

NJDOT Workshop Report

Date: October 20th and 21st 2021

Location: Microsoft Teams (Virtual Workshop)

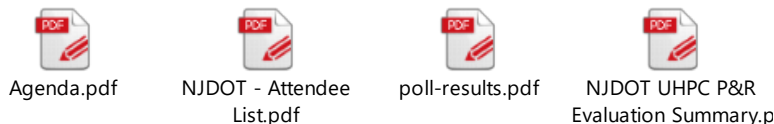
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Purpose: The workshop provided participants with a greater understanding of what UHPC is, as well as a suite of solutions which include using UHPC for bridge deck overlays, link slabs, and steel girder end repairs. It also gave participants information on where to obtain the guidance necessary to implement different types of UHPC preservation and repair strategies. The workshop also provided participants with the opportunity to discuss their UHPC implementation strategy, construction specifications, and design details with FHWA EDC-6 UHPC team members.

Activities/Description: On October 20th and 21st, Zach Haber, Justin Ocel, Andy Foden and Jordy Padilla delivered the workshop which was presented over two half-day sessions (4 hours each). A total of **194** participants were present on October 20th. A total of **173** participants were present on October 21st.

Agenda, Attendees, Poll Results, Evaluations: A copy of the agenda the sign-in sheet, poll results, and evaluation summary are attached below.



Handouts:

1. **Agenda**
2. **PDF Copy of the Slide Deck**
3. **FHWA-HRT-19-011: Design & Construction of Field-Cast UHPC Connections**
4. **FHWA-HIF-18-030: Example Construction Checklist for UHPC Connections**
5. **FHWA-HRT-18-036: Properties and Behavior of UHPC-Class Materials**
6. **FHWA-HRT-17-097: UHPC for Bridge Deck Overlays**
7. **FHWA-HRT-17-096: Field Testing of an UHPC Overlay**
8. **FHWA-HIF-20-062: Eliminating Bridge Joints with Link Slabs – An Overview of State Practices**
9. **NJDOT UHPC Overlay Specifications (2020): Performance Specifications**

10. **NYSDOT UHPC Joint Fill Specifications (2021): Performance Specifications**
11. **WVDOT UHPC Joint Fill Specifications (2017): Product Specification**
12. **NMDOT UHPC Overlay Specifications (2021): Performance Specifications**
13. **Improving Bridge Preservation with UHPC, *Public Roads Magazine*, Winter 2021**
14. **Workshop Evaluation Form (Online Form)**

**All poll questions can be found within the "Poll Results" attached PDF. The Q&A listed below are solely for questions received from the participants.*

Module 1: Welcome and Introductions (Haber, 8:05 – 8:25 am)

Zach initiated the meeting by discussing the purpose of EDC 6. Then, the presenters, Zach Haber, Justin Ocel, Andy Foden, and Jordy Padilla briefly introduced themselves. Zach laid out the workshop outline and discussed the specific handouts that will be thoroughly discussed in the upcoming modules. Participants were briefly introduced to SLIDO which was used for polling as well as submitting questions for Q&A.

Q&A

None.

Module 2: FHWA Every Day Counts Overview (Ocel, 8:25 – 8:40 am)

Justin Ocel provided an overview of EDC, deployment implementations of agencies, and outlined resources including websites and contact information.

Q&A

None.

Module 3: Introduction to UHPC (Foden, 8:40 – 9:40 am)

Andy Foden presented this module. This module included information on UHPC constituents, material properties, mechanical properties, and emerging repair strategies: headers, seismic retrofits, column repairs, connection repairs, steel girder flexural strengthening, concrete patching, and shotcrete.

Q&A

- For the column retrofit for the bridge in Canada, there appeared to be a gap between the bottom of the column and the top of footing. Can you please comment. Also, what type of reinforcement was provided for confinement.
 - The issue on this project was that the ground was subject to lateral spreading during an earthquake. The column was retrofitted to account for this lateral demand. The gap was a concentrated plastic hinge that could accommodate such movement.
- On culvert strengthening, how small of a culvert/pipe can you use it on?

