Maintenance and Repair of Bridge Infrastructure

Using Ultra-High Performance Concrete

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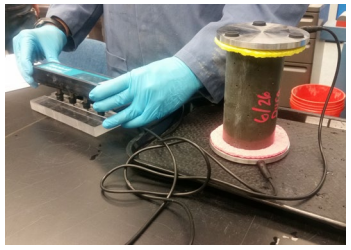
Midwest Bridge Preservation Partnership Annual Meeting in Bismarck, ND
October 16th, 2019

Structural Materials Research Program
Turner-Fairbank Highway Research Center


U.S. Department of Transportation
Federal Highway Administration

Overview

- What is UHPC?
- Where has UHPC been used?
- What are some specific applications related to maintenance and repair?
- What are some resources if you have questions?

Traditional constituent materials

Ordinary Portland Cement

Supplementary Cementitious Materials

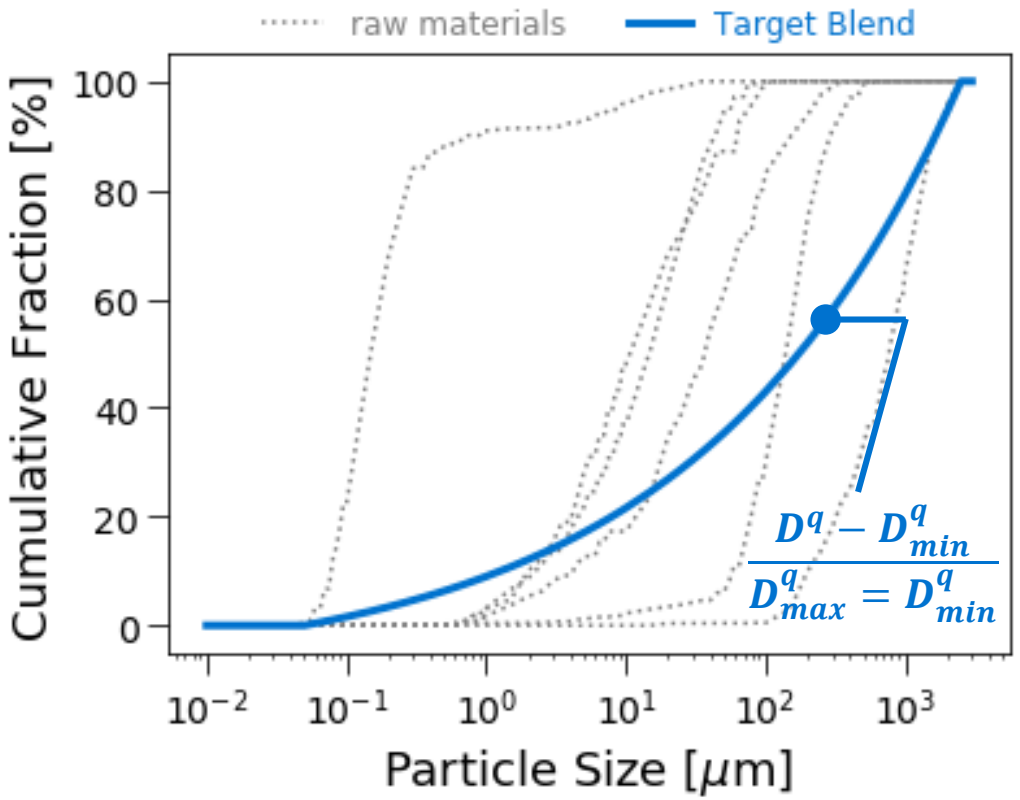
Fine Sand and Fillers

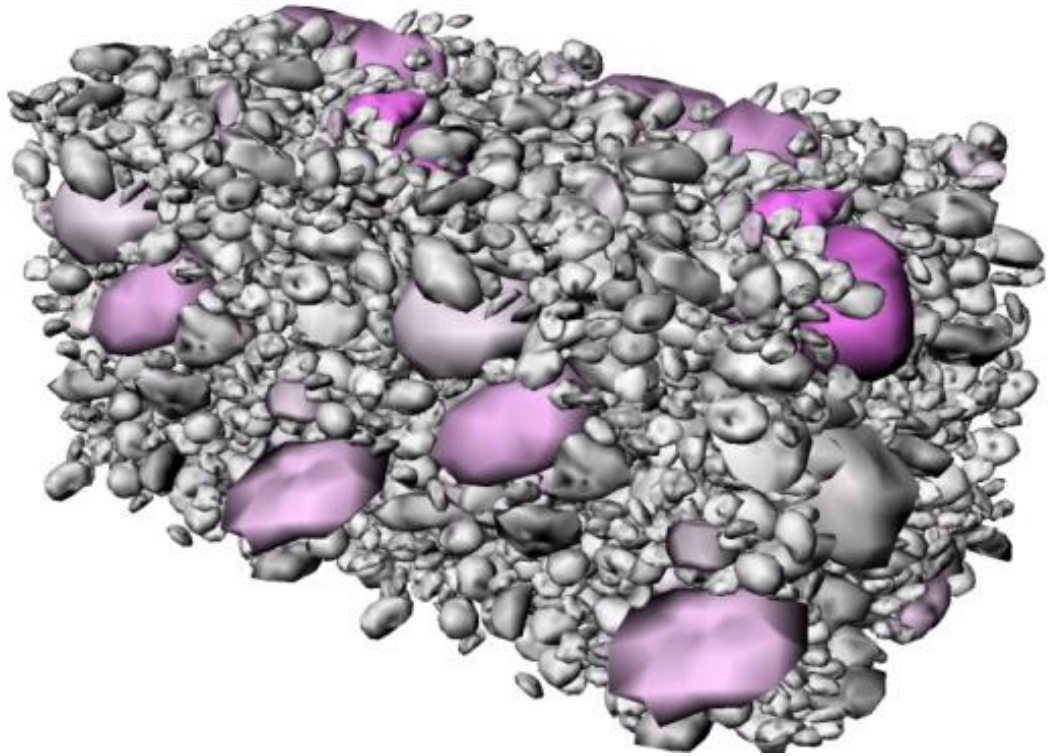
Water

Chemical Admixtures

Steel Fibers (0.01x0.5 in)

Optimize particle packing





nist.gov/mml

Andreasen and Andersen 1930; Yu, Spiesz, and Brouwers, 2014

Availability




Material	Approximate Material Cost (USD/yd^3)
Portland Cement Grouts	1,000 – 2,000
Repair Mortars	1,500 – 3,000
Epoxy Grouts	2,500 – 3,500
UHPCs	2,500 – 3,500

