Scope of Work

Establishing Inspection Periods and Preliminary Recommendations for Preventive Measures for Mid-Rise Buildings Near Coastal and Inland South Florida Environments

Florida Department of Business and Professional Regulation
Florida Building Commission

and

Dept. of Civil and Environmental Engineering (CEE), Florida International University (FIU)

Project Lead: Atorod Azizinamni

1. Introduction

Carbonation of concrete and ingress of chloride are the most common factors responsible for the observed corrosion of reinforced concrete elements in buildings in Florida. The incidence of carbonation-induced corrosion depends on many factors, among them the presence of concrete pore water, concrete quality, grade of steel, and concrete cover depth.

The goal of the proposed project shall be to develop protocols for the first and subsequent inspection intervals of Mid to High-Rise Buildings. This study shall concentrate on establishing the inspection period that is based on carbonation of concrete. FIU has carried out significant studies on chloride-induced corrosion. The outcomes of these chloride-induced corrosion studies shall be considered where possible, in the development of project deliverables, described later. Another goal of this project shall be to make the first step in providing preliminary recommendations for taking preventive measures, in the form of wrapping concrete columns prone to corrosion due to concrete carbonation with Ultra-High Performance Concrete (UHPC). Large-scale testing of concrete columns shall be made to establish proof of concept. Specific objectives of the research shall include: 1) determination of the benefit of UHPC in concrete repairs to mitigate concrete carbonation and steel corrosion, 2) determination of the effect of concrete quality, environmental exposure, and loading on concrete carbonation and steel corrosion, 3) development of fast practical field measurements to identify concrete susceptibility to carbonation, and 4) development of recommendations for the inspection period of reinforced concrete based on concrete carbonation and recommendations for taking proactive steps in preventing corrosion using UHPC wrap.

2. Scope of Work

Task 1- Conducting tests on large scale column test specimens for establishing time to corrosion due to concrete carbonation- **Without Applied Axial Load**

The objective of Task 1 shall be to identify concrete carbonation and steel corrosion rates for concrete with various repairs to identify the extent of corrosion mitigation afforded by the repair.

- FIU-CEE shall incorporate four large-scale concrete columns that are under construction at FIU under the supervision of the PI as test specimens with various concrete repairs using Normal Strength concrete and UHPC. Funds for conducting structural testing of these concrete columns are provided from elsewhere.

- FIU-CEE shall conduct durability tests to establish the rate at which carbonation can occur for the reference column, column retrofitted using normal strength concrete, and column retrofitted using UHPC. The corrosion rates of the steel shall be measured. An exposure chamber with a carbon dioxide inlet shall be placed around the columns for a period of 2-weeks to expedite concrete carbonation.

Task 2- Conducting tests on large-scale column test specimens for establishing time to corrosion due to concrete carbonation- **With Applied Axial Load**

The objective of Task 2 shall be to identify concrete carbonation and steel corrosion rates for concrete with various repairs and under various loading conditions. This will help elucidate the effect of loading and identify where the concrete may be more susceptible to carbonation.

- FIU-CEE shall repeat tests as described in Task 1 after a constant axial load is applied. The constant axial load shall be kept for two weeks before applying lateral loads. Concrete carbonation tests shall be carried out during those two weeks. It is believed that the presence of axial load, which is closer to real world condition, might help to increase time to corrosion due to concrete carbonation.

Task 3- Relation to quick durability test developed by PI

The objective of Task 3 shall be to implement a novel, fast and practical test methodology to identify materials and locations where concrete may be susceptible to carbonation. The liquid pressure test is based on the resistance of the concrete material to the penetration of moisture and transport of dissolved ionic species. Laboratory testing has demonstrated that differentiation between low and high permeability concretes can be made. Transport of gases such as CO_2 dissolved in the pore water are likely to be similarly differentiated.

- FIU-CEE shall conduct the liquid pressure test developed by the PI for all the tests to be conducted under Tasks 1 and 2. The newly developed FIU durability test shall be conducted in less than 30 minutes and shall differentiate concrete quality by means of penetration of pressurized liquid.

Task 4- Small-scale test to establish concrete carbonation time

The objective of Task 4 shall be to identify concrete carbonation and steel corrosion rates for concrete of various quality under various environmental and loading conditions. This will identify structure locations where the concrete can be susceptible to carbonation. The time duration for conducting carbonation concrete tests on large test specimens described under Tasks 1 and 2 shall be limited to two weeks because of other project limitations. To complement tests under Tasks 1 and 2, a series of concrete carbonation tests shall be carried out on small concrete specimens for longer periods.

- FIU-CEE shall fabricate small scale laboratory concrete test specimens to assess the effect of concrete quality, environmental condition (including moisture availability), and loading on the susceptibility of concrete to carbonate. These tests may take three months to complete. The sets of small-scale specimens shall be made of Normal Strength concrete of various strengths and cement content as well as UHPC. The concrete specimens shall be divided into two groups: axially loaded and unloaded. The small-scale specimens shall be placed in an accelerated carbonation chamber and maintained in various moisture environments. Each concrete specimen shall be instrumented with corrosion probes to monitor the corrosion rate of reinforcing steel. After accelerated carbonation, the concrete carbonation through the concrete shall be verified by pH-indicating tests using phenolphthalein solutions. Detailed description these tests shall be provided in the draft final report.

Task 5- Development of recommendations

The objective of this task shall be to provide recommendations for the inspection period of reinforced concrete that is based on concrete carbonation and recommendations for taking proactive steps in preventing corrosion using UHPC wrap.

- FIU-CEE shall consider the outcomes of Tasks 1-4 to assess rates of carbonation and steel corrosion in concretes of various quality, environmental exposures, and loading. The results of research shall be considered to provide recommendations for inspection schedules for reinforced concrete structures, concrete repair implementing UHPC, as well as to develop practical testing of concrete durability.

3. Staffing

PI: Dr. Atorod Azizinamini, CEE, Florida International University
Dr. Joe Colaco, CEE, Florida International University
Mr. Larry Griffis, CEE, Florida International University
Dr. Kingsley Lau, CEE, Florida International University
Dr. Ankitha Prakash, CEE, Florida International University

4. Method of Payment

A purchase order will be issued to FIU. This project shall start on the date of execution of the purchase order and end at the midnight on June 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.

5. Deliverables

a. An interim report shall be prepared and delivered no later than February 28, 2023. The interim report shall cover the progress of Tasks 1, 2, 3, and 4. This report will constitute as a progress update in detail and will include description of any issues that might be affecting the project goals and objectives.

   In addition, the interim report shall be formally presented to the Florida Building Commission's Hurricane Research Advisory Committee at a time set by the Contractor and the Department's Program Manager. The due date could be extended with the approval of the Department's Program Manager.

b. A final report shall be prepared and delivered no later than by June 1, 2023 for review and comments, by the Research Advisory Committee. The final report shall include:
   a- Recommendations for inspection periods based on concrete carbonation,
   b- Preliminary recommendations on procedures for assessing durability of concrete columns in mid- to high-rise buildings that uses FIU durability test, and
   c- Preliminary recommendations on taking proactive measures to protect concrete columns against carbonation induced corrosion using UHPC.

In addition, 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.

6. Financial Consequences

FIU-CEE will be 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.

7. Program Manager

The Program Manager for this project is Mo Madani. Mo Madani's email address is Mo.Madani@myfloridalicense.com 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 and her phone number is 850-717-1838.