





Introduction to UHPC

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Efficiency through technology and collaboration

Design and Construction of UHPC Field-Cast Connections


- FHWA-HRT-14-084
- What is UHPC?
- Example Connections
- Structural Design
- Construction
- Quality Assurance
- Deployments



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FHWA UHPC Web Resources

- Web Search: **FHWA UHPC**
- <https://www.fhwa.dot.gov/research/resources/uhcp/>



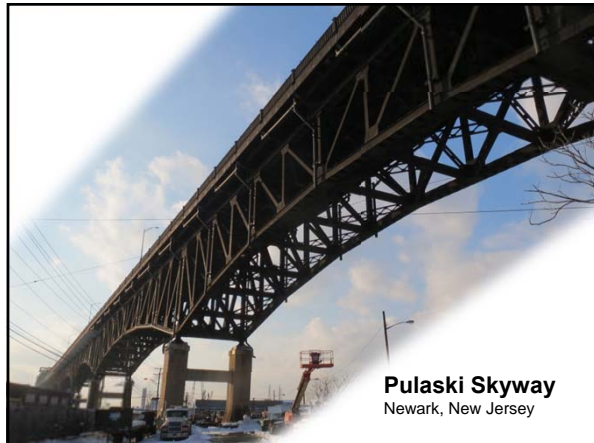
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1st Intl. Interactive Symposium on UHPC

- July 18-20, 2016
- Des Moines, Iowa
- ABC
- Structural Design
- Material Design
- Repair & Retrofit
- Bridge Site Visits



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Pulaski Skyway
Newark, New Jersey

Foot Bridge of Peace – Seoul, South Korea



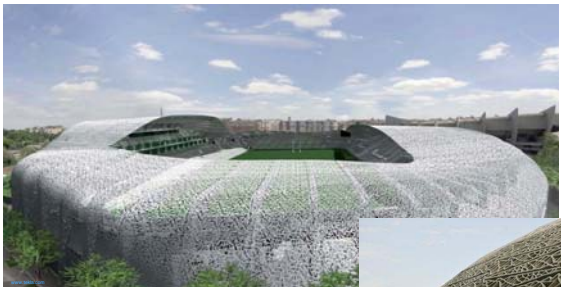
Toll Plaza Roof – Millau Viaduct, France



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Jean Bouin Stadium Façade – Paris, France

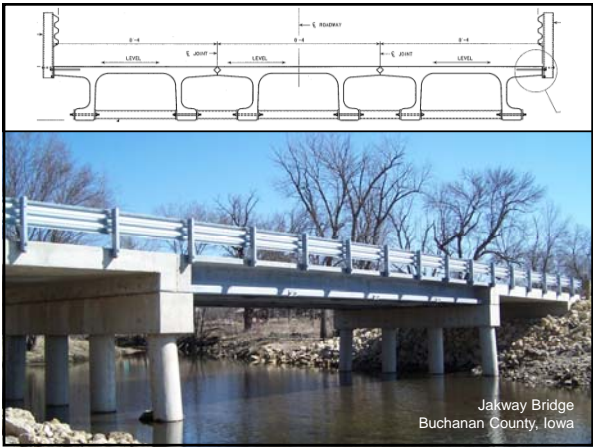


Footbridge – Marseille, France

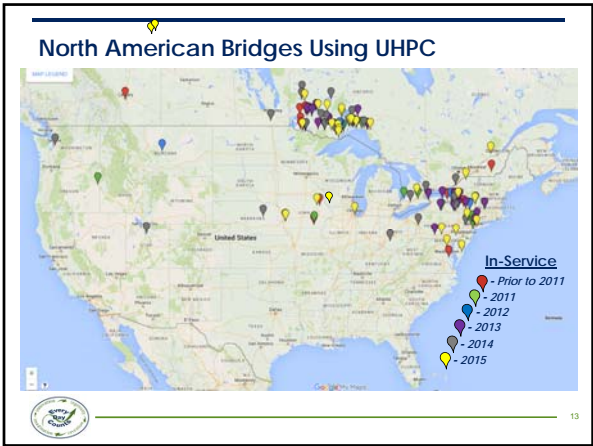


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UHPC: Applications in the Highway Sector

Efficiency through technology and collaboration

U.S. Department of Transportation
Federal Highway Administration

UHPC for Bridge Deck Rehabilitation

Chillon Viaduct near Lausanne, Switzerland

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UHPC for Bridge Deck Rehabilitation






