Use Of All Lightweight Concrete in Conjunction With UHPC Connection For Prefabricated Barrier System

Quarterly Progress Report
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Submitted by:

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1. Background and Introduction

Barriers are one of the essential components in bridges to ensure safety for vehicles and redirect the errant vehicles passing over bridges. Several attempts were taken place to develop prefabricated barriers with connection to the bridge deck using post-tensioned thread rods and stainless-steel bars. However, those connections are associated with higher cost and durability issues. A new prefabricated barrier system utilizing UHPC connection to deck overhangs was developed under an on-going project [ABC-UTC-2016-C3-FIU05]. To further enhance the developed prefabricated barrier system, the barriers, in this proposed project, will be fabricated from all lightweight concrete with a unit weight of 100 pounds per cubic yard. The use of all lightweight concrete in barriers and in some cases bridge overhangs provides a reduction in the total weight of the barriers by almost 33% allowing the transportation of more barrier units on one truck and easy handling. Furthermore, in seismic regions, lighter barrier contributes to a lesser total mass of bridge superstructures which is beneficial in many cases. In this project, two barriers, made of all lightweight concrete, will be tested under static load test setup and the results will be compared to the specimens which are being tested under project number [ABC-UTC-2016-C3-FIU05].

2. Problem Statement

At the present time, there is no well-accepted barrier system for ABC applications. The use of lightweight concrete for prefabricated barrier system has potential for ABC application. Constructing prefabricated barrier systems using all lightweight concrete that has about 100 pounds per cubic yard as unit weight reduces the weight by almost 33%. This will allow transporting more prefabricated barrier system on a truck and significantly help the transportation and field handling. Furthermore, in seismic regions, lighter barrier contributes to a lesser total mass of bridge superstructures which is beneficial in many cases.

Under an ongoing research project entitled “Prefabricated Barrier System Utilizing UHPC Connections [ABC-UTC-2016-C3-FIU05]”. The research team developed UHPC based connection for prefabricated barriers made of normal weight concrete, as shown in Figure 1. The detail consists of a recess joint filled with ultra-high-performance concrete (UHPC) between prefabricated barriers and the bridge decks. The use of UHPC allows for shorter development length and lap splice length for dowel bars and the material characteristics provide strength and durability to the connection. Besides simplified details, the construction sequence of the proposed connection is suitable for accelerated bridge construction applications. Nonlinear finite element analyses (NLFEA) were conducted to investigate the structural performance and failure mode of prefabricated barriers with associated connections and a comparison is drawn with an emulative cast-in-place (CIP) concrete barriers under transverse loadings. The results show that the proposed connection instigates a yield line failure for the critical length of the system, as shown in Figure 2.

Results of the numerical investigation indicate that the load capacity of the proposed connection could be about 10% more than the corresponding cast-in-place barrier, as shown in Figure 3. The dowel bars in the connection region remain under the yield stress and the cracks are limited within the barrier. Based on the results of NLFEA, an experimental program is underway for validating the concept and development of predictive equations for the ultimate strength of the connection.

3. Objectives and Research Approach

The main objectives of this project are:

1- Verification of the suitability of the developed UHPC connection for all-lightweight concrete barrier systems,
2- Conducting detailed finite element modeling on the proposed all-lightweight concrete barrier system and connections,
3- Conducting experimental work on the proposed prefabricated/all lightweight concrete barriers with UHPC connections,
4- Assessment of the performance of prefabricated/all-lightweight concrete barriers with UHPC connections if compared to barriers made of normal concrete (prefabricated and cast-in-place barrier), and
5- Developing detailed finite element models for the proposed all-lightweight concrete barriers with UHPC connections for better understanding of system performance, therefore, extending the study to analyze other specimens which will not be possibly tested.

After conducting component testing, recommendations for the next phase of the study will be prepared for future research proposal for MASH crash testing.

DETAILED WORK PLAN

An overview of the study tasks is given below.

Task 1 – Verification of the proposed UHPC connection for all-lightweight concrete barrier systems

In this task, the developed UHPC connection for prefabricated barrier will be verified and evaluated for prefabricated/all lightweight concrete barriers. It is possible that changes will be made for the developed connection based on the test results from the on-going research. The detail will be revised to avoid forming the backside of the barrier and stabilize the barriers during construction.

Progress: A UHPC connection has been tested as part of ABC-UTC project entitled "Prefabricated barrier system utilizing UHPC connections". *This connection was modified to overcome some constructability issues.*

Task 2– Preliminarily finite element modeling for the proposed all-lightweight concrete barrier system

In this task, numerical investigation using finite element analysis (ATENA) will be conducted on the proposed prefabricated/all-lightweight concrete barrier system with UHPC connection to verify that the proposed barrier complies with TL-4 requirement. In this task, the design of test specimens will be finalized.

