BRIMMING WITH POTENTIAL

The application of UHPC is gaining momentum in USA bridge engineering. Professor Zachary B Haber discusses with **Eve Boykova** the rising popularity of a material five times stronger and ten times more durable than conventional concrete

Delaware Memorial Bridge post-restoration *(Zachary Haber, University of South Florida)*

Be it by pouring record amounts of ultra-high performance concrete (UHPC) like in the Delaware Memorial Bridge restoration *(Bd&e issue 110)*, codifying the use of UHPC or researching new applications of the material – the bridge engineering industry in the USA is looking to scale up use of a material still considered new in many parts of the world.

UHPC expert Professor Zachary B Haber is a structural engineer who – during eight years at the US Department of Transportation – has researched the material for use in a variety of engineering applications. Haber was part of the team that created the 2022 Aashto guide specifications, *Design and construction of UHPC-based bridge preservation and repair solutions*, and he is currently working on researching the service life and limitations of the material at the University of South Florida (USF).

UHPC is a class of cementitious composite materials with a compressive strength over 150MPa and a water-to-cementitious materials ratio less than 0.25%. It is typically composed of high-strength steel fibres, fine sand, cement, fly ash, and a large volume of silica fume. Adding small amounts of specific fibres to UHPC can produce ultra-high performance fibre reinforced concrete (UHPFRC) *(Bd&e issue 111)*.

Over the last decade, explains Haber, UHPC has mainly been used in the US for connecting prefabricated bridge elements, which has helped it gain popularity as a potential structural engineering solution. While precast concrete construction has often been used in bridge engineering, many in the industry felt that traditional grout or regular concrete connections were not delivering the performance required, especially when the high cost of precast concrete elements was considered alongside their durability. The industry began exploring how to make precast elements last longer, and field-cast UHPC connections appeared to offer a simplified alternative that provided better durability. As familiarity with the material grew, so did the interest in scaling up its application.

According to the US Federal Highway Administration (FHA), UHPC has so far been used in field-cast connections between prefabricated bridge components, simple-span prestressed concrete girder bridges and precast concrete deck panels. The publication in 2022 of the aforementioned Aashto guidelines is therefore an important milestone for the material, providing bridge design engineers with a set of detailed instructions on its use.

The FHA is also looking into a variety of other UHPC applications such as precast concrete piles, seismic retrofit of substandard bridge substructures, thin-bonded overlays on deteriorated bridge decks and security and blast mitigation. UHPC has proven to be particularly relevant where conventional solutions have limitations: "In terms of moisture intrusion and salt deterioration, both of those things are not significant concerns for UHPCs," explains Haber.

As regards sustainability, UHPC has a relatively large upfront carbon footprint due to its cement base. In Haber's opinion, a lifecycle assessment that considers the carbon and environmental impact of a bridge with UHPC elements can show that in many cases UHPC will be more sustainable than traditional concrete materials.

Another misconception around the material is its cost performance. "Most people tend to hear about the cost [of the material] and how extreme it is, and they're not focused on the cost of the [end] product," comments Haber. Calculating an UHPC component's whole-of-life cost can provide a more accurate assessment.

Haber envisions that – due to its properties – UHPC has significant future potential in unique applications rather than in a full replacement of standard concrete or steel. He expects that within the USA bridge industry, the next area to scale up UHPC use will be precast prestressed concrete elements. Reportedly, there is significant interest in using the durability of UHPC for driven piles in Florida because the state is surrounded by saltwater that corrodes steel bridge elements exposed to it. UHPC piles can also be driven faster, which would reduce costs in addition to prolonging the lifespan of the prestressed precast concrete piles in coastal states. Other areas that could potentially see an uptake of UHPC are prestressed girder elements and segmental construction.

"I would encourage structural engineers to find UHPC experts in their countries...in almost every country, there is a handful of people that do work on this," says Haber. "They are usually more than happy to talk about UHPC and its benefits. I would encourage structural engineers to learn about it and find and think about innovative ways to use it."

Haber will be developing application-oriented and state-specific design and construction guidance at the USF to help bridge engineers use UHPC ■