- Shotcrete is typically completed by an experienced technician, so the limitations will be based on accessibility. However, most culverts, even smaller, will most likely be accessible to shotcrete technicians.
- Hydrodemolition and slurry management techniques. Are they Environmentally friendly?
 - Measures need to be provided that protects contaminated water from impacting local areas or waterways.
- What is the cure time difference for repairs between UHPC vs HPC?
 - Curing times will be dependent on the admixtures, temperature, and other environmental factors. Curing time can vary between 18 hours to 3 days.
- What prevents the small steel fibers in the UHPC from oxidizing/rusting the same way traditional rebar does?
 - Any exposed fibers will corrode; however, the deterioration of the exposed fibers will not affect the performance of the UHPC. Due to the discontinuous pore structure of UHPC the fibers within the UHPC matrix will not corrode below the surface.
- Does UHPC require wet cure?
 - UHPC should not be wet cured. Curing will be typically be done by applying a curing compound immediately after placement and then plastic sheeting for an overlay or a top form for link slabs.
- Can cracks on the surface of the UHPC allow water to seep through? What's the lifetime of the product?
 - It is designed to crack. However, the crack width is small and is controlled by the fibers. The expected service life of an UHPC overlay is at least 35 years and could be much more.
- Is it possible to use UHPC to repair and strengthen steel girders without field welding to the existing girder?
 - No. The repair will not work unless you place Studs. The studs are designed to sustain dead load, live load or both.
- Do UHPC repairs on steel girders comply with the American Welding Society D 1.5?
 - FHWA recommends following AWS. Just note that it will be welded in a vertical position.

- What is the minimum thickness of UHPC overlay?
 - It can be as thin as 1.0" but 1.5" is recommended to account for any tolerances.
- Have UHPC overlays been validated to have a 75-year service life in the laboratory?
 - Generally, yes. UHPC could provide a 75-year life, but it is dependent on multiple factors. Rutgers University will conduct accelerated testing of the long-term performance of UHPC overlays.

[15 MINUTE BREAK]

Module 4: General Design and Material Specifications (Haber, 9:40 – 10:30 am)

Zach presented this module. This module covers material availability in the industry including commercial material suppliers, proprietary products, suppliers of fabricated products, and non-proprietary products. General UHPC design recommendations along with typical properties used for design were also discussed in this module.

Q&A

- Cement is susceptible to cracks, so which properties of UHPC prevent the cracks from occurring?
 - UHPC will crack. For tension behavior to work, it needs to crack. When cracking occurs, the steel fibers are able to bridge the cracks and control crack width and provide durability.
- Can UHPC projects be done via Design-Build?
 - Yes. There is a project in Boston that has an UHPC overlay, and it is a design-build project.
- Cost of hydro demo per square feet?
 - Hydrodemo cost/SF varies depending on the size, location and depth of removal. Based on historical bids, a 5,000 SF size project (2" UHPC depth) can range between \$15 to \$20/SF.
- What's the maximum % fiber you can add and how much tensile strength can you get at max?
 - Hypothetically you can add as much fiber as you want. However, the rheology of the UHPC is impacted or it no longer behaves as normal UHPC if the fiber is greater 4%. The goal is to provide a fiber volume of 2-3% that will provide an acceptable tensile strength.
- Can you pump UHPC? Is there any limitation?

- On the Pulaski Skyways, the contractor was able to pump during the cool weather but as the weather got warmer the contractor struggled to properly pump UHPC. This is due to the mix being a low moisture content and being effected by the heat in longer slick lines in warmer waether. It is very challenging since a successful pump mechanism needs to adjust to different ambient temperatures.
- Is a bonding agent needed when pouring UHPC up against existing concrete?
 - FHWA does not recommend a bonding agent. UHPC will bond better to a SSD surface than a bonding agent.
- Are there any studies showing the longevity of stainless fibers vs carbon steel fibers?
 - No studies have been completed. However, the fibers are protected by the UHPC and are generally not susceptible to corrosion.
- If direction of flow affects fiber orientation, is the effect on strength sufficient to specify direction of flow?
 - Flow direction will play a significant role on fiber orientation as the fibers will tend to align with the direction of flow. It is important for structural applications that the fiber alignment is distributed randomly in the section. This can be controlled by limiting the flow distance.

Module 5: Construction (Ocel, 10:50 – 11:40 am)

Justin Ocel provided a general overview of Constructability approaches to UHPC including but not limited to the following: pre-batching, material prepping, testing, formwork, placement, finishing, and surface defects.

Q&A

- Can you elaborate on what a proper SSD condition is? How much time to saturate, no standing water, slightly dried surface, etc.?
 - SSD condition is a wet surface that has no standing water. The goal is to saturate the pours but to keep the surface dry to the touch. It takes anywhere from a minimum of 6 hours up to the preferred duration of 24 hours.
- What is the level of difficulty of removing a UHPC overlay?
 - It is very difficult to remove UHPC, especially if it has reached its full compressive strength.
- Would methacrylate sealing be recommended for minor surface defects after finishing?
 - Yes. Methacrylate is acceptable.