Progress: Several FEA have been performed on the new proposed connection with LWC barriers in order to check the lateral capacity. In addition, new FEM for end details and slab reinforcement have been performed

Task 3– Construction and Experimental work

In this task, experimental work will be conducted to verify the outcome of Task 2. The test will be conducted for two specimens. In the first specimen, prefabricated/all-lightweight concrete barrier system will be connected to deck overhang, made of normal concrete, using UHPC connection. In the second specimen, prefabricated/all-lightweight concrete barrier system will be connected to deck overhang, made of all-lightweight concrete, using UHPC connection.

Progress: The construction of two large scale specimens as part of ABC-UTC project entitled "Prefabricated barrier system utilizing UHPC connections" is ongoing, it is expected that the testing of these two specimens will be conducted during the next quarter report. Once the experimental data for those tests are available, details of specimen with prefabricated barrier made of lightweight will be finalize, it is expected that the construction and testing of the proposed specimen will be conducted during first quarter of 2022.

Task 4 – Assessment of the performance of the proposed prefabricated/all lightweight concrete barrier system

In this task, full performance assessment of the proposed prefabricated/all lightweight concrete barrier system will be conducted in addition, a comparison between the proposed prefabricated/ all lightweight concrete barrier system with cast-in-place barrier and prefabricated barrier, made of normal concrete with the same UHPC connection will be conducted.

Progress: No progress

Task 5 – Final Report

In this Task, full assessment of the findings from Task 1 throughout Task 4 will be conducted and a report will be published including design recommendations of the proposed prefabricated/all lightweight barrier system with UHPC connections.

Progress: No progress

4. Schedule

Item	% Completed
Percentage of Completion of this project to Date	20%

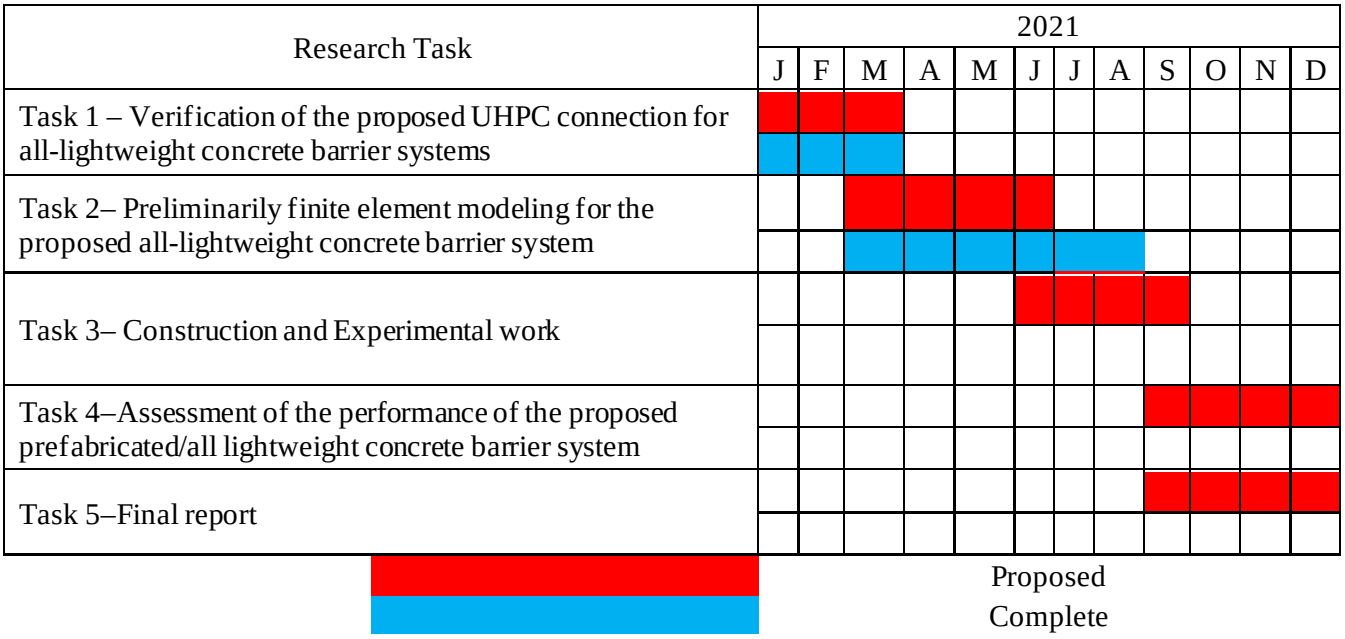

Figure 10. Schedule for future work and current progress.