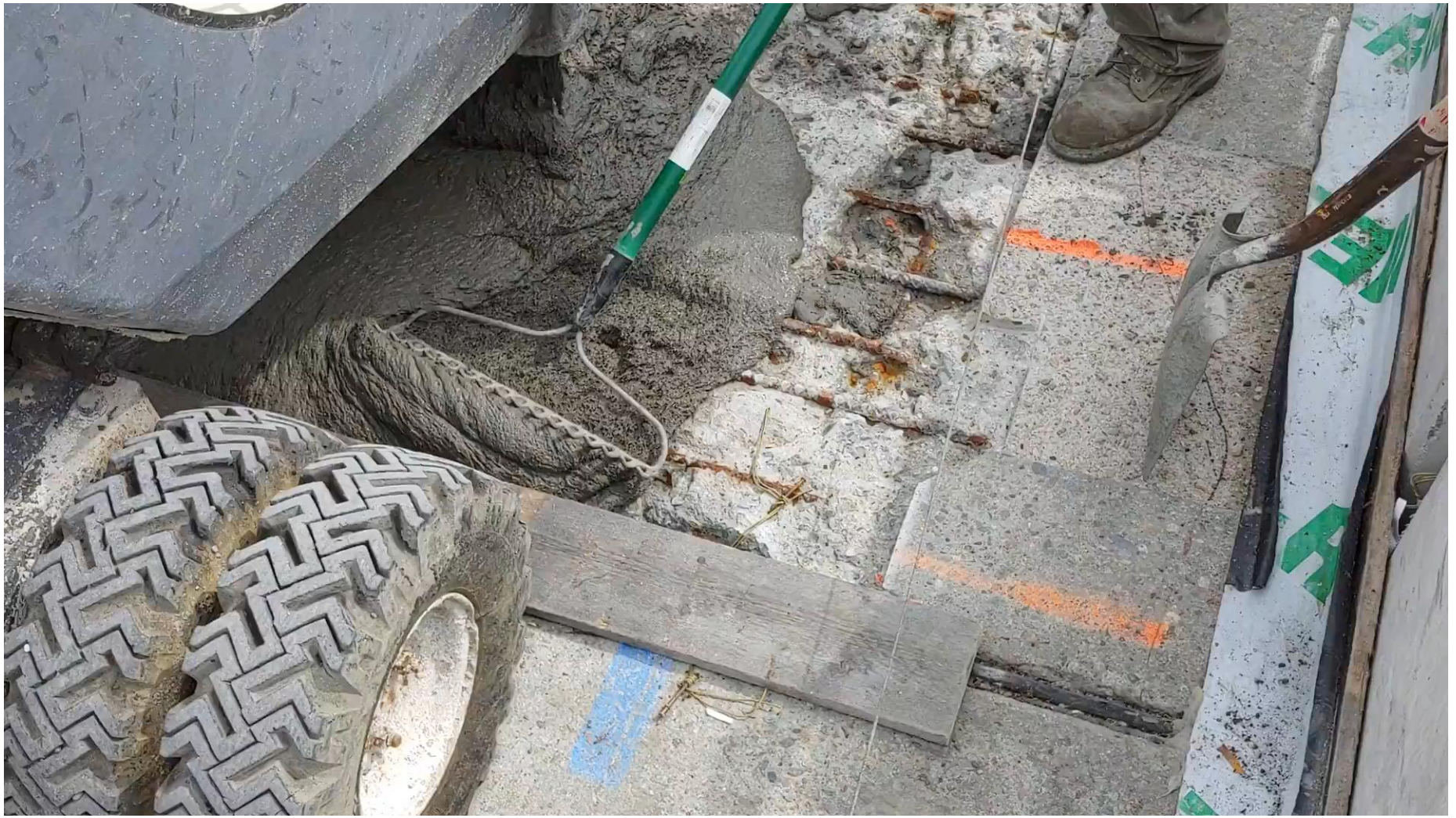
UHPC Overlay – Newport/Pell Suspension Bridge, RIBTA

UHPC Overlay – Newport/Pell Suspension Bridge, RIBTA

Hydro-Demolition of the Claiborne Pell Newport Suspension Bridge, RI
(Courtesy of Aetna Bridge)

Finished Surface after Hydro-Demolition of the Claiborne Pell Newport Suspension Bridge, RI

UHPC Overlay – Newport/Pell Suspension Bridge, RIBTA



UHPC Overlay – Newport/Pell Suspension Bridge, RIBTA

Placing the UHPC Overlay with a Vibrating Bridge Deck Truss Screed.

Placing the UHPC Overlay with a Self-Propelled UHPC Paver.

UHPC Overlay – Newport/Pell Suspension Bridge, RIBTA

The finished surface of UHPC Overlay (L); Sprayed White Pigmented Curing Compound (Top); Covered with Wet burlap & Poly sheet (R).

UHPC Overlay – Newport/Pell Suspension Bridge, RIBTA

Finished & Cured UHPC Overlay surface prior to Grinding & Grooving.

UHPC Overlay Surface after Grinding & Grooving.

The 'Big' Opportunity for you:

There are more than 75 Suspension Bridges in North America that have been in-service for more than 50 years, just waiting for their turn to get a UHPC Overlay!

THANK YOU!

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