Rice Hull Ash Flowable Fill Research

By

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Motivation

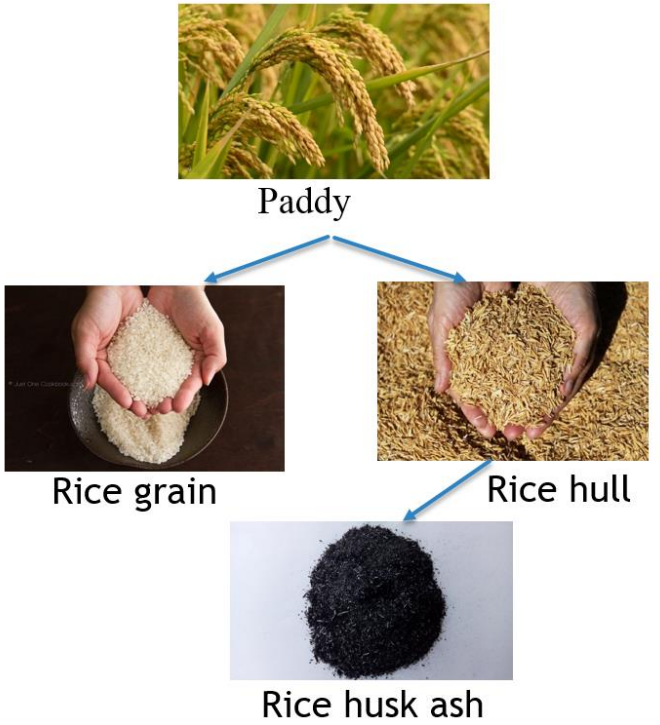
- RHA is a waste material, but it is pozzolanic
- RHA is locally available
- There might be imminent shortage of quality CFA
- RHA is an alternative of CFA
- RHA is significantly cheaper than CFA
- But, no construction and performance data is available in conditions and specifications prevailing in the USA

Riceland Temporary Storage. Stuttgart, AR

Some statistics

- Arkansas, produces 49% of the rice supply in the United States, ranking it first in the nation.
- Arkansas's rice production is valued at nearly $2 billion annually, and rice is the state's top export.
- Riceland is the largest rice milling and marketing company in the world
- Riceland mills 112 million bushels (2.1 million metric tons) of grain on yearly basis

- Rice Husk Ash (RHA) is a residue obtained during the milling of rice.
- 20% of paddy is Rice Hull
- In the burning process, about 20% of rice hull's weight converts into RHA
- An inexpensive source of pozzolanic material due to the presence of silica (80-85%)
- Approved pozzolanic material, if processed appropriately, by AASHTO



Flowable Fill Concrete (FFC)

- A self compacting low strength material

- In most applications, compressive strength is <1200 psi
- For extractable FFC, compressive strength varies from 30 to 200 psi
- As a measure of flowability, flow = 8 to 12 inch.

Flowable Fill Concrete (FFC)

- FFC is also known as controlled low strength material (CLSM), unshrinkable fill, flowable mortar, controlled density fill (CDF), plastic soil-cement, K-Krete, etc.

Primary Advantages

- Less costs associated with the moving of excavated soil
- Less time, manpower, and equipment than granular fill.
- Strength testing of FFC is more efficient than granular backfill
- FFC generally results in accurate installation on the first try, less problems and subsequent costs associated with re-compacting and re-testing the surrounding
- For installations such as flexible pipe that require considerable soil support, embedment soils often have to be imported to the site, increasing the cost and making flowable fill a more economical method.

Per ArDOT, SECTION 206 FLOWABLE SELECT MATERIAL

FFC can be used for backfilling bridge abutments, pipe culverts, box culverts, structural plate pipe and arches, or other uses as approved by the Engineer.

Materials: The Portland cement, fly ash, and chemical admixtures shall be listed on the QPL.

- No segregation.
- Material for one cubic yard, absolute volume, shall be as follows:
  - Cement 80 - 100 lbs.
  - Fly ash 220 - 300 lbs.
  - Sand Variable to equal one cubic yard
  - Water Approximately 65 gallons (300 liters)
- Minimum flow of the mixture shall be 8"
- Unit weight shall be a minimum of 110 lbs./cft

Background Study

Givi et al. (2010)

- The high percentage of silica content in RHA makes it a potential pozzolanic compound.

Ali et al. (2011)

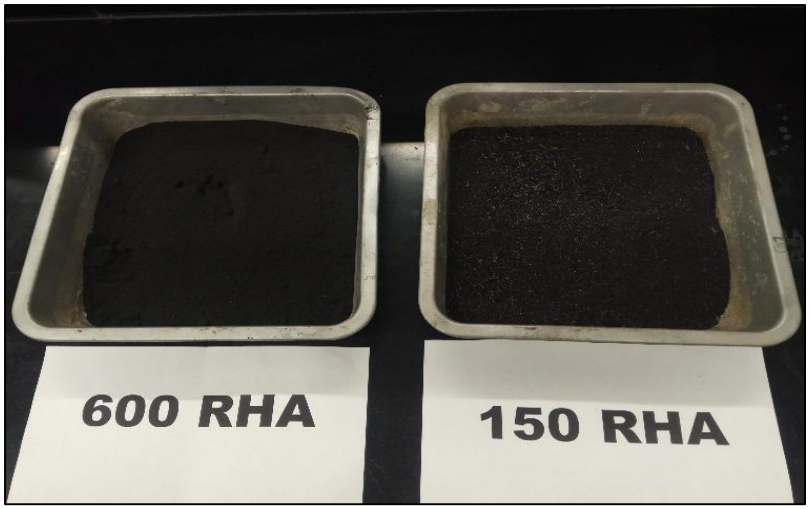
- Studied the feasibility of use of RHA for low-cost self-compacting concrete (SCC) production.

- A cost analysis showed that the production of certain SCC mix would result in a reduction of 42% cost with the incorporation of RHA.

