# CONSTRUCTION OF THREE LARGE-SCALE ROBOTS CAPABLE OF CONSTRUCTING UHPC SHELL, REPAIR OF CULVERT AND AUTOMATED MFL

**Quarterly Progress Report**

**For the period ending May 31, 2021**


Submitted by:

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Submitted to:

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# 1. PROJECT ABSTRACT

Three ongoing ABC projects involve tasks, that demand the development of specialized robots. Within those projects, small scale robots are developed. However, students, do not have the knowledge or capability to develop robots that can print or function at full-scale. Applied Research Center (ARC) at FIU has a division that specializes in development of full-scale and functional robots, mainly for the Department of Defense. Under this project, ARC will assist the graduate students involved in the three ongoing ABC projects to develop full scale, customized robots and allow achieving the objectives of those three projects. The three ongoing ABC projects are related to 3D-printing of UHPC shells, UHPC shotcrete for culvert repair, and accelerated inspection of steel strands using MFL technology. The success of this project will have payoff by assisting the three on-going project which have high potential payoffs.

# 2. RESEARCH PLAN

## 2.1. PROBLEM STATEMENT

Conceptual design for each large scale robot was envisioned from the abovementioned projects. **Figure 1** shows the envisioned concept for a mobile robot for 3D-printing of UHPC shell based on the outcomes from "*Robotics and Automation in ABC Projects: Exploratory Phase [ABC-UTC-2016-C2-FIU05]"* and *Robotic Bridge Construction: Experimental Phase I [ABC-UTC-2016-C3-FIU06]*. **Figure 2** shows the envisioned concept for a mobile robot for shotcreting UHPC for culvert repair based on the outcomes from "*Use of UHPC in Conjunction with Pneumatic Spray Application and Robotic for Repair and Strengthening of Culverts- Phase I" [ABC-UTC-2016-C3-FIU04]*. **Figure 3** shows an initial envisioned concept for a mobile robot for inspecting corrosion of steel strands using MFL technology based on the outcomes from "*Automated MFL System for Corrosion Detection" [ABC-UTC-2016-C3-FIU08]*.

