

# PUBLICROADS

www.fhwa.dot.gov

Winter 2021



IMPROVING  
BRIDGE  
PRESERVATION  
WITH  
ULTRA-HIGH  
PERFORMANCE  
CONCRETE



U.S. Department  
of Transportation  
Federal Highway  
Administration

## Also in this issue:

Partnering to Halt Human Trafficking

Making Safer Crossings for People with Disabilities

Enterprise Risk Management – Path to Continuous Improvement

# PUBLICROADS

Winter 2021 | Vol. 84, No. 4



## FEATURES

### 6 Reducing Rural Roadway Departures: Moving FoRRRwD, Part II

by Cathy Satterfield and Richard B. Albin

FHWA's Every Day Counts initiative is taking a comprehensive approach to saving lives on rural roads.

### 12 Combating Human Trafficking

by Jihan Noizet and Shari Schaftlein

USDOT is working with partners and stakeholders across the transportation industry to put the brakes on human trafficking.

### 17 Technology to Make Signalized Intersections Safer for Pedestrians with Disabilities

by Govindarajan Vadakpat, Stephen F. Smith, Zachary B. Rubinstein, and M. Bernardine Dias

FHWA's ATTRI program is funding PedPal, a mobile app that enables pedestrians to communicate directly with signalized intersections and actively influence traffic control decisions to enhance their safety.

### 22 Improving Bridge Preservation with UHPC

by Zachary B. Haber

Ultra-high performance concrete can advance highway bridge preservation and repair to enhance durability and resiliency.

### 28 Handling Risk: FHWA's Integrated Approach

by Daniel Fodera

FHWA is working to make the organization more effective and efficient by applying an enterprise risk management framework that combines strategic planning, performance planning, and internal controls.

### 32 Evaluating Ultrasonic Techniques to Detect Bridge Weld Flaws

by Hoda Azari and Russell Kok

FHWA researchers examined phased array ultrasonic testing for performing bridge weld inspections and compared the method to the historically used technique of radiographic inspection.

### Improving Bridge Preservation with UHPC

PAGE 22



PAGE 28

Source: FHWA

## DEPARTMENTS

Guest Editorial.....	1
Hot Topic.....	2
Innovation Corner.....	4
Along the Road.....	41
Training Update.....	44
Internet Watch.....	45
Communication Product Updates.....	46

ABOVE and FRONT and BACK COVERS—Installation of a UHPC overlay on a single lane of the Claiborne Pell Bridge (commonly known as the Newport Bridge) as a part of a UHPC overlay pilot project. The 2-plus mile-long suspension bridge structure spans Narragansett Bay in Rhode Island and is owned by the Rhode Island Turnpike and Bridge Authority. It is the longest suspension bridge in New England.

© Rhode Island Turnpike and Bridge Authority.



Ultra-high performance concrete (UHPC) has long been used for new construction in connections between prefabricated bridge elements. In the last few years, its use in bridge repair and preservation has increased as well. Here, crews install the first U.S. deployment of UHPC as a bridge deck overlay on a reinforced concrete slab bridge located in Brandon, IA, completed in May 2016.

Source: FHWA.

by ZACHARY B. HABER

You do not have to work in the surface transportation sector in order to be aware of the state of repair of many of the highway bridges in the United States. News headlines often contain the word “infrastructure” along with “crumbling” or “deteriorating.” But those stories do not always include a description of what individuals and agencies are doing to effect change and spur innovation in the area of bridge preservation.

The Federal Highway Administration’s *Bridge Preservation Guide* (FHWA-HIF-18-022) defines bridge preservation as “actions or strategies that prevent, delay, or reduce deterioration of bridges or bridge elements, restore the function of existing bridges, keep bridges in good or fair condition, and extend their service life.” Keeping highway bridges in a state of good repair is

challenging and requires bridge owners to be vigilant. There are numerous factors to be considered, such as availability of funding, time, volume of an owner’s inventory, age of the structures in that inventory, and service conditions.

Another challenge is the durability of traditional materials and methods used for bridge preservation and repair. If a bridge owner repairs an element of a bridge with a material that deteriorates within 5 years, the same issue will need to be readdressed soon. Bridge owners have a choice: repeat the same course of action in a continuous cycle, or seek out a different, potentially more innovative, resilient, and permanent solution. The latter option is what some bridge owners are choosing to do.