Objectives

- Prepare RHA modified FFC
- Evaluate workability and flow behavior
- Evaluate the effect of curing time and environmental conditions on strength properties and durability of RHA-modified FFC
- Evaluate field constructability of FFC mixes

Materials and Methodology



600-RHA (600 µm): RHA-1

150-RHA (150 µm):RHA-2

CFA

- **Cement Type: Ordinary Portland Cement (Type-I)**
- **Replacement level by RHA**
  - **70% Fly Ash (Control)** • **40%** • **60%**

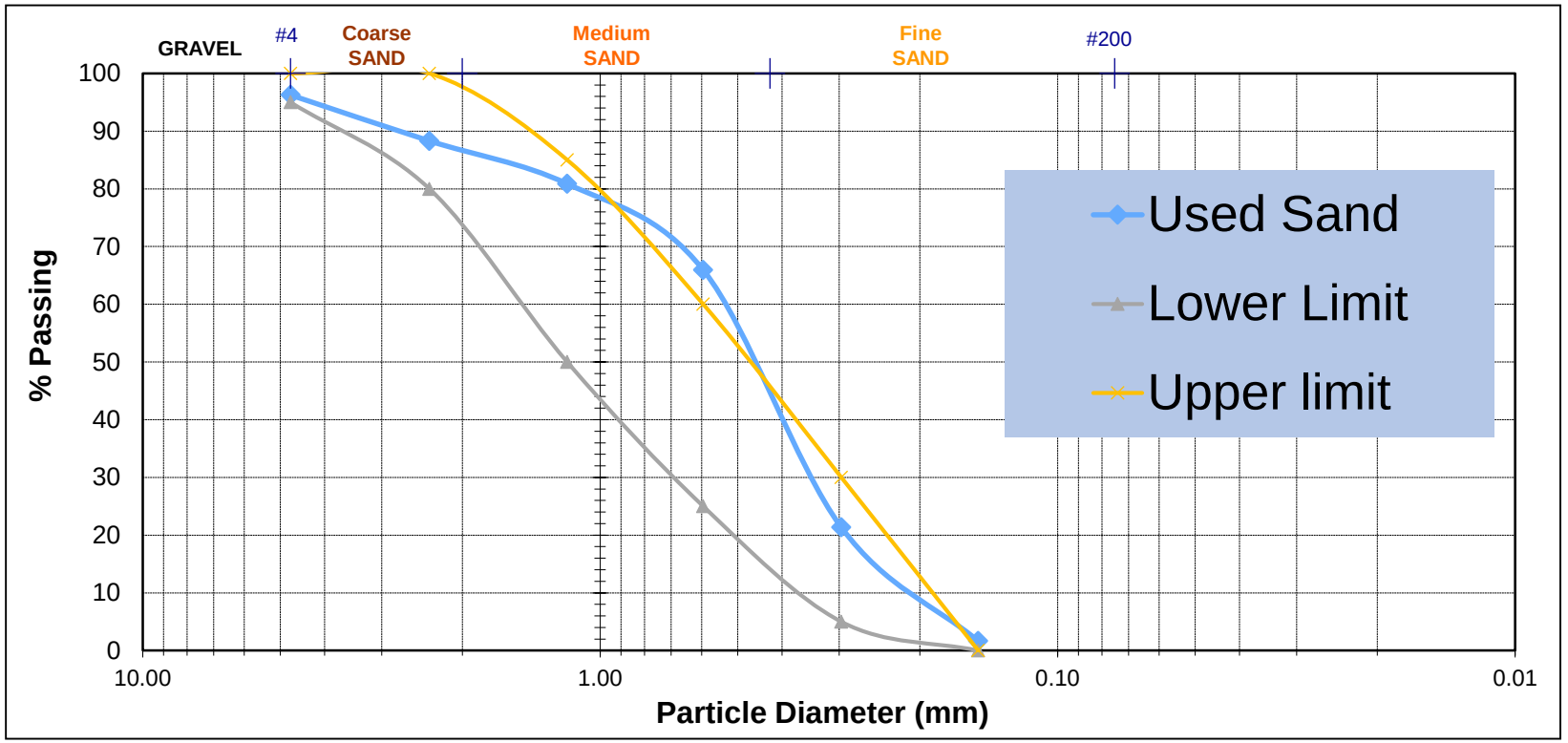
Test Materials

Material	Description	Source of Material
RHA-1	Coarse RHA with a particle size of 600 µm	Riceland Food, Inc., Stuttgart, AR
RHA-2	Finer RHA with a particle size of 150 µm	Riceland Food, Inc., Stuttgart, AR
CFA	The particle size of 44 µm	Charah Inc., Louisville, KY
Note: RHA2 was produced after grinding RHA-1 (Ball mill)		

Chemical properties of RHA, CFA, and SF

Chemical Properties	RHA-1	RHA-2	CFA	AASHTO M 321-04
Reactive oxides (SiO_2+Al_2O_3+ Fe_2O_3)	95.50%	95.50%	60.02%	75% (minimum)
Loss on ignition (LOI)	8.98%	8.98%	0.22%	6% (maximum)
Moisture content	3-5%	3-5%	0.04%	3% (maximum)

Fine Aggregate



Physical Properties	Used Fine Aggregate
Fineness Modulus	2.46
Bulk Specific Gravity (SSD)	2.63
Absorption	0.55%
Moisture Content	0.15%

Literature Review

Collect RHA, CFA, OPC and Fine aggregate

Collect and Determine Chemical and Physical Properties

Prepare FFC Mix Design and Trial FFC Design

Prepare FFC Cylinders, and Mortar Bars

FFC Cylinders

- Compressive Strength Tests
- Tensile Strength Tests

Mortar Bars

- ASR

Analyze and Document Test Results

Field Demonstration

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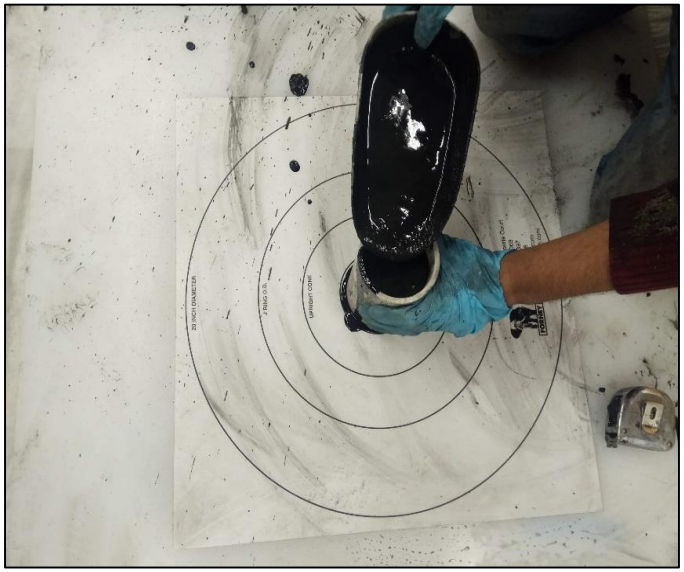
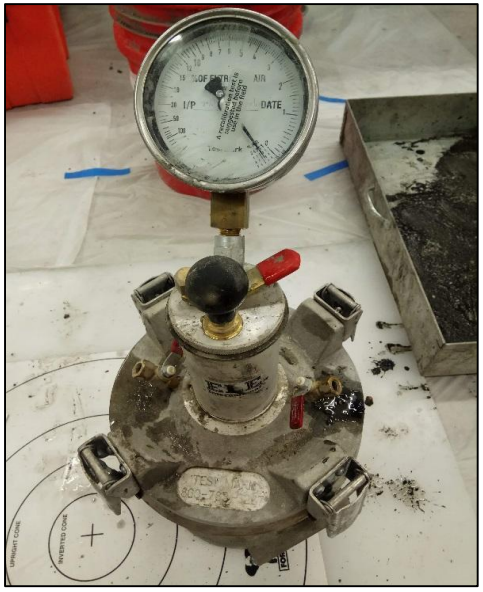
Test Setup