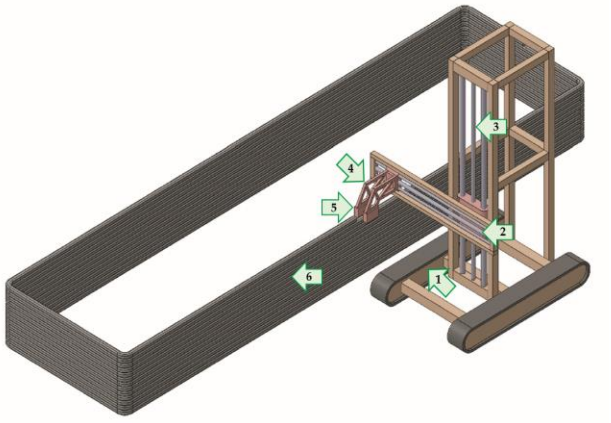


**Figure 1.** Envisioned Concept for Large Scale Mobile Robot for 3D-printing.

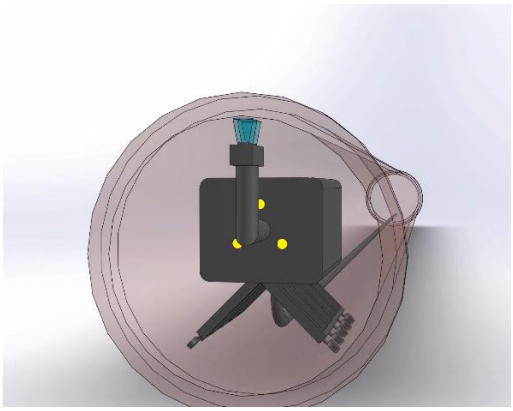

**Figure 2.** Envisioned Concept for Large Scale Mobile Robot for UHPC Shotcrete for Culvert Repair.

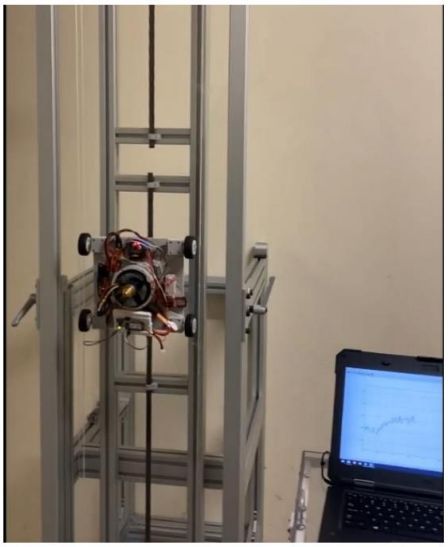

**Figure 3.** Envisioned Concept for Large Scale Mobile Robot for Steel Strand Inspection using MFL technology.

## 2.2. RESEARCH OBJECTIVES AND APPROACH

Construction of three large scale robots for following three Sub-Tasks

a) Printing UHPC Shell

b) Repair of Culverts Using Shotcrete

c) Automated Inspection of Steel Strands using MFL Technology

Under this project, the staff from ARC will provide all technical assistance needed for graduate students successfully constructing the large scale robots capable of achieving the objectives of the three projects.

All necessary part will be purchased by ABC-UTC, outside the $40,000 budget assigned to this project. The assigned $40,000 budget to ARC will be devoted to PI salary at ARC, hourly students or other staff that ARC deems necessary to complete the construction of large scale robots, associated with three projects.

Bi-Weekly meetings will be held between ARC PI, Co-PI and graduate students working on these projects to monitor the project progress.

The assigned ABC-UTC graduate students to each project are as follows:

a) 3D-Printing UHPC Shell – Ali Javed

b) Repair of Culverts Using Shotcrete– Atif Anwer and Mohamed Faheem Afzal

c) Automated Inspection of Steel Strands Using MFL Technology– Amir Sadeghnejad, Sheharyar-E-Rehmat, and Ali Javed

### 2.2.1. DETAILED WORK PLAN

An overview of the study tasks is given below.

**Task 1 – Development of a large robot for 3D-Printing of UHPC Shells**

Within **Project A** subtask, developing and assembly of a functional mobile robot capable of 3D-printing UHPC shell.

*In this subtask, new concept of section printing was envisioned to allow the printing of the shell elements with minimum number of interfacial layers with help of heat curing. Research team successfully printed 3 ft long U-shape shell specimen using this concept. It is anticipated that during the next quarter, printing of large scale specimen will be conducted.*

**Task 2– Development of a large robot for shotcrete of culverts**

Within **Project B** subtask, developing and assembly of a functional mobile robot capable of shotcreting UHPC for culvert repair.

*In this subtask, the latest version of the shotcrete robot which has been evolved from pipe crawler concept is envisioned. The robot will be mounted on wheels, thus will enable it of overcoming many difficult terrains. The UHPC will travel on the back of the robot towards the front of boom arm via steel pipes. It is planned to conduct pumpability testing for this envisioned concept during the next quarter; However, it is planned that the UHPC shotcrete to be conducted manually as part of the parent project during the next quarter.*

**Task 3– Development of robots for automated inspection of steel strands using MFL technology**

Within **Project C** subtask, developing and assembly of a functional mobile robot capable of inspecting steel strands to automat MFL technology developed by FIU.

*In this subtask, Different options for automating the magnetic flux leakage for bridge applications are envisioned. An aerial vehicle is a viable option which can access areas of interest, provide autonomous control and transmit data wirelessly. Under the planned tasks, different aerial drones were assembled based on considerations of payload, stability and mobility for a set of target bridge elements. The prototype drone will be installed with a sensor package which can transmit data to the base station and provide a mapping of flux signals for a*

*target element. The laboratory validation is planned once stability issues are resolved. The field demonstration on an in-service bridge will be carried out after laboratory validation is established.*

**Task 4 – Final Report**

In this Task, final report will be submitted to ABC-UTC.

*No progress yet.*

## 3. SCHEDULE

**Figure 4** shows the progress of the project during the first quarter.

| Item | % Completed |
|---|---|
| Percentage of Completion of this project to Date | 55% |