Bi-Monthly Progress Report

TIDC Transportation Infrastructure Durability Center AT THE UNIVERSITY OF MAINE

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

Research Area: New materials for longevity and constructability

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Reporting Period: 05/31/2018 – 07/31/2019

Date: 07/31/2019

Overview:

For the first part of the research, the necessary materials were identified and purchased from the respective suppliers. The properties of aggregates, cementitious material and admixtures were studied and quantified. Since, the properties of aggregate varies from source to source, the material properties such as gradation, absorption, specific gravity, rodded and loose density of the aggregates were identified. Based on the mix proportions from NETC 13-1 report, the mixture design sheet was finalized with the materials available in the Storrs, CT area. A few trial batches of concrete had been cast so far. These concrete batches included two selected concrete mixtures developed by Professor Brena's group at the University of Massachusetts.

In order to reduce the quantity of materials, the experiment was proceeded by mixing and casting mortar samples rather than concrete and tested as per ASTM C 109. The mortar with different percentage of nano silica and replacement of rapid set cement had been mixed. The cube samples were cast with the mortar mixture. The fresh properties like slump, consistency, and flow ability were investigated. Similarly, the compressive strengths along with density and air void percentage were determined from the cast samples. The results are tabulated in the following section.

Provide context as to how these activities are helping achieve the overarching goal of the project…

The overarching goals of the research are developing and testing of high / ultra-high early strength concrete for durable bridge components and connections.

Up to now, the research emphasis has been placed on selecting, ordering and testing of the properties of the ingredients used in the concrete mixtures, followed by mixing and casting concretes and mortars. Since the first part of the research is aimed at testing and enhancing the robustness of the suggested concrete mixtures in the NETC 13-1 report, repeating the same mixture proportions with locally available materials is an important step. In the recommendation section of the NETC final report, it was suggested to use locally available material for cost efficiency.

Describe any accomplishments achieved under the project goals…

A few batches of the concrete had been cast. The concrete mixture had been proportioned as per the NETC report 13-1 except that locally available material had been used.

In addition we have been 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. An independent research report has been completed and finalized.

Following are the compressive strength test results obtained from concrete and mortar mixes so far:

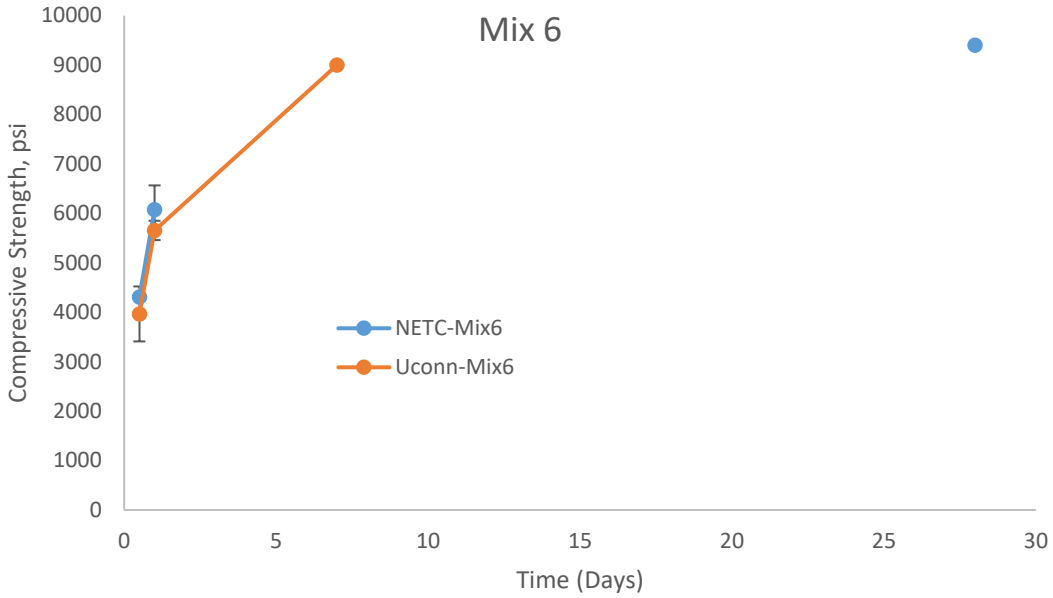

Figure 1: Comparisons between Concrete Compressive Strength NETC 13-1 Mix 6 and UConn Mix