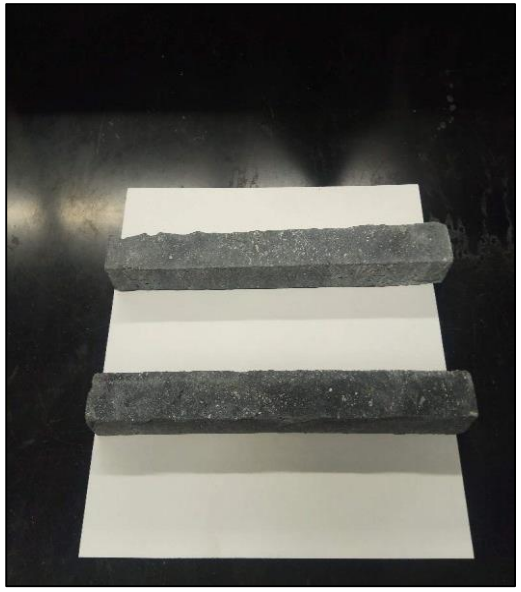
Flowable Fill Concrete Preparation and Test Sample Preparation

Test Setup

FFC Tests







Test Results and Discussions

Properties of Fresh FFC Mix

Types of FFC Mix	Unit Weight (lb/ft^3)	Air Content (%)	Temperature (^oF)
Mixture-1 (70% Fly Ash)	134	1.1	63
Mixture-2 (40% 600 RHA)	114	2.5	65
Mixture-3 (60% 600 RHA)	109	2.4	60
Mixture-4 (40% 150 RHA)	117	0.7	60
Mixture-5 (60% 150 RHA)	114	0.5	58

- According to section 206 ArDOT specification minimum unit weight of flowable fill concrete needs to be 110 lb/ft3

- Air contents of 2.5% and 2.4% were measured for 40% 600-RHA and 60% 600-RHA modified FFC mixtures, respectively.
- Air contents of 0.7% and 0.5% were measured for 40% 600-RHA and 60% 150-RHA modified FFC mixtures, respectively

FFC Mix Design

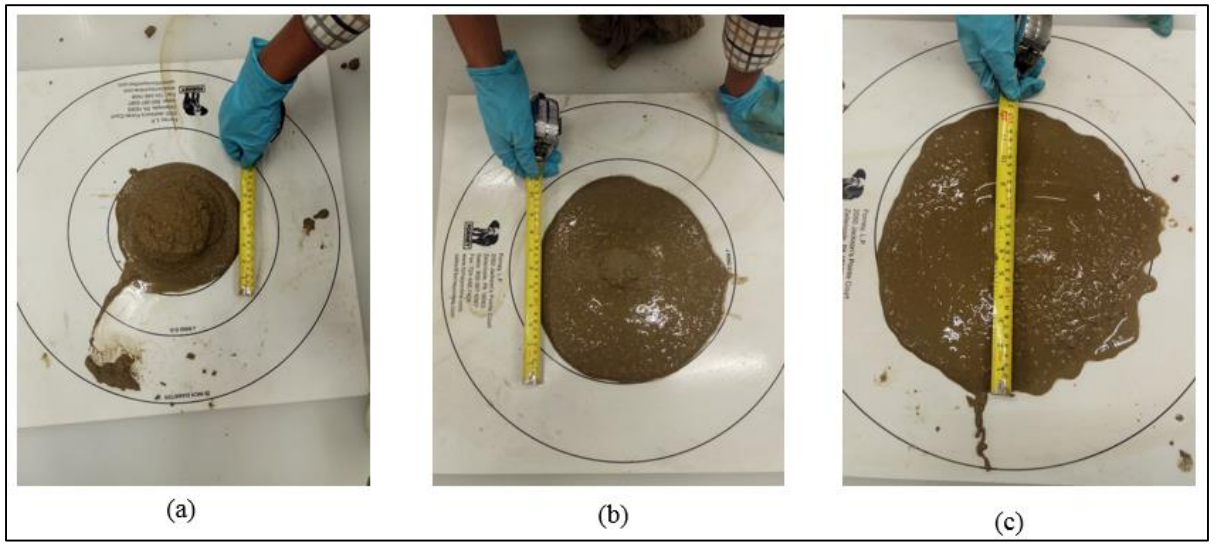


Figure: Mixture-1 flow diameter with (a) w/c-1.7, (b) w/c-1.75, and (c) w/c-1.80.