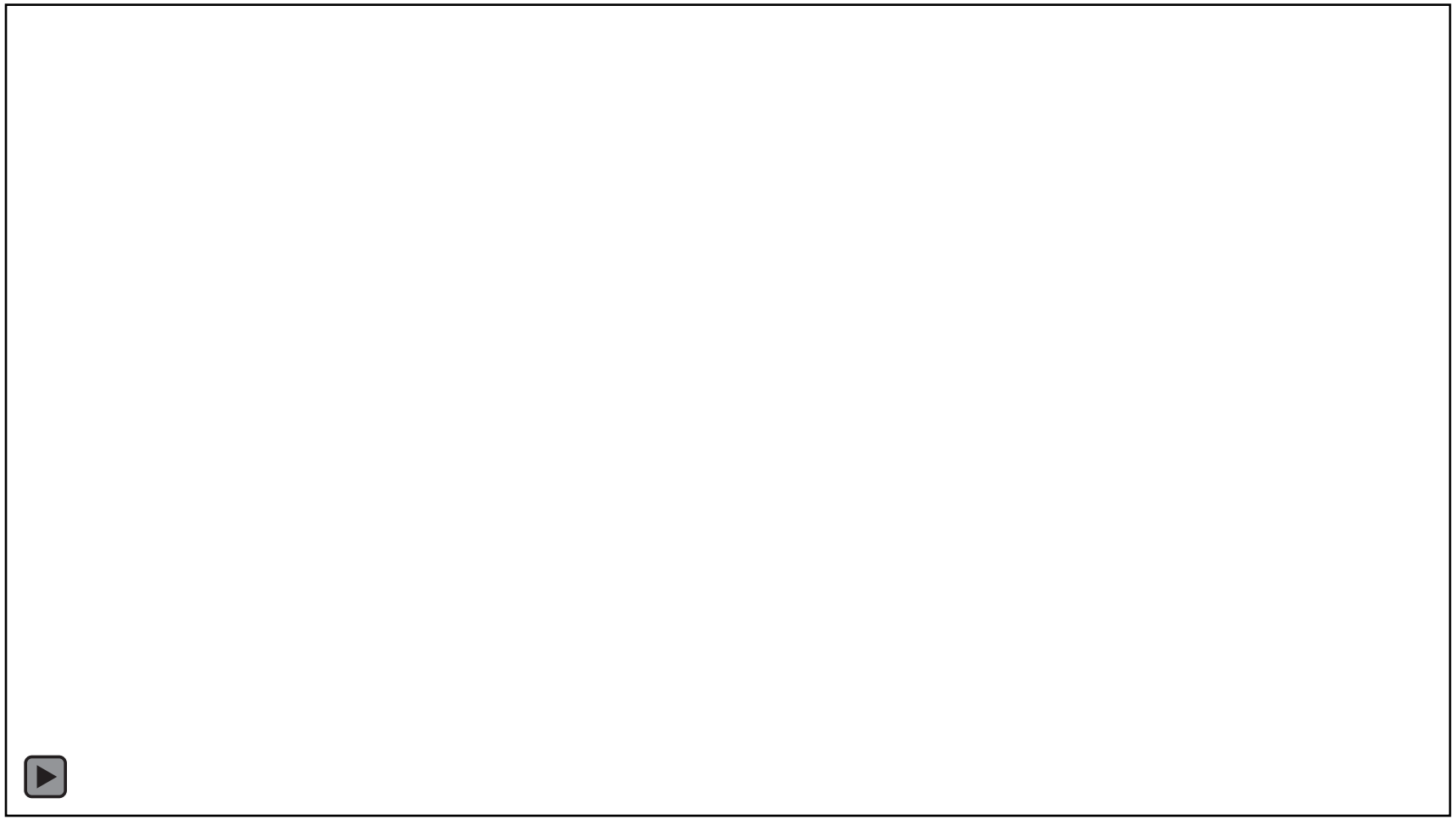
Haber, 2016

Definition and general properties

- Cement-based composite with an optimized gradation of granular constituents
- **Water-to-cementitious materials ratio less than 0.25**
- Discontinuous fiber reinforcement
- **High Compressive Strength** (> 21,000 psi)
- **High Sustained Tensile Strength** (> 720 psi)
- Resistant to freeze-thaw damage
- Low chloride penetration
- Highly resistant to abrasion
- **Exceptional bond to existing concrete**
- **Exceptional bond to rebar**
- **Engineered flow properties** (self-consolidating or thixotropic)

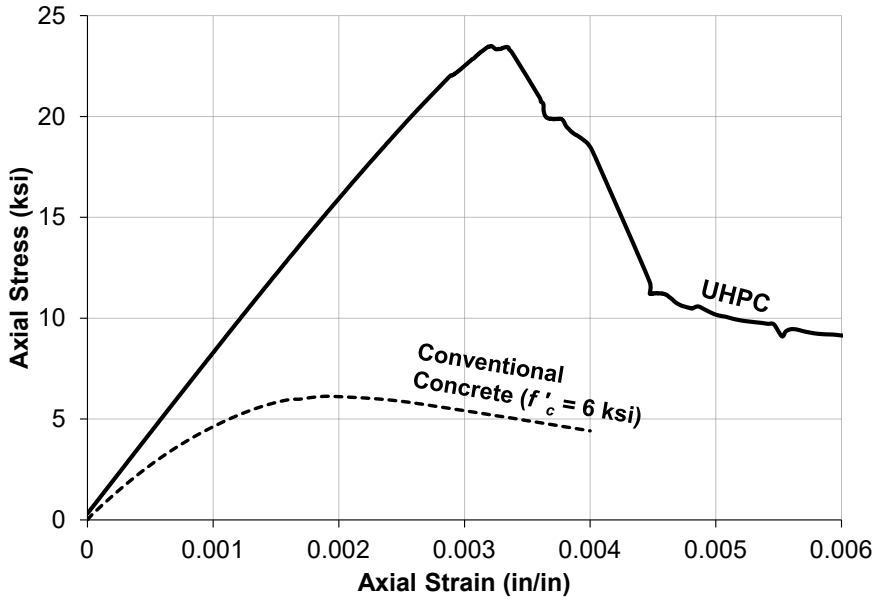
Graybeal, 2011. *Ultra-High Performance Concrete*, FHWA-HRT-11-038.

Engineered Flow Properties

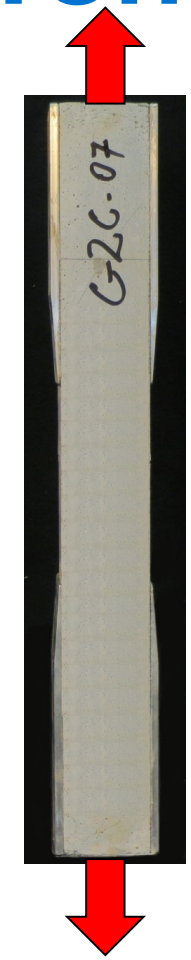


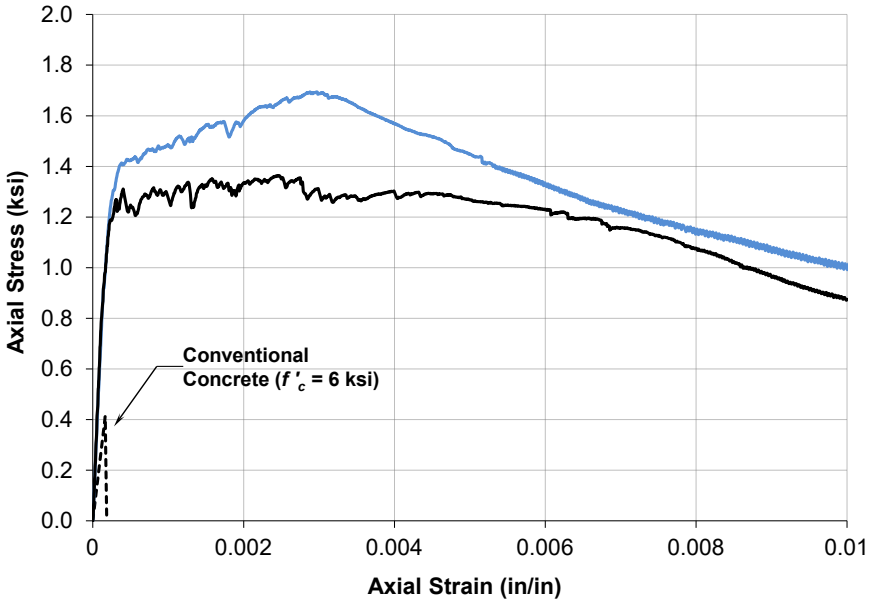
Mechanical Properties

Compression



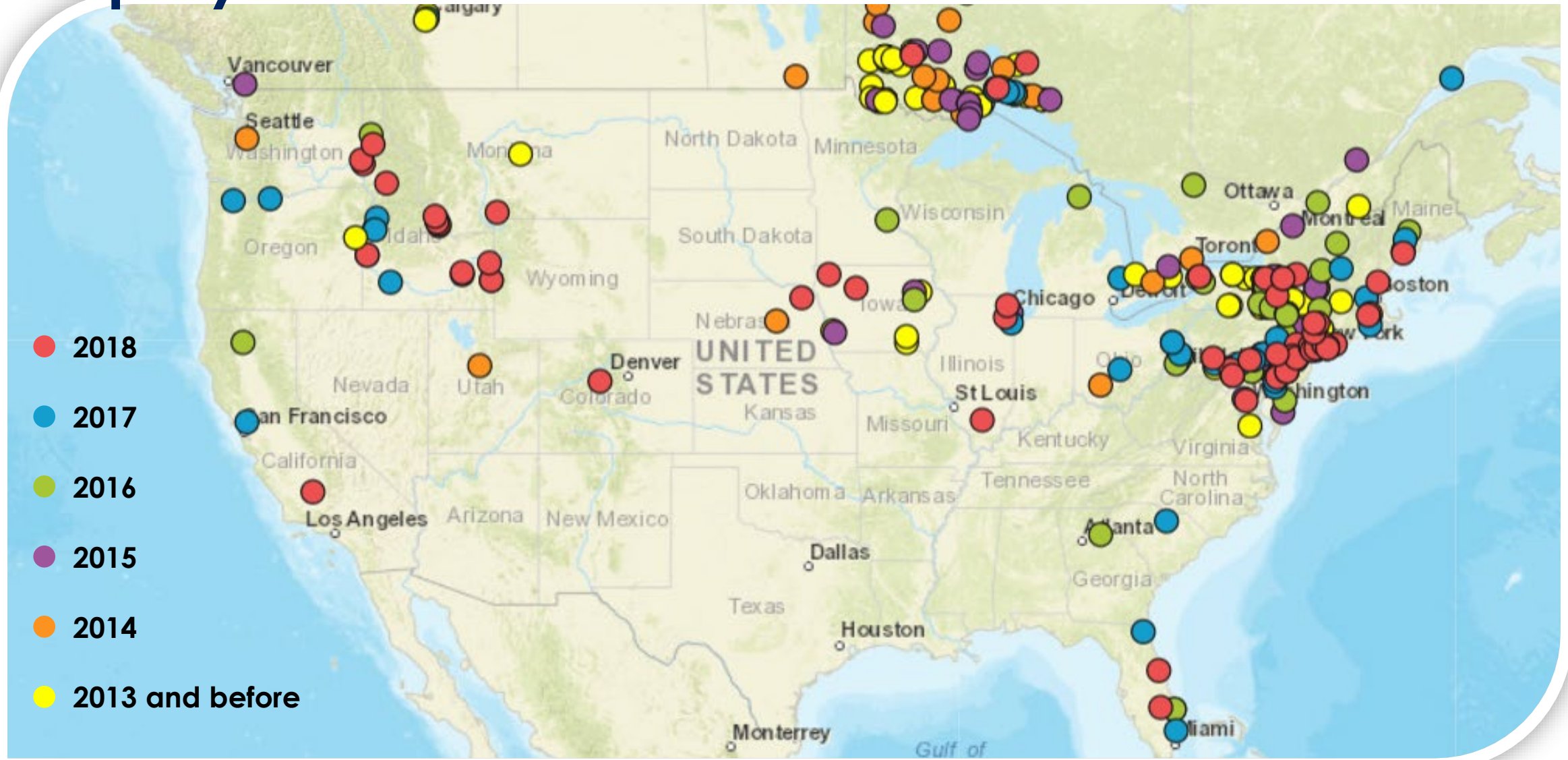
Tension





El-Helou et al., 2019

Deployments



go.usa.gov/xEWCF

Deployments: Repair

go.usa.gov/xEWCF

just because you are unique does not mean you are useful

The most dangerous phrase is "But we've always done it that way."

