Development and Testing of High / Ultra-High Early Strength Concrete for Durable Bridge Components and Connections

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Background and Objectives

Accelerated Bridge Construction (ABC) is a very popular construction method due to its time efficiency, structural reliability, cost and overall impact on the surrounding transportation system. Bridge joint elements are one of the very critical elements in the ABC technology.

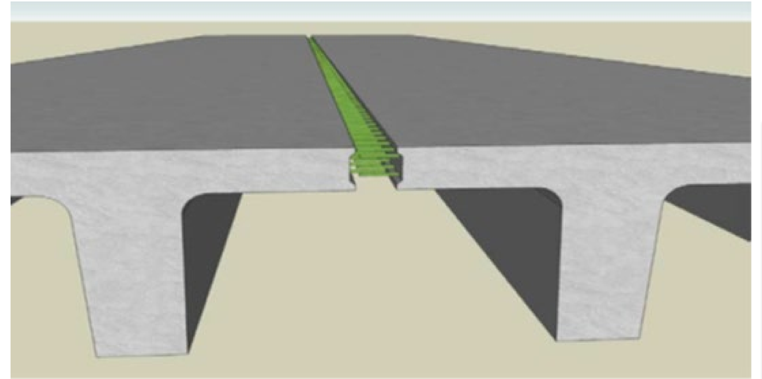
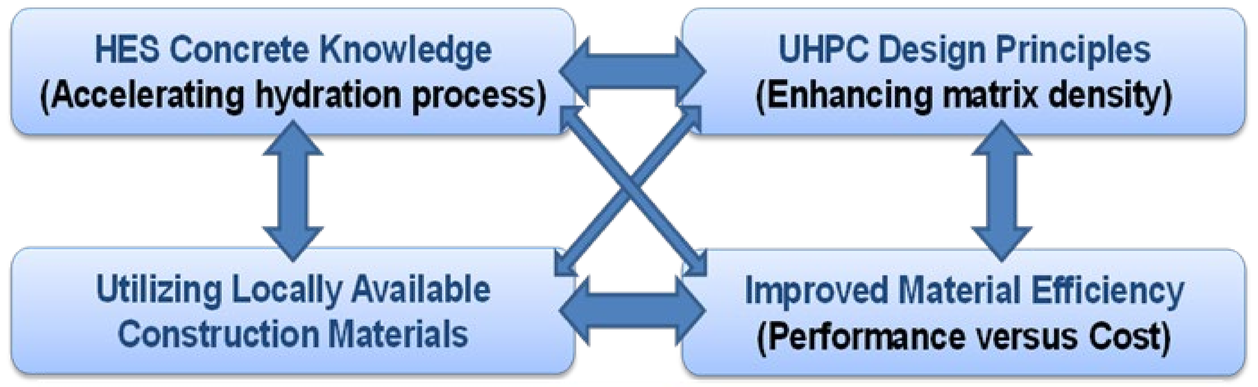


Figure 1: Cast in place longitudinal closure pour connection (FHWA ABC Manual, 2011)

The first objective of this project is to enhance the robustness of current high early strength (HES) concrete. And second to develop a next generation early high strength concrete for sustainable and durable ABC.

Methodology and Approach



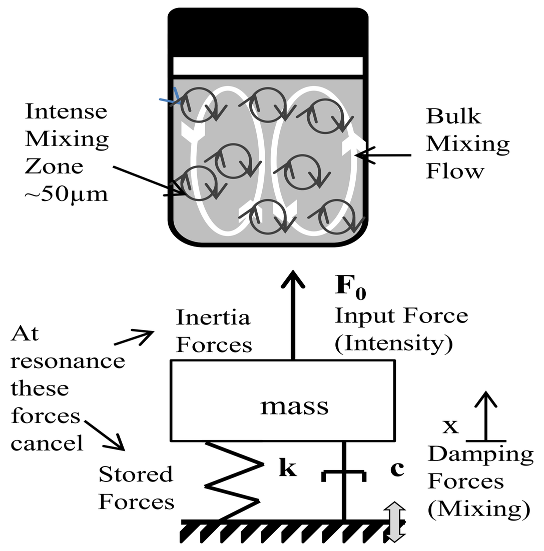
- ➢ Good understanding of the hydration process of HES Concrete
- ➢ Utilization of locally available material for cost efficiency and environmental impact
- ➢ Enhancement of HES by applying UHPC design principle
- ➢ Analysis of improved material efficiency verses cost