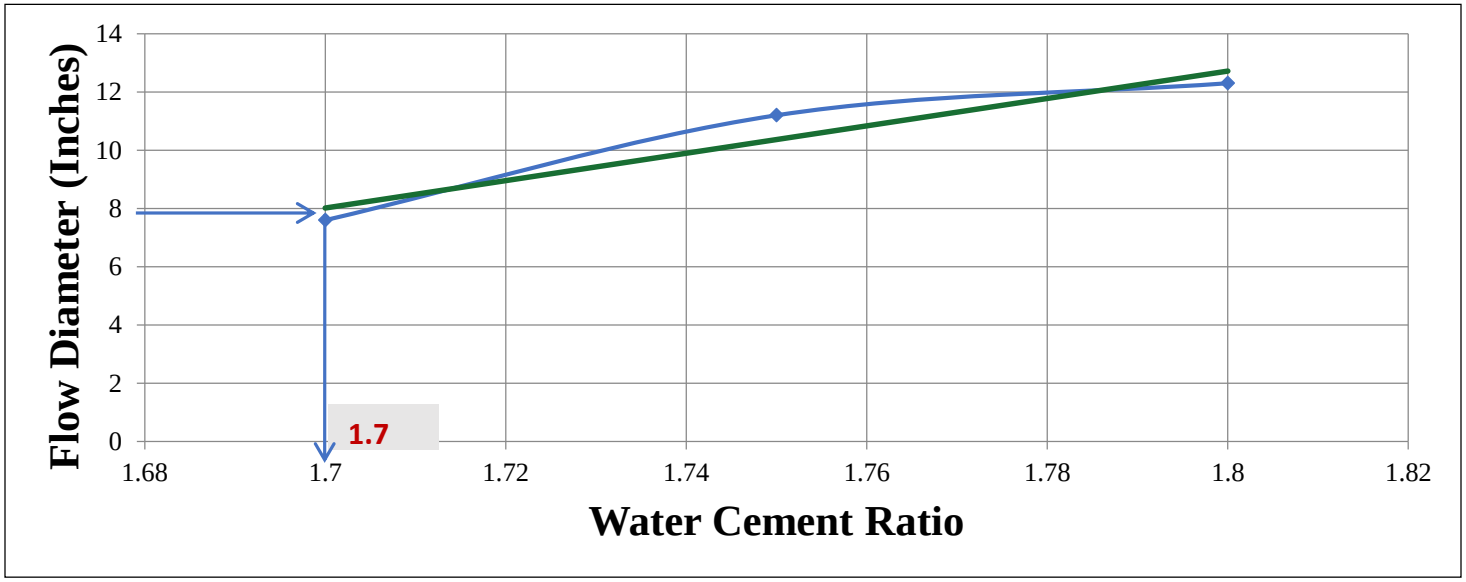


Figure: Flow consistency diagram for Mixture-1.

FFC Mix Design

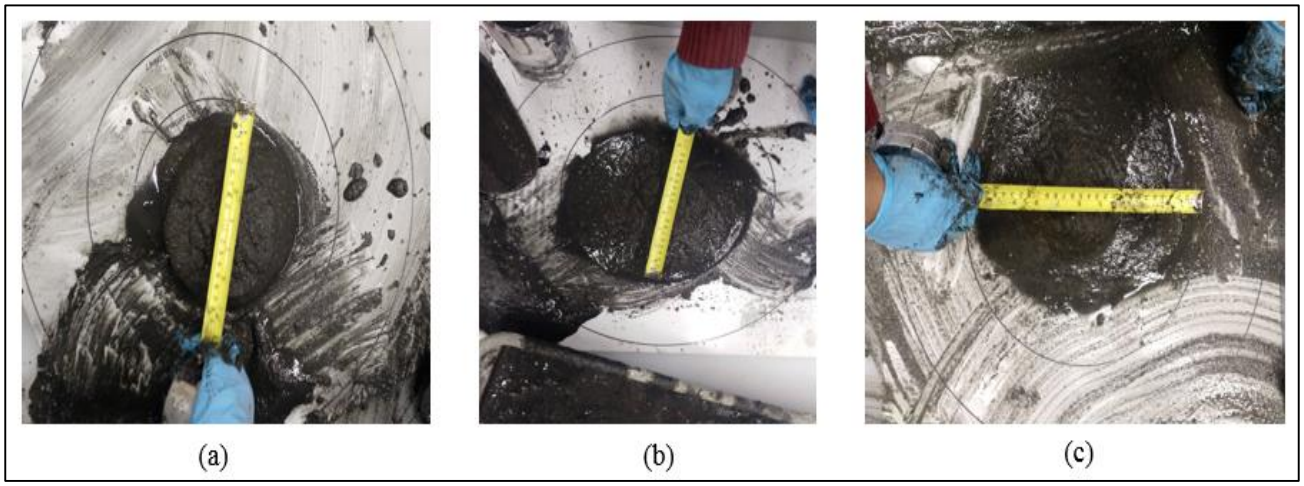


Figure: Mixture-2 flow diameter with (a) w/c-2.2, (b) w/c-2.3, and (c) w/c-2.5.

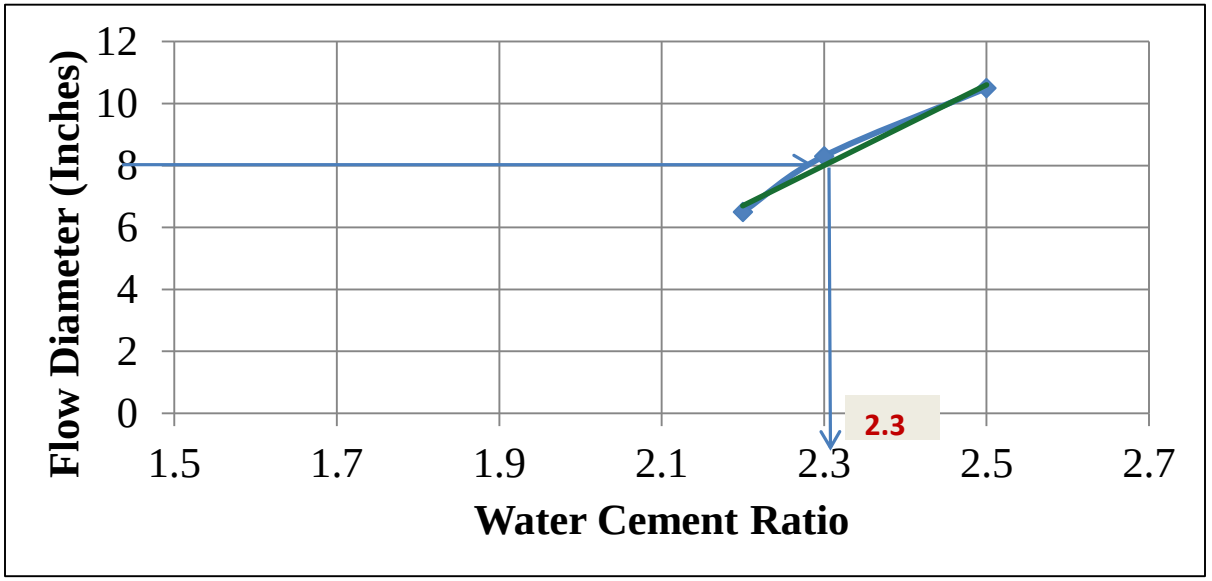


Figure: Flow consistency diagram for Mixture-2 (40% 600-RHA and 60% Cement).