-Admiral Grace Hopper

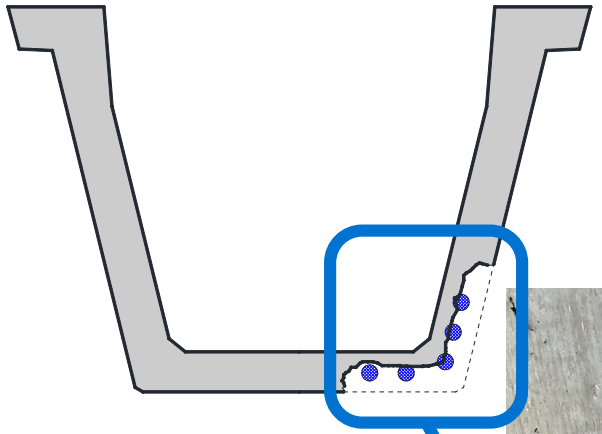
Repair Applications of UHPC

UHPC can represent a potential solution to:

- Mid-span void repair
- Differential deflection of slab beams and reflective deck cracking
- Excessive deck damage as a deck overlay
- Leaking expansion joints as a link slab
- Corroded beam ends
- Fatigue crack at stiffeners or connection plates
- In-place girder strengthening

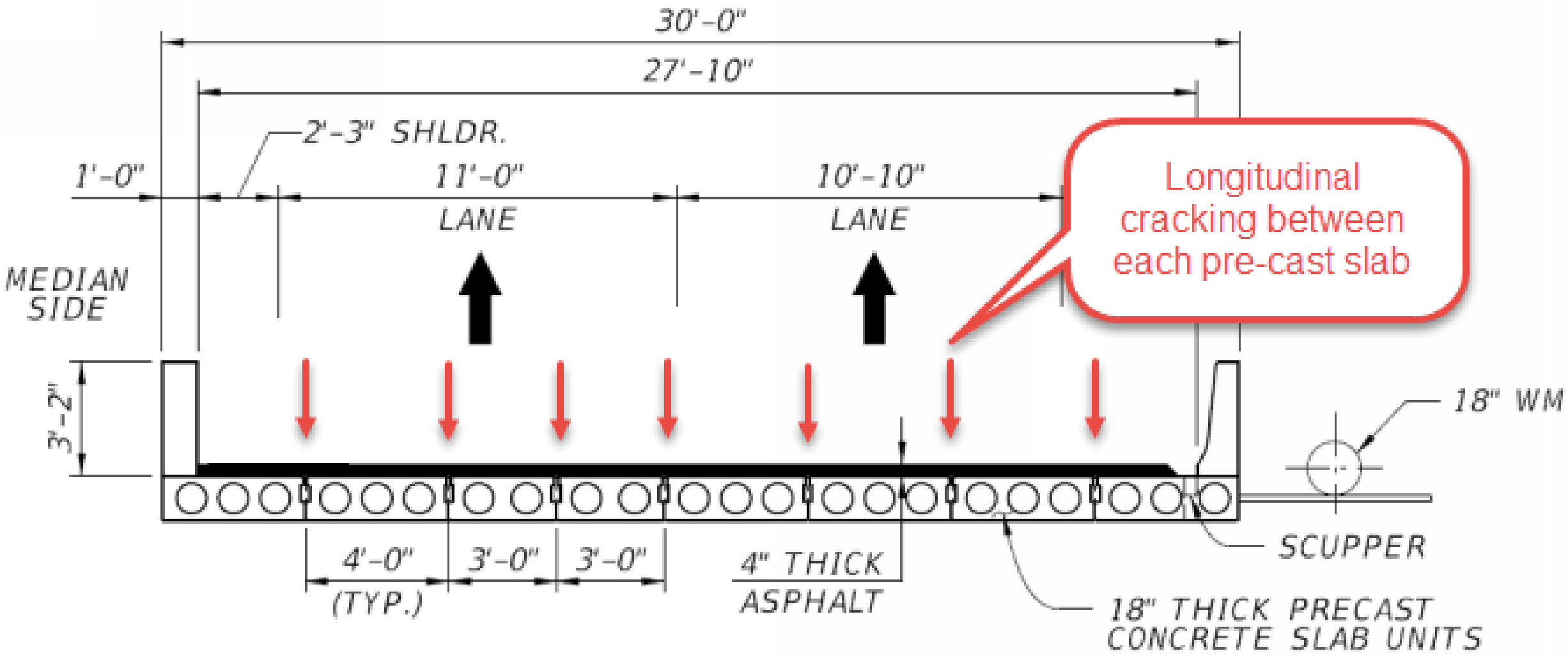
Concrete Girder Repair

- Poorly consolidation at mid-span



Completed Void Repair

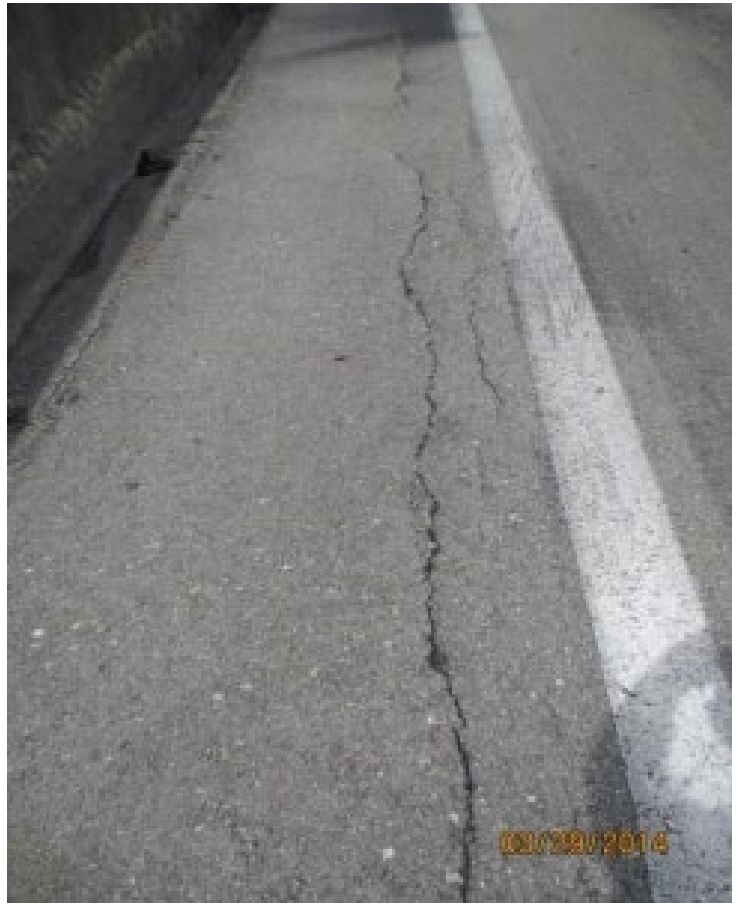
Adjacent Slab Beams



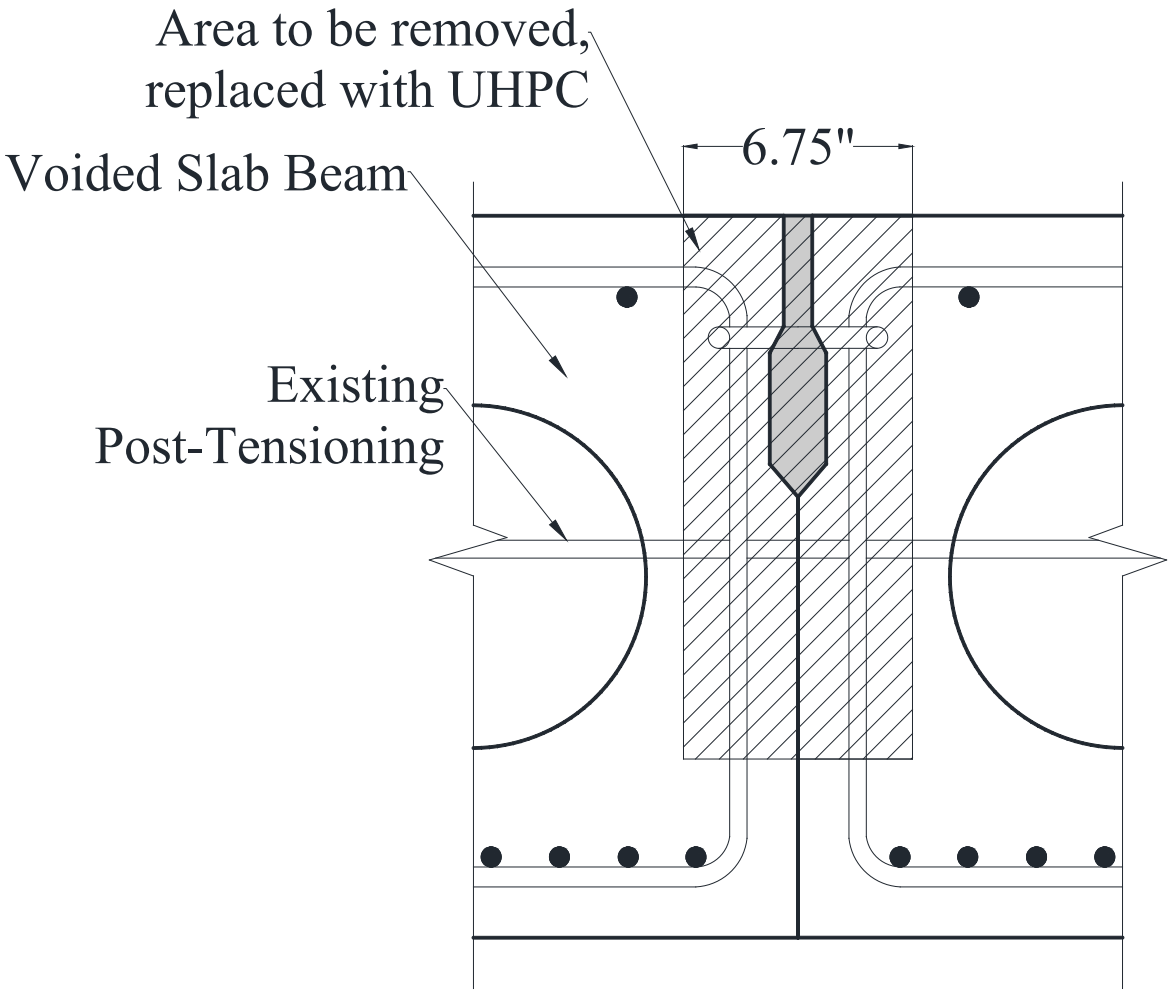
Florida Department of Transportation, 2017

Connection Repair Between Slab Beams

Reflective cracking in asphalt overlay



Removal of Deteriorated Connection



Florida Department of Transportation, 2017

Fill with UHPC