“As a bridge owner with constrained resources such as money and time to

make repairs that impact mobility, we are always on the lookout for new technologies that can help us with long-lasting bridge preservation actions that are life-cycle cost effective,” says James Nelson, director of the Iowa Department of Transportation’s Bridges and Structures Bureau, and chair of the American Association of State Highway and Transportation Officials’ Bridge Preservation Technical Committee.

Ultra-high performance concrete (UHPC) is a fiber-reinforced, cementitious composite material with mechanical and durability properties that far exceed those of conventional concrete materials. These properties have made it popular for bridge construction, especially for field-cast connections between prefabricated bridge elements. Bridge infrastructure preservation and repair is a new application of UHPC

that offers enhanced performance and improved life-cycle cost over traditional methods. FHWA will be promoting the use of UHPC for bridge preservation and repair over the next 2 years through the sixth round of the Every Day Counts (EDC-6) program (for more information, visit [www.fhwa.dot.gov/innovation/everydaycounts/edc\\_6](http://www.fhwa.dot.gov/innovation/everydaycounts/edc_6)).

## || UHPC in Highway Infrastructure

It has been nearly 15 years since UHPC made its debut on a bridge construction project in the United States. Since its first deployment in 2006, the use of UHPC in U.S. bridge construction has increased significantly. Today, there are more than 250 bridges in the United States that employ UHPC. Most of these bridges use UHPC for field-cast connections between prefabricated bridge elements.

The rise in popularity can be attributed to a handful of factors. First, there is increased awareness on behalf of bridge owners and designers and more readily available technical guidance and support. This factor was greatly aided by FHWA selecting UHPC connections for prefabricated bridge elements for inclusion in EDC-3 and EDC-4. Second, in the past 5 years,

## Find out where UHPC is being used near you!

FHWA created and maintains an interactive map (<https://bit.ly/UHPCMap>) that shows the locations and details of bridges in the United States that used UHPC in their construction. Each icon shown represents an individual bridge. By clicking on an icon, users can access information about the selected bridge, such as the year built, the bridge owner, and how UHPC was used on the structure. The interactive map also features other data visualization and filtering functions. For example, a user can search for bridges that have been repaired using UHPC.



Source: FHWA. © ESRI (for map image).



In 2017, the St. Clair County Road Commission in Michigan was the first to deploy an open-source UHPC mixture on a U.S. bridge. UHPC was used to repair the joints between the bridge's precast double T-beams.

© Andrew Tai and Sherif El-Tawil, University of Michigan.

UHPC has a proven history for use in connections for prefabricated bridge elements. The Florida Department of Transportation leveraged this fact in 2016 when it first used UHPC to repair an existing bridge with precast, prestressed adjacent slab units whose connections were failing. The agency removed the concrete in the failing connections and replaced it with UHPC.

© Florida Department of Transportation.



new UHPC suppliers have entered the U.S. market, increasing competition and technical advancement. Third, nonproprietary or open-source UHPC mixtures are becoming more readily available. Fourth, contractors are gaining experience with UHPC and specialized UHPC installers are emerging, which reduces contingency or risk-based costs associated with using UHPC in construction. Last and most important, UHPC connections for prefabricated bridge elements addressed a critical need: simple, constructable, and robust connection details that provide rapid installation, better durability, and long-term performance.

### || An Emerging Application, A Proven Technology

Some bridge owners are now addressing another critical need by turning to UHPC as a solution for bridge preservation, repair, and strengthening to maintain or extend the service life of bridge structures. As a repair solution, UHPC offers enhanced performance and improved life-cycle costs over traditional methods. Furthermore, UHPC can provide an optimum solution for some repairs because of its strength and durability. It can be used in situations that normally use conventional concrete or repair mortars, and even in some cases that typically use structural steel.

“UHPC has been a game-changer in our industry, particularly in accelerated bridge construction applications. I see UHPC having a similar impact on the repair and preservation of concrete structures,” says Jason Hastings, chief of bridges and structures at the Delaware Department of

Transportation (DelDOT).