FFC Mix Design

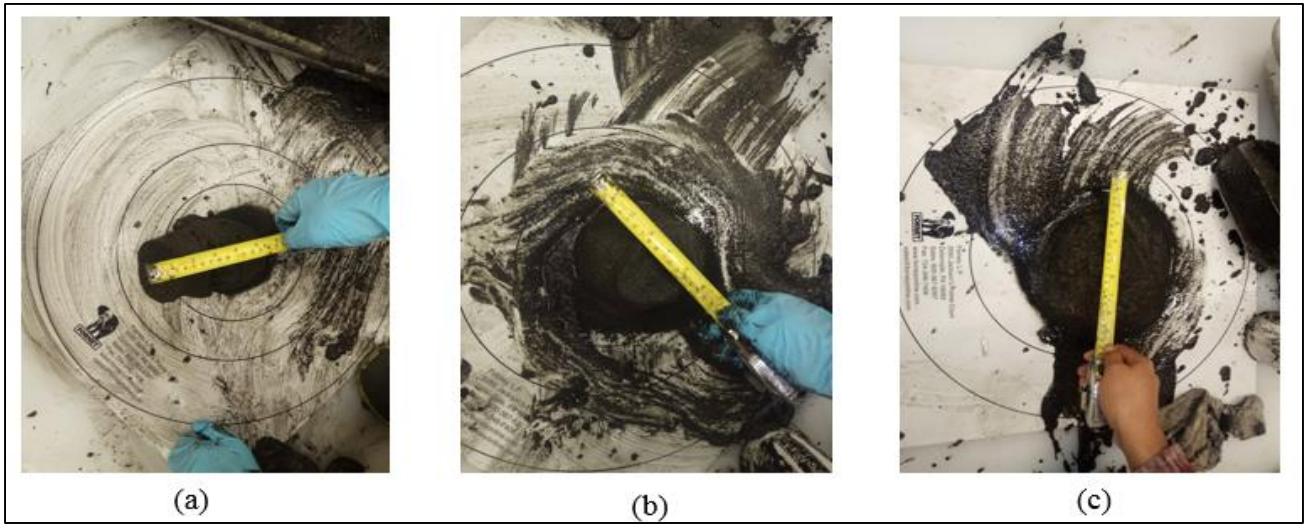


Figure: Mixture-3 flow diameter with (a) w/c-2.5, (b) w/c-2.7, and (c) w/c-3.0.

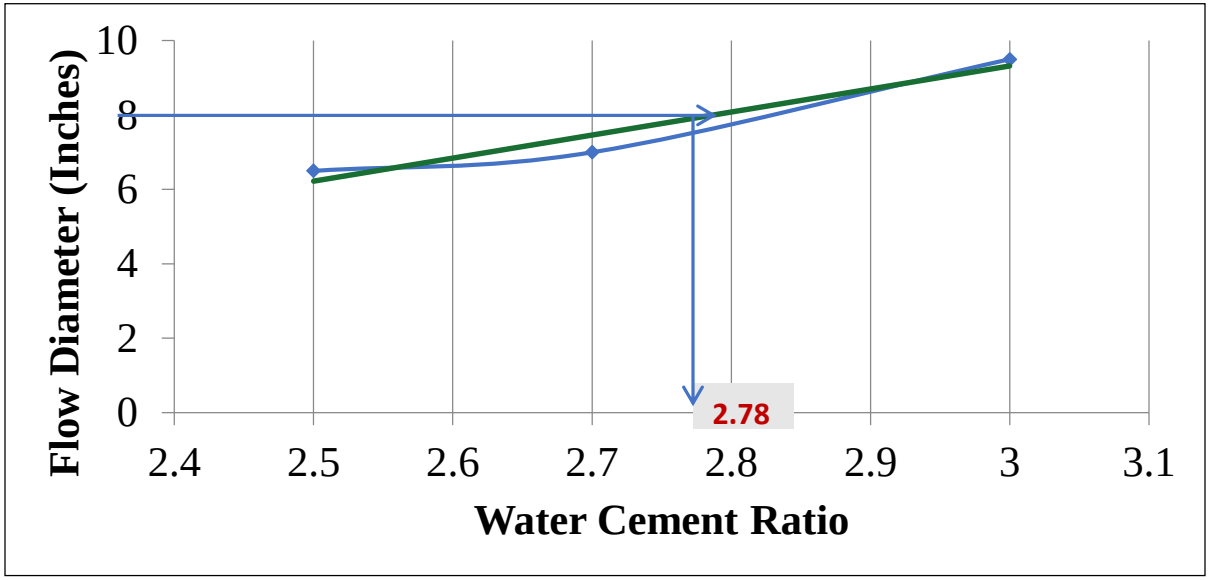


Figure: Flow consistency diagram for Mixture-3 (60% 600-RHA and 40% Cement).

FFC Mix Design

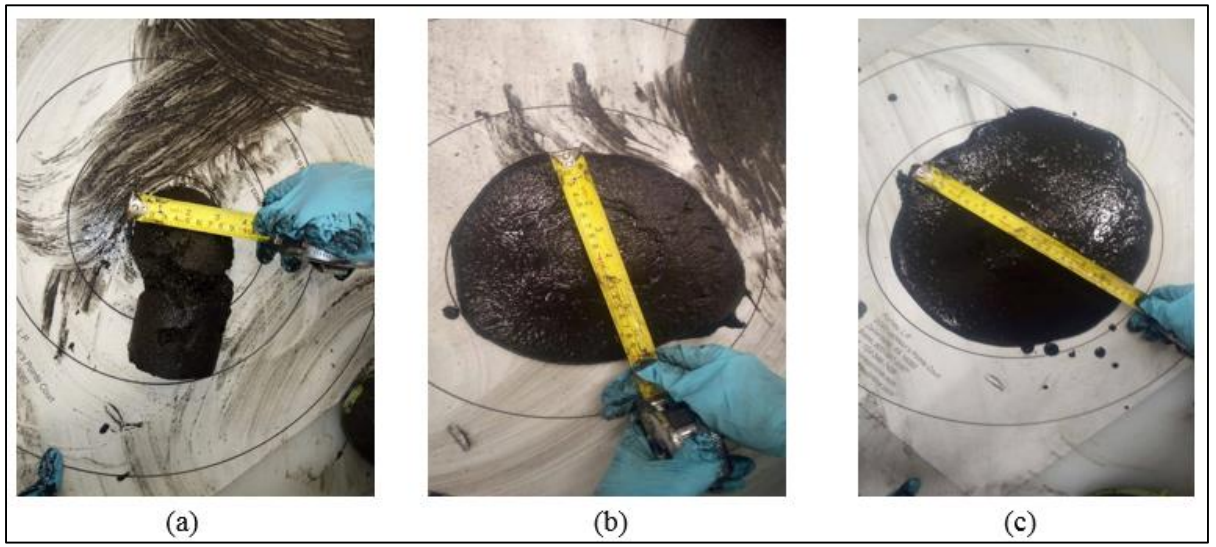


Figure:Mixture-4 flow diameter with (a) w/c-2.0, (b) w/c-2.3, and (c) w/c-2.5.

