



UNIVERSITY OF  
**ILLINOIS**  
URBANA-CHAMPAIGN

# Enhancing Strength and Reducing Porosity with Nucleation Seeding

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Baltimore, Maryland

Macro



Micro

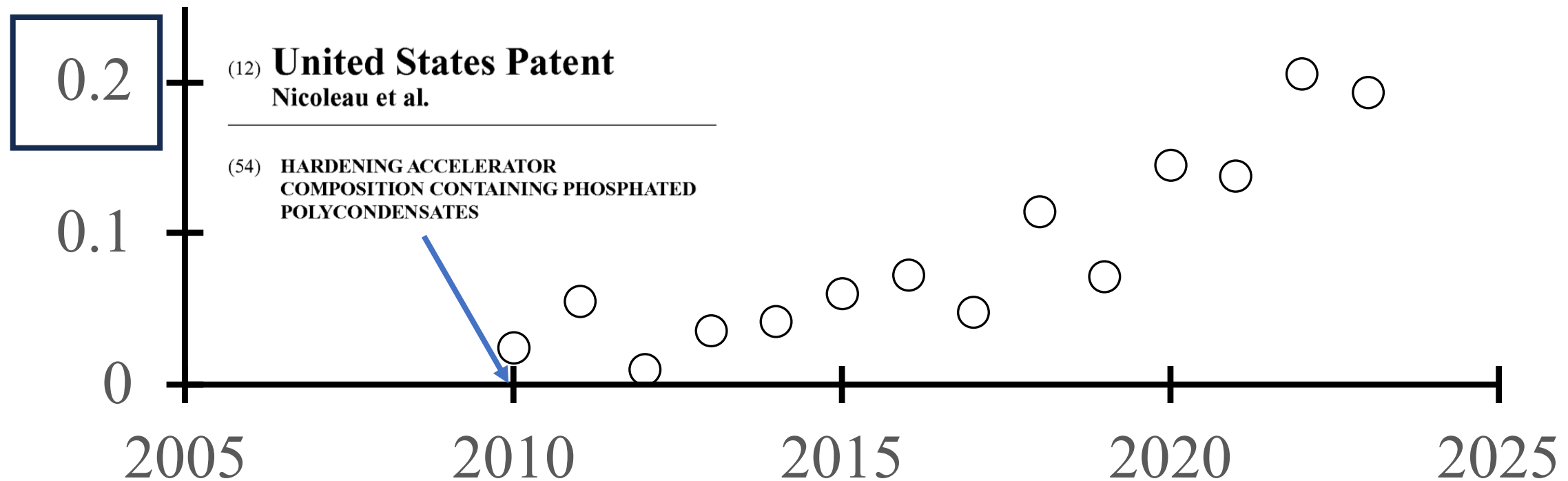


Nano



# C-S-H Seeds – Prevalence in Literature

## Normalized Data (%)

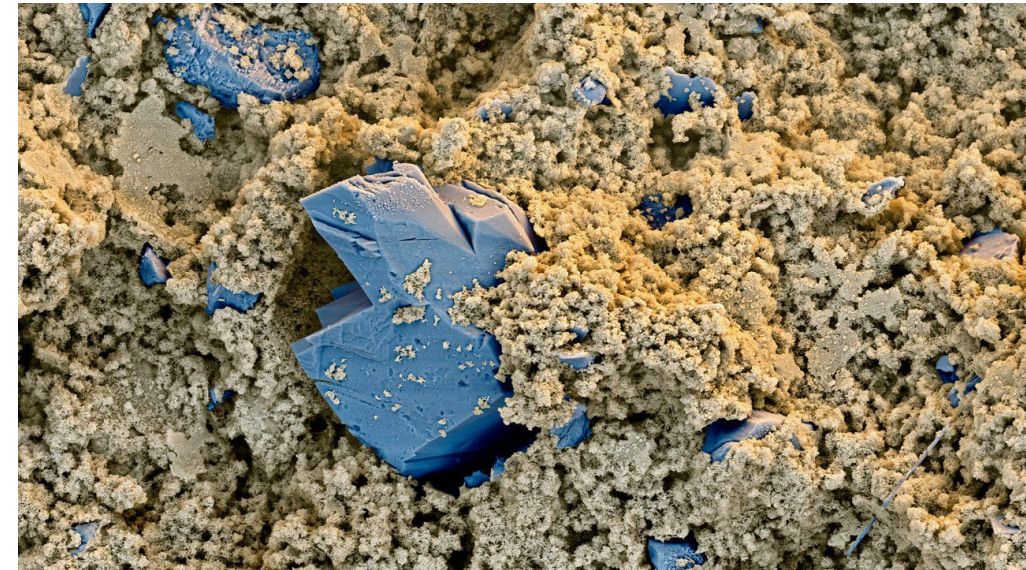


## Research Objectives:

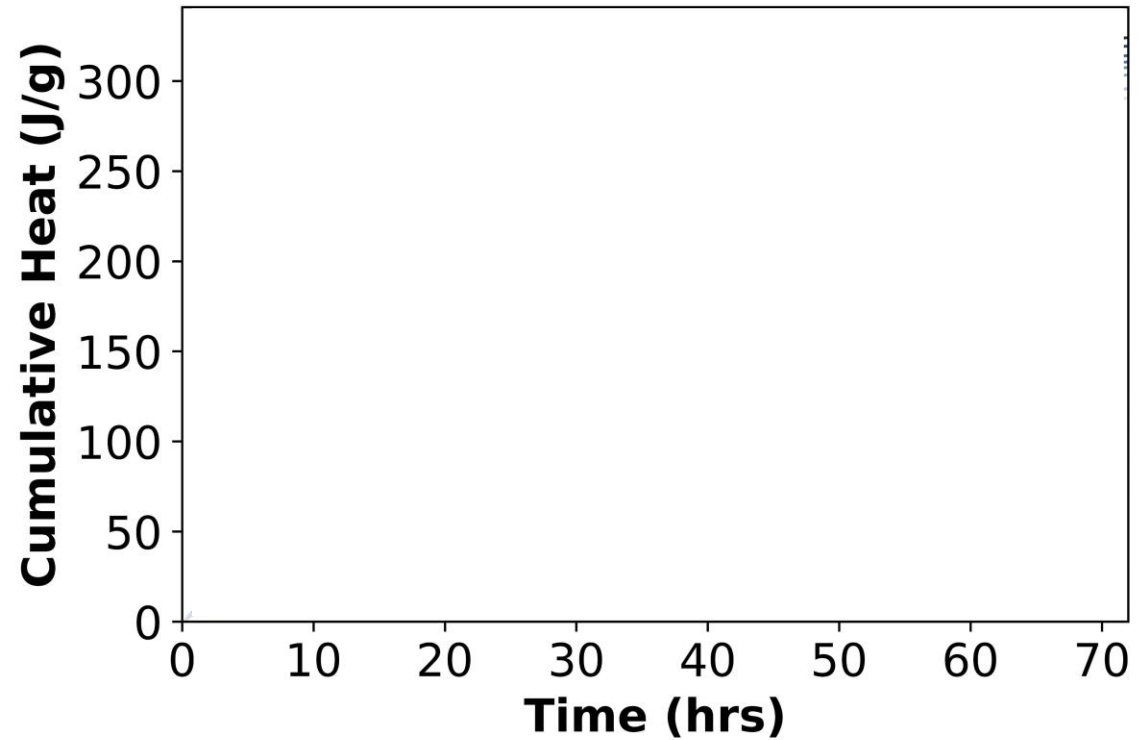
