Request for Research Funding for FY 2023-2024			
Project Number (Research Center Use Only: STR-24-02			
Requesting Office	CO Structures Design	**Priority**	2 of 5
Proposed Title	Driving Assessment of UHPC Piles		
Justification	Ultra-high-performance concrete (UHPC) piles provide numerous advantages compared to traditional concrete piles, prestressed with steel carbon reinforcement, primarily used for foundations in Florida. These include enhanced durability, tensile and compressive strength, sustained post-cracking tensile strength, and lower surface permeability. Compared to traditional concrete, UHPC piles have improved corrosion resistance and intended service life, especially in areas with high water tables or marine environments. The widespread use of UHPC members is restrained by the absence of standards for the design and installation, and the currently substantially higher cost of materials. Consideration of higher allowable driving stress, driving speed, and transportation time (due to the lighter section) can make the use of UHPC cost-effective[1]. With enhanced corrosion resistance and lower life-span maintenance cost, UHPC piles may be competitive with piles prestressed with carbon fiber or stainless steel reinforcement. There are several recently completed and ongoing UHPC-related projects funded by FDOT investigating reliable and cost-effective designs and practices for the material. Florida DOT has experience testing octagon- and H-shaped UHPC piles recently. The scope of the project includes but is not limited to the following experimental and analytical deliverables: - Summary of conducted research and findings regarding the drivability of UHPC piles. - Experimental evaluation of the UHPC pile (possibly small-scale H-shape section) with a four-point flexure test and reduced-scale impact test in the lab using a pendulum setup. The latter can provide PDA data applicable to the driving stress limit during construction. - Conclusions and recommendations for the efficient driving practices of UHPC piles. - Draft developmental specification to be used by the FDOT State Materials Office as a starting point to update Standard Specifications. The proposed project will visit the unknowns in UHPC pile design and installation and serve as the basis for the Florida Structures Design Guidelines, and Standard Specifications for Road and Bridge Construction. In particular, the test data can be used to push the UHPC-specific stress limits in AASHTO Guide Specification for Structural Design with Ultra-High Performance Concrete, establish the allowable stress limits for prestressed UHPC piles in Section 455 of Standard Specifications and justify the increase in the driving speed for UHPC piles. The outcome will promote the use of UHPC piles where applicable and increase the resiliency of structures, especially in corrosion-prone regions.		
Impact	This research is needed to provide numerical data on UHPC pile strength and durability, an understanding of the installation protocols, and equipment specific to UHPC piles including allowable driving stresses and speed of installation. The obtained results will be employed to develop local, and potentially national design standard provisions along with the construction specification. These efforts will contribute to the use of UHPC members as common practice structural components within Florida for projects with specific needs.		
Affected Offices	CO Structures Design Office, CO Construction Office, CO State Materials Office		
Existing Work	Reference list: 1. Suleiman, M. T., Vande Voort, T. & Sritharan, S. Behavior of Driven Ultrahigh-Performance Concrete H-Piles Subjected to Vertical and Lateral Loadings. *J. Geotech. Geoenviron. Eng.* **136**, 1403–1413 (2010). 2. Isa, M. N., Pilakoutas, K. & Guadagnini, M. Shear behavior of E-UHPC containing recycled steel fibers and design of E-UHPC screw piles. *Construction and Building Materials* **304**, 124555 (2021). 3. Loh, P., Booya, E. & Gardonio, D. Design and Installation of UHPC H-Piles at the Lily River Detour Bridge, Highway 11, Near Kapuskasing, Ontario, Canada. in *Proceedings of the Canadian Society of Civil Engineering*		