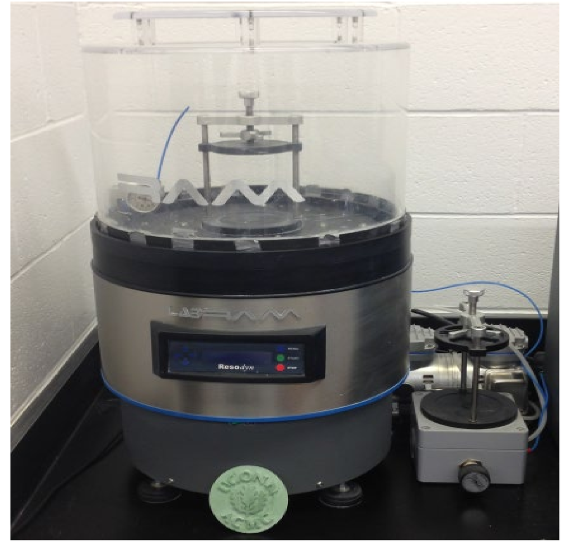
Ultra High Performance Concrete (UHPC)

- ➢ uses a relatively high binder ratio
- ➢ a water to cementitious ratio (or water to binder ratio) less than 0.2,
- ➢ shows a compressive strength in excess of 150 MPa (22 ksi)
- ➢ very high packing density
- ➢ significantly higher durability compared to conventional concrete
- ➢ incorporates discontinuous fibers, leading to significantly higher ductility and durability of the cracked matrix

Resodyn Acoustic Mixer

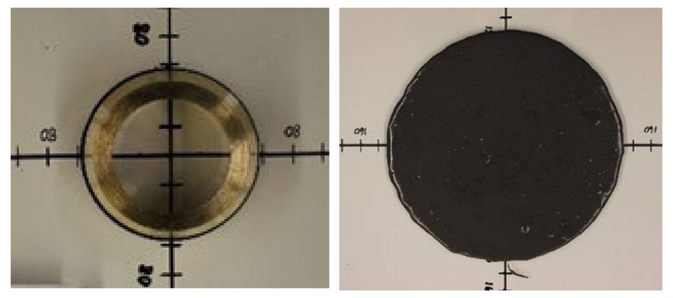
- ➢ innovative mixing technology for paste & mortar development
- ➢ enhanced mixing consistency and reliability among various mixes in comparison to conventional mechanical shear
- ➢ mixing behavior is scalable to large batches 1:1
- ➢ enhanced particle dispersion
- ➢ disadvantage: limited to small mixing volume



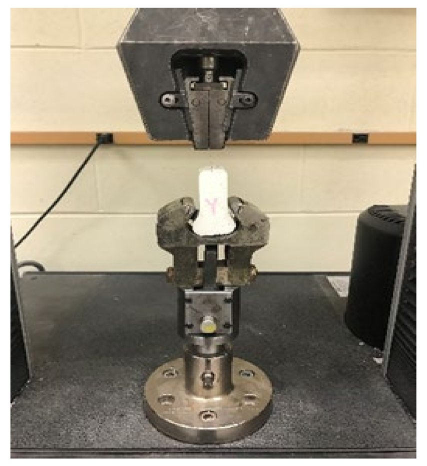


Mixture Performance Evaluation

- ➢ spread test using a mini-cone
  - efficient indicator for effective particle packing



