**Scope of Work**

**Assessment of Durability Requirements for Concrete Structures in Florida**

Florida Department of Business and Professional Regulation

Florida Building Commission

and

Engineering School of Sustainable Infrastructure and Environment (ESSIE)

University of Florida (UF)

Project Leader: Christopher. C. Ferraro., University of Florida

1. **Introduction**

The 2021 collapse of the Champlain Towers South in Surfside, Florida highlights the need for a broad assessment of durability and structural integrity concrete building structures in the State of Florida. A critical first step toward this assessment is to gain a clear understanding of condition of existing structures through research which examines the design requirements, construction practices, concrete mixture parameters and condition of buildings in South Florida.

Currently, Florida requires buildings older than 40 years to be inspected by a licensed engineer or architect to receive recertification During this year’s legislative session there were several proposals for initial building recertification at ages of 20 or 25 years for coastal buildings.  There are communities requiring building recertification for coastal buildings at later ages, but a scientific rational for a particular recertification age has not been established. Historically, (prior to 1989) the concrete Building Code Requirements for Reinforced Concrete (ACI 318) and the South Florida Building Code did not emphasize the importance of considering durability requirements and concrete cover (protective layer of concrete) over the reinforcing steel. In 2008, concrete exposure categories were introduced into ACI 318 which require the designer to consider applicable durability requirements [ACI 318-2008]. These requirements are still minimal and are not based on a particular service life. They also do not require any special protection for coastal buildings exposed to airborne chlorides but not touching seawater, however changes to the building code are currently being considered to add durability requirements if a structure is within a mile of the coast.

The durability of portland cement concrete in structures is one of the key components to ensuring the long-term structural adequacy and safety of Florida’s building inventory. The deterioration of reinforced structural concrete near Florida’s coastline is typically a result of exposure to chlorides borne from the coastal environment and carbonation of the concrete. The environmental conditions near Florida’s coastline include high temperature, high humidity, and salt spray and are favorable for corrosion of reinforcement and carbonation of concrete. The corrosion of steel reinforcement within concrete is typically accelerated by a combination of chloride intrusion and carbonation of the concrete. Corrosion of embedded steel reinforcement results in expansion, which leads to cracking and spalling of concrete and accelerates further deterioration of the structure. Carbonation of concrete is the chemical reaction between carbon dioxide in the atmosphere and cement hydration products. As carbonation progresses inward from the surface of the concrete, the concrete pH is reduced, making the protective passive layer around the steel unstable. This makes the reinforcing steel corrosion rate increase by orders of magnitude, causing corrosion. Even if the carbonation doesn’t reach the level of the steel, carbonated concrete has very little chloride binding capacity. When the concrete carbonates, chlorides bound by the cement can be released to further penetrate into the concrete, increasing the risk of corrosion. The combined effect of the carbonation and chloride induced corrosion is the primary mechanism of deterioration of concrete which leads to reduced service life and the need for additional maintence to concrete structures.

This project seeks to provide a scientific basis for the determining the appropriate age for initial inspection of buildings in Florida. However, the complexity of the environment and airborne chlorides may require that structures located near the shoreline have different considerations than those structures which are further inland. Currently, members of the research team are working on a project for the Florida Building Commission (FBC) which includes the statewide survey of inspection reports. The project has provided the team with invaluable knowledge of the condition and types of defects observed which provides insight regarding durability of buildings in South Florida.

1. **Scope of Work**

*Task 1: Review of Literature, Codes and Practices*

Perform a literature review documents relevant to the building codes, specifications, environmental conditions and practices for construction of concrete structures relevant to Florida. The review will document will be provided the research team and the FBC.

* The review of the literature will account for the requirements for building codes, practices and concrete mixture designs used in Florida from 1980 to present day.
* The following concrete properties as they pertain to durability and service life will be investigated:
  + Concrete mixture design
  + Concrete durability and proximity to the coastline
  + Acceleration of corrosion within concrete exposed to chlorides
  + Detection and mitigation of carbonation of concrete
  + Carbonation depth and strength reduction of concrete
  + Permeability as it relates to durability of concrete
* The physical properties of concrete as they pertain to concrete durability will be reviewed for the use in development of a modeling program to be carried out in Task 2.