Florida Department of Transportation, 2017

Bridge Deck Repair: Overlays

Chillon Viaduct,
Switzerland

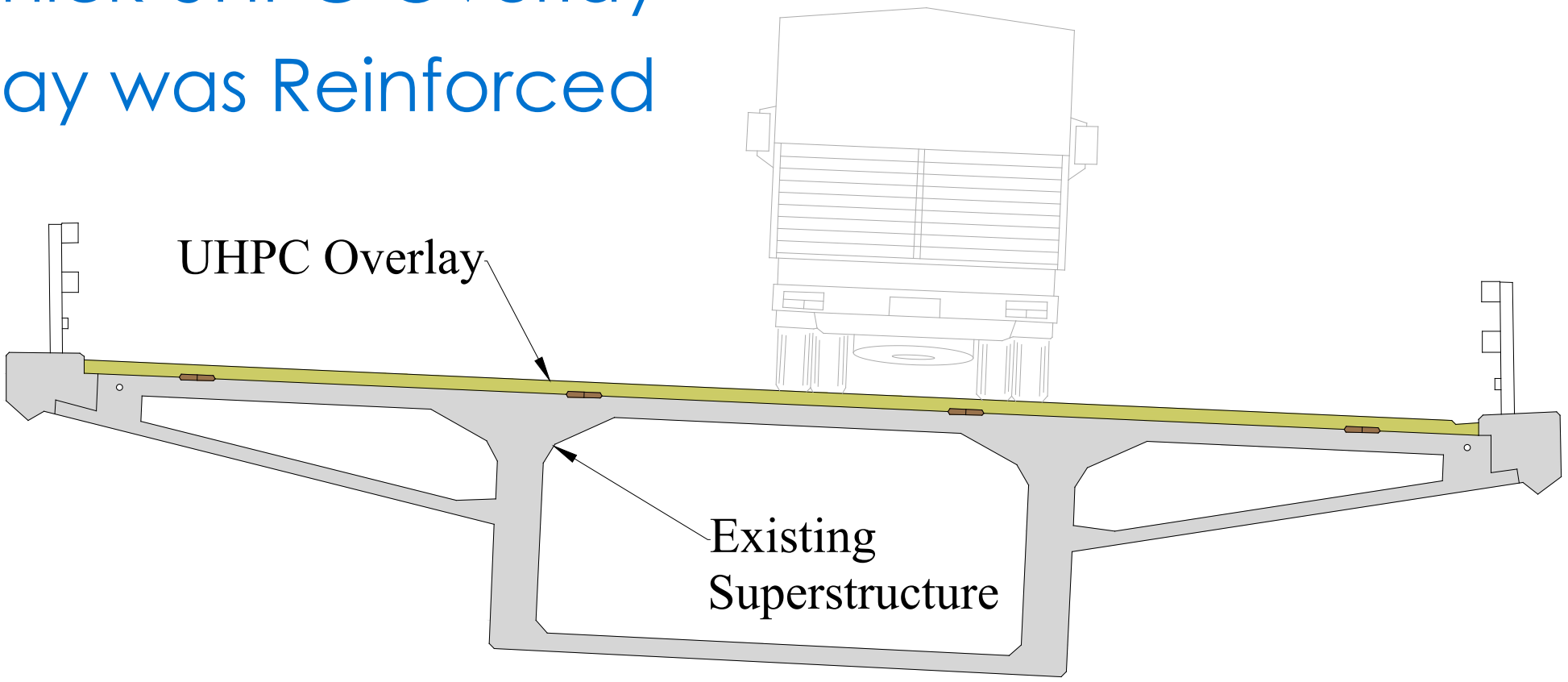
2016
Laporte Road Bridge,
Brandon, IA

2018
Blackbird Road,
Townsend, DE

Haber and Graybeal, 2018

Chillon Viaduct UHPC Overlay Project

- Existing Deck was Thin (7.25”), ASR Damage.
- 1.6” Thick UHPC Overlay
- Overlay was Reinforced



Haber and Graybeal, 2018.

Chillon Viaduct Overlay Project

Chillon Viaduct Overlay Project

- Specially-Designed, Multi-Functional UHPC Placement Machine

Haber and Graybeal, 2018.

Laporte Road Bridge Project – Brandon, IA

Haber et al., 2018. *Bond characterization of UHPC overlays for concrete bridge decks: Laboratory and field testing.*

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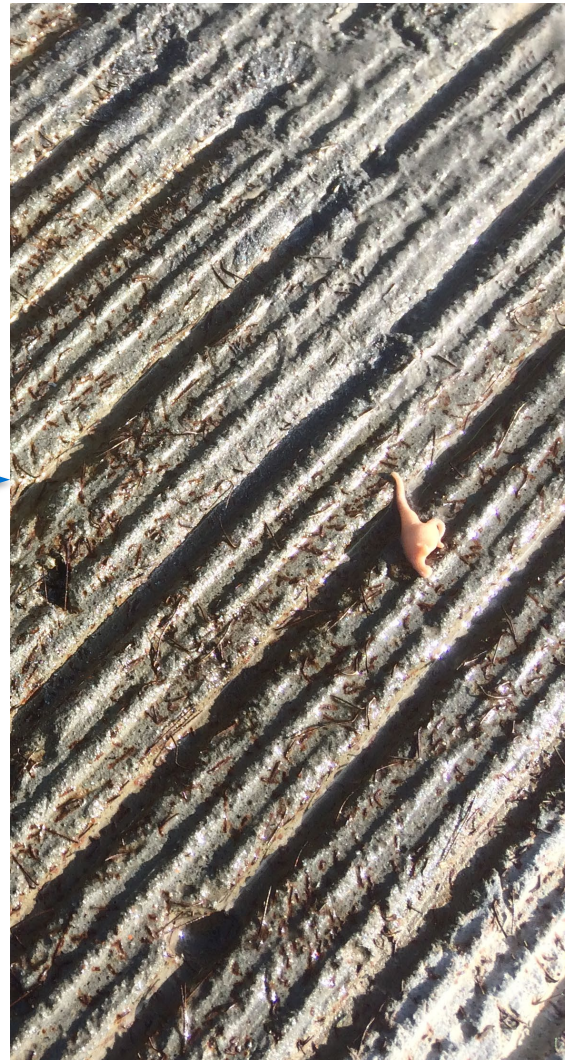
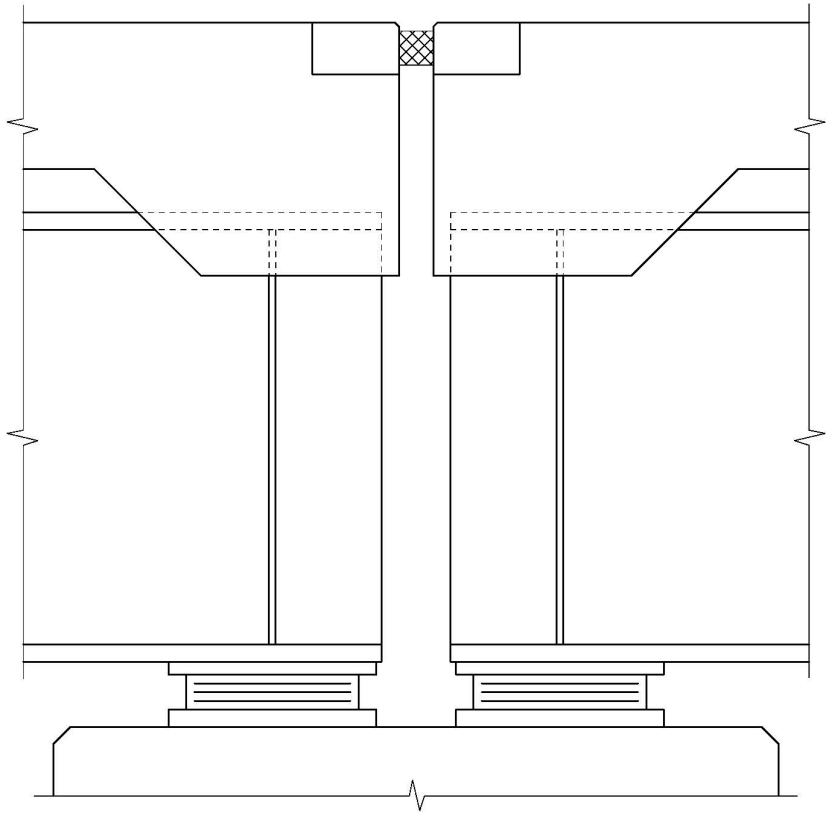


