Request for Research Funding for FY 2021-2022			
Requesting Office	CO Structures Design	**Priority**	5 of 5
Proposed Title	Acceptable Crack Width Limit for UHPC Structural Members Under Coastal and Marine Environment		
Justification	Ultra-high-performance concrete (UHPC) has been widely researched as a durable and high-performance alternative to conventional concrete in FDOT bridge construction. With dense microstructure and high tensile strength and tight crack width, UHPC has demonstrated much higher durability compared to conventional concrete. Past research has shown that uncracked UHPC has significantly lower water permeability, chloride diffusivity, and gas permeability, which offers great protection against corrosion of steel reinforcement. This is particularly desirable for structures exposed to coastal and marine environments. The durability of UHPC under cracked condition, on the other hand, has not been fully studied. For conventional concrete, several researchers pointed out that when crack width increases beyond a threshold value (in the range of 50–100 μm), the water permeability and chloride diffusivity notably increase. Although limited studies have been conducted on UHPC, such trend is expected. The crack width is governed by UHPC mixture design (e.g. fiber content, type), placement condition, (e.g. fiber distribution), and crack control reinforcement, which could exceed the abovementioned threshold range, and may also be subjected to high variability if UHPC is not mixed and placed properly. Preliminary studies also show that when cracked, the steel fibers within UHPC may be susceptible to corrosion when exposed to chloride solutions, causing the mechanical performance to degrade when corrosion progresses. However, there is no comprehensive study that investigated the corrosion resistance of UHPC members with cracks in a realistic condition and especially under coastal and marine environment, as well as the influence of crack width and potential self-healing of cracks. To fully understand the durability and corrosion resistance of UHPC members, the cracking behavior of UHPC and the influence of cracks and crack width need to be investigated. In particular, the limit for acceptable crack width of UHPC for different exposure conditions, especially under coastal and marine environment, is of high interest to the structural design engineers. In the proposed study, we intend to study 1) the corrosion resistance of UHPC structural members with cracks; 2) the influence of crack width and self-healing on the durability and corrosion resistance of UHPC members; and 3) the uncertainty of crack widths in UHPC members and its effect on durability. The research result will help to determine the durability and corrosion resistance of UHPC under realistic cracking conditions, identify crack width limit for structural design, and understand the extent and influence of crack width variability.		
Impact	UHPC is generally believed to be a particularly durable material, with improved permeability compared to conventional concrete. It has been commonly used throughout the U.S. to join prefabricated concrete components. There is an increasing interest in its use for full scale structural members, such as piles and beams. Conventional concrete members such as those are generally designed for serviceability to limit crack size. As this would be a new application for UHPC, the acceptable crack size and design requirements to ensure serviceability are unknown. UHPC is an expensive material but its cost is justified because of improved durability and efficient section types. If this research is not completed and the allowable crack widths are unknown, UHPC may not achieve the desired durability and the added cost for its use would be wasted.		
Affected Offices	Structures Design, State Materials Office (Concrete)		
Existing Work	Li, Junquan, et al. "Durability of ultra-high performance concrete–A review." Construction and Building Materials 255 (2020): 119296. Gowripalan, N., V. Sirivivatnanon, and C. C. Lim. "Chloride diffusivity of concrete cracked in flexure." Cement and Concrete research 30.5 (2000): 725-730. Jang, Seung Yup, Bo Sung Kim, and Byung Hwan Oh. "Effect of crack width on chloride diffusion coefficients of concrete by steady-state migration tests." Cement and Concrete Research 41.1 (2011): 9-19. Shin, Wonsik, and Doo-Yeol Yoo. "Influence of steel fibers corroded through multiple microcracks on the tensile behavior of ultra-high-performance concrete." Construction and Building Materials 259 (2020): 120428. Graybeal, Benjamin. “Simultaneous Structural and Environmental Loading of an Ultra-High Performance Concrete Component.” FHWA Publication No. FHWA-HRT-10-054.		

Keywords Used In Existing Work Search **(Cannot leave blank)**	UHPC crack width		
Related Contracts (Give contract numbers)	BDV29-977-28, BDV31-977-94, BDV31-977-105, BDV31-977-101		
Funding Request	$300k	**Anticipated Duration**	3 years
Project Manager	Will Potter, Christina Freeman	**Contracting Method**	direct contract with university
Urgency	5	This project scored fifth in a rating of research ideas by FDOT's Central and District Structures Design Offices.	
Implementability	1	Design requirements to ensure crack widths do not exceed limits can be implemented in the FDOT Structures Manual.	

Project Benefits (Succinct, complete explanation)

UHPC is rapidly gaining popularity as a material of choice in Florida for its improved durability and section efficiency (reduced weights) compared to conventional concrete. This research will develop guidance to ensure that durability is realized as the material is used for more types of bridge members.

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		This research is required to ensure that UHPC members are designed to maximize the durability of the material. That will lead to longer service life.
○ Materials Savings		Longer service life means bridges are replaced less frequently and therefore there are materials savings.
○ Time Savings		
○ Lives Saved/Injuries Prevented		
○ Other (Explain)		

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