*Task 2: Model Development*

The objective of Task 2 is to create a computational model designed to determine the service life of concrete.

* Upon completion of Task 1, UF ESSIE will utilize the information gained in the review od the literature to create a computer model which accounts the rate of chloride ingress into concrete
* The model will consider the rate of chloride ingress in conjunction with the carbonation of concrete. Model parameters will include”
  + Concrete mixture design
  + Diffusion coefficient
  + Carbonation rate

*Task 3: Establishment of a scientific basis for age initial inspection of buildings*

The objective of Task 3 is to use the modelling program developed in Task 2 to provide a scientific basis for the determining the appropriate age for initial inspection of buildings in Florida. The computer model will incorporate the information obtained from the building codes, specifications, environmental conditions and practices for construction of concrete structures in Task 1 as modeling inputs. The modeling program will determine the time to chloride ingress to corrode rebar while addressing carbonation of the concrete.

*Task 4: Final Report*

1. **Staffing**

**PI:** Christopher Ferraro, Ph.D.,P.E., FACI Assistant Professor, Engineering School for Sustainable Infrastructure and Environment, University of Florida

**Co-PI:** Kyle A. Riding Ph.D.,P.E., FACI Professor, Engineering School for Sustainable Infrastructure and Environment, University of Florida

**Co-PI:** Jennifer Bridge, Ph.D., Associate Professor, Engineering School for Sustainable Infrastructure and Environment, University of Florida

1. **Method of Payment**

A purchase order will be issued to the University of Florida. This project shall start on date of execution of the purchase order and end at the midnight on August 30, 2023. This purchase order shall not exceed $100,000.00 and shall cover all costs for labor, materials and overhead. Payment will be made for the study after the Program Manager and the Florida Building Commission’s Hurricane Research Advisory Committee have approved the final report. Additionally, the Contractor agrees to provide additional documentation requested by the Program Manager to satisfy all payment and audit requirements.

1. **Deliverables**
2. An interim report shall be prepared and delivered no later than February 28, 2023. The interim report shall cover progress to date on all tasks. This report will serve as a progress update that details the current state of research, preliminary results, and descriptions of any issues that may have been encountered. In addition, the interim report shall be formally presented to the Florida Building Commission’s Hurricane Research Advisory Committee at a time agreed to by the Contractor and Department’s Program Manager. The due date may be extended with the approval of the Department’s Program Manager.
3. A draft final report shall be prepared and delivered no later than May 16, 2023, for comments by the Florida Building Commission’s Hurricane Research Advisory Committee. The report shall contain deliverables of the 4 tasks discussed in Section 2. The final report shall be prepared with revisions to address Hurricane Research Advisory Committee comments and delivered no later than June 15, 2023. In addition, the draft final report and the final report shall be formally presented to the Hurricane Research Advisory Committee at a time agreed to by the Contractor and Department’s Program Manager. The due date may be extended with the approval of the Department’s Program Manager.

# Financial Consequences

UF ESSIE is solely responsible for the satisfactory performance of the tasks and completion of the deliverables as described in this Scope of Work. Failure to complete the tasks and deliverables in the time and manner specified in Sections 2 and 5 shall result in a non-payment of invoice until corrective action is completed as prescribed by the program or contract manager.

# Program Manager

The Program Manager for this project is Mo Madani. Mo Madani’s email address is [Mo.Madani@myfloridalicense.com](about:blank) and his phone number is 850-717-1825. The contract manager for this project is Barbara Bryant. Barbara Bryant’s email address is [Barbara.Bryant@myfloridalicense.com](mailto:Barbara.Bryant@myfloridalicense.com) and her phone number is 850-717-1838.