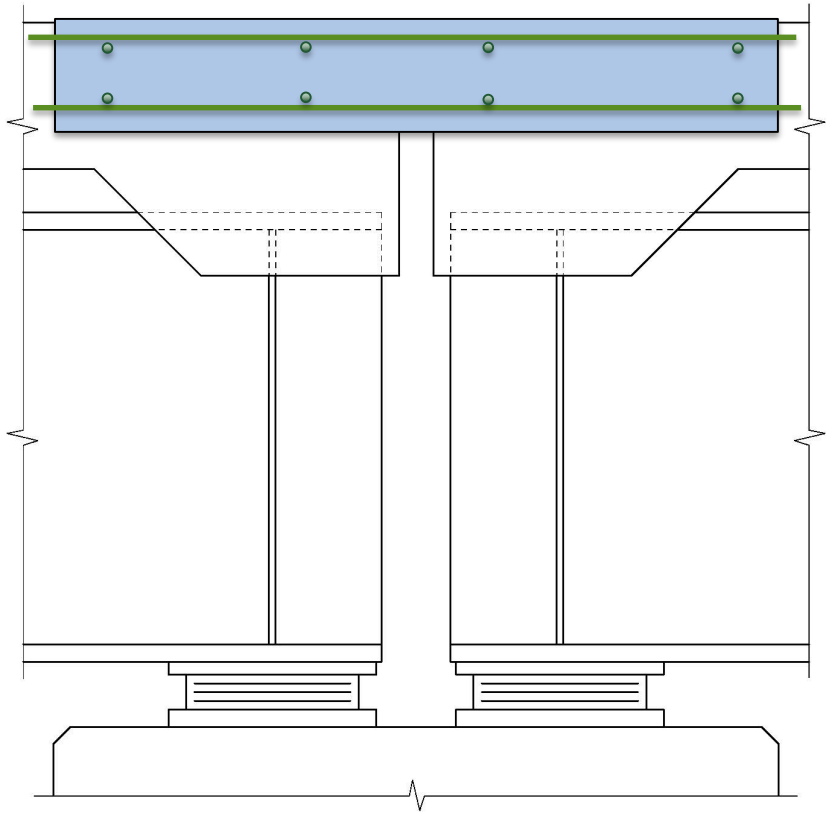
Haber et al., 2018. *Bond characterization of UHPC overlays for concrete bridge decks: Laboratory and field testing.*