Chillon Viaduct near Lausanne, Switzerland



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UHPC for Bridge Girders


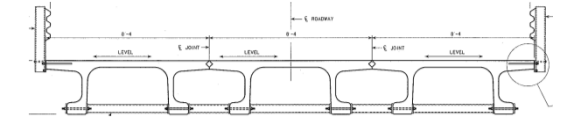


Jakway Bridge
Buchanan County, Iowa

Mars Hill Bridge
Wapello County, Iowa

Cat Point Creek Bridge
Richmond County, Virginia





Jakway Bridge
Buchanan County, Iowa

UHPC for Bridge Decks

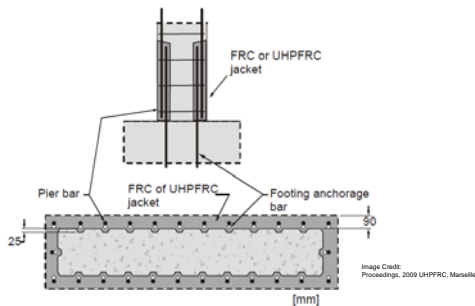


Dahlonega Road Bridge in Wapello County, Iowa



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UHPC for Seismic Retrofit



Bruno Massicotte, Polytechnique Montreal



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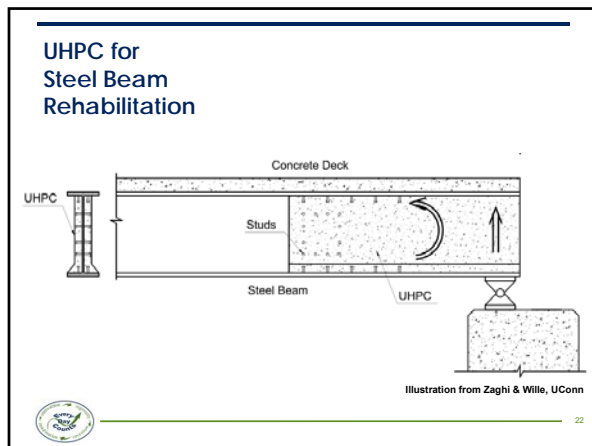
UHPC for Steel Beam Rehabilitation



Photos from Rose & Picard, NYSDOT



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What is Ultra-High Performance Concrete?

- Portland cement-based composite material
- Castable
- **Highly durable, strain-hardening concrete**
- Wide variety of potential applications
 - Infrastructure
 - Architecture
 - Urban Furniture
 - Security Applications



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What is Ultra-High Performance Concrete?

- Advanced cementitious composite material
- High strength, high stiffness
- Exceptional durability
- Internal steel fiber reinforcement for ductility
- Self-consolidating

21 ksi Compression
720 psi Tension
Fiber Reinforced
Self-Consolidating
Low Permeability



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What is Ultra-High Performance Concrete?

- ACI 239 – Ultra-High Performance Concrete
 - Concrete, ultra-high performance - concrete that has a minimum specified compressive strength of 150 MPa (22,000 psi) with specified durability, tensile ductility and toughness requirements; fibers are generally included to achieve specified requirements.



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What is Ultra-High Performance Concrete?

- FHWA
 - UHPC is a cementitious composite material composed of an optimized gradation of granular constituents, a water-to-cementitious materials ratio less than 0.25, and a high percentage of discontinuous internal fiber reinforcement. The mechanical properties of UHPC include compressive strength greater than 21.7 ksi (150 MPa) and sustained post-cracking tensile strength greater than 0.72 ksi (5 MPa).



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What is Ultra-High Performance Concrete?

- Highly durable, strain-hardening concrete



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Availability

- Proprietary Versions
 - Similar to conventional grouts
 - Availability depends on market
- Non-Proprietary Versions
 - Many academic lab mixtures under development
 - Dr. Kay Wille at UConn developed/published mixes
 - FHWA-HRT-13-100



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Typical Composition of UHPC

Constituent	Amount	% by Weight
Portland Cement	1200 lb/yd ³	28.5
Silica Fume	390 lb/yd ³	9.3
Ground Quartz	355 lb/yd ³	8.5
Fine Sand	1720 lb/yd ³	41.0
Steel Fibers	263 lb/yd ³	6.3
Superplasticizer	51 lb/yd ³	1.2
Water	218 lb/yd ³	5.2