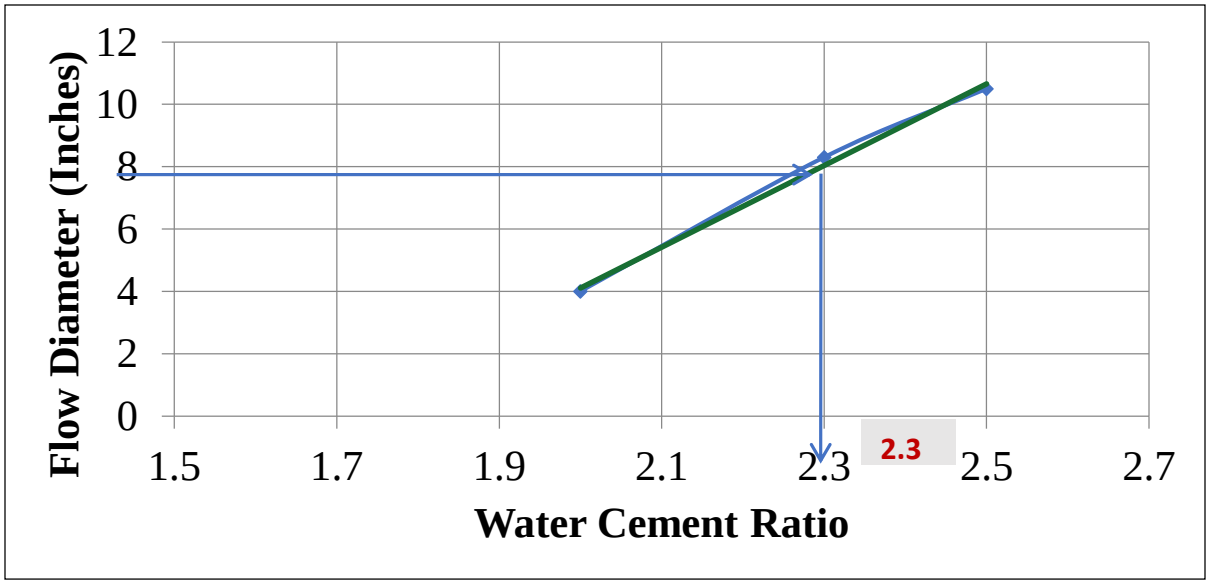


Figure: Flow consistency diagram for Mixture-4 (40% 150-RHA and 60% Cement).

FFC Mix Design

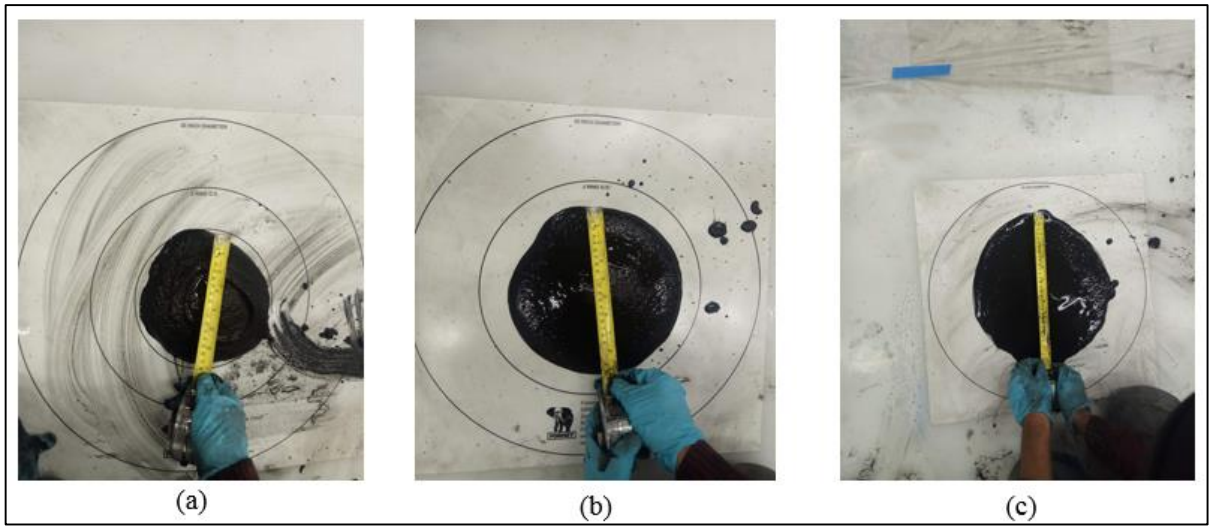


Figure:Mixture-5 flow diameter with (a) w/c-2.3, (b) w/c-2.5, and (c) w/c-2.7.