Another attractive aspect of using UHPC for preservation and repair is that some repair projects are relatively small in scale and are viewed as low risk by the bridge owners. As such, repair applications have become an alternative entry point for bridge owners looking to generate institutional knowledge and familiarize local contractors with UHPC. For example, States such as California, Colorado, Connecticut, Florida, and Rhode Island all got their first experience deploying UHPC through a bridge repair application.

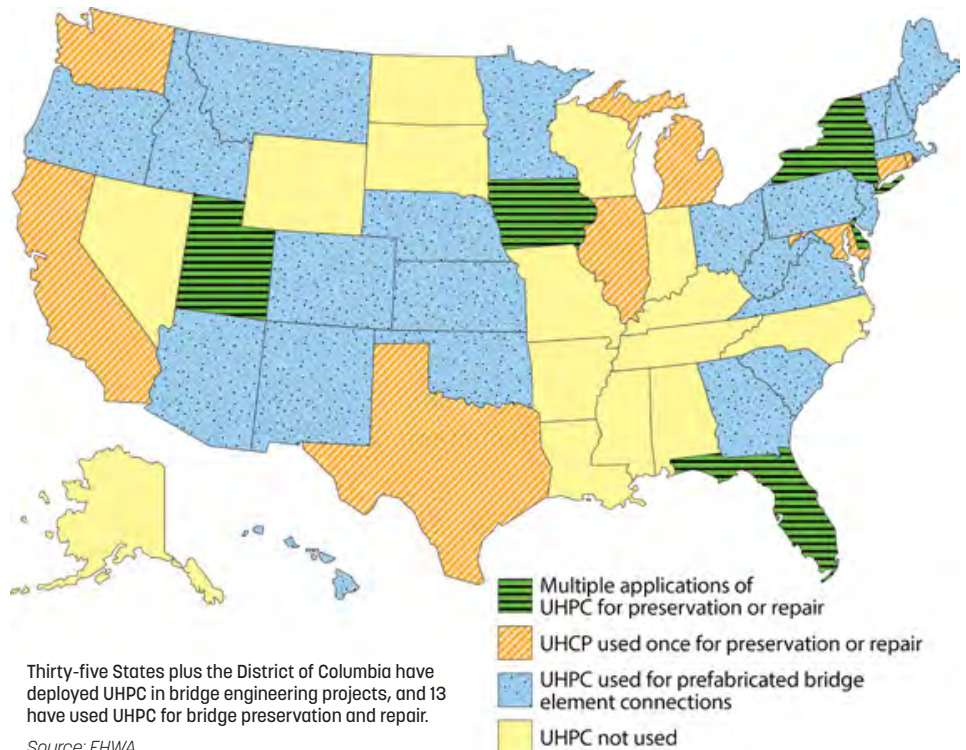
### || Early Adopters, Accessibility at All Levels

UHPC-based solutions can be used by local, State, Federal, and private transportation agencies, and, although some new knowledge is required, designers and contractors will be able to leverage their existing skill sets to deploy UHPC-based solutions. To date, more than 20 bridges in the United States have been repaired or strengthened using UHPC. Half of these projects were completed in 2019. As some States use repair applications to gain experience with UHPC, others have institutionalized UHPC-based repairs or made considerable investments to vet UHPC-based solutions. Furthermore, local transportation agencies have also played a role in the early deployment of this technology.

The New York State Department of Transportation (NYSDOT) is a great example of an agency that has institutionalized the use of UHPC for bridge repair.

“UHPC’s proven ability to withstand the harsh environment our bridges experience here in New York State, combined with its versatility and high strength, make UHPC an ideal material for extending the service life of our bridges,” says Jim Scarlata, a major projects engineer with NYSDOT’s Structure Policy & Innovation Bureau.

NYSDOT has deployed UHPC link slabs on more than 20 bridges for both repair of expansion joints and new construction. Because of NYSDOT’s commitment to advancing the use of this technology, other transportation agencies



The University of Connecticut conducted extensive research on the uses of UHPC for beam end repair. Researchers load tested numerous large- and full-scale specimens with repaired steel beam ends, completed extensive computer simulations, and developed engineering design guidance.