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Steel Fibers



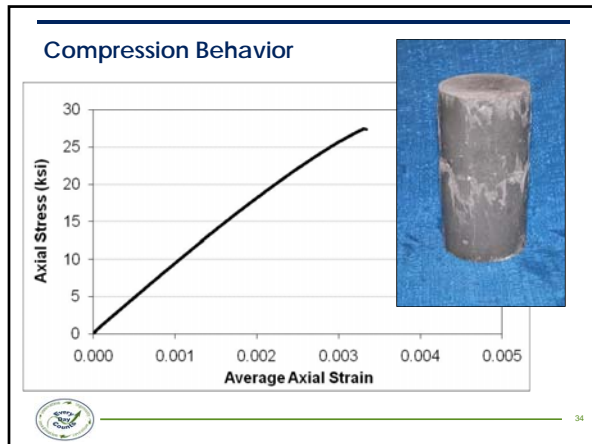
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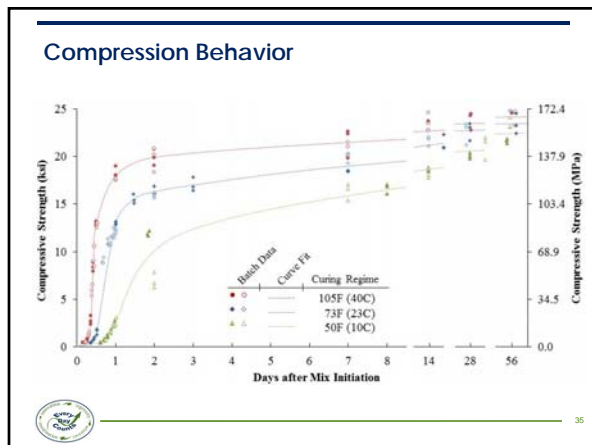
UHPC Properties: Some Ballpark Values

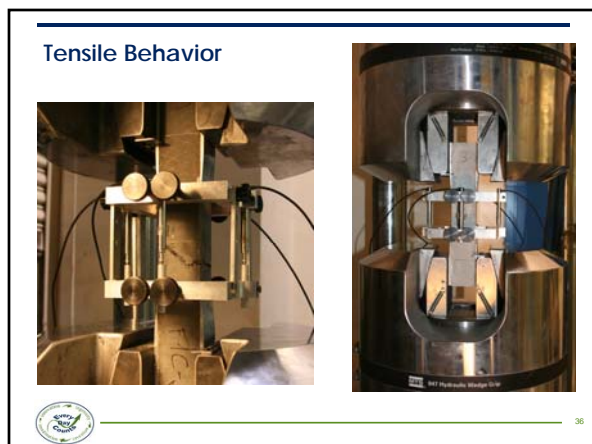
- Compressive Strength – 18 to 35 ksi
- Modulus of Elasticity – 6000 to 8000 ksi
- Sustained Tensile Capacity – 0.9 to 1.5 ksi
- Rapid Chloride Test – 20 to 360 Coulombs
- Freeze/Thaw Resistance – RDM > 95%