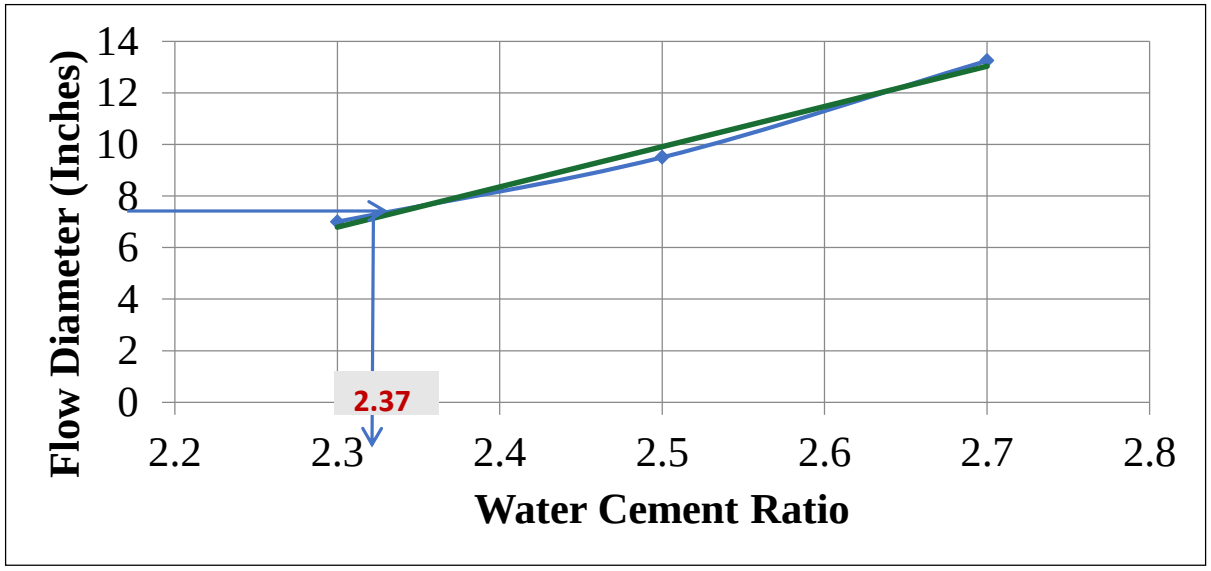


Figure: Flow consistency diagram for Mixture-5 (60% 150-RHA and 40% Cement).

FFC Mix Design

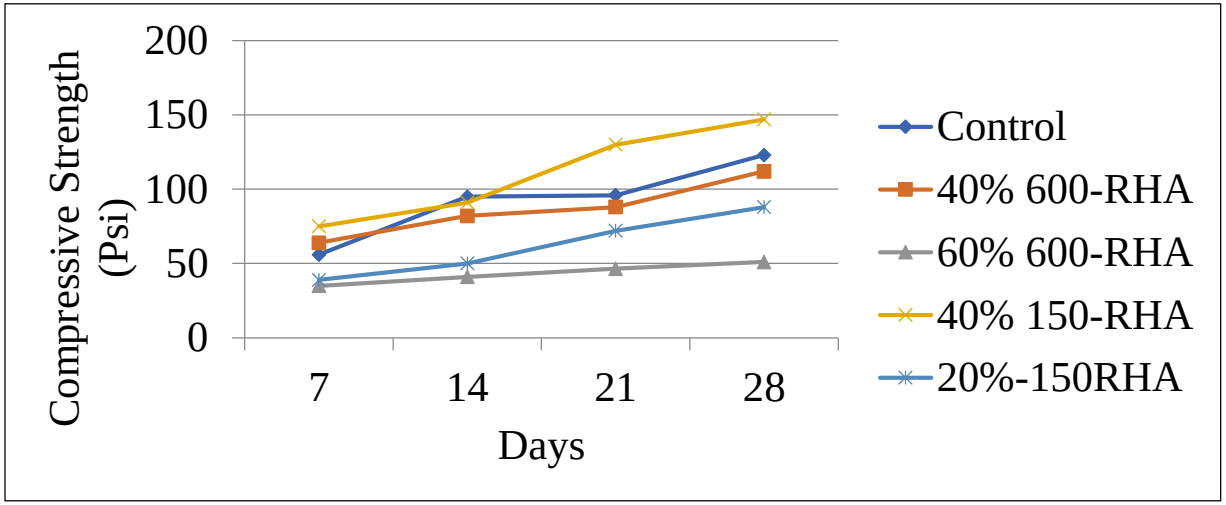
Mix proportion for different types of modified FFC mixtures

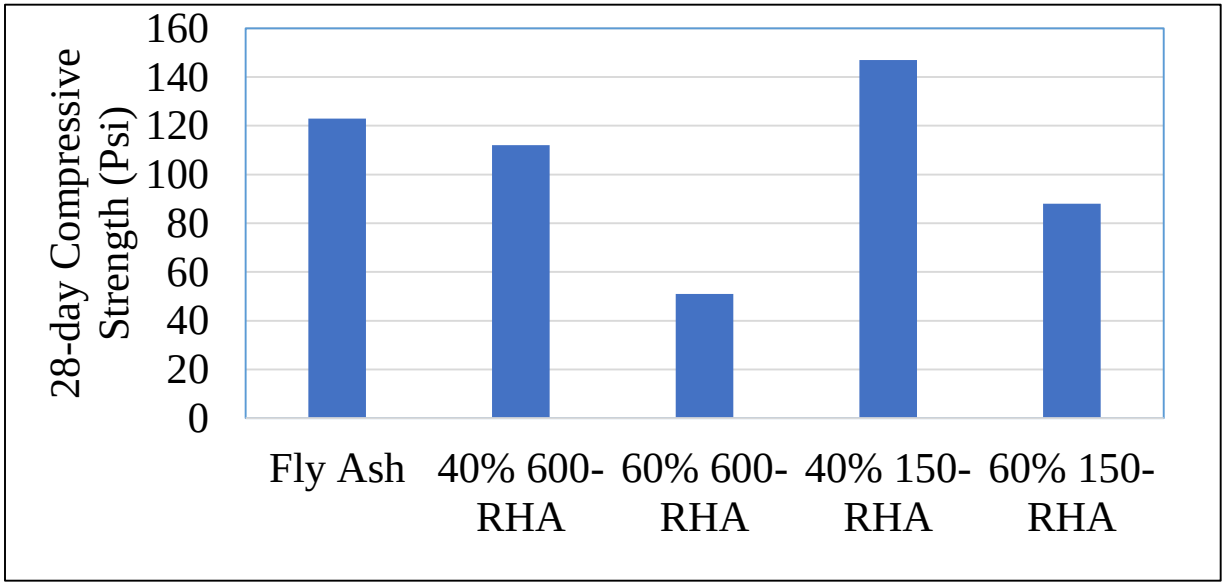
Types of FFC Mix	Fly Ash (%Wt)	Cement (%Wt)	600 RHA (%Wt)	150 RHA (%Wt)	W/C	Flow Dia. (in)
Mixer-1 (70% Fly Ash)	70	30	0	0	1.7	8
Mixer-2 (40% 600 RHA)	0	60	40	0	2.3	8
Mixer-3 (60% 600 RHA)	0	40	60	0	2.78	8
Mixer-4 (40% 150 RHA)	0	60	0	40	2.3	8
Miser-5 (60% 150 RHA)	0	40	0	60	2.37	8

Test Results and Discussions

Compressive Strength Test

- Samples made from 600 RHA showed less compressive strength compared to the FFC mixture made from fly ash.
- FFC mixture made with 40% 150 RHA showed a 19% increase in compressive strength