© Kevin McMullen, University of Connecticut.



commonly look to the standard UHPC link slab details developed by NYSDOT as a point of reference.

The Connecticut Department of Transportation (CTDOT) took its own approach to deploying a UHPC-based repair solution. The agency invested in a multiyear research and development effort with the University of Connecticut and bridge engineering consultants to develop and vet the solution they needed prior to deploying it on a bridge. CTDOT needed a more efficient and cost-effective way to repair deteriorated steel beam ends, which corrode as a result of water laden with de-icing salt spilling down from leaky expansion joints. The agency installed its first beam end repair solution on an I-91 highway bridge in New Haven in 2019.

“The use of UHPC has transformed the way we look at the rehabilitation of deteriorated steel beam ends,” says Andrew Cardinali, CTDOT’s State bridge engineer. “It has opened the door to additional tools in CTDOT’s toolbox to address the ever-growing problem of bridge maintenance.”

## II Promising UHPC-Based Repair Solutions

There are a number of different UHPC-based preservation and repair solutions that have been deployed by State or local transportation agencies, or conceptualized and laboratory tested by university or Federal researchers. Some of these solutions include:

- UHPC overlays for bridge deck rehabilitation.
- Structural strengthening of deteriorated girder ends.
- Expansion joint removal and replacement using UHPC link slabs.
- Structural patching of reinforced concrete bridge decks, prestressed girders, and bearing pedestals.
- Repair of existing connections between prefabricated bridge elements.
- Expansion joint repair with UHPC header.
- Seismic retrofit of deficient bridge column-footing lap splices.

Some applications can extend the service life of bridges well beyond that of traditional repair strategies and are more cost efficient than bridge replacement. For example, UHPC overlays for highway bridge decks are gaining attention from State, Federal, and privately owned toll bridge authorities due to their potential for extending the service life of bridges. UHPC overlays have

been extensively used in Europe with much success, and were first deployed in the United States in Iowa in 2016.

DelDOT was an early adopter of UHPC overlay technology and has implemented this solution on multiple bridges in the State. “We have installed a couple of UHPC overlays in Delaware, and we see them [having] a significant role in extending the service life of bridges,” says DelDOT’s Hastings.

Other promising solutions, which FHWA will be emphasizing through its EDC-6 deployment of UHPC for preservation and



UHPC overlays are an emerging solution for enhancing the durability and extending the service life of highway bridge decks. Typically, UHPC that has been specially formulated for overlay applications can be applied to the bridge after deteriorated concrete has been removed and the deck surface roughened.

Source: FHWA.



Fresh UHPC can be finished using a vibrating screed bar or more specialized equipment.

Source: FHWA.

repair, are UHPC link slabs and beam end repair. Both solutions have immense potential to advance current practices related to the repair of failing expansion joints and the associated maintenance challenges they cause.

“NYSDOT has found UHPC to be an excellent material for link slabs due to its capability to accommodate high tensile strains, exceptional bond to existing concrete and rebar, and extremely low permeability,” says NYSDOT’s Scarlata.

### Addressing Needs through Applied Engineering Research

With any new technology, there will be a learning curve, new challenges, and new questions that require answers. Luckily, FHWA is well positioned to provide support.

“FHWA’s research branch, the Turner-Fairbank Highway Research Center (TFHRC), has a track record of developing innovations, then delivering them to stakeholders,” says Benjamin Graybeal, the leader

of the Bridge Engineering Research Team within FHWA’s Office for Infrastructure Research and Development. “Based on our years of success with UHPC-based concepts, we will provide technical support to our partners as they engage this promising set of preservation and repair solutions.”

Since 2016, researchers at TFHRC have been working to address questions from early adopters of UHPC for preservation and repair. TFHRC staff have been developing technical guidance and best practices by executing laboratory-based, applied engineering research. Much of this work is influenced and carried out by forming collaborations and partnerships with transportation agencies and stakeholders.

For example, a few months after the installation of the first UHPC overlay in the United States, researchers from TFHRC visited the Iowa bridge site to conduct field testing of the UHPC overlay to assess the installation quality. The findings of this work and subsequent research have been published and have been used to develop

UHPC overlay installation guidance (see *Field Testing of an Ultra-High Performance Concrete Overlay* [FHWA-HRT-17-096] and *Ultra-High Performance Concrete for Bridge Deck Overlays* [FHWA-HRT-17-097], for example).

