Semi-Annual Progress Report

Project Number and Title: 2.5 - Development and Testing of High / Ultra-High Early Strength Concrete for durable Bridge Components and Connections

Research Area: Thrust 2 - New materials for longevity and constructability

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Reporting Period: October 01, 2018 – March 31, 2019

Date: March 31, 2019

Overview:

In the first part of the reporting period emphasis was placed on a successful and efficient start of the research activities. This included reviewing the literature regarding high-early strength concrete methodologies, preparing for and participating in the TIDC workshop held at Portsmouth, NH (from Nov. 8th to 9th, 2018), connecting to the Connecticut Department of Transportation, successfully revising the research project based on the comments provided by the New England's Departments of Transportation and completing the hiring process for Bijaya Rai, Ph.D. student leading the research efforts. In the second part of the reporting period emphasis was placed on extensive literature review regarding high-early strength concrete (HES) methodologies as part of Task 1 of the research project. This included studying the final report of NETC 13-1 "Development of High Early-Strength Concrete for Accelerated Bridge Construction Closure Pour Connections" and identify knowledge gaps to enhance the applicability and robustness of the suggested mixture designs of HES. The literature review also included high-impact publications from the Federal Highway Administration and numerous scientific journal publications. In addition Bijaya have been safety trained to be able to work in laboratory conditions and educated to operate various testing machines, such as a 300 kip load compression frame.

With regards to the literature review the following main observations and conclusions are shared. The completed NETC 13-1 research project had employed the following parameters to tailor the development of high-early concrete compressive strength: low w/c ratio, fine ground hydraulic Portland cement type III, aggregate gradation, curing condition, use of fly ash as supplementary cementitious material, accelerators, concrete proportioning method, and volume of paste to volume of void ratio. Still the existing research did not include testing of durability properties such as salt scaling, rapid chloride permeability and resistivity, testing of a few mechanical properties like creep, elastic-modulus and splitting tensile strength, as well as testing of the flexural bond and bond pull off which is necessary for evaluating the bond between precast deck and new concrete. Thus, we plan to complement the existing research with additional material characterization to enhance the applicability of the suggested mixture designs.

Furthermore we plan to extend this research by incorporating other materials in the mixture design to address future material property requirements. This includes materials such as silica fume, nano-silica particles, use of other accelerators and high range water reducer. Additionally we will explore a novel high packing density concept in collaboration with the research group of Assistant Professor Stefan Schaffoener at the University of Connecticut.
Apart from the literature review, Bijaya went through all the necessary ASTM and AASHTO test procedures required for this research project. A list of equipment was prepared and quotations from different vendors were requested to prepare for the next stage of concrete testing and characterization.

Provide context as to how these activities are helping achieve the overarching goal of the project…
The activities and accomplishments mentioned above are in line with the first objective of the project which is to enhance the robustness of current specified HES concrete mixtures. Student training, literature review, complementing existing research by identifying knowledge gaps, interacting with the New England's DOT and preparing for experimental testing and characterization are paramount for the success of the research.

Describe any accomplishments achieved under the project goals…
Based on the information provided above, a few knowledge gaps in the research of high-early strength concrete mixture design have been identified. Based on the results of NETC 13-1 a compressive strength development in average of 5100 psi within 12 hours does not leave much room for covering statistical deviation. Strength requirements with regards to the

specific concrete strength and thus the ACI rule of normal distribution, are beneficial to investigate. Furthermore there is a need for investigating the robustness of the mixture design and if necessary for enhancing the robustness. Literature review has been carried out to identify additional methodologies which could be investigated to further enhance the early-strength development. This includes as novel high packing density concept, incorporating of finer highly reactive puzzolanic materials such as silica fume or nano-silica particles.

Describe any opportunities for training/professional development that have been provided…
Bijaya Rai, Ph.D. student, has joined the research group to lead the research effort and will be closely advised by the PI and Co-PI. Weekly research meetings allow for necessary discussions, exchange of information, potential redirection of the research and planning for the next research steps. In addition, Bijaya participates in research group meetings on UHPC which offers opportunities for collaborations. As mentioned above Bijaya has taken the necessary lab safety training, which includes "Initial Laboratory Safety and Chemical waste management", "Personal Protective Equipment" and "Respiratory Protection-Voluntary Masks". In addition she completed the necessary lab tour with our lab manager.
Furthermore Bijaya attended the meeting between Conn DOT representatives and UConn's research Team on Feb 28th, 2019.

Describe any activities involving the dissemination of research results (be sure to include outputs, outcomes, and the ways in which the outcomes/outputs have had an impact during the reporting period)…
Research project information have been shared through presentation and group discussions at the TIDC workshop held at Portsmouth, NH from Nov. 8th to 9th, 2018 as well as with the CT DOT representatives on Feb. 28th, 2019.

Encouraged to add figures that may be useful (especially for semi-annual reporting by the project manager and management team)…

n.a.

Participants and Collaborators:

List all individuals who have worked on the project
PI: Kay Wille, Ph.D., Associate Professor
Co-PI: Ramesh Malla, Ph.D., F. ASCE, Professor
Bijaya Rai, Ph.D. Student

List all students who have participated in the project.
Bijaya Rai, Ph.D. Student
In the future, few undergraduate students will be included in the research team.

What organizations have been involved as partners on this project?
UTC-TIDC
ConnDOT
New England DOTs
Maine DOT

Have other collaborators or contacts been involved? If so, who and how?
Contacts to the research group of Assistant Professor Stefan Schaffoener at the University of Connecticut has been established and potential collaborations have been initiated.

Changes:

Discuss any actual or anticipated problems or delays and actions or plans to resolve them…
Bijaya has joined our research group in January 2019. In order to prevent a further delay in the research Bijaya is closely advised so that the research is being carried out most effectively.

Discuss and changes in approach and the reasons for the change…

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After receiving feedback from the New England's DOT at the TIDC workshop held at Portsmouth, NH in November the research proposal was successfully revised to focus on the enhancing the robustness on existing HES concrete mixtures and to develop the next generation of non-proprietary HES concrete mixture design specifications.

Planned Activities:

Description of future activities over the coming months.

For the next 6 months we will closely follow the plan in the project description and carry out numerous concrete mixing and material characterizations in order to evaluate robustness of the suggested concrete mixtures in the NETC 13-1 report. For that, we have contacted Prof. Brena's research group at the University of Massachusetts Amherst to request concrete mixture proportions, hydraulic cement composition, aggregate gradation, name of accelerator, name of shrinkage admixtures and name of superplasticizer.

Furthermore we will start planning and working on the second objective "Develop the next generation of non-proprietary HES concrete mixture design specifications" by investigating the incorporation of nano-sized materials and the application of a novel high particle packing concept. In addition we will start working on the third objective "Expand the applicability of high / ultra-high performance concrete to other critical bridge elements such as parapets" by working together with Raymond Basar from ConnDOT through an independent research. This has already been initiated.