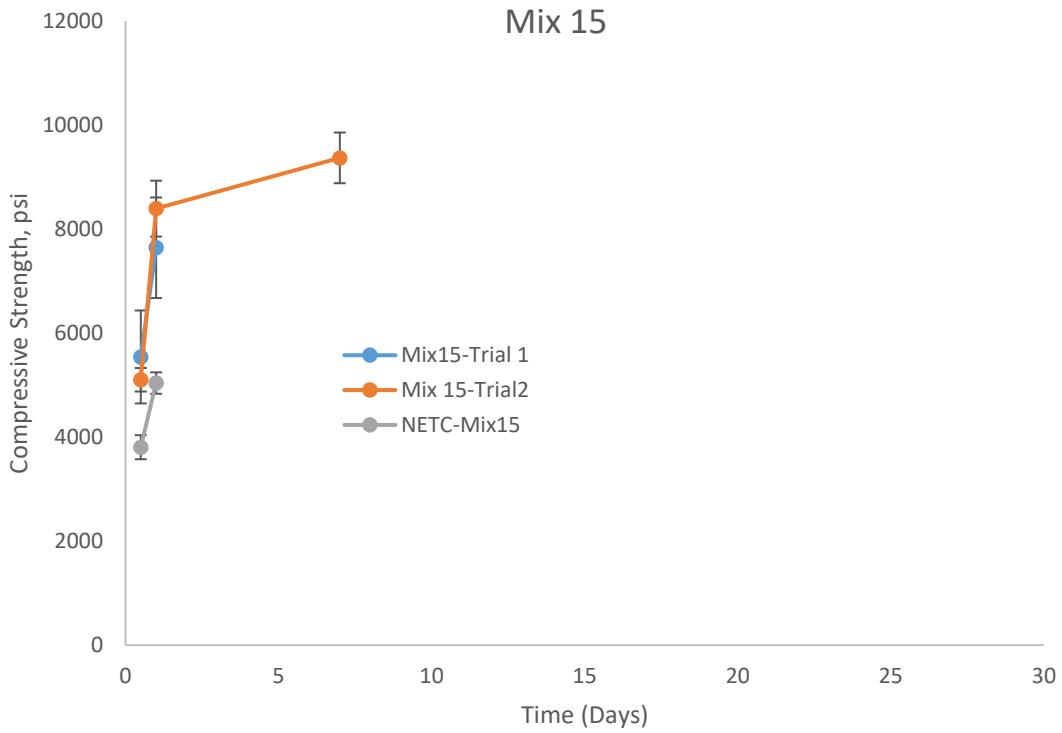

Figure 2: Comparisons between Concrete Compressive Strength NETC 13-1 Mix 15 and UConn Mix

By comparing Figure 1 and 2, it can be seen that Mix 15 develops higher compressive strengths than Mix 6 at same age. On the other hand it can be seen that Mix 15 shows more strength variability than Mix 6.

One research approach to accelerate the strength development of concrete is the addition of very fine pozzolanic reactive material, such as nano silica. In order to reduce the quantity of material, the mortar mixes with different percentages of nano silica were cast and properties were investigated as per ASTM C109. Some results:

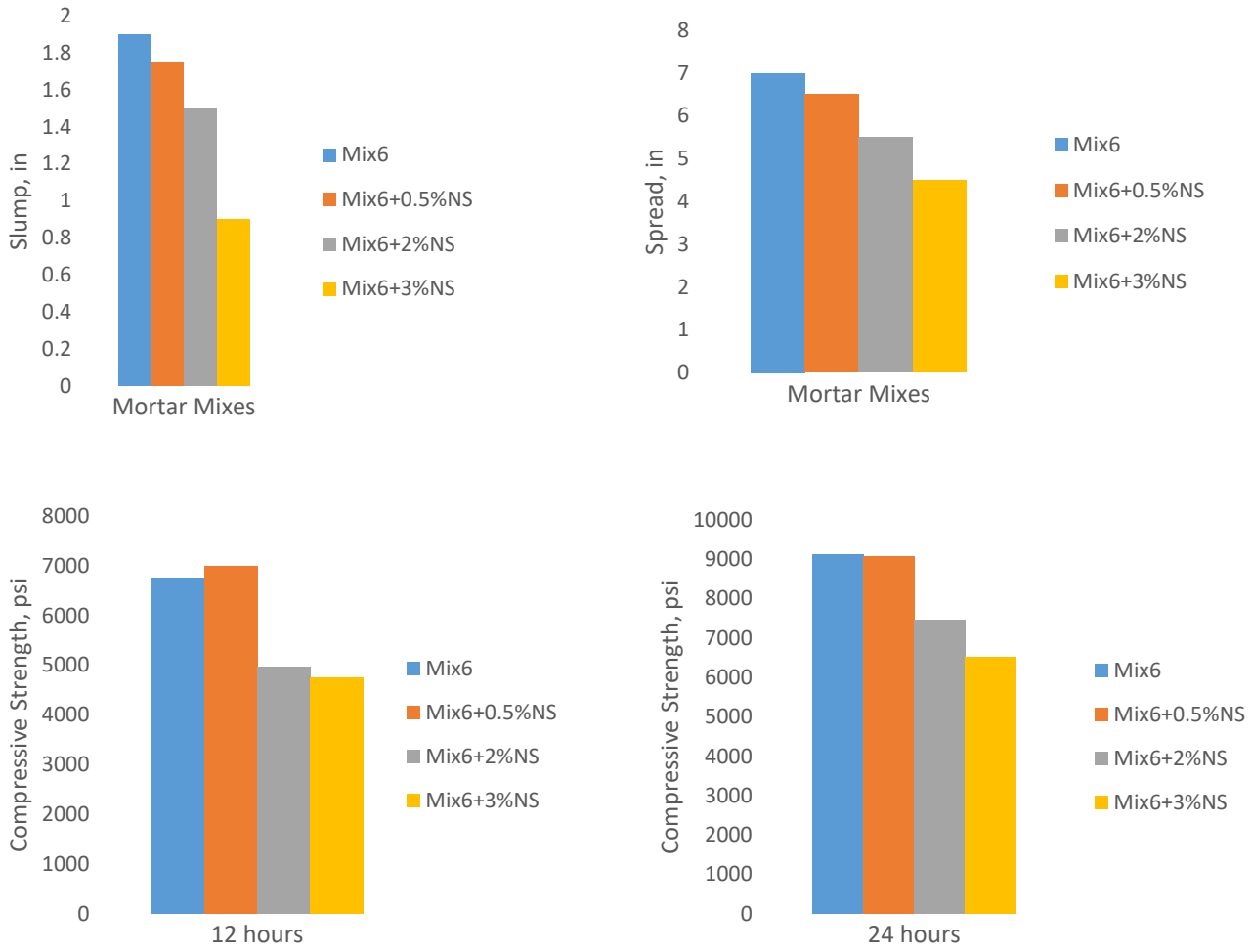

Figure 3: Influence of different amounts of nano silica (NS) on slump, spread and compressive strength after 12h and 24h

From the graphs in Figure 3, it can be seen that addition of nano silica decreased the compressive strength at 12 hours and 24 hours. A similar trend was observed for the slump and spread of the mixes. The decrease in compressive strength with the addition of nano silica might be due to the re-agglomeration of particles in the concrete mixture since most of the literatures had suggested that a combination of Type II or Type V cement with nano silica resulting in an increase in concrete strength. Collaborate research is being carried out at the ACMC lab at UConn to find suitable polymers to stabilize nano silica in concrete.

Another research approach to accelerate the strength development of concrete is the partial replacement of Portland cement by Calcium Sulfoaluminate cement (CSA cement). In the first step we replaced 10% by weight of Portland cement of Mix 6 with CSA cement. The results of slump, spread and compressive strength after 12h and 24h are summarized in Figure 4.