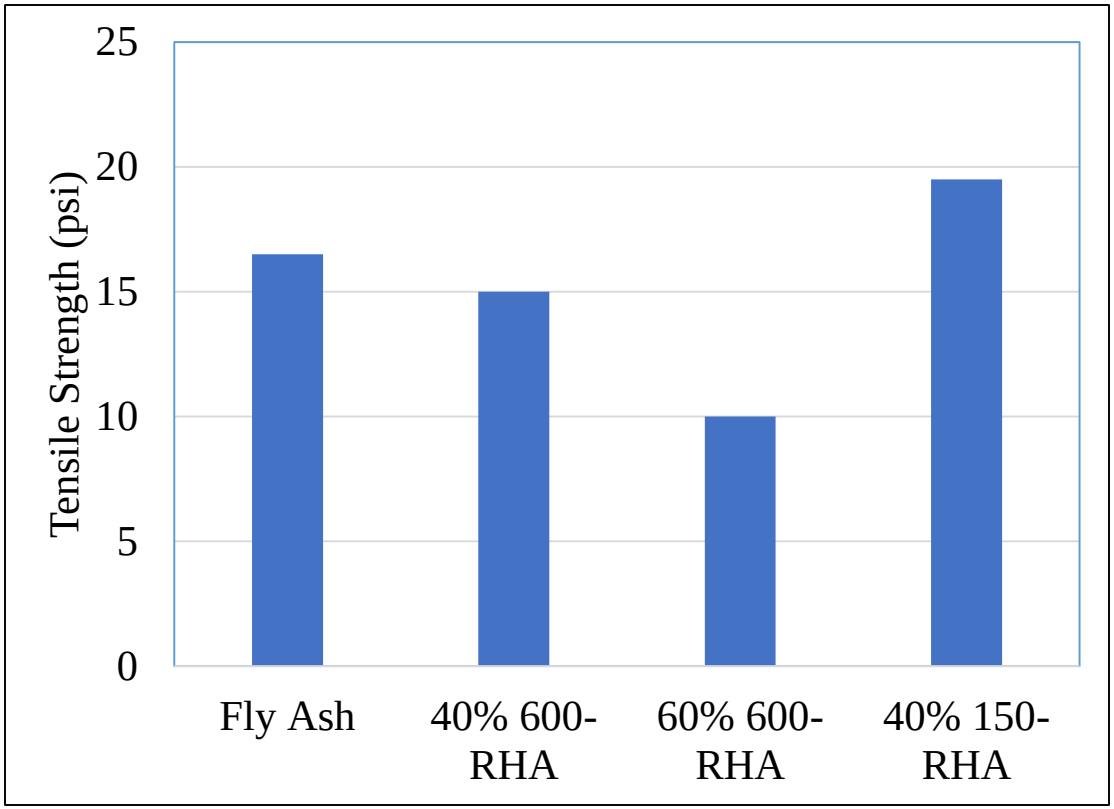




Test Results and Discussions

Tensile Strength Test

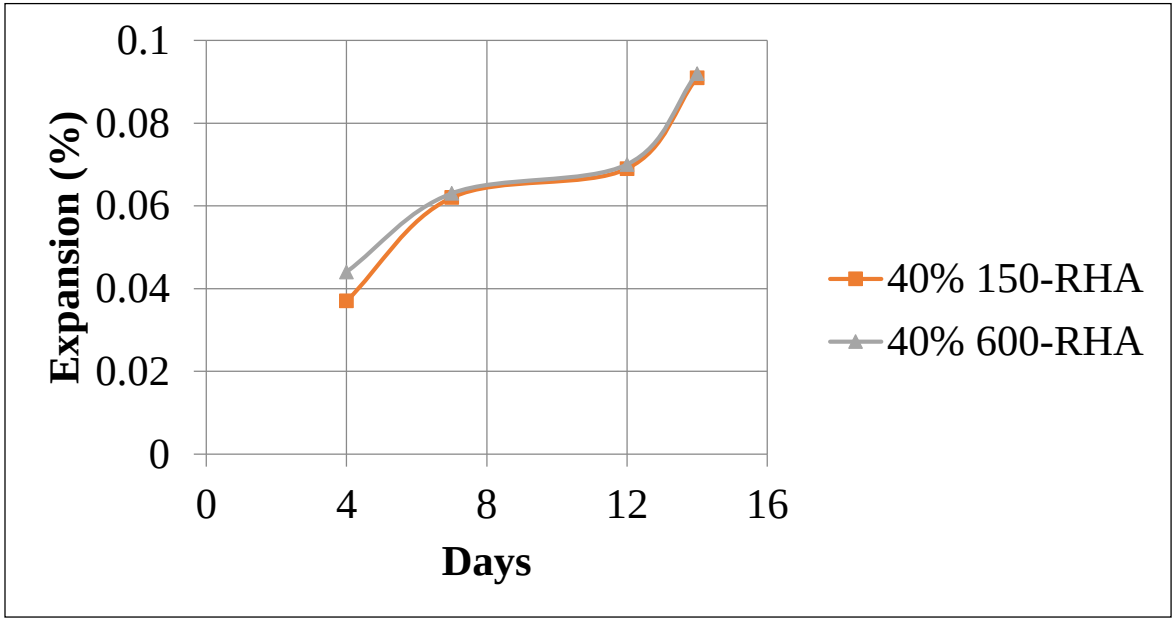
- A similar trend of strength gain was observed in the split tensile strength test results.
- Both 40% 600-RHA and 60% 600-RHA modified flowable fill concrete samples showed a reduction of tensile strength.
- 40% 150-RHA modified FFC showed more tensile strength values compared to the control sample.



Test Results and Discussions

Alkali Silica Reactivity Test

- ASR data for 40% 600-RHA, and 40% 150-RHA, respectively.
- Both samples exhibited expansion lower than the ASTM C1567 recommended limit of 0.10% in 14 days.



Field Demonstration

Figure: Presentation session and field demonstration of an FFC mixture.

Field Demonstration

Figure: FFC placement pit site and FFC mixture placing.

Conclusions and Recommendations

- RHA is a viable material for FFC
- Coarse RHA should be ground and/burnt to obtain finer RHA since pozzolanic activity increases with the fineness of RHA
- RHA-modified FFC mixtures required more water compared to the regular CFA-modified FFC to maintain the same flowability.
- 40% addition of 150 RHA particles in producing FFC would increase the strength properties

Acknowledgement

- Transportation Consortium of South-Central States (Tran-SET)
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- NEAR Ready Mix Concrete, Paragould (Eric Gohn)
- Razorback Concrete Company
- Riceland Foods, Inc., Stuttgart, AR

Thank You !!

Questions…???