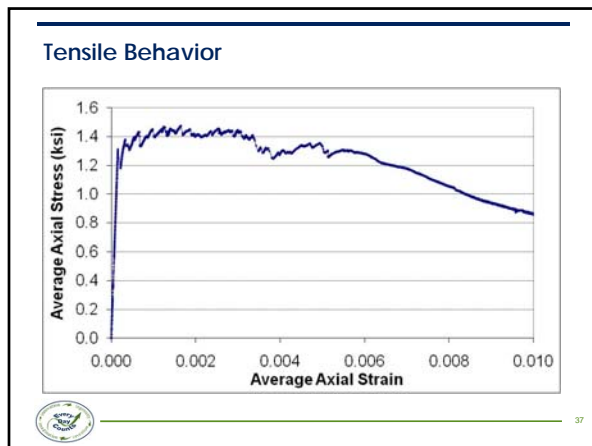


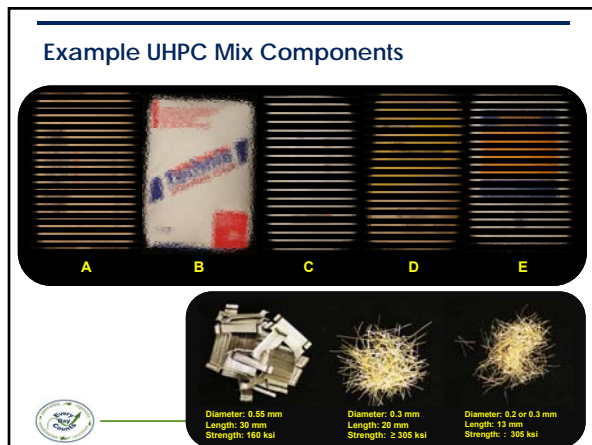
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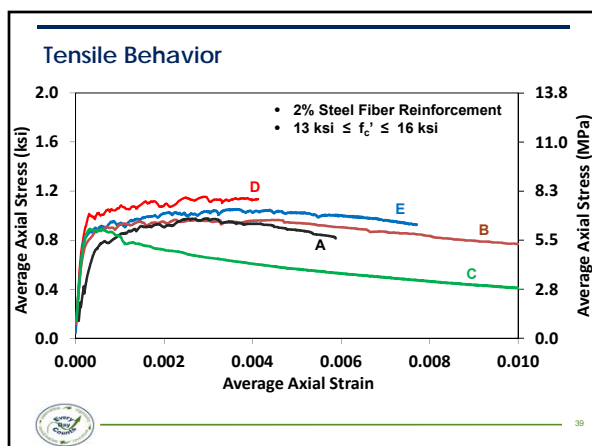


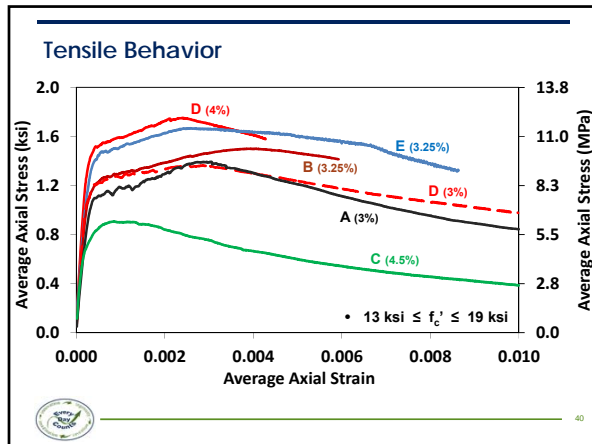


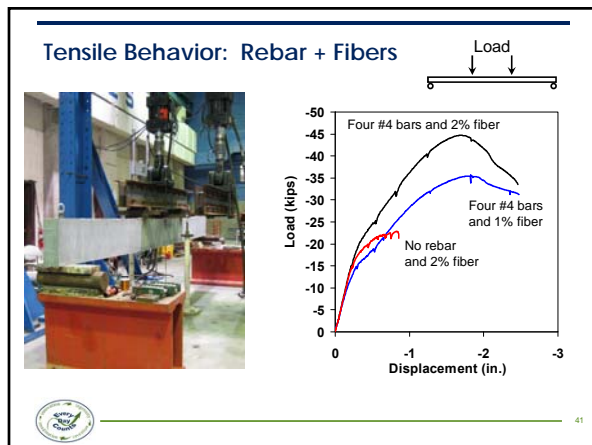


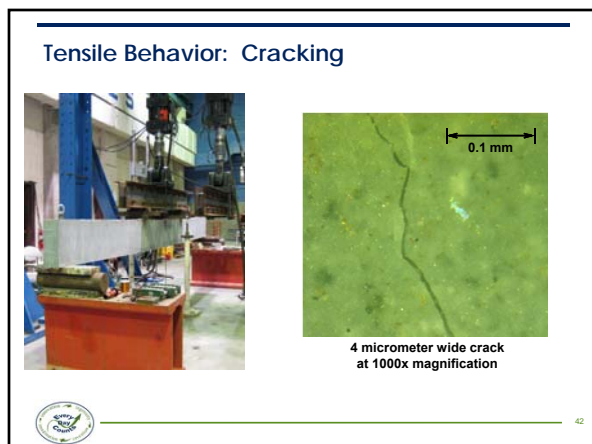












UHPC Permeability

- Chloride Ion Diffusion Coefficient

2×10^{-11} m²/s for conventional concrete

2×10^{-12} m²/s for HPC

2×10^{-13} m²/s for UHPC



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UHPC Mixing



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UHPC Mixing



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UHPC Mixing



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UHPC Rheology



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UHPC Casting



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UHPC Casting



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UHPC Casting



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Casting for Bridge Deck Rehabilitation



Chillon Viaduct near Lausanne, Switzerland

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UHPC Casting (Video)



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UHPC Casting (Video)



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