Request for Research Funding for FY 2021-2022			
Requesting Office	CO Structures Design	**Priority**	3 of 5
Proposed Title	Bond Performance Between Precast UHPC Substrates and Field Cast UHPC Connections		
Justification	With advancement in the implementation of ultra-high performance concrete (UHPC) precast structural elements in bridges, design and detailing of connections between precast UHPC members becomes an emerging research topic. These connections will be required to provide sufficient strength and long-term performance equal to or better than the adjacent UHPC precast elements that they are connecting. Therefore, it is expected that these connections will be primarily made out of UHPC or similar grouting materials. As a result, the interfacial bond between precast UHPC members and field cast UHPC connections needs to be investigated to provide a knowledge base for design and detailing of the connection. Several studies have been conducted on the UHPC/conventional concrete interfacial bond performance and found that the surface roughness, moisture condition of the concrete substrate, shrinkage property and curing condition of UHPC all affect the bond performance. But to date, there has been little research on the interfacial bond behavior between (precast) UHPC and (field cast) UHPC materials. On one hand, the UHPC/UHPC interfacial bond may be an even more critical issue than that of UHPC/concrete interfaces. For example, some effective surface preparation methods, such as exposure of aggregates, are not applicable for UHPC substrates. On the other hand, due to the high strength and ductility of UHPC material, mechanical interlocking and anchors may be more effective than those in a UHPC/concrete connection. Nevertheless, it is important to experimentally investigate and understand the bond behavior between precast and field cast UHPC, factors that affect the bond performance, and effective ways to ensure adequate bond. In the proposed study, the interfacial bond between existing UHPC and newly cast UHPC mixtures and the associated failure mode will be experimentally measured using push-out shear test and ASTM C1583 direct tension pull-off test to evaluate the bond performance under shear and tensile loading, respectively. Several parameters will be investigated to determine their influence on the bond performance, which include the moisture content of the existing UHPC substrates; fiber type, flowability, tensile strength, shrinkage, curing condition, and age of the field cast UHPC; substrate surface roughness and textures; and the use of bonding agent. The research result will generate firsthand data on the interfacial bond between precast UHPC and field cast UHPC, which will aid the design of the connections.		
Impact	UHPC is touted as a great material for corrosive environments due to its improved durability compared to conventional concrete. It has successfully been used many times throughout the U.S. for connecting prefabricated conventional concrete members and studies have proved that connection to be durable if the conventional concrete surface is properly prepared. There is a growing interest in using UHPC for full-scale prefabricated items, such as prestressed beams. To realize the enhanced durability of those items, the cast-in-place connection between them must also exhibit good durability performance. Since UHPC has more impermeable surface than conventional concrete, that means it may be inherently more difficult to form a good bond to hardened UHPC than to conventional concrete. If the bond is not sufficiently durable, the potential life cycle cost gains from using UHPC will not be realized.		
Affected Offices	Structures Design, State Materials Office (Concrete)		
Existing Work	Valikhani, Alireza, Azadeh Jaberi Jahromi, Islam M. Mantawy, and Atorod Azizinamini. "Experimental evaluation of concrete-to-UHPC bond strength with correlation to surface roughness for repair application." Construction and Building Materials 238 (2020): 117753. Graybeal, Benjamin A., Igor De la Varga, and Zachary B. Haber. Bond of field-cast grouts to precast concrete elements. No. FHWA-HRT-16-081. United States. Federal Highway Administration, 2017. Carbonell Muñoz, Miguel A., Devin K. Harris, Theresa M. Ahlborn, and David C. Froster. "Bond performance between ultrahigh-performance concrete and normal-strength concrete." Journal of Materials in Civil Engineering 26, no. 8 (2014): 04014031. Zhang, Yang, Chongyang Zhang, Yanping Zhu, Junhui Cao, and Xudong Shao. "An experimental study: various influence factors affecting interfacial shear performance of UHPC-NSC." Construction and Building Materials 236 (2020): 117480.		
Keywords Used In Existing Work Search **(Cannot leave blank)**	UHPC bond, UHPC-to-UHPC, UHPC joint		

Related Contracts (Give contract numbers)	BDV29-977-28, BDV31-977-94, BDV31-977-105, BDV31-977-101		
Funding Request	$250,000	**Anticipated Duration**	2.5 year
Project Manager	Christina Freeman	**Contracting Method**	RFP to all registered vendors
Urgency	3	This project scored third in a rating of research ideas by FDOT's Central and District Structures Design Offices.	
Implementability	1	UHPC is already being used in Florida bridge projects and many pre-casters are developing their own UHPC formulations. Due to the appeal of the material's durability, growing availability and subsequent price reductions, implementation is likely.	

Project Benefits (Succinct, complete explanation)

Several concrete pre-casters in Florida are developing their own UHPC mix formulations, making the material more readily available and driving down its cost. But UHPC continues to be much more expensive than conventional concrete. UHPC is much more durable than conventional concrete and can be used as an alternative to other corrosion resistant approaches such as the use of stainless steel or CFRP strands. This research needs to be completed to use ensure the success of the bond between precast UHPC components. The addition of another method of achieving durability in corrosive environments adds competition which will in turn drive down costs. If UHPC is not used correctly and its potential durability gains are not realized, the added cost for the material will be wasted.

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		This research could enhance the current methods and materials by enabling the use of more durable UHPC for full-scale prestressed members.
o Materials Savings		Fewer bridge replacements means less material used.
o Time Savings		UHPC is ideal for accelerated construction due to its high early strength so further development of applications for the product may result in more accelerated construction and therefore time savings.
o Lives Saved/Injuries Prevented		Improved safety is associated with accelerated construction.
o Other (Explain)		

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