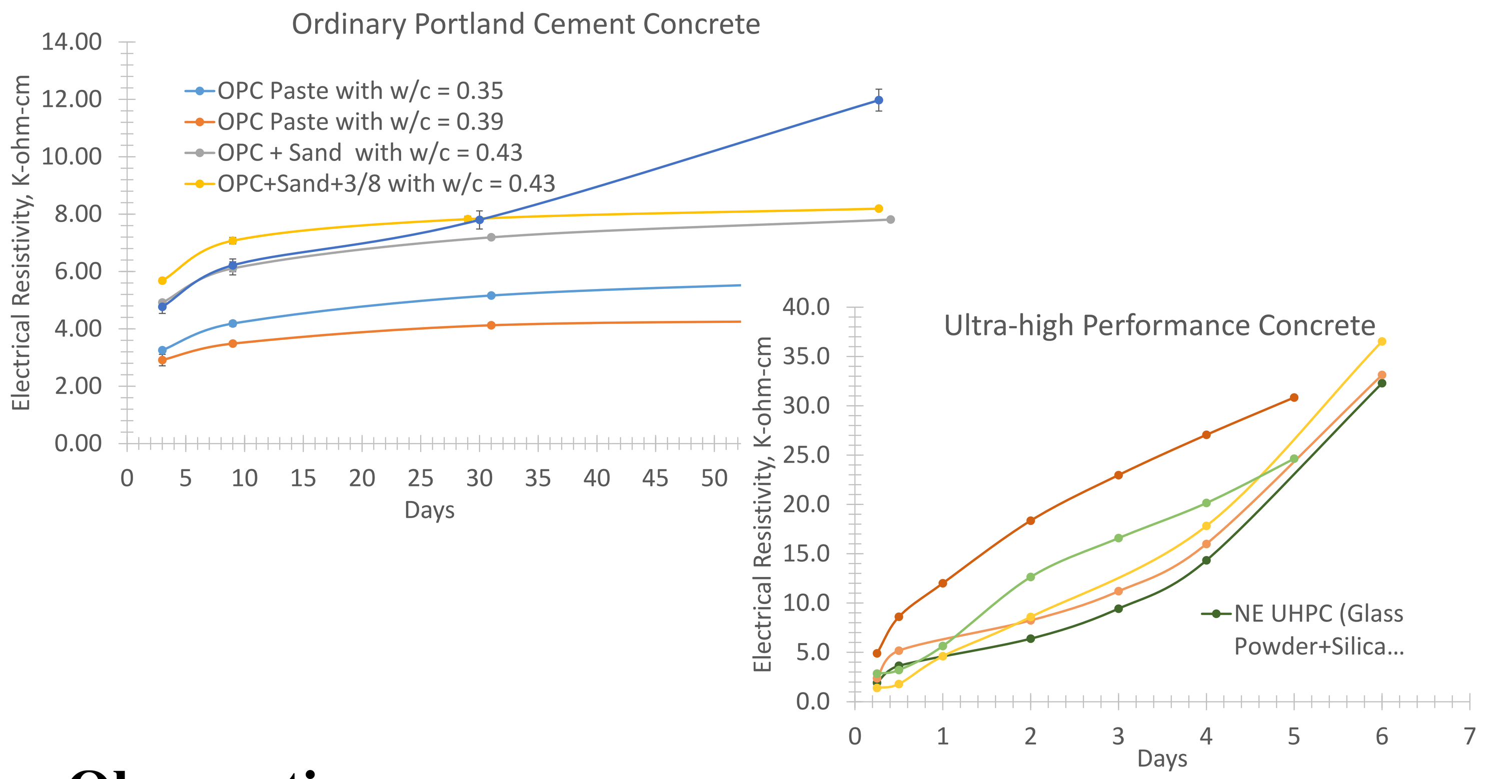
- ➢ compressive strength using 2 inch cubes
  - mechanical performance and indicator for particle packing (so far 30 ksi after 28 days and **8** ksi after 12h)
- ➢ single fiber pull-out test
  - direct tensile performance, ductility and limiting crack width
  - also indicator of quality of interfacial transition zone between fiber and matrix



- ➢ direct tensile strength (> 1.5 ksi so far)
- ➢ Electrical surface resistivity test (> 30 kohm–cm after 5d)
  - pore structure, durability and sustainability
  - categorize low permeability concrete

Electrical surface resistivity test / Permeability Investigation

- ➢ In line with and in collaboration with the Connecticut DOT - concrete specification tailored towards the concept of low permeable concrete → increase durability and thus service life
- ➢ The concrete permeability can be quantified by measuring the electrical resistivity. Lower permeability results from a finer pore network with less connectivity and eventually leads to higher electrical resistivity. That is the goal.



Observations:

- ➢ Decreasing w/c ratio increases the electrical resistivity
- ➢ Addition of aggregates increases the electrical resistivity
- ➢ Flyash as a ternary blend reacts delayed, increases the electrical resistivity

Acknowledgement

1. Transportation Infrastructure Durability Center (TIDC)
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3. Institute of Material Science (IMS at UConn) – Mechanical Testing Lab
4. Industry partner LafargeHolcim and Steelike Concrete
5. Advanced Cementitious Materials and Composites (ACMC) Lab
6. UConn – School of Engineering