- Is it ideal to take away the responsibility from the contractor, if you add a clause in the specs for the methodology of correcting defects?
 - If they know what is acceptable, they will bid accordingly.
- Is Heat of Hydration high? Any special requirements for curing of concrete?
 - FHWA recommends following the same concrete concepts for curing that deal with ambient temperature. UHPC temperature should be kept below 140 degrees to avoid delayed ettringite formation.
- Would a moisture gauge work?
 - It may not work. It has to be calibrated but it has not been used previously. It also will be hard to use it on rough surface
- With low water content in the mix, I would assume shrinkage is minimal. Is shrinkage a concern at all for closure pours?
 - UHPC can exhibit large autogenous shrinkage. UHPC does not exhibit a lot of drying shrinkage since water cannot get out.
- Does the stiffness of the deck or bridge system effect the UHPC overlay behavior during curing or long term? How is early age shrinkage accommodated?
 - Shrinkage is accommodated by the fibers to control crack widths.

Wrap-up (Day 1) (11:40 -12:00)

[ADJOURN FOR DAY 1]

Module 6: UHPC Bridge Deck Overlays (Foden, 8:05 – 9:10 am)

Andy Foden presented a general overview of UHPC overlays. This module covered the advantages of UHPC overlays, history of overlays, design approaches and constructability considerations.

Q&A

- What is the bond strength between the fresh and cured UHPC? How does it compare to regular concrete and UHPC bond?
 - 120 psi bond strength is attainable with a roughened surface. Reinforcing bars can also be added to strengthen the interface, particularly in a negative moment region.

- Any load testing to verify the additional Capacity that UHPC overlay added by calculations?
 - There has been a lot of laboratory testing done. FHWA is also initiating this type of test and results will be published in the future.
- What is the size range of typical hydrodemolition equipment?
 - The size varies depending on application. It is important to note that a bigger size does not equate to more pressure. In addition, the removal depth can be modified by changing the nozzles of the machine.
- Would the steel fibers bend if the UHPC is mixed in a ready-mix truck?
 - Bending will not occur.
- Would the hand chipping under the hydro demolished reinforcement induce some microcracking? They all appear in line looking down the deck, would that be a problem?
 - Yes. Pneumatic hammers were used to remove concrete underneath the reinforcement, shadowing under the rebar. Microcracking may have occurred but these were localized areas and not representative of the entire deck. Pull-off testing on the overlays showed that the overlay remained intact, even in areas where pneumatic hammers were used.
- Are there drawbacks to placing a UHPC overlay on top of a not fully cured deck? Does concrete need to be cured 28 days before a UHPC overlay is placed on it?
 - It is recommended to place UHPC on a deck that has reached its full designed strength.
- What is the impact of live traffic induced vibration during overlay operations?
 - UHCP has been placed while maintaining live traffic without any issues.
- What are typical admixtures for UHPC overlay?
 - Similar concrete admixtures used in regular concrete can be used for UHPC. High range water reducers and/or superplasticizers are very common. Admixtures that accelerate strength gain or modify the rheology of UHPC can also be used.
- Should the plastic sheeting be opaque white plastic? Can you seal UHPC cracks with an approved concrete sealer?
 - A specific color is not required for plastic sheeting. UHPC cracks can be sealed using UHPC slurry or methacrylate. In terms of approved concrete sealers, this will need to be verified with the designer. There is no standard approved material.

- For UHPC, especially overlay, wouldn't we lose time with ready mix truck versus using high shear mixers on site? Time is money.
 - Depends on location, accessibility, and project placement constraints.
- After hydro demo do existing rebar have to be re-tied?
 - Yes. Any loose reinforcement should be retied.
- What's the immediate corrective action to remove air bubbles in UHPC overlay?
 - On previous projects, the contractors tried to break any air bubbles that were noticeable during placement with a hand trowel. However, most visible air bubbles will be removed via grinding and grooving.
- If Hydrodemolition blows out a large deck area to full depth, can UHPC be used for the full depth repair while pouring the overlay?
 - No. Full depth repairs will require two separate operations. UHPC can be used but it will require a joint fill UHPC mix, not a thixotropic mixture.
- Can a conventional concrete plant provide a small batch of UHPC to the project via a transit mix?
 - This is possible. One fabricator has successfully placed UHPC with ready mix trucks.

Module 7: UHPC Link Slab (Haber, 9:10 – 10:00 am)

Zach presented a general overview of UHPC link slabs. This module covered the advantages of UHPC link slabs, concept of link slabs, design approaches, design example and constructability considerations.

Q&A

- In new deck construction is there a specific link slab detail at the construction deck stage line?
 - FHWA recommends referencing NYSDOT link slab details.
- Can UHPC overlay be placed over an old deck with new UHPC link slab retrofit?
 - Yes. A construction joint may need to be introduced to connect the link slab to the overlay.
- Is bearing rearrangement required if bearings are replaced?
 - At least one bearing needs to be an expansion bearing, but both can be as well. Bearing type may need to be modified if the global analysis shows that modifications are needed

to better distribute forces on the substructure. In addition, rocker bearing may have excessive wear and tear over time due to the modified behavior. Thus, the NYSDOT guidance is to replace existing steel bearings with elastomeric bearings.