### Moving Forward with EDC-6

FHWA has a strong, proven history of providing technical assistance and outreach on UHPC. UHPC for prefabricated bridge element connections was an innovation included in EDC-3 and EDC-4, and it was a highly successful effort by bridge engineering stakeholders, TFHRC, and FHWA as a whole. Yet this technology is still being underused when compared to its transformative potential. Bridge preservation and repair is also an area where UHPC can have a dramatic impact.

In 2020, FHWA selected UHPC for Bridge Preservation and Repair as one of the technologies to be included in EDC-6, which runs throughout 2021 and 2022. Under the EDC banner, FHWA is ready to



Replacing deteriorated, leaky expansion joints with UHPC link slabs offers bridge owners a maintenance-free, permanent solution.

LEFT: First, the existing expansion joint and some of the surrounding concrete must be removed. CENTER: Workers install components of the new link slab, such as new steel reinforcing bars and UHPC. RIGHT: The cured UHPC link slab is ground to match the profile of the existing deck and grooved for skid resistance.

© NYSDOT, 2019.



Deterioration of steel bridge girder ends is a prevalent challenge for bridge owners in the northeastern part of the United States.

LEFT: Rusting steel leads to section loss, compromising the strength of the steel beam. CENTER: To strengthen the deteriorating steel, before adding UHPC, a worker welds headed shear studs to the remaining quality steel. RIGHT: The end region is encased in field-cast UHPC, resulting in a strong and durable repair.

© University of Connecticut.

assist States and especially local partners in maintaining and preserving their bridges using proven UHPC preservation and repair solutions. This initiative will focus on a suite of UHPC-based preservation and repair solutions, with an emphasis on solutions that have the most promise, such as UHPC overlays for bridge decks, UHPC link slabs for repair of failing expansion joints, and UHPC for repair of deteriorated steel beam ends.

To support the deployment of this initiative, FHWA is developing a guidance document entitled *Design and Construction of UHPC-Based Bridge Preservation and Repair Solutions*, which is scheduled for publication in 2021. The document will provide a background on UHPC-class materials, discuss common applications of UHPC for preservation and repair, provide design guidance and commentary, and offer a few case studies on successful projects.

The document will serve as a cornerstone for other technical assistance and outreach efforts.

Other planned activities include virtual or in-person 1-day workshops for State and local transportation agencies, a four-part national webinar series, and development of training content for local agencies and contractors. Transportation agencies interested in hosting a UHPC preservation and repair workshop should contact their FHWA division office or Zachary Haber.



Collaboration is a critical aspect of advancing new technology in civil infrastructure. In 2019, researchers at TFHRC's Structures Lab tested an innovative UHPC-based strengthening method to increase structural strength of riveted steel thru-girder bridges. This was a collaborative effort between FHWA and NYSDOT, which was looking for a unique solution and which has partnered with FHWA in the past for research-to-deployment projects.

Source: FHWA.

**ZACHARY B. HABER**, Ph.D., is a research structural engineer with the Office of Infrastructure Research and Development at FHWA's Turner-Fairbank Highway Research Center. Dr. Haber leads research and provides technical assistance on topics related to UHPC, conventional structural concrete, bridge engineering, and seismic design. He holds a doctorate in civil engineering from the University of Nevada, Reno.

For more information on FHWA's EDC deployment of UHPC for preservation and repair of bridges, contact Zachary B. Haber at [zachary.haber@dot.gov](mailto:zachary.haber@dot.gov) or Mark A. Leonard at [mark.leonard@dot.gov](mailto:mark.leonard@dot.gov). For more information on FHWA's UHPC research activities, contact Benjamin A. Graybeal at [benjamin.graybeal@dot.gov](mailto:benjamin.graybeal@dot.gov).

U.S. Department  
of Transportation  
Federal Highway  
Administration  
Attn: HRTM  
1200 New Jersey Avenue, SE  
Washington, DC 20590

Official Business  
Penalty for Private Use \$300

