

Request for Research Funding for FY 2022-2023

SPR Subpart B Project: STR-23-03

Requesting Office	CO Structures Design	Priority	3 of 4
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Proposed Title	Assessment and Optimization of the Casting Procedure for UHPC Structural Elements
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Justification	<p>Ultra-High Performance Prestressed Concrete (UHPC) structures have become widely known for their superior structural properties (higher tensile and compression strength) and durability performance. However, the limited usage of UHPC structures in Florida is due to the following:</p> <ul style="list-style-type: none"> - The design procedure is not yet introduced in the national (US) or state design codes. - There is a lack of understanding and control on the impact of fiber dispersion and orientation on UHPC structural properties (Several researchers confirm the importance of fiber distribution and orientation to ensure the desired element structural performance.)¹⁻⁴ - The casting protocols that ensure the sufficiently uniform distribution of fibers and desired orientation are not yet developed for the main types of a structural element (several studies were conducted in the past to correlate the casting sequence and flow properties of UHPC to fiber dispersion and orientation).^{5,6} <p>The existing design procedures require comprehensive procedures to ensure the expected high capacity of the member. The most precise approach is recommended by the AFGC⁷ and referred by the fib Model Code⁸, the Canadian Highway Bridge Design Code^{9, 10, 11} and¹². The approach implies the direct measure of the effect of the fiber orientation through direct testing of the structural element mock-up. However, this makes the design and fabrication/field construction of the UHPC members expensive, time-consuming, and, therefore unfeasible for the majority of the projects in the US. The proposed AASHTO specification¹³ is intended to specify the conservative resistance factor and require proper casting procedure to ensure adequate fiber dispersion and orientation. Therefore, the development of the casting protocols with a defined confidence level is needed to enhance the implementation of the design procedure in the US design codes and populate the usage of UHPC for the US bridge projects.</p> <p>The study proposed includes the following:</p> <ol style="list-style-type: none"> 1. Define representative UHPC structural elements and fabricate full-scale samples. 2. Determine the critical sections of the element and conduct flexural and direct tension tests on selected specimens. 3. Formulate several casting scenarios/protocols per each type of structure (girder, pile, etc.), specifying casting sequence, direction, number of lifts, material flowability, and fiber content, and local mold geometry 4. Deliver recommendations for casting UHPC members with defined/certain confidence level. 5. Define state-specific reduction factors to account for unfavorable location/position of fibers. <p>The development of the casting procedure with a defined confidence level for UHPC products would remove the necessity of full-scale testing of the structural elements mock-ups for individual FDOT projects and give a confidence boost to the use of UHPC structures in the design.</p>
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Impact	<p>The proposed study is expected to have a significant impact on the design practice since, as of now, there is no official design procedure specified by the US design standard, which accounts for fiber dispersion in UHPC. Implementation of such a design procedure is substantially retained by the structural properties of the UHPC being unpredictable due to fiber dispersion and orientation in a real structure. The developed casting procedure will reduce the uncertainties in UHPC design and operation. The results are expected to improve the currently developed design procedure and enhance the usage of UHPC structures within the state.</p>
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Affected Offices	FDOT M.H. Ansley Structures Research Center
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Existing Work	<p>Reference list:</p> <p>(1) Pansuk, W.; Hideki, S.; Yasuhiko, S.; Ryosuke, S. Tensile Behaviors and Fiber Orientation of UHPC. In <i>Proceedings of second international symposium on ultra high performance concrete</i>; Kassel, Germany, 2008; pp 161–168.</p>
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Implementability	1	FDOT has already sponsored 3 related research projects listed in “Related Contracts” Section that further emphasizes the importance of this study to be funded and implemented.
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The deliverables of the project greatly benefit current bridge design and construction practice due to the following:

- Better understanding of the impact of the fiber dispersion and orientation on structural properties (tensile strength and durability).
- Defined reduction factor reflecting the effect of the fiber orientation on tensile strength of UHPC members.
- Casting protocols for contractors on the best practices of the casting process to ensure the quality of precast or cast-in-place UHPC members.

The deliverables listed above need to be developed to support a level of confidence in the design provisions incorporated in the upcoming FHWA/AASHTO Guide Specifications.

Project Benefits (Select all that apply and explain)	Quantifiable Benefits (units, dollars, etc...if applicable)	Methodology or Data Sources Used to Determine Quantifiable Benefits. If not applicable, please give justification of project benefits
○ Materials Enhancement		UHPC is reinforced by carbon, steel, or glass fibers which enhance the material tensile strength and energy dissipation capacity.
○ Materials Savings		UHPC has higher strength ** allows reasonable reduction of section areas and reinforcement. Higher durability reduces need in frequent repair and reinforcement. ** This is subject to the impact of fiber dispersion and orientation.
○ Time Savings		UHPC elements are faster in manufacturing and require less efforts in maintenance and rehabilitation.
○ Lives Saved/Injuries Prevented		Higher durability provides safer operation of the structure without extensive maintenance.
○ Other (Explain)		

*Comments should explain and support urgency, financial benefit, and implementability scores