Expansion Joint Repair / Elimination

One repair solution is to eliminate the joint…

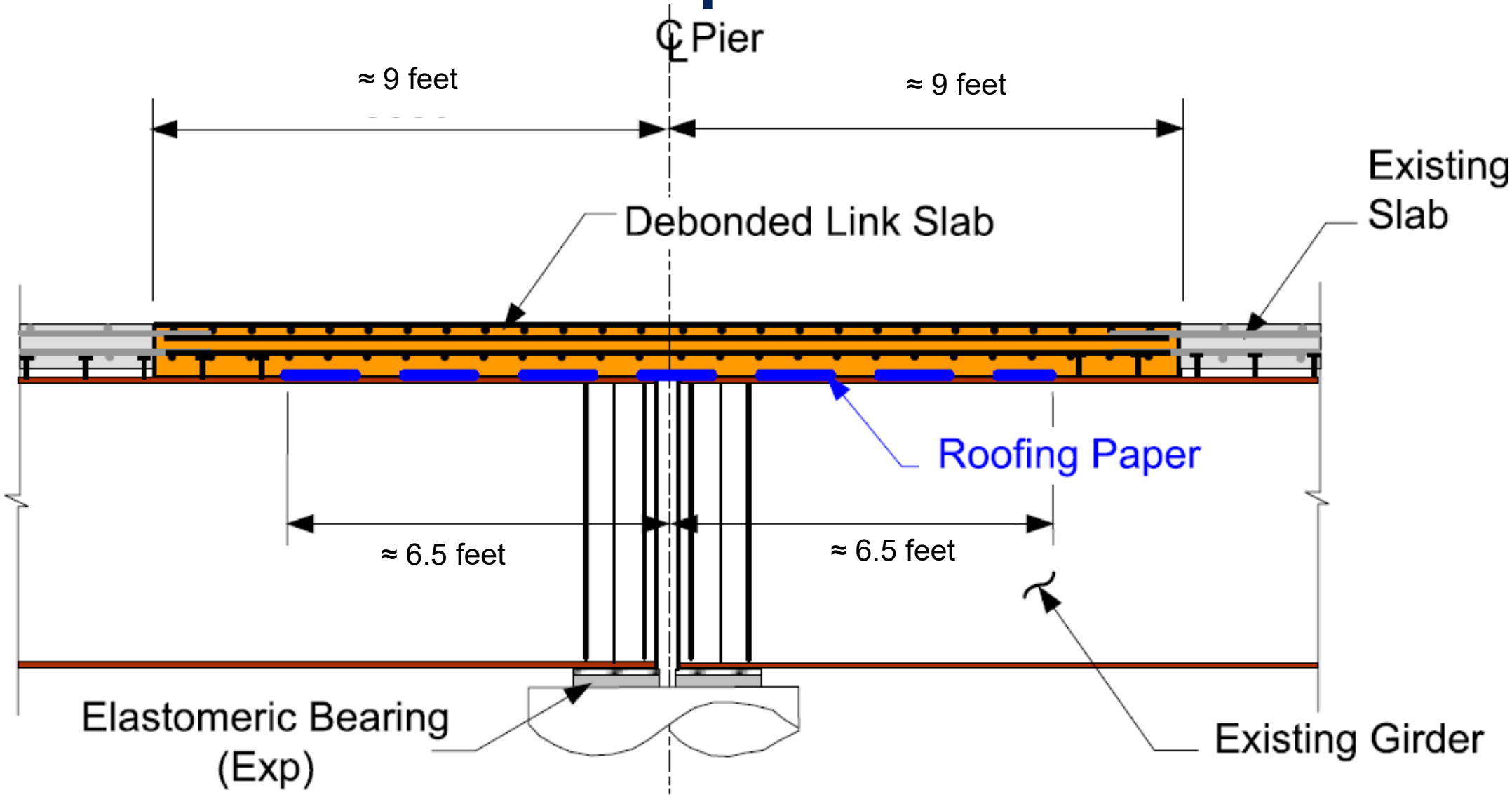


Jointed



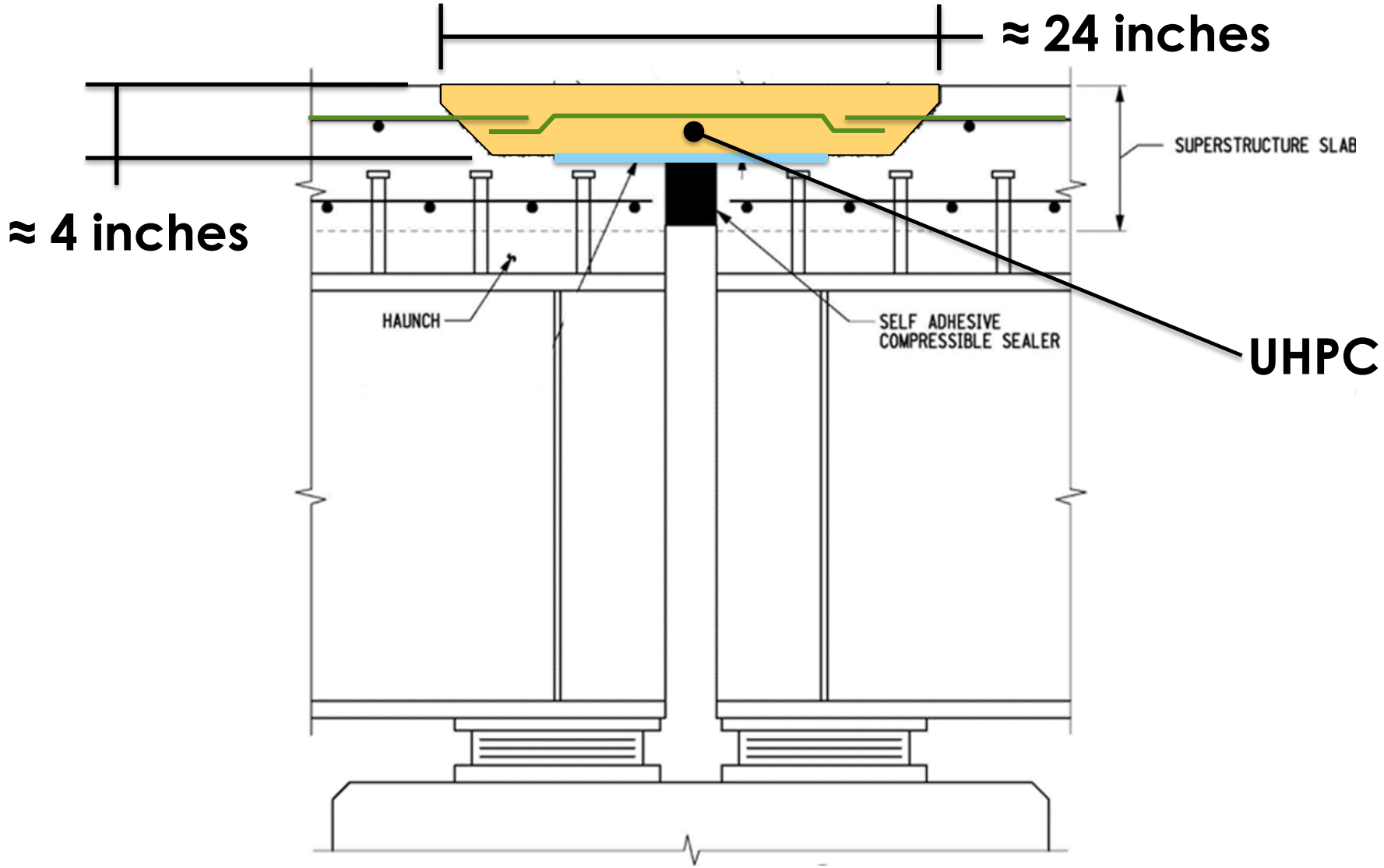
Joint Eliminated

Traditional Link Slab Example



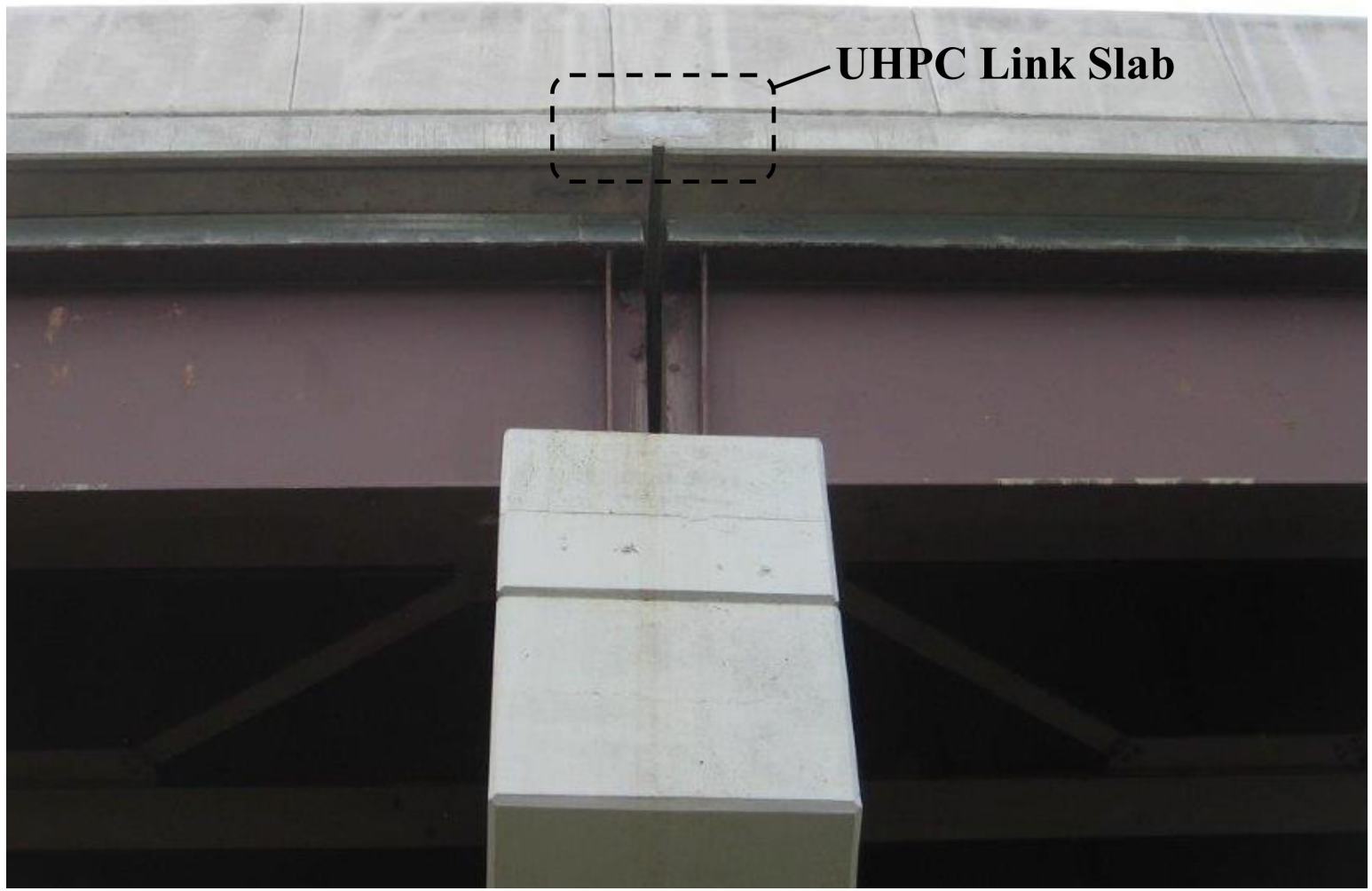
ascelibrary.org

Conceptual Example of a UHPC Link Slab

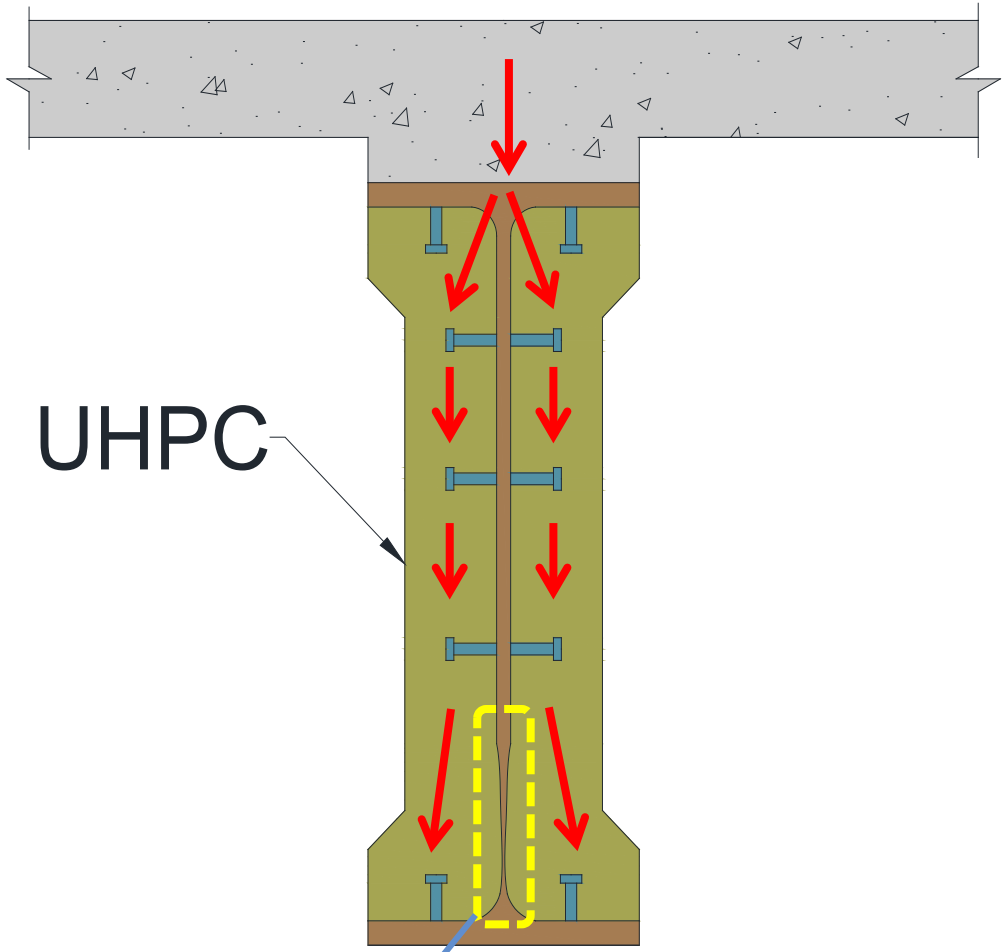


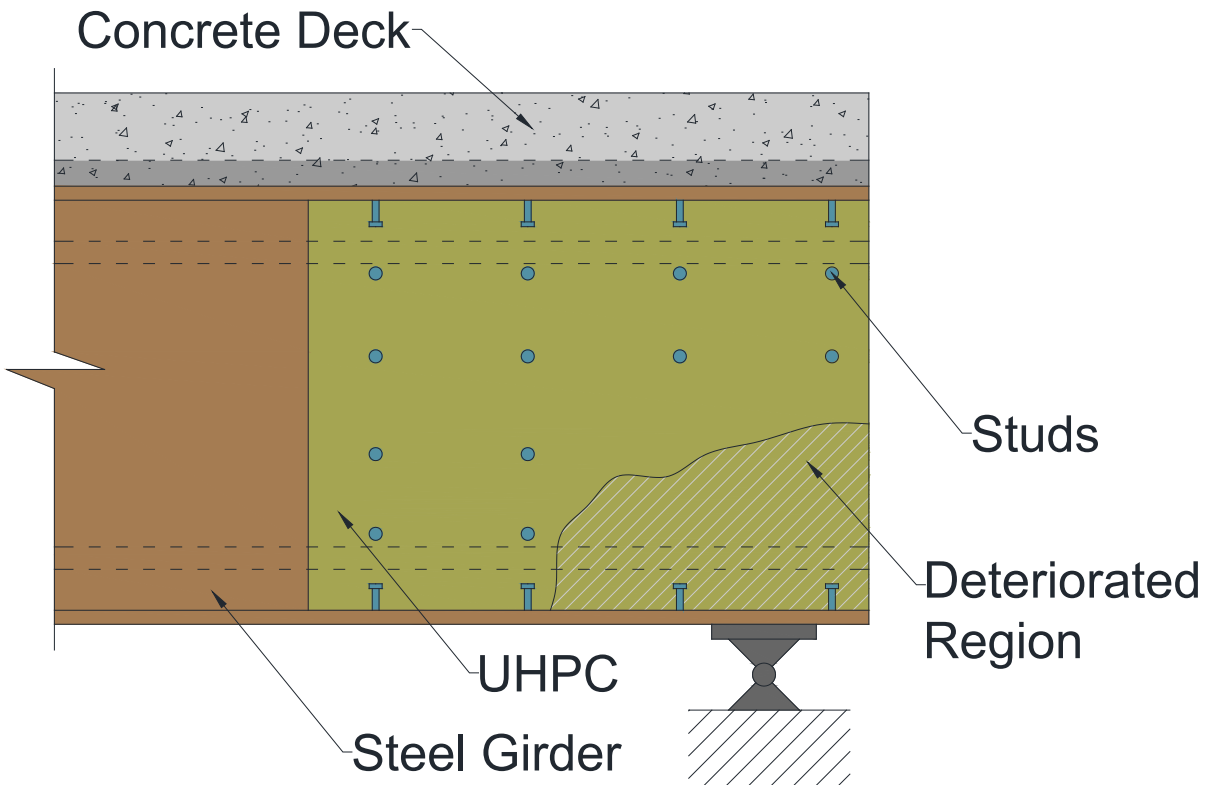
Expansion Joint Repair / Elimination

Deployment: SR962G, Owego, NY



Repair of Corroded Beam Ends



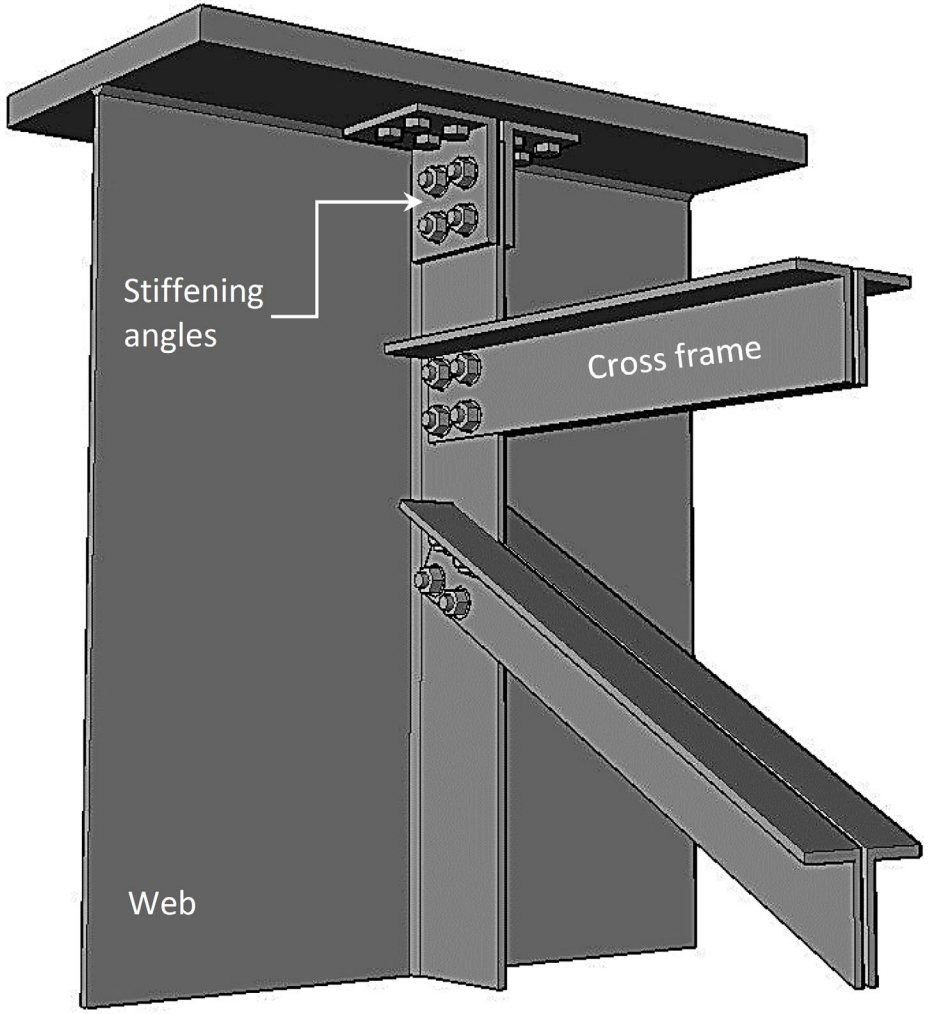


Source: K. Zmetra

Strengthening of Deteriorated Beam Ends

