SMART^UP UHPC

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Presentation Outline

What is UHPC?

Why UHPC/How do we justify UHPC?

DOT Update

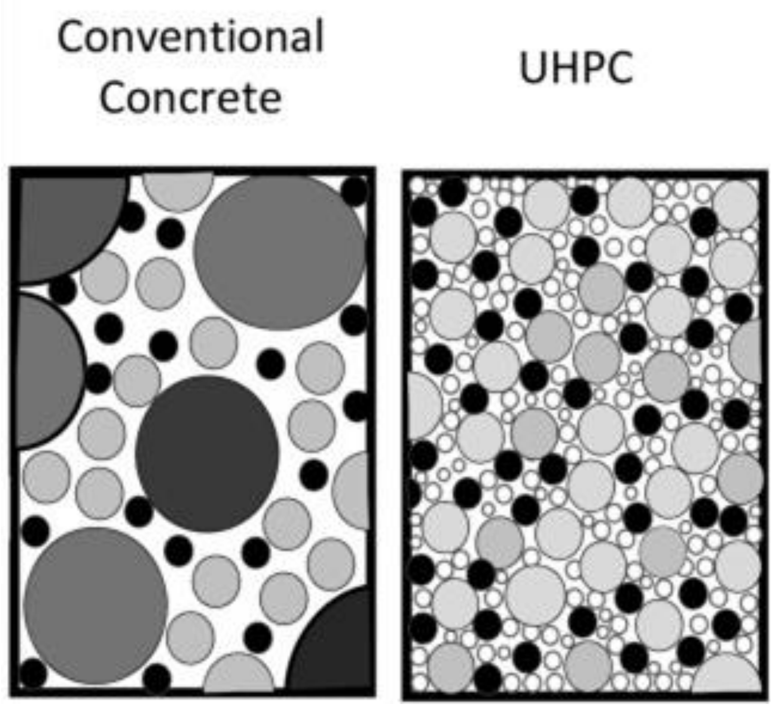
Architecture

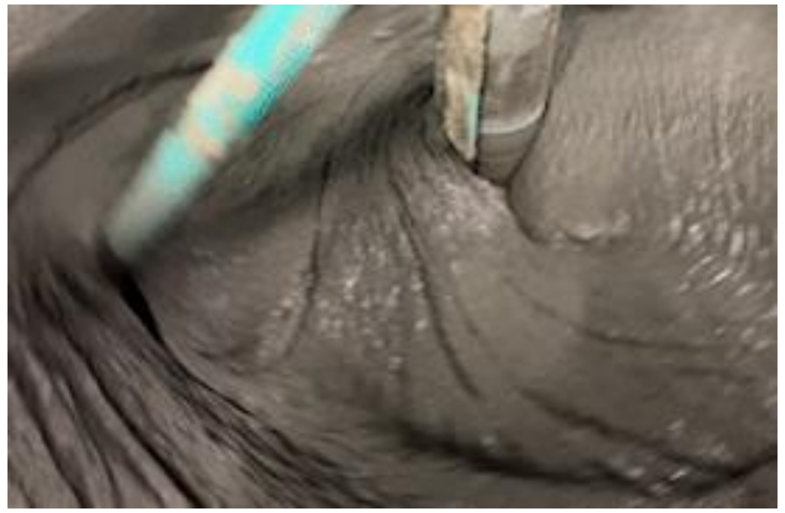
What is UHPC

UHPC Composition

Particle Packing Theory

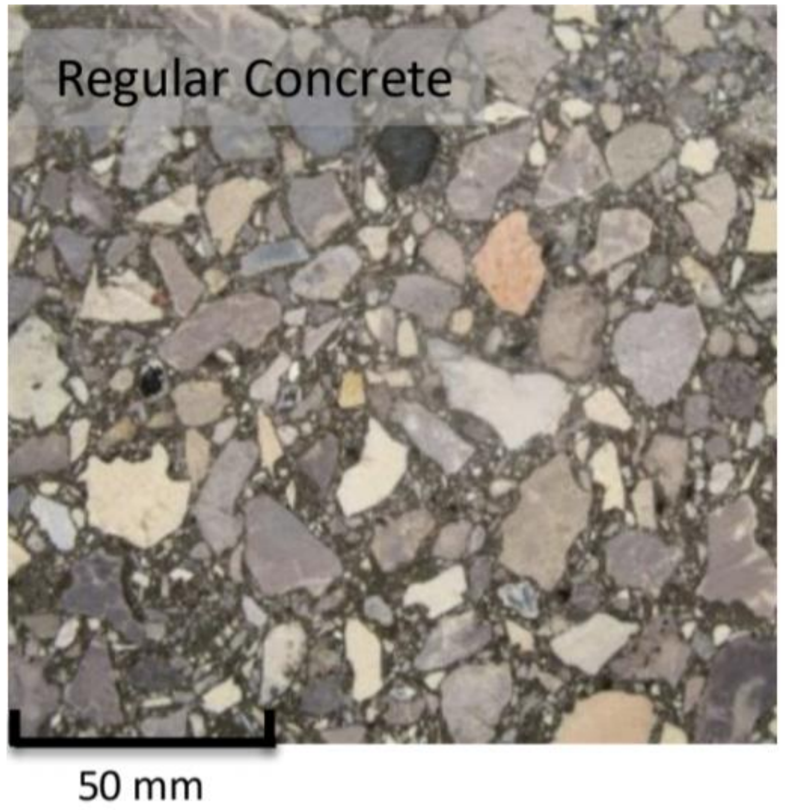
- Optimal gradation of particles to significantly reduce air voids and increase particle-to-particle surface contact
- Cement supplemented with SCMs and fine powder fillers
- No coarse aggregate, only very clean fine aggregates
- Extremely high compressive strengths achieved

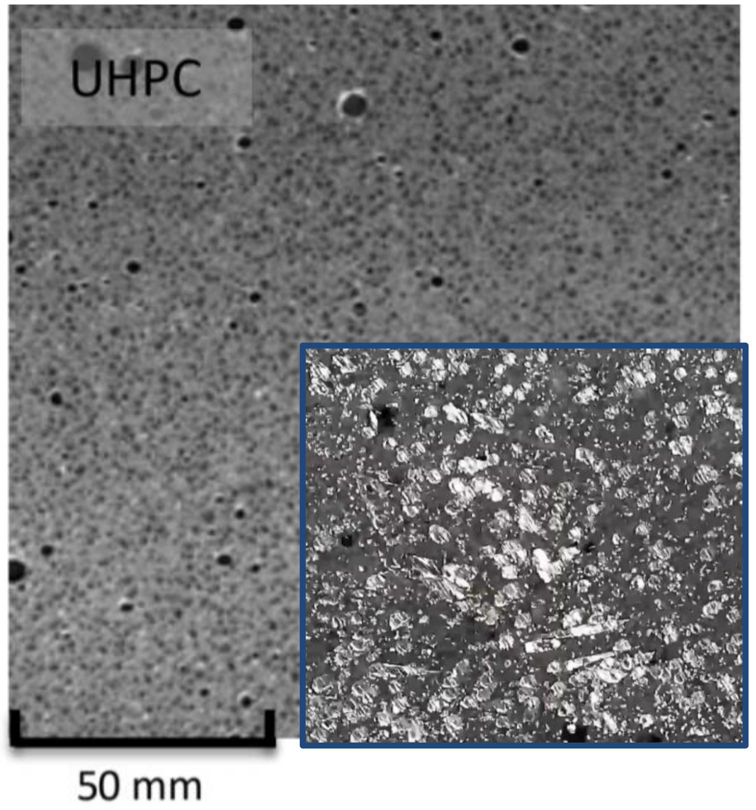




Additional Improvements

- Microfibers to bridge microcracking and improve concrete's weakest performance (tension)
- High-range water reducers (superplasticizers) maintain high flowability while keeping w/c ratio very low
- Accelerators encourage rapid strength gain





Smart-Up Composition

Smart-Up is a ready-to-use solution - “just add water”

Why UHPC?

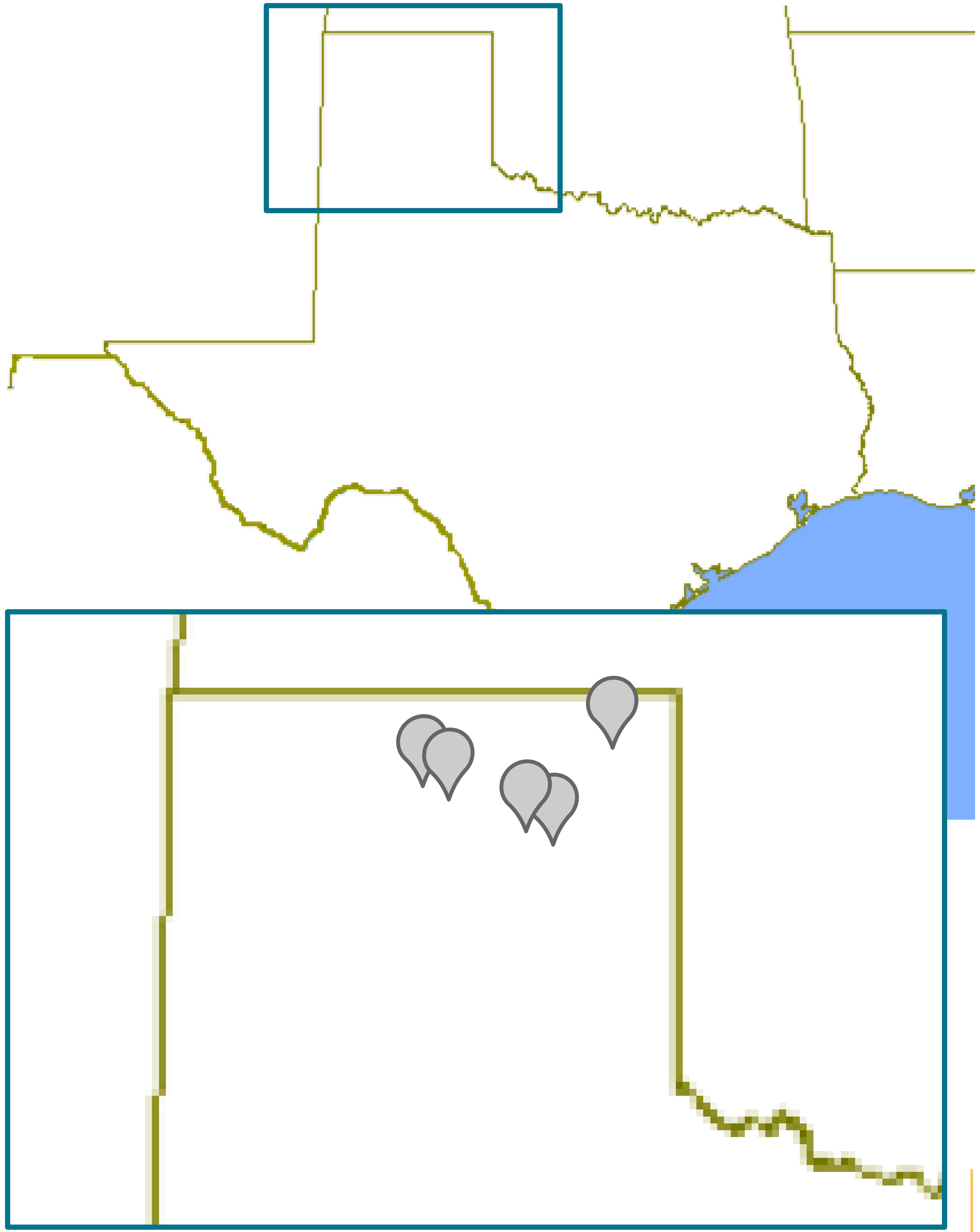
Project Scope

Stakeholders

- Owner: TxDOT
- Design Engineer: Thompson Engineering
- Contractor: Webber Construction
- Fabricator: Texas Concrete Partners (precast NEXT beams and bent caps)
- UHPC Supplier: UHPC Solutions and SMARTUP

Project included 5 bridges

- US83 at West Fork Horse Creek (North): 70-70-60 ft. spans
- US83 at West Fork Horse Creek (South): 70-70-70 ft. spans
- SH15 at Palo Duro Creek: 60-60-60-60-60 ft. spans
- SH15 at Farwell Creek: 70-70 ft. spans
- SH15 at Ivanhoe Creek: 60-60-60-60 ft. spans



SMARTUP Ultra High Performance Concrete

Precast Elements

Majority of bridge is precast

- Abutments and wing walls
- Bent caps
- NEXT beams
- Bridge end slabs and safety barriers are cast-in-place on this project, but could also be precast to reduce construction time.

UHPC joints and concrete bridge end slabs are the only cast-in-place components needed before traffic can return.

Safety barriers are cast-in-place but can be poured after traffic returns.

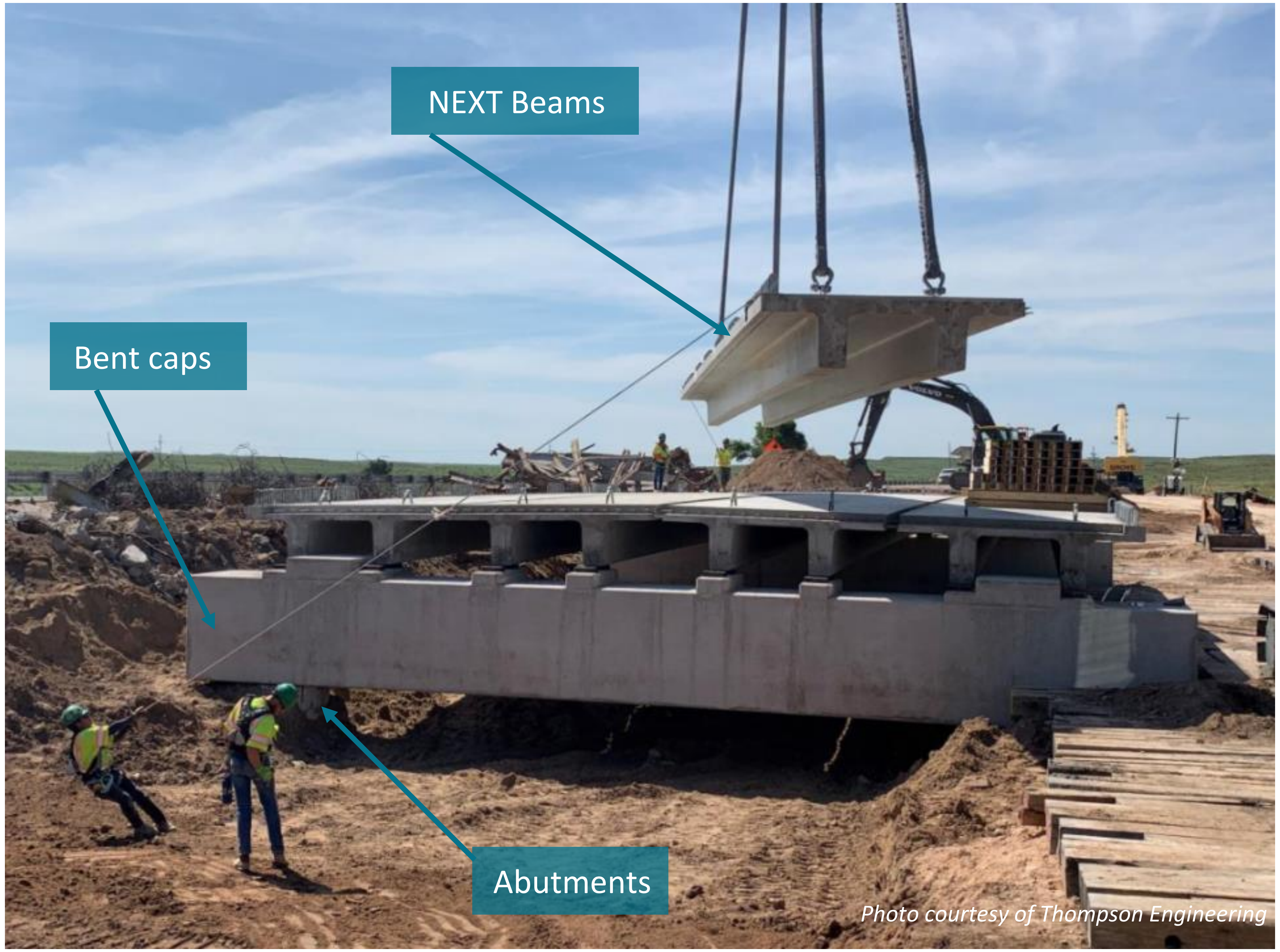


Photo courtesy of Thompson Engineering

Joint Configuration

Compared to traditional concrete:

- Connections between precast elements are simplified and smaller
- Volume of UHPC and length of rebar reduced by up to 50%
- Straight rebars develop adequate strength - no bending or headed bars needed
- After prep work, UHPC placement averaged 5-6 hours on each bridge
- No consolidation methods needed - UHPC is self-consolidating and self-leveling
- Connections are possibly strongest part of bridge instead of weakest part, and durability of the bridge is enhanced

Interstate System

Constructed in the 1960-1970's.

Bridges designed for 50 years

Truck Traffic Estimates were 10%

Truck Traffic Today is 50+% in many Urban Areas

Average Daily Traffic has Sky Rocketed

Why?

Pros

Permeability	Freeze thaw resistance
Carbonation	Abrasion resistance
Sulfate resistance	Alkali-silica resistance
Marine exposure	Fire resistance
Impact resistant	Longer last
Longer elements	Reduced steel
Smaller/lighter elements	

Advantages for Transportation Sector

Harsh Conditions

- Most transportation infrastructure is completely and consistently exposed to weather, road surface treatments, and debris tracked in by tires
- Per the properties mentioned earlier, UHPC is incredibly resistant to challenging environments
- Constructing components from UHPC or covering/protecting them with UHPC repairs can mitigate this environmental attack
- **Service life is significantly extended**

Accelerated Bridge Construction Methods

- Stakeholders are requiring shorter timelines for construction projects and fewer traffic interruptions than ever before
- UHPC achieves rapid, high strength gain that can support traffic loads in a matter of days
- UHPC facilitates ABC methods (discussed in depth later) to rehabilitate infrastructure in a fraction of a traditional timeline
- **Detours, road closures, and accidents/injuries are reduced**

Sustainability

- For a typical structure, UHPC will outlast conventional concrete by 2 to 3 times
- Higher energy/emissions per CY are offset by less initial quantity needed and longer life cycle
- **Fewer materials, fewer emissions, fewer replacements, and better quality maintained throughout service life**

Lower life cycle cost

- Higher initial cost is offset by lower maintenance costs and fewer repairs needed over the life cycle of a UHPC structure
- **Initial investment is paid back over the service life of the structure**

DOT Update

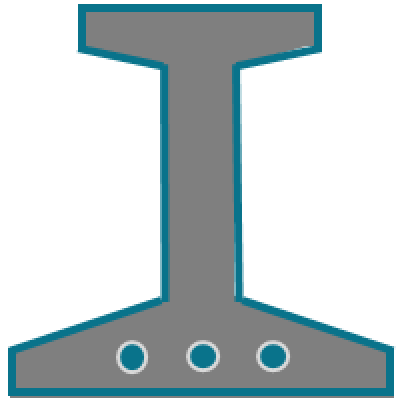
DOT Update

Presentations

ALDOT, MDOT, TDOT, GDOT NCDOT, LaDOTD

Photo courtesy of Vicat Group

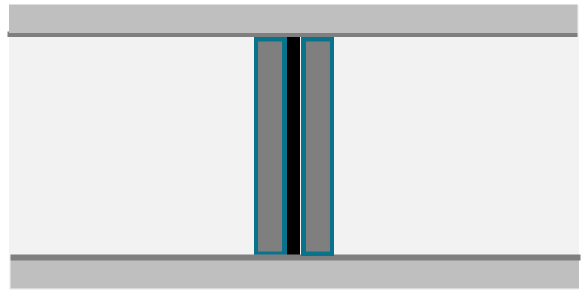
SMARTUP for Structures



Structural Members

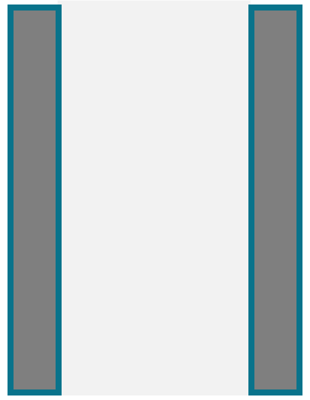
Joint Fills

Link Slabs

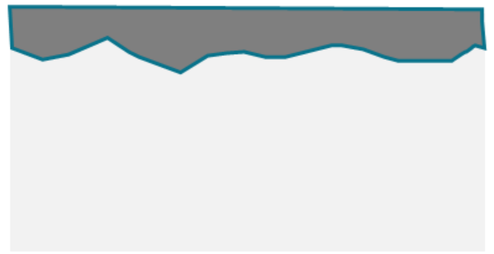


Joint Header Repairs

Beam End Repairs



Column Jacketing

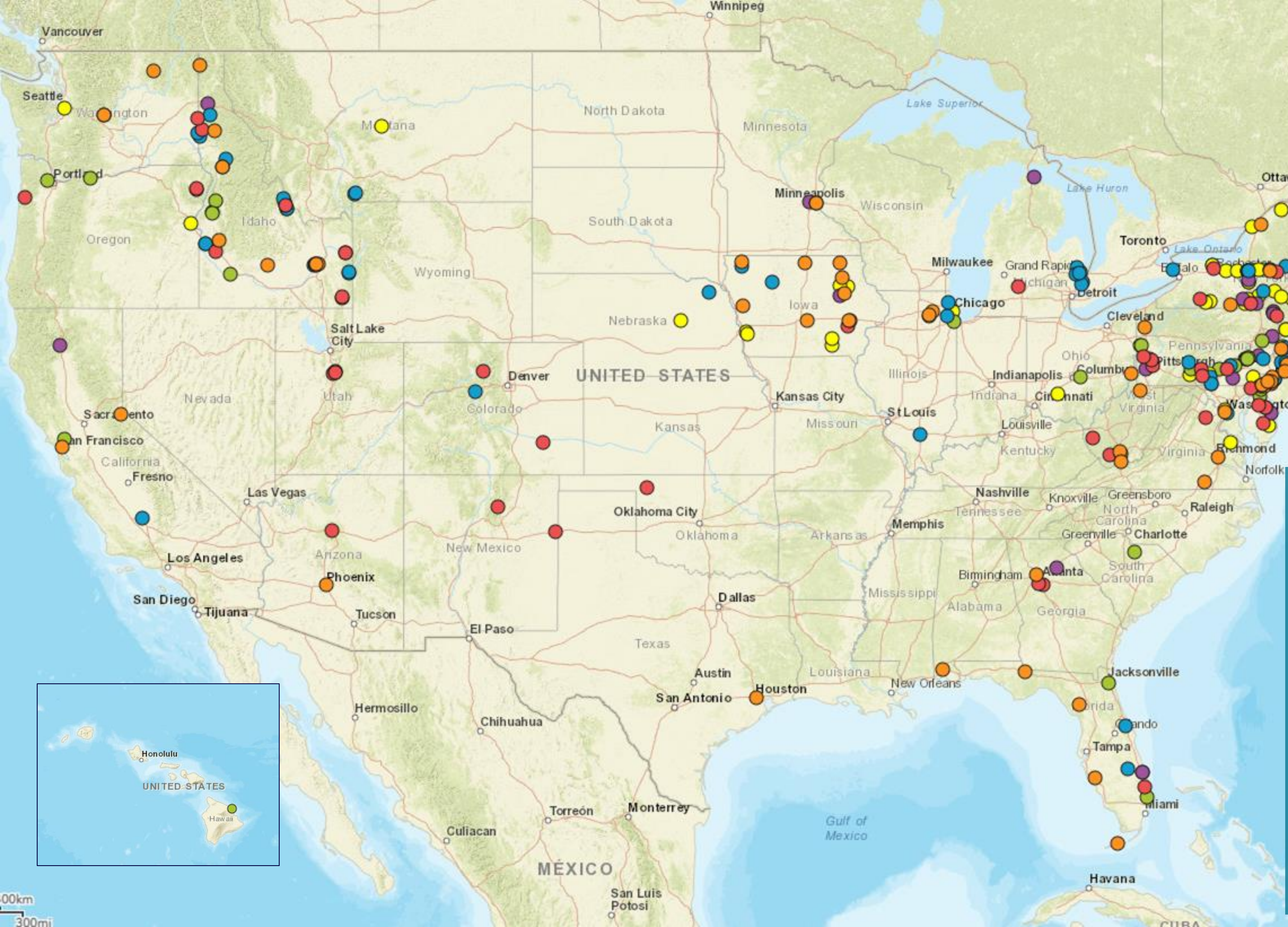


Overlays

Alternative H-Pile Design with UHPC

ALDOT Research Project

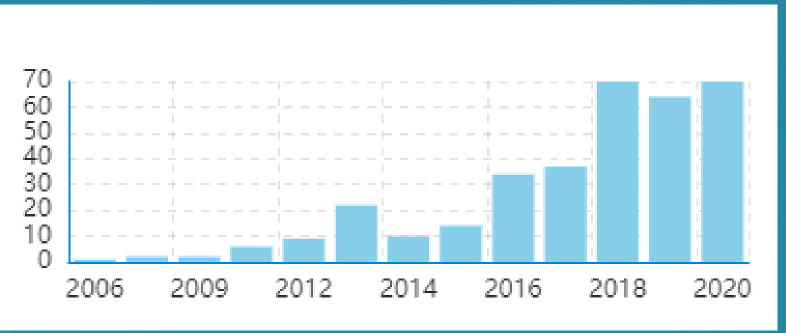
- Collaboration with the University of Alabama, Forterra Pipe & Precast, and SMARTUP
- Steel and concrete substructure is easily deteriorated by harsh ground conditions (water and chloride intrusion)
- Prestressed UHPC H-piles that mimic the shape and drivability of standard steel cross sections, but will provide longer service life and fewer maintenance costs
- Precaster gains experience working with UHPC on their yard and with their crew
- UA researchers included hundreds of sensors that will capture performance



UHPC Deployments in the United States

Total of 341 projects realized

The future is here!



Photos courtesy of the FHWA Interactive Deployments map

Applications

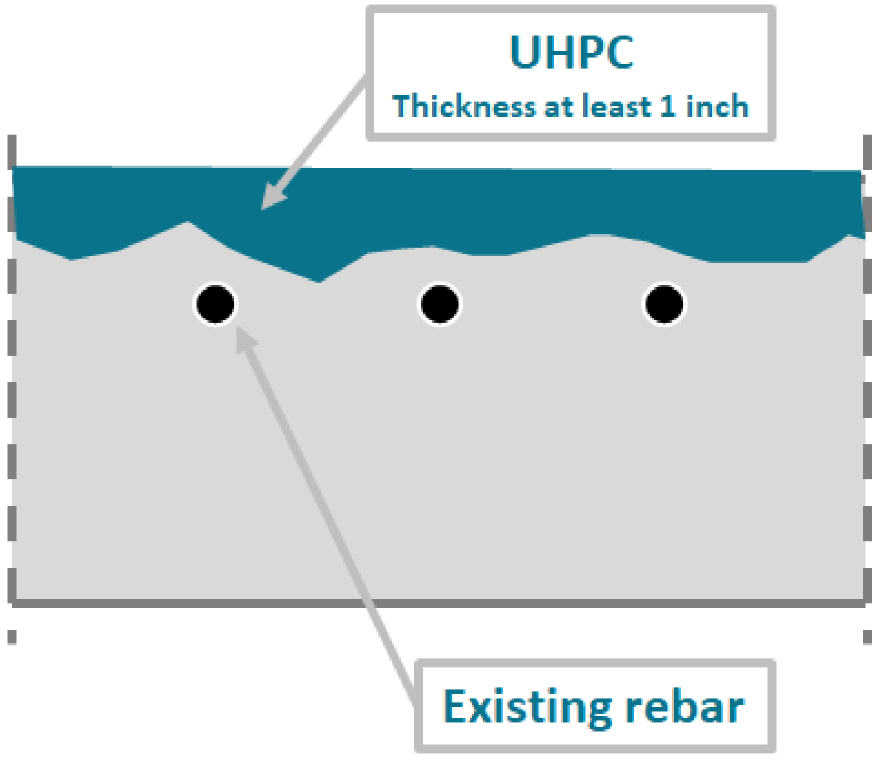

SMART^UP for
Architecture


Photo courtesy of WALO

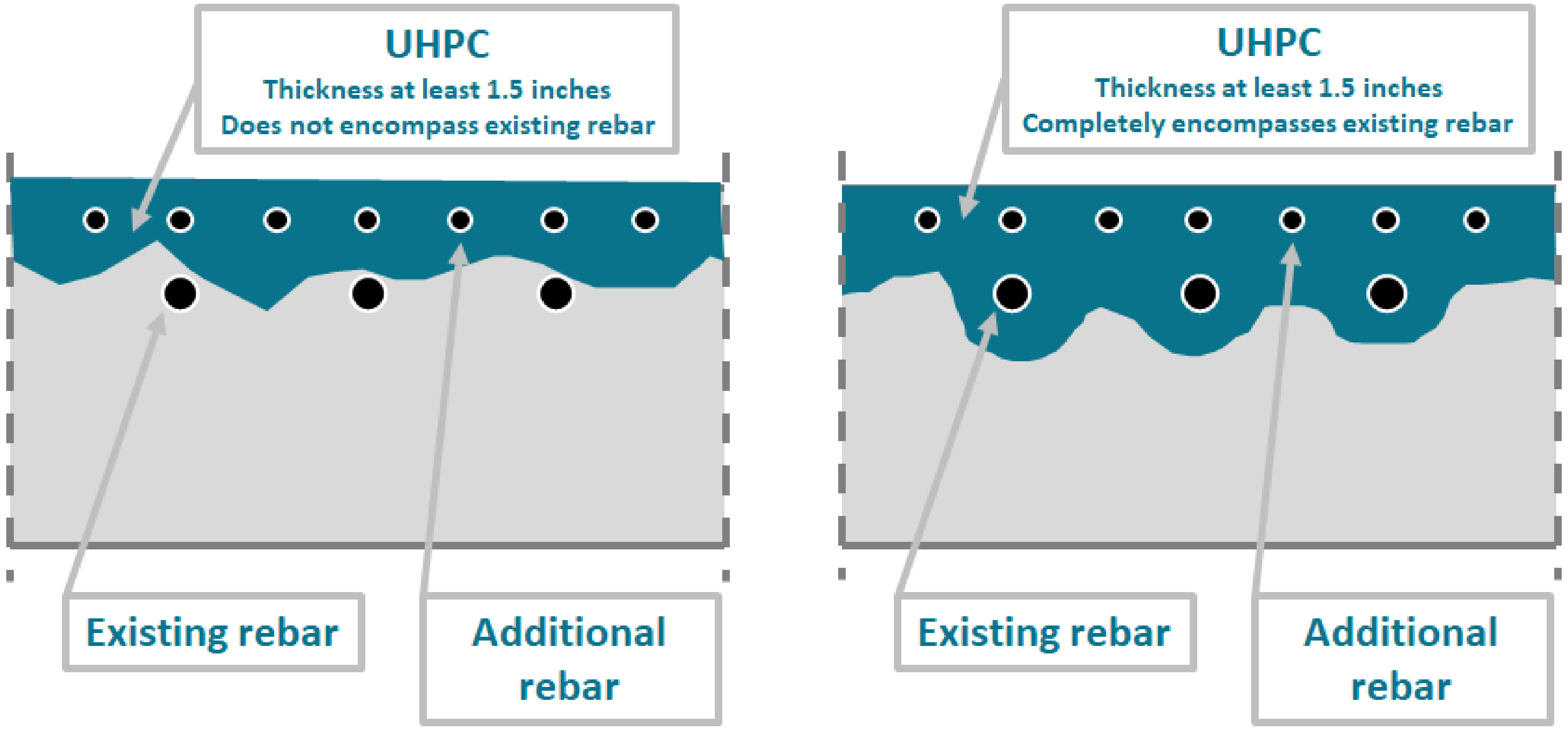
UHPC Overlays

UHPC Overlay Options

Protective Overlays



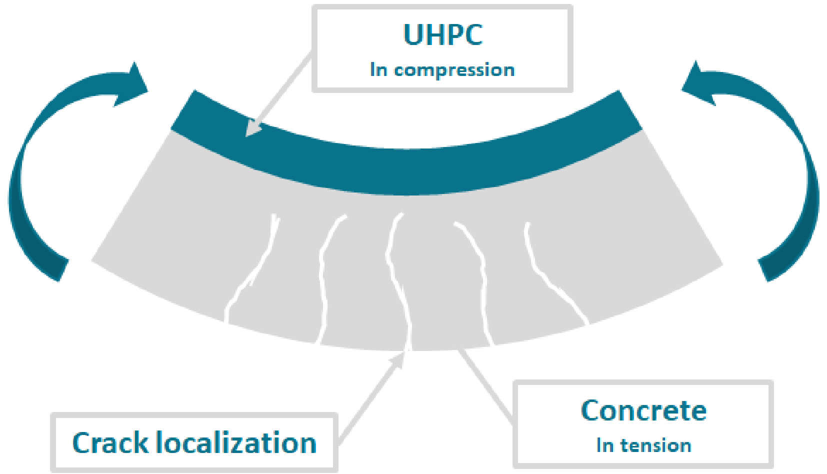
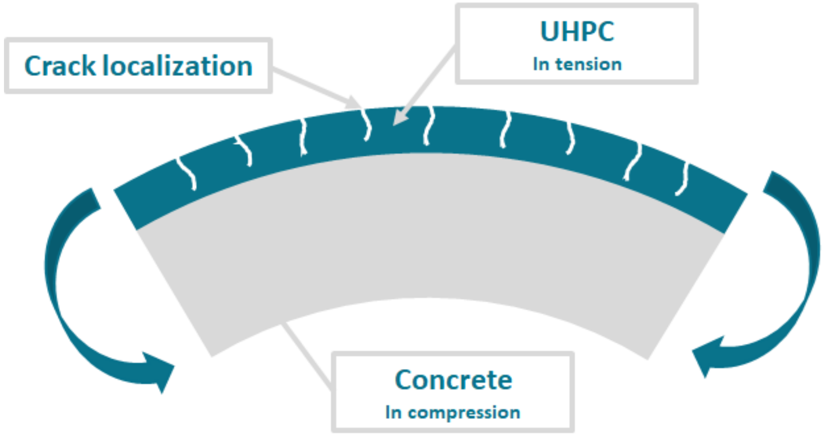
Structural Overlays



Riding / Walking Surface Finishes

- Ground and grooved UHPC, even with steel fiber reinforcement, is safe for vehicle tires and provides a smooth ride
- Additional asphalt topping can be applied as a riding surface

Strength Gain Possible with UHPC Overlay

Bending Direction	Moment Capacity Increase per UHPC Overlay Thickness			
	0.5 in	1 in	2 in	3 in
Positive Bending Capacity lost when UHPC is crushed 	+ 31%	+40%	+60%	+60%
Negative Bending Capacity lost when UHPC reaches crack localization 	+0%	+15%	+44%	+66%

Strength gain through a UHPC overlay requires full composite action between the original reinforced concrete and new UHPC layer.

Without shear studs linking the two layers as might be expected in a steel-concrete composite deck, the concrete-UHPC slab relies on excellent interface bonding.

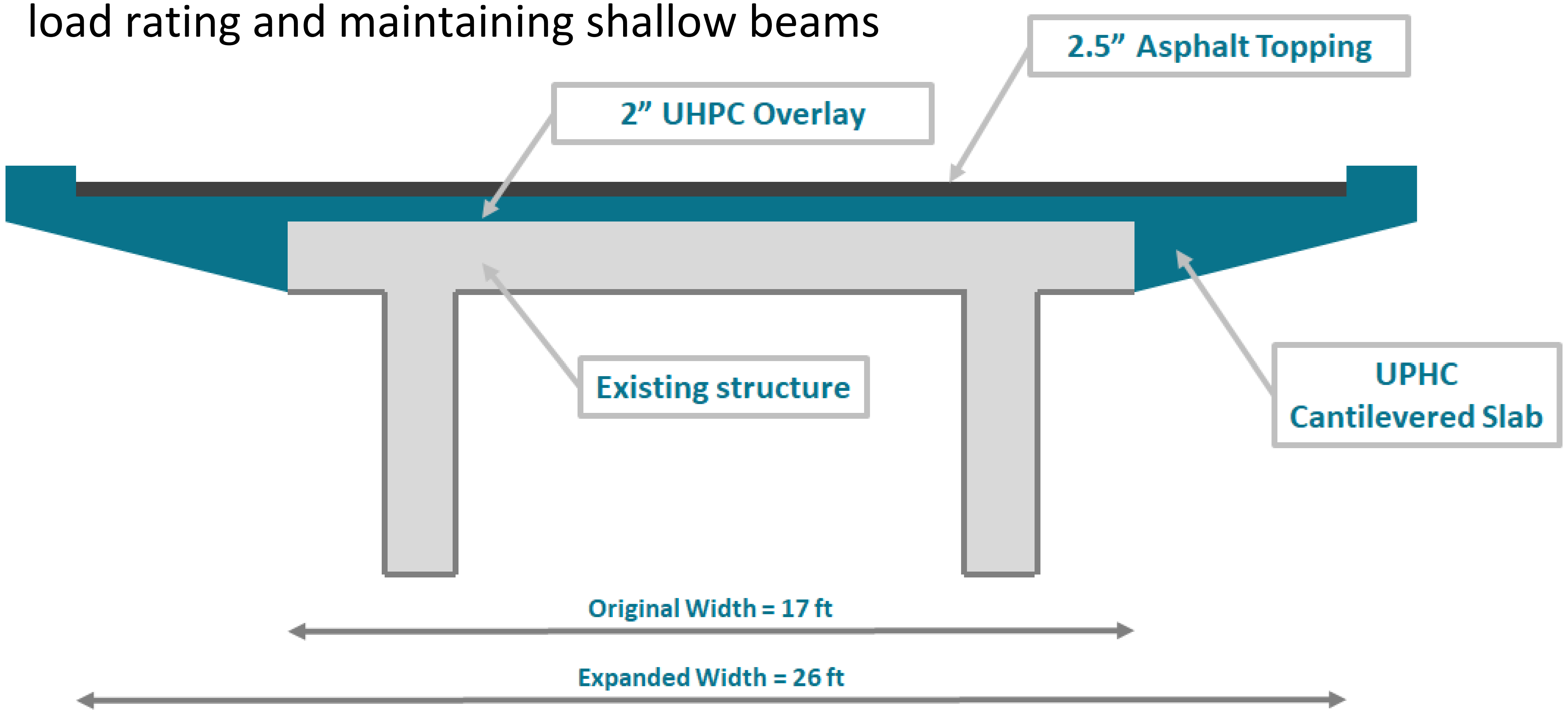
Data courtesy of FHWA

Widening the Road with a UHPC Overlay

Post-Tensioned Bridge, Switzerland

- 115-ft span bridge with tight clearance requirements over river, originally built in 1958
- Wider lanes needed to accommodate changing traffic patterns
- Structural UHPC overlay increases width by 50% while also increasing structural capacity / load rating and maintaining shallow beams

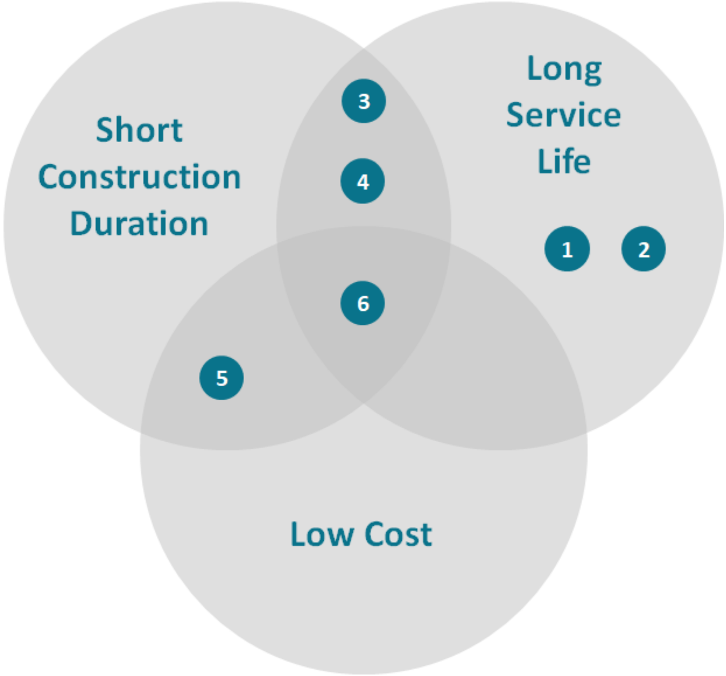
Photos courtesy of Eugen Bruhwiler



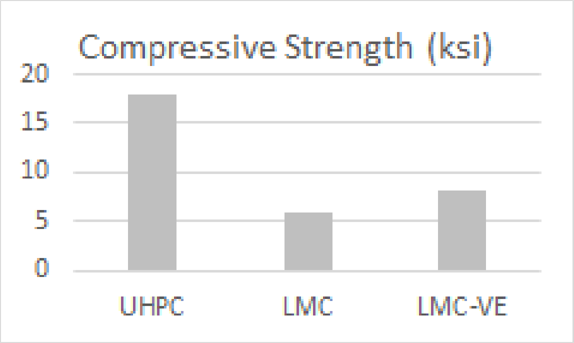
Financial Argument for UHPC Overlays

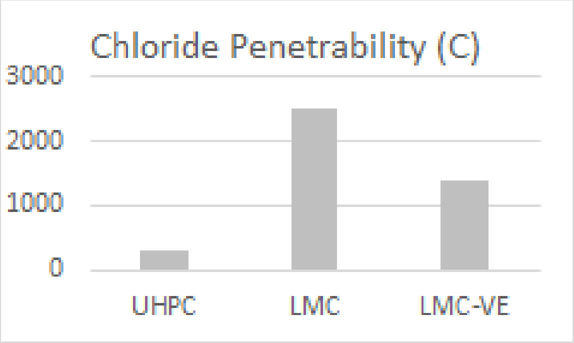
Delaware Memorial Bridge, DE/NJ Border

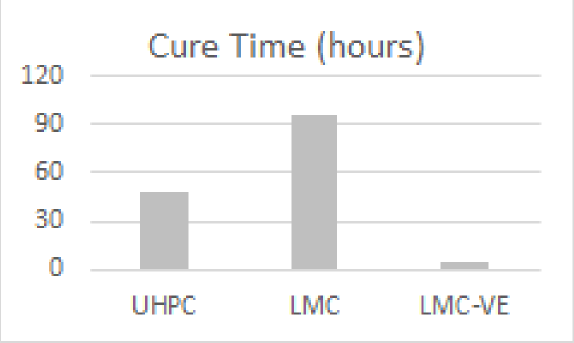
- First bridge built in 1951 with second twin span added in 1968, estimated at $940 million today
- Rehabilitation of the deck to extend service life after decades of use - compared replacement with overlays
- 4-inch UHPC overlay extends life for 50 years or more, with partial lane closures allowing continued traffic during construction
- Over 50 years, estimated $30 million saved using UHPC compared to other types of overlays

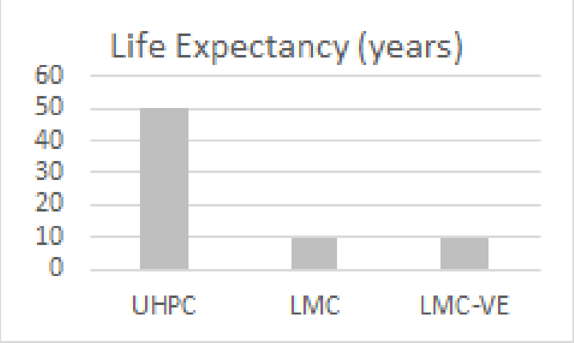


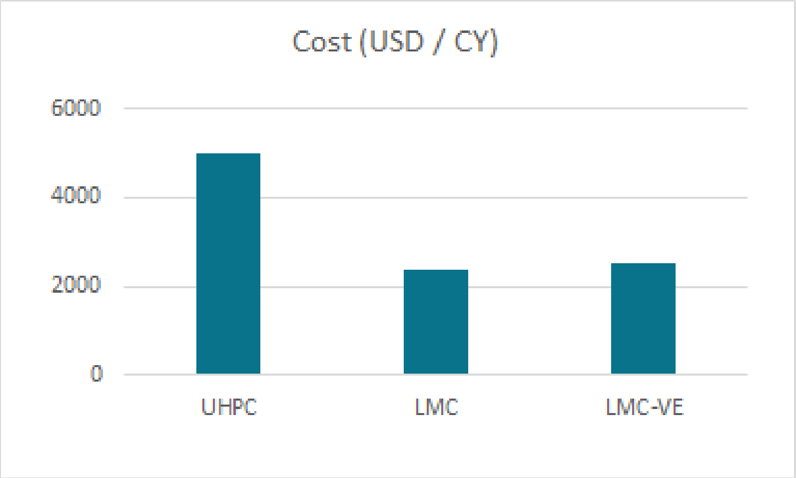
1. Cast-in Place Deck
2. Orthotropic Deck
3. Exodermic Deck
4. Precast Deck
5. LMC Overlay
6. UHPC Overlay

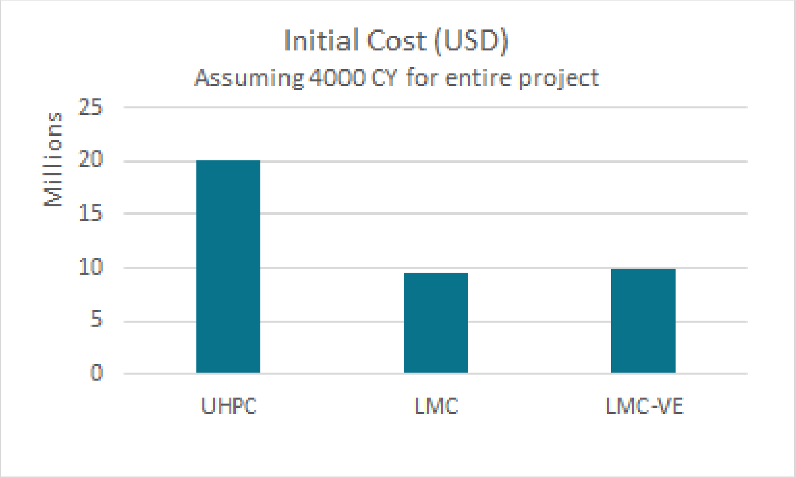


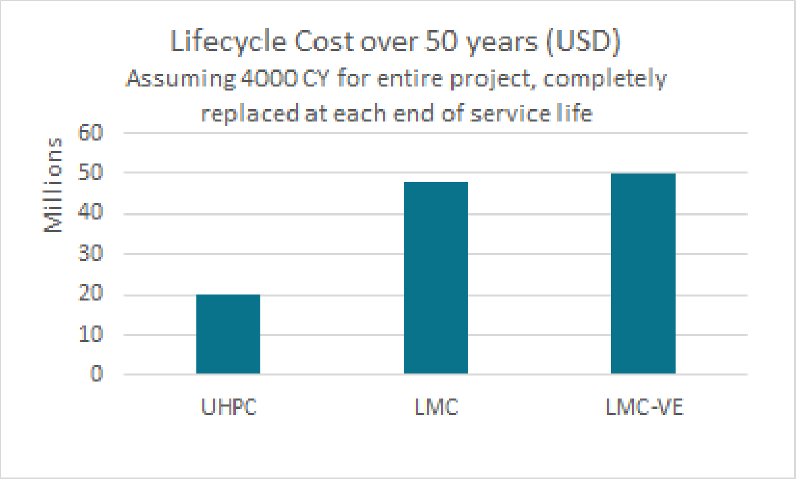












Data courtesy of DRBA

Case Study

Smart-Up UHPC Bridge Deck Replacement

Thouare sur Loire Bridge - Summer 2017

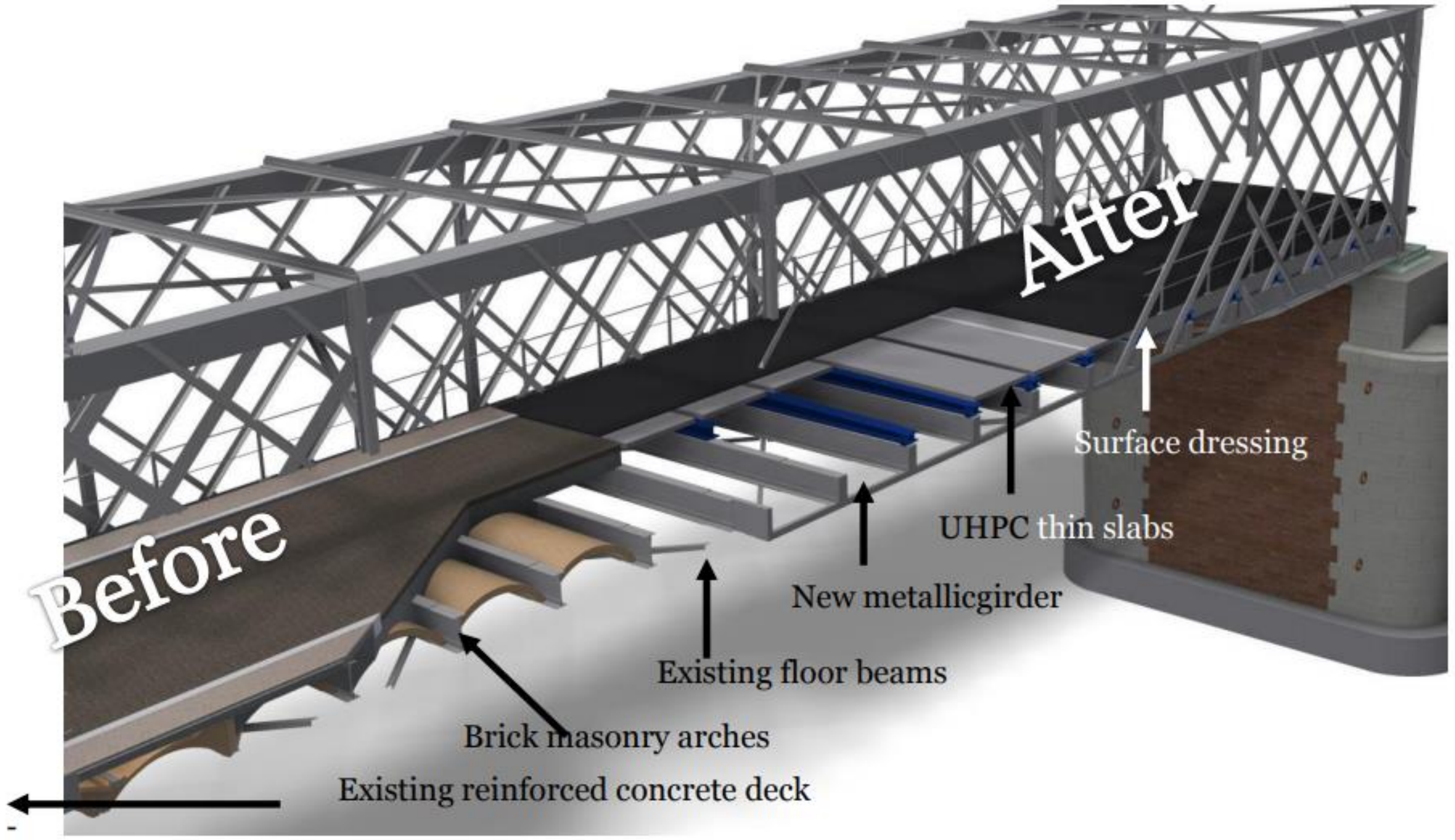
Project Scope

History and Challenges

- 1280 ft multispan bridge over Loire River
- Built in 1882 and experiencing deck and beam deterioration from failed waterproofing efforts
- Could not safely carry modern traffic loads
- Preserve historic structure while updating structural capacity


Photos courtesy of Vicat Group

UHPC Bridge Deck Replacement



Solution

- Remove brick masonry arches, and replace with thin UHPC slabs connected with UHPC joints
  - Waterproofing solution
  - Reduces deadweight by 3.3 million pounds, allowing increased traffic loads
- Replace deteriorating steel girders and apply new paint to address corrosion

Photos courtesy of Vicat Group

Case Study

Smart-Up UHPC Joint Fill for ABC Project

TxDOT, Hemphill County Bridges - Summer 2021