- Can a link slab still be used when a negative haunch condition occurs?
 - Yes, but the rotations need to be evaluated.
- How does the rebar splice length relate for use in link slab in UHPC? Is there any guidelines from NYSDOT or NJDOT?
 - FHWA recommends using the same guidelines that are discussed in the design portion of Module 4, slide 35 named “Non-Contract Lap Splicing of reinforcement.”
- Why debond the middle portion of a UHPC link slab?
 - It is important to allow the required rotation to be distributed over a larger length and reduce the stress in the link slab.
- On average, what is the anticipated service life of UHPC link slab?
 - Similar to a UHPC overlay it is anticipated that a minimum service life of 35 years can be anticipated. There is ongoing research on this topic that will help validate this assumption.
- What are critical concerns in link slabs as you get into higher skew bridges nearing 45 degrees? Differential movement at acute and obtuse corners?
 - For Link slabs, NYSDOT has a limitation of no greater than 45 degrees. Analysis should be done to determine whether a link slab will alter the existing behavior of the structure.

Module 8: UHPC Steel Beam End Repair (Ocel, 10:00 – 10:50 am)

Justin presented a general overview of UHPC steel beam end repairs. This module covered the advantages of UHPC steel beam end repairs, concepts, testing, design approaches, design example and constructability methods.

Q&A.

- Does the UHPC repair crack under live load during its curing time, or do you need to keep traffic off that lane of the repair location?
 - CTDOT kept traffic off till it reached 14 ksi. Not as much for concern about cracking but more of a potential issue with fiber segregation from the vibrations.
- What is the advantage of UHPC for bearing stiffener repair? Can it be done with other types of concrete that are not UHPC?

- UCONN conducted a test with different grouts. It was found that the grouts used in the experiment split during loading since it didn't have the fibers. They found that you need the contribution of fibers to resist the splitting.
- Can it be done on the vertical columns as well as part of rehabilitation of structure?
 - This situation requires axial load capacity, and it will need additional evaluation. Zach mentioned that this application has been done in the past, but it requires a different approach.
- Knowing all joints leak at some point, is using UHPC at Beam Ends under joints, a cost-effective prevention measure over the life cycle of a new bridge?
 - It depends on the condition of the structure. A new structure might not warrant a UHPC beam end encasement. However, a structure that requires a full restoration of the capacity of the girder might justify such approach.
- Has there been experience and/or are there provisions for how to inspect the beam ends which have had this type of retrofit implemented?
 - UCONN has vetted that corrosion is unlikely to happen in these areas. There is no concern that will require specialized inspection, other than the typical annual or bi-annual bridge inspection.
- For girder end repairs, what steel preparation is required? Blast cleaning?
 - Full blasting to white metal is required. Light blasting to remove heavy corrosion product is appropriate.
- If there is full-height deterioration at the beam end, then presumably you can't place studs or use a UHPC repair?
 - If the web has reduced thickness for the full height consideration of the minimum ratio between the stud size and base metal needs to be maintained. It may be possible to just use smaller studs.
- Is there a strength reduction factor?
 - No. There is no established reduction factor.
- Why not clean the whole web, not just the stud area? The entire web would need to be cleaned prior to concrete placement, right?
 - A full white metal surface preparation is not required. We are not relying on the bond of UHPC to steel for the capacity.

[15 MINUTE BREAK]

Module 9: Specifications (Padilla, 11:05 – 11:30 am)

Jordy presented this module. This module covered the different specification types: Prescriptive, Product, and Performance. Example specifications were reviewed with the audience for each type of specification, highlighting language that is most important to its respective type and providing general approaches to specification writing.

- How useful is such a small mockup that was shown? Wouldn't a larger mockup be more useful?
 - The case that was presented does not require a large mockup. The purpose of the mockup is to verify that the contractor and supplier are able to place UHPC properly and meet the depth and grade of the specific project. Larger mockups may be required to test the performance of a contractor but add cost. The availability of experienced contractors would eliminate the need for a larger full scale mockup.
- For specs, is the maturity method specified for joint fill UHPC or also overlay UHPC?
 - The maturity method can be specified for both.

Q&A.

Module 10: Summary of Successful Practices (Padilla, 11:30 am – 11:55 am)

Jordy presented this module. This module covered successful implementations of UHPC by NJDOT, NYSDOT and TXDOT.

Q&A.

- Does NYSDOT require 28-day cure before placing the UHPC in their link slab detail?
 - The concrete that the UHPC is placed against should have its full design strength. For new decks NYSDOT also has a link slab detail that uses the traditional concrete.

Module 11: Discussion and Wrap-Up (Ocel, 11:55 am – 12:05 pm)

Justin closed out the workshop

Q&A

None.