<table>
<tr><td></td><td colspan="3">*Annual Conference 2021* (eds. Walbridge, S. et al.) 663–677 (Springer Nature, 2023). doi:10.1007/978-981-19-0503-2_53.
4. Voort, T. V., Suleiman, M. & Sritharan, S. Design and Performance Verification of UHPC Piles for Deep Foundations.
5. Garder, J., Aaleti, S., Zhong, L. & Sritharan, S. Connection Details and Field Implementation of UHPC Piles – Phase II. (2019).
6. Leonhardt, S., Lowke, D., Stengel, T. & Gehlen, C. Impact Tests on Ultra-High Performance Concrete - Characterization of Strains and Ultrasonic Velocities. *Materials Testing* 53, 736–740.
7. Voort, T. V., Suleiman, M. & Sritharan, S. *Design and Performance Verification of UHPC Piles for Deep Foundations*. (2008).
8. Aaleti, S. R. Experimental Evaluation of UHPC Piles with a Splice and Pile-to-Abutment Connection Performance. 14 (2012).
9. Sritharan, S. & Aaleti, S. Experimental and Analytical Investigation of UHPC Pile-to-Abutment Connections. in *First International Interactive Symposium on UHPC* (Iowa State University Digital Press, 2016). doi:10.21838/uhpc.2016.117.
10. Connection Details and Field Implementation of UHPC Piles – Phase II Final Report. 314.
11. Ronanki, V. S. & Aaleti, S. Experimental and analytical investigation of UHPC confined concrete behavior. *Construction and Building Materials* 325, 126710 (2022).
12. Shrestha, B., Gheni, A., Abdulazeez, M. M. & ElGawady, M. A. Innovative Approach to Repair Corroded Steel Piles using Ultra-High Performance Concrete. *Transportation Research Record* 2674, 1–14 (2020).
13. Zhang, Y., Zheng, H. & Li, G. Experimental Study of UHPC-RC Composite Pile Connected by Shear Keys. *Structural Engineering International* **32**, 1–14 (2022).</td></tr>
<tr><td>Keywords Used In Existing Work Search

(Cannot leave blank)</td><td colspan="3">Ultra-high-performance concrete (UHPC), Tension capacity, Durability, Driving Stress, Skin Friction,</td></tr>
<tr><td>Related Contracts (Give contract numbers)</td><td colspan="3">BED30 977-05 – Acceptable Crack Width Limit for UHPC Structural Members Under Coastal and Marine Environment

BDV31 977-105 – Ultra-High Performance Concrete (UHPC) Use in Florida Structural Application

– Evaluation of Ultra-High-Performance Concrete (UHPC) Pile Splices*

* Project has not yet been executed and a project number assigned</td></tr>
<tr><td>Funding Request</td><td>$650k (If that exceeds the allowable limit, this project could be split into two projects, one to UCF and one to USF.)</td><td>Anticipated Duration</td><td>3 years</td></tr>
<tr><td>Project Manager</td><td>Christina Freeman</td><td>Contracting Method</td><td>Direct contract to university collaboration of UCF and USF or two separate projects for each team.</td></tr>
<tr><td>Equipment</td><td>None</td><td colspan="2"></td></tr>
<tr><td>Urgency</td><td>2</td><td colspan="2">This project has been ranked #2 out of 25 ranked research ideas by FDOT’s Central and District Structures Design Offices for 2023-2024. Thus, it has been recognized as important for the state to be funded.</td></tr>
<tr><td>Implementability</td><td>1</td><td colspan="2">Recently FDOT Structures Design Office became deeply involved in the development of the standard UHPC H-pile section. There are also no state-specific design, fabrication, or installation regulations for UHPC H-pile developed. The research projects listed in the</td></tr>
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		"Related Contracts" Section further emphasize the importance of this study to be funded and implemented.

Project Benefits

The deliverables of the project greatly improve the understanding of the UHPC pile installation practice due to the following:

- Evaluation of driving stresses and speed of installation that makes the adoption of UHPC piles more cost-effective and structurally reliable.

- Test data regarding the bearing, stress concentration, and appropriate splice location will be collected and used to develop design provisions for UHPC piles.

The deliverables listed will create a robust basis for the FDOT design guide and Standard Specification provisions for the installation of UHPC piles. UHPC pile-specific driving stress limits, including tensile stress, and driving speed can be incorporated into AASHTO and FDOT Section 455.

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**
o Materials Enhancement		Ultra-high-performance concrete reinforced with steel fibers has higher tensile and compression strength and higher energy dissipation capacity. Lower permeability of the surface improves corrosion resistance.
o Materials Savings		- Due to higher durability, the UHPC piles can be used in highly corrosive environment for longer service life than currently available alternatives. - Higher tension capacity results in smaller sections with less reinforcement compared to conventional prestressed concrete piles. - Effective H-cross section provides sufficient skin friction capacity for the non-bearing type of piles and allows length reduction.
o Time Savings		- UHPC piles can resist higher driving stresses allowing larger hammers and, therefore, less driving time. - Lighter weight* results in cost saving during transportation. * Compared to the equivalent concrete section
o Lives Saved/Injuries Prevented		Higher durability provides safer operation of the structure without extensive maintenance. Less frequent maintenance results in improved safety for the traveling public.
o Other (Explain)		

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