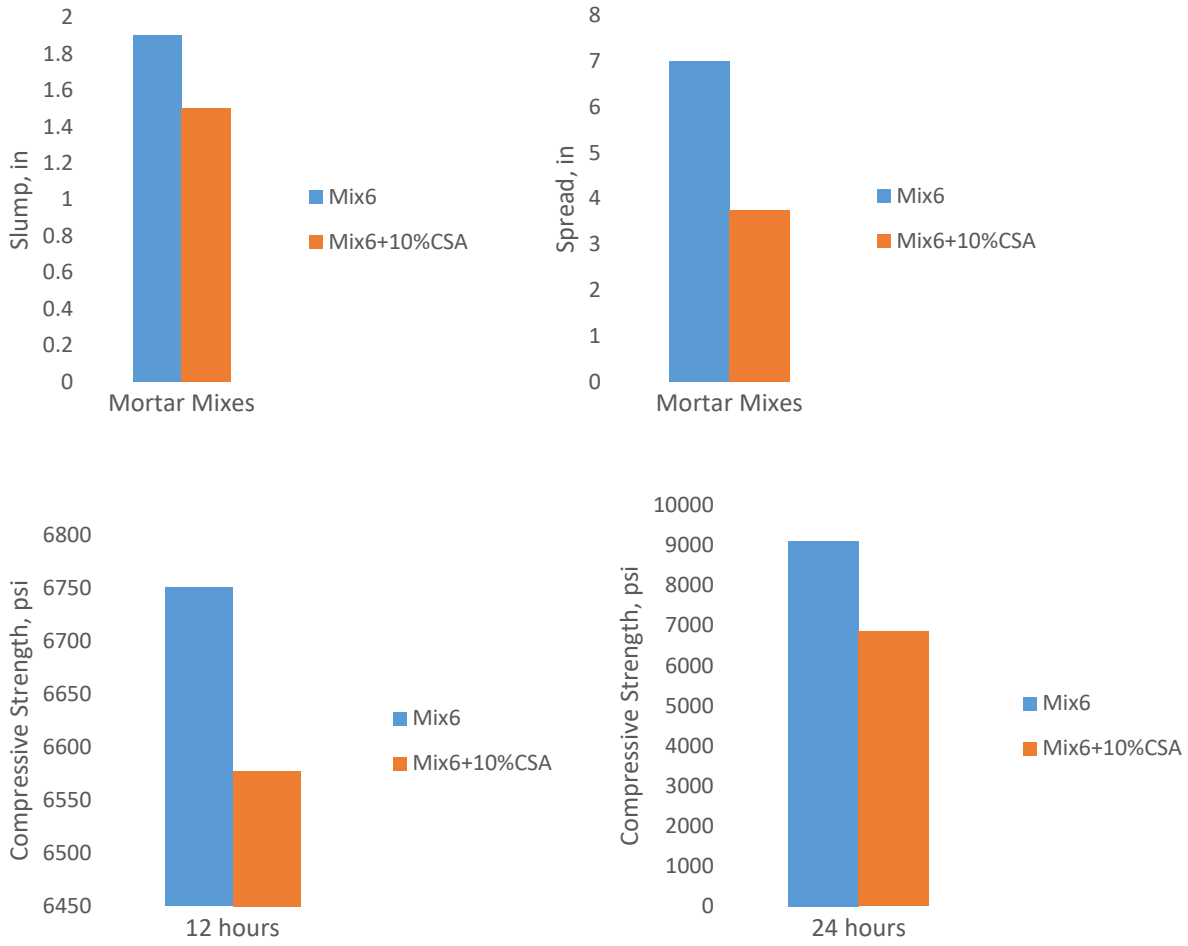

Figure 4: Influence of CSA cement replacement (10%) on slump, spread and compressive strength after 12h and 24h

Figure 4 shows that the 10% by weight replacement of Portland cement by CSA cement reduced the slump, the spread, and the compressive strength at 12 hours and 24 hours of concrete age. Due to the difficulty to consolidate the concrete mix with CSA cement the next mixture proportion will consider an increase in superplasticizer and potentially increase in the w/cm ratio as well.

Describe any opportunities for training/professional development that have been provided…
Two undergraduate students, Jeet Rosa and Alex Distelman, have been hired to support the research and outreach activities. They have been safety trained and have joined the laboratory activities.
The graduate student, Bijaya Ray, has attended the regular UConn team TIDC Annual Conference on June 5-7 2019 in Orono, Maine at the University of Maine. All group members, both graduate and undergraduate students have been involved in the Engineering Explore 2019 for high school students and Da Vinci outreach activities for high school teachers recently.

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)…
The graduate student has attended the regular UConn team TIDC Annual Conference on June 5-7 in Orono, Maine at University of Maine and presented the research activities in a poster display. At the same conference the current progress of the research was presented in a power point presentation by the PI of this project, Kay Wille. Moreover, Bijaya Ray and Kay Wille attended the Second International Interactive Symposium on Ultra-high performance concrete in Albany, NY, June 2-5th, 2019. Research results were presented in a poster display and connections to different companies were made.

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Encouraged to add figures that may be useful (especially for semi-annual reporting by the project manager and management team)…
(Note: Figures are in above questions)

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
Alex Distelman, Undergraduate Research Assistant
Jeet Rosa, Undergraduate Research Assistant

List all students who have participated in the project.
Bijaya Rai, Ph.D. Student
Alex Distelman, Undergraduate Research Assistant
Jeet Rosa, Undergraduate Research Assistant

What organizations have been involved as partners on this project?
UTC-TIDC
Conn DOT
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.
Contact to Steelike® Concrete has been established and material for research purpose has been delivered free of charge.

Changes:
Discuss any actual or anticipated problems or delays and actions or plans to resolve them…
Many of lab accessories were bought. One mixer broke down and is in the process of getting repaired. Training to operate a high-shear intensity mixer has followed.

Discuss and changes in approach and the reasons for the change…
As the research progressed, it was found out that the nano silica inclusion in the mixture did not increase the compressive strength, potentially due to nano silica agglomeration in concrete environment. As for the alternative, the research has been advanced to partially replace Portland cement with CAS cement. In addition to that, the research had been partly directed to investigate the porosity in the concrete and mortar which is an important parameter for the mechanical and durability performance of the material. In addition, it has been started to explore the heat evolution of cement paste over time.

Planned Activities:
Description of future activities over the coming months.
The research will continue by mixing mortar and concrete samples with different percentage of CSA cement replacement, addition of non-chloride accelerating admixture, investigating porosity, heat of hydration and linking those results with strength gain at 12 hours.

The results of the independent research project with Raymond Basar from Conn DOT titled “Ultra-High Performance Concrete for Highway Bridge Parapets” will be further disseminated.

References:

1. ASTM C109 Standard Test Method for Compressive Strength Testing of Hydraulic Cement Mortars Using 2” Cube Specimens