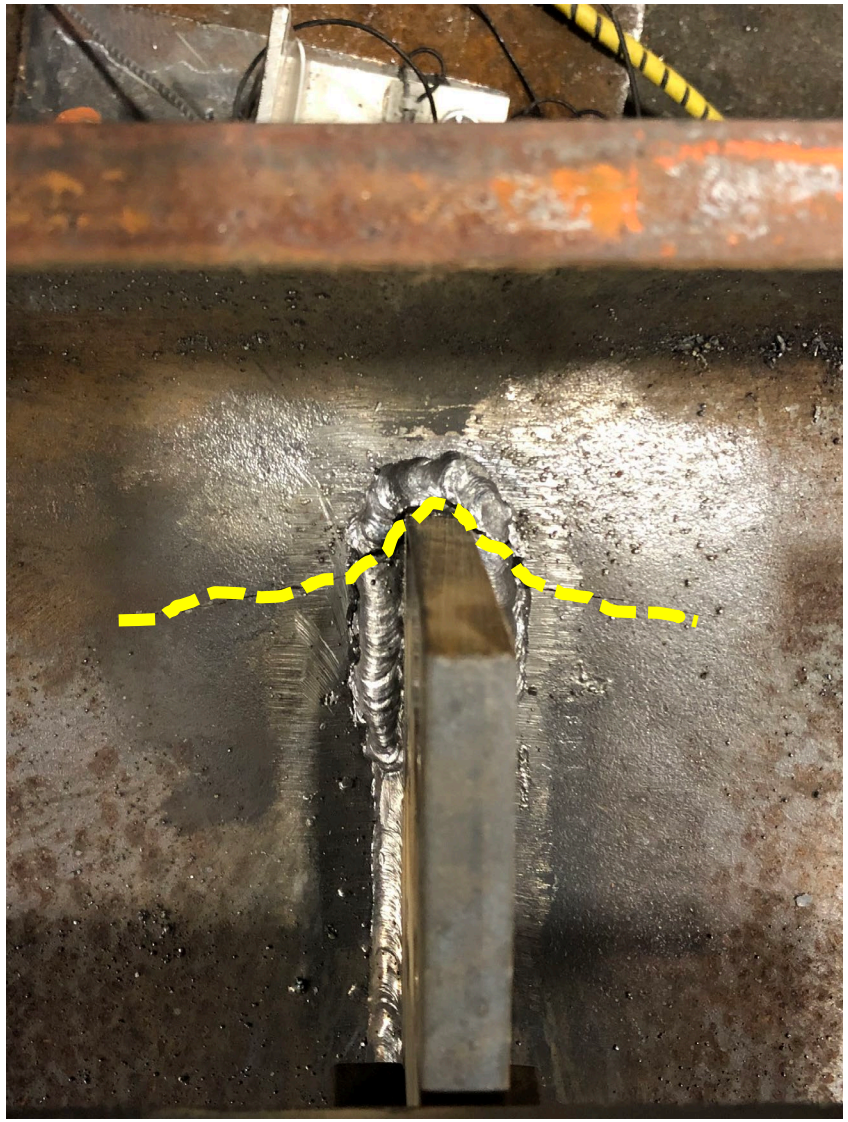
Fatigue Crack at Connection Plates

Distortion Induced Cracking



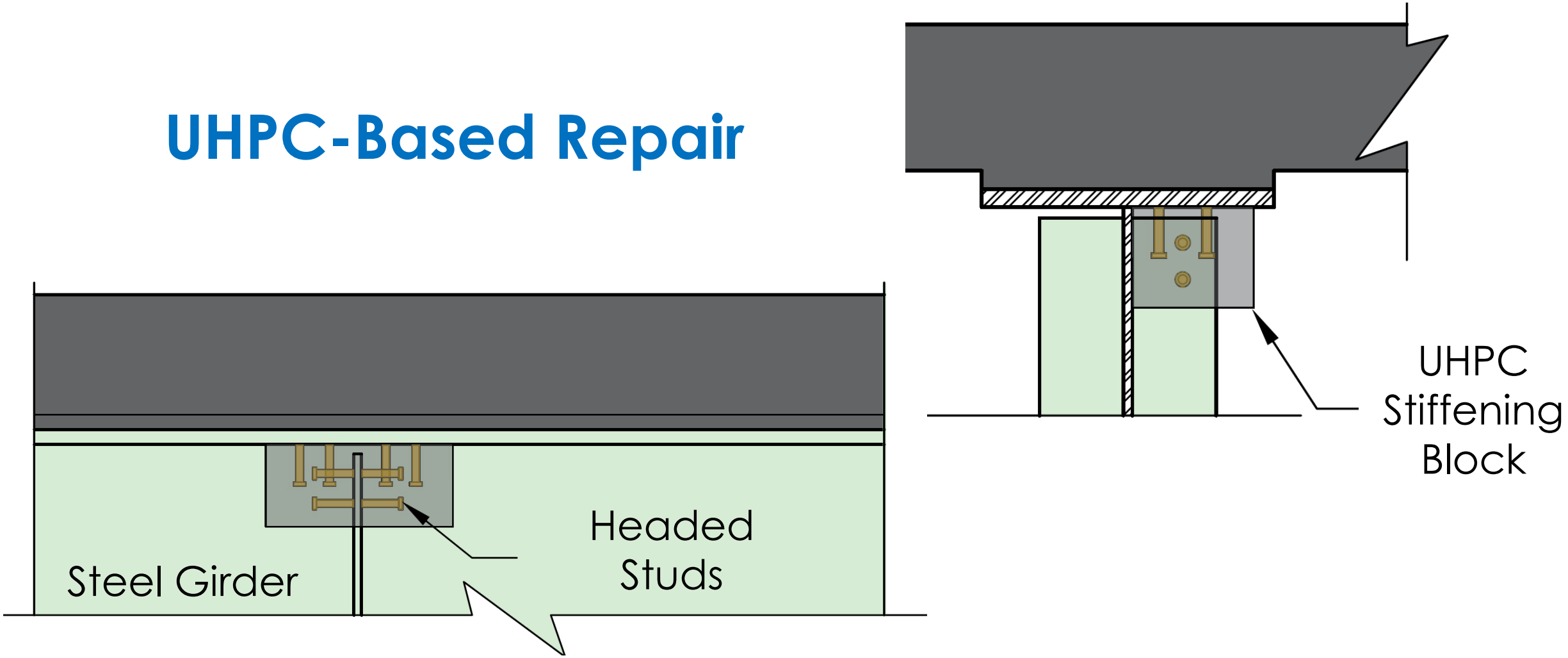
Conventional Repair

Web-Gap Fatigue Crack Repair



Web-Gap Fatigue Crack Repair

UHPC-Based Repair

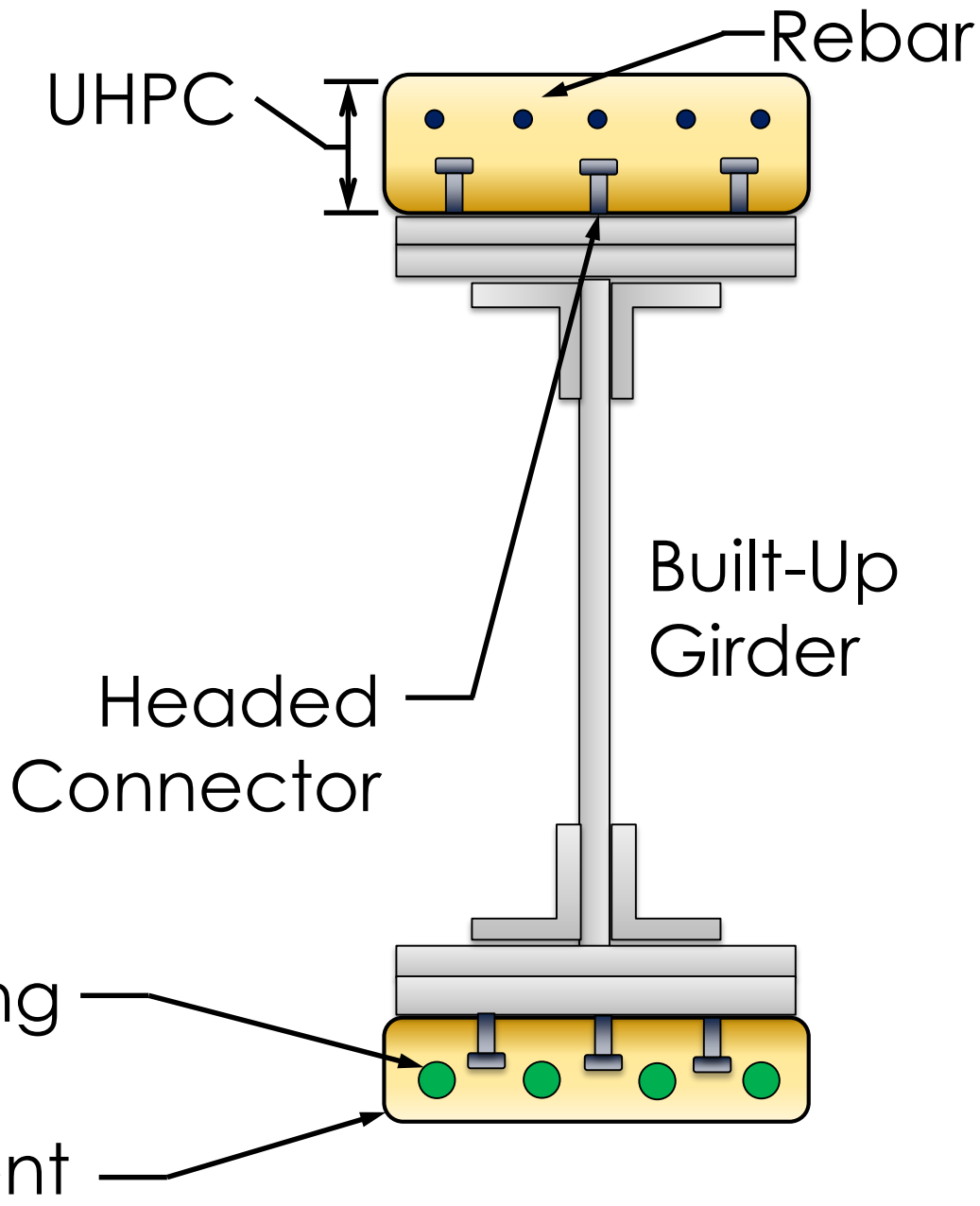


Strengthening of Riveted Thru-Girders

Early 1900s Riveted Steel Bridge Structures

A Potential Solution

- **UHPC Topping + Bonded Post-Tensioning**
- Capacity Increase
- Live + Dead Load Stress Reduction
- Complete Composite Action
- Enhanced Structural Efficiency
- Impact Protection



In Partnership with

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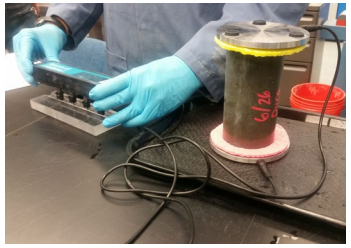
Some resources

- UHPC Project Website
  - go.usa.gov/xEWCf
  - Google: **UHPC FHWA**
- Design guidance document is forthcoming, hopefully early next year
- Project team
  - A team of FHWA structural and materials engineers based at Turner-Fairbank that can provide technical assistance with your project

Structural Materials Research Program
Turner-Fairbank Highway Research Center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More info at: go.usa.gov/xEWCf

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