

# UHPC Overlays for Bridge Preservation – Lessons Learned

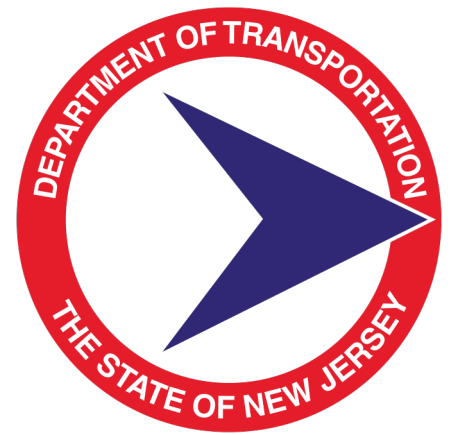
New Jersey  
Department of Transportation

Jess Mendenhall

Samer Rabie

Bureau of Structural Engineering

Structural Value Solutions (SVS)



# Overview – NJDOT Overlay Research Projects

- Pilot project to investigate UHPC overlay
- Ultra-High-Performance Concrete (UHPC) as a thin-bonded overlay
- Focus on rehabilitation and increased service life of bridge decks.
- 4 Bridges
- ~48,000 SF deck area
- 2 Contracts (North/South)



# Background

- Thin overlays are suitable to seal existing or new decks as surface treatment without a major change in the roadway profile.
- Concrete overlays not often used by NJDOT in recent years.
- UHPC overlay is high cost but offers potential life cycle cost benefits (\$\$)
- NJDOT is in the Demonstration and Assessment phases with pilot projects.



# Background

Advantages of UHPC overlays published include superior bond strength, compressive strength, lower permeability, more resistant to freeze thaw-damage, good abrasion resistance, rapid cure times, etc...

..Many ideal properties for a deck surface.

## Disadvantages:

- Material cost for UHPC is high; Bids for this project yielded an average cost of \$270 to \$410/SY or \$35 to \$46/SF (overlay only)
- Fresh UHPC does not bond well to hardened UHPC - careful consideration for joint construction is needed, including reinforced staging joints.
- Limited test data for construction materials to determine their ability to perform well with UHPC
- The NJ construction force is not familiar with the use of UHPC as an overlay.





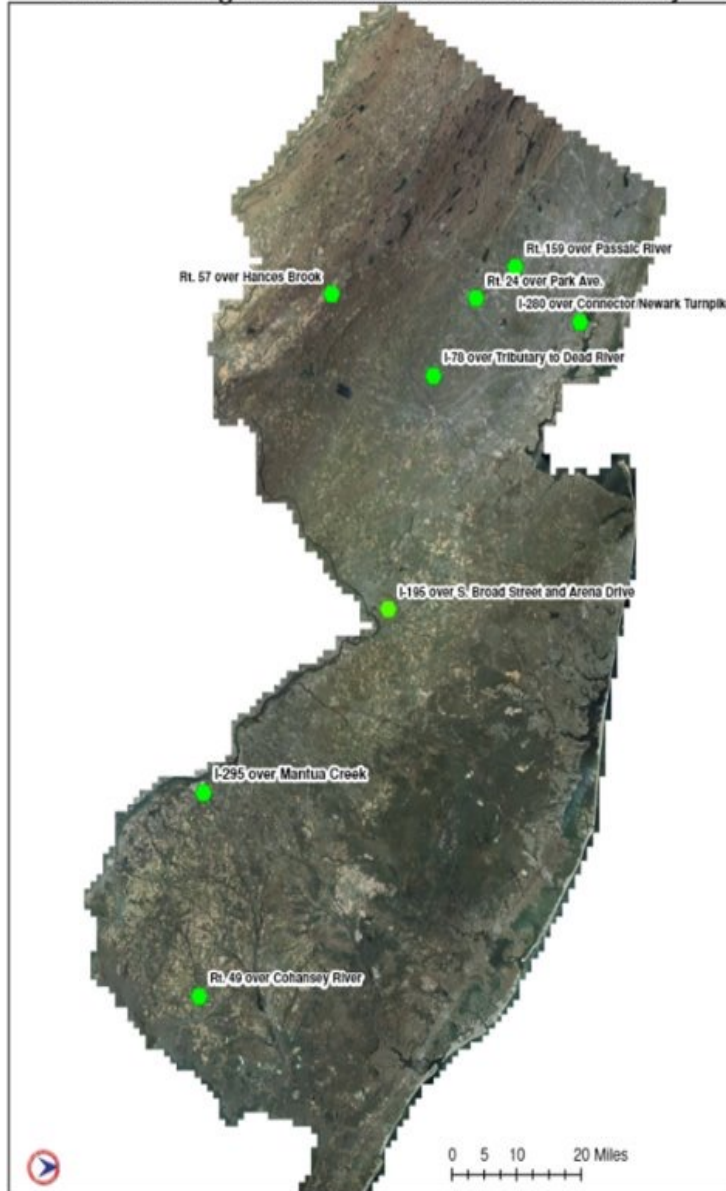


# Bridge Selection Process





## Ultra-thin High Performance Concrete Overlay



- Considerations: condition ratings (good condition), load ratings, deck chloride content, construction staging and traffic volumes, existing overlay depths
- Eight (8) structures fully evaluated/tested, four (4) were advanced
- Deck slab ages from 10 years up to 40 years
- Deck slab areas from 800 SF to over 20,000 SF
- All bridges had asphalt overlay
- Structures were eliminated due to load ratings (unexpected asphalt thicknesses discovered), heavy traffic volumes and/or difficulty in limiting number of stages

## Bridge Selection Process

# Initial Conditions & Testing

- Concrete cores were taken at each bridge:
  - overlay thickness
  - chloride contents
- Chloride Content:
  - ensure deck concrete to remain isn't overly contaminated
  - provide baseline data for future testing
  - NJDOT consider the threshold to initiate corrosion based on chloride content to be 2.0 pounds per cubic yard (PCY).
- Ground penetrating radar (GPR):
  - estimate area of deck repairs
  - increase confidence in the overall condition of the deck.

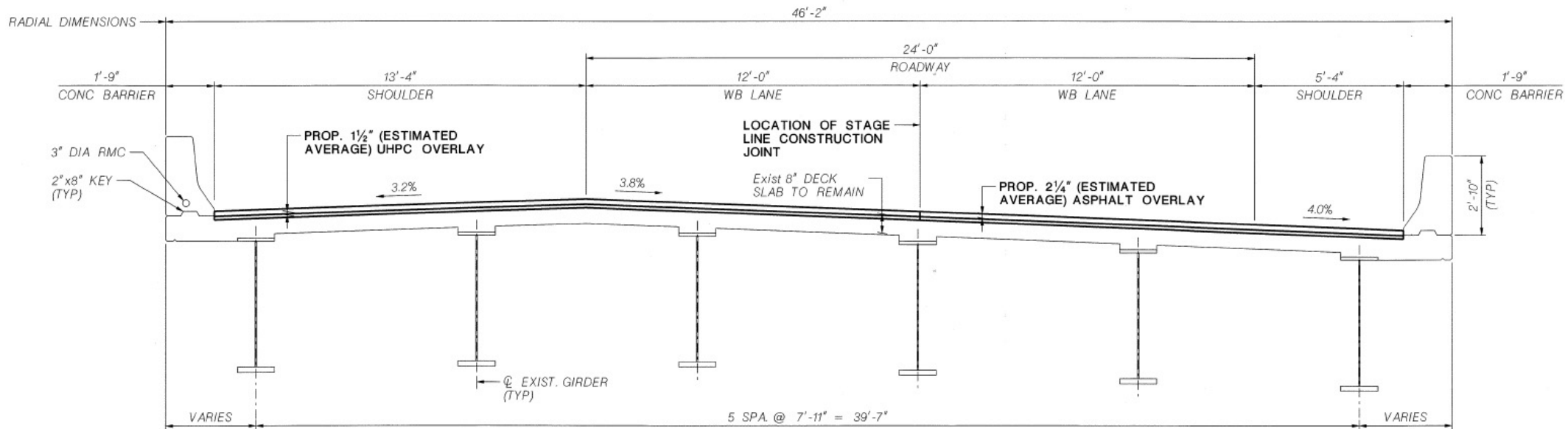
## Chloride Content Test Results (Maximum Chloride Content)

Site No.	Structure Name	Acid Soluble Chloride (PCY) 0.75"-1.25" Depth	Acid Soluble Chloride (PCY) 1.75"-2.25" Depth
1	NJ 49 over Cohansey River	Eliminated	Eliminated
2	I-295 NB & US 130 NB over Mantua Creek	3.062	2.983
3	I-195 EB over S. Broad St WB (CR 524) & Arena Dr.	Eliminated	Eliminated
4	I-78 EB over Tributary to Dead River	Eliminated	Eliminated
5	NJ 57 over Hances Brook	0.529	0.438
6	I-280 WB over Newark Turnpike (CR 508)	3.794	3.821
7	NJ 24 Over Park Avenue	Eliminated	Eliminated
8	NJ 159 WB over Passaic River	0.438	0.407



# Project Details

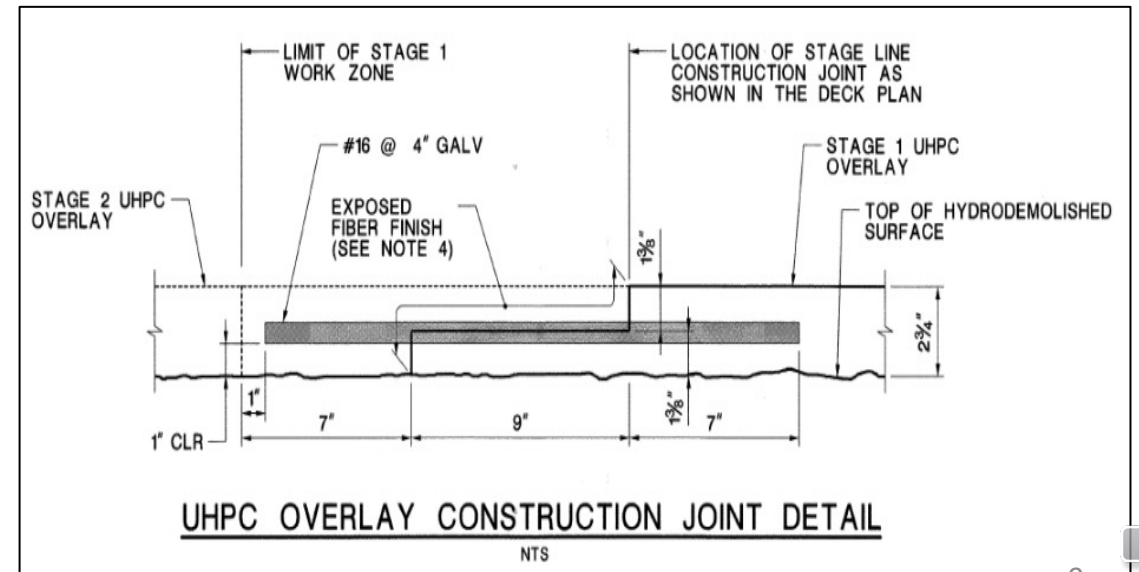
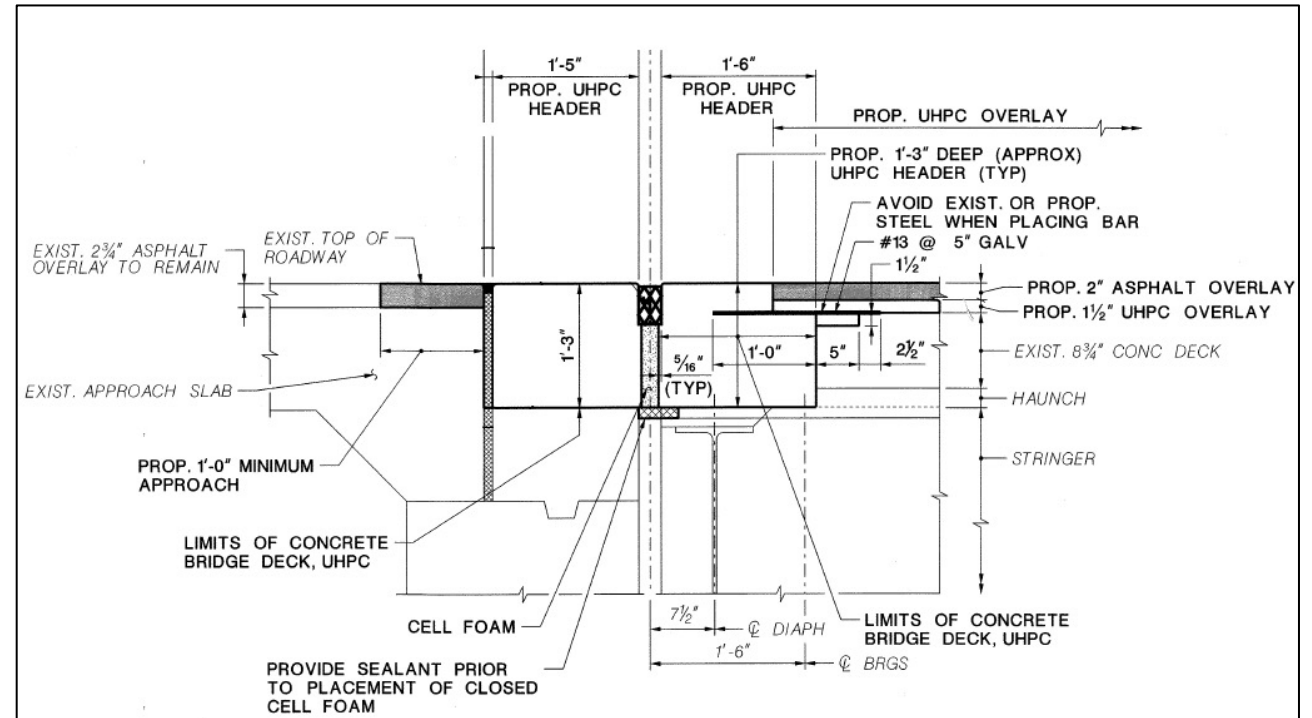
- Maintain grades (limit impacts, environmental impacts/permits)
- Staged construction (2-stage)
- Sequence: **1.)** Existing overlay removal **2.)** Hydrodemolition ( $\frac{3}{4}$ " ) **3.)** Deck Patching **4.)** Reconstruct deck joints (UHPC headers) **5.)** UHPC Overlay (1-1/2" to 2-1/2") **6.)** Overlay or Diamond Grind





# Contract Documents

- Structure Plans
- Performance Specifications
- Submittals
- Details
- Deck survey after existing overlay removal and after UHPC overlay installation
- Contract Pay Items





# Material Testing

- The UHPC mixes consisted of a partial premix made by the supplier, sand, water, liquid admixtures, and steel fibers (3.25% of the total dry volume).
- To ensure the consistency of each UHPC batch, a procedure of overlay flow testing in accordance with ASTM C1437 was followed.
- With 3.25% steel fibers, the values of static and dynamic flows were 4-6 inches & 6-8 inches, respectively.

Description	Test Method	Acceptance Criteria
Compressive Strength	ASTM C1856	≥14 ksi at 28 days
Direct Tension Cracking Strength	FHWA-HRT-17-053	≥1100 psi
Direct Tension Sustained Post-Cracking Tensile Strength	FHWA-HRT-17-053	≥1250 psi
Direct Tension Bond Strength	ASTM C1583, bonded to an exposed aggregate concrete surface.	100% failure in substrate concrete with concrete compressive strength ≥ 4 ksi
Modulus of Elasticity	ASTM C1856	≥ 6500 ksi
Long-Term Shrinkage	ASTM C1856	≤ micro-strain
Rapid Chloride Ion Penetrability	AASHTO T277 / ASTM C1202	≤ 250 coulombs
Scaling Resistance	ASTM C672	$Y \leq 3$
Freeze-Thaw Resistance	ASTM C1856	Relative Dynamic Modulus of Elasticity ≥ 95%
Alkali-Silica Reaction	ASTM C1260	Innocuous







Supplier X



Supplier Y



## Test Slabs

UHPC Overlay Mockup Tests : Per the contract documents, contractors were required to successfully place a 4'x12'x3" deep rectangular test slab of UHPC with a grade of 8% in the longitudinal direction.







# Construction : General Contractors vs. Specialized UHPC Contractors

- A specialized contractor brings in prior experience placing UHPC, has established relationships with UHPC suppliers, and has specialized UHPC equipment.
- More contractors are expected to join this industry allowing more competition and competitive bid pricing.
- The most crucial element is the mixing and establishing the correct amount of UHPC fluidity to ensure the UHPC holds the grade of the deck.
- Specialized UHPC pavers are available for purchase by any contractor.
- As long as the documents require the appropriate measures be taken by the contractor along with the quality control requirements, the desired end product should be attainable by a general contractor or a subcontractor.





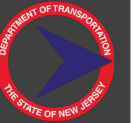


# Construction Submittals





# Construction Joints and Formwork







# Construction: Headers and Curing

- Ensure proper curing in accordance with the approved procedures to prevent dehydration cracks.
- For UHPC Headers, Contract B used a semithixotropic mix while Contract A used a self-consolidating and self-leveling mix.
- Self-consolidating UHPC is preferred for the full-depth UHPC header placement.
- Consideration of partial depth UHPC headers or HPC headers with UHPC over the top should be included for individual projects.
- Specify water tight forms, top forms, and a minimum ¼" overfill of UHPC followed by grinding the surface per the specifications.





# Final Product

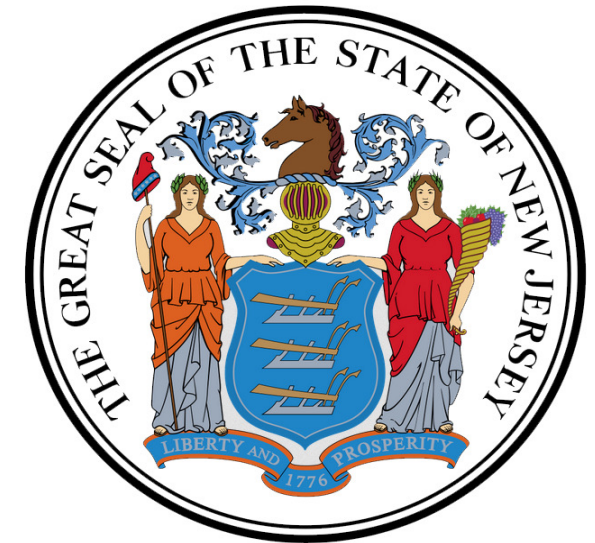
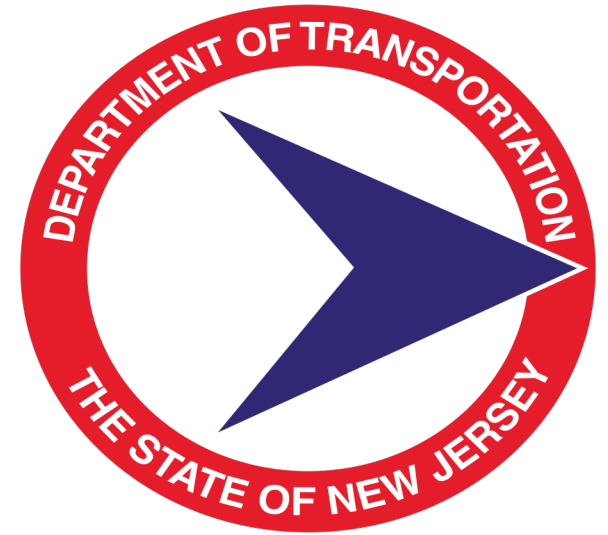
- Surface defects were addressed before asphalt paving, out of an abundance of caution, these locations were identified for future monitoring.
- UHPC slurry with no fibers was placed in any identified air voids.
- On one structure the UHPC overlay serves as the final riding surface.
- UHPC overlay surface finish acceptance criteria, beyond the basic rideability requirement, should be added to the specifications to improve the quality of exposed UHPC overlay surfaces.
- An image of the desired surface in the contract documents would help reduce confusion.
- In the contract documents define an overpour thickness as a minimum of  $\frac{1}{4}$ " to  $\frac{1}{2}$ ".
- Asphalt overlays on top of UHPC will be avoided especially as the performance evaluation of the material is still on-going.





# Future Work

- A long-term testing program is presently being developed to gather performance data in the assessment phase.
- Incorporating UHPC for several applications in the new design manual, including P&R.
- After data collection and lessons learned are finalized, Standard Specifications will be revised.
- Further investigation, performance data, and Life Cycle Cost analysis.
- Additional UHPC overlay applications.



*Thank You*

- Contacts for further Questions:
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([Samer.Rabie@dot.nj.gov](mailto:Samer.Rabie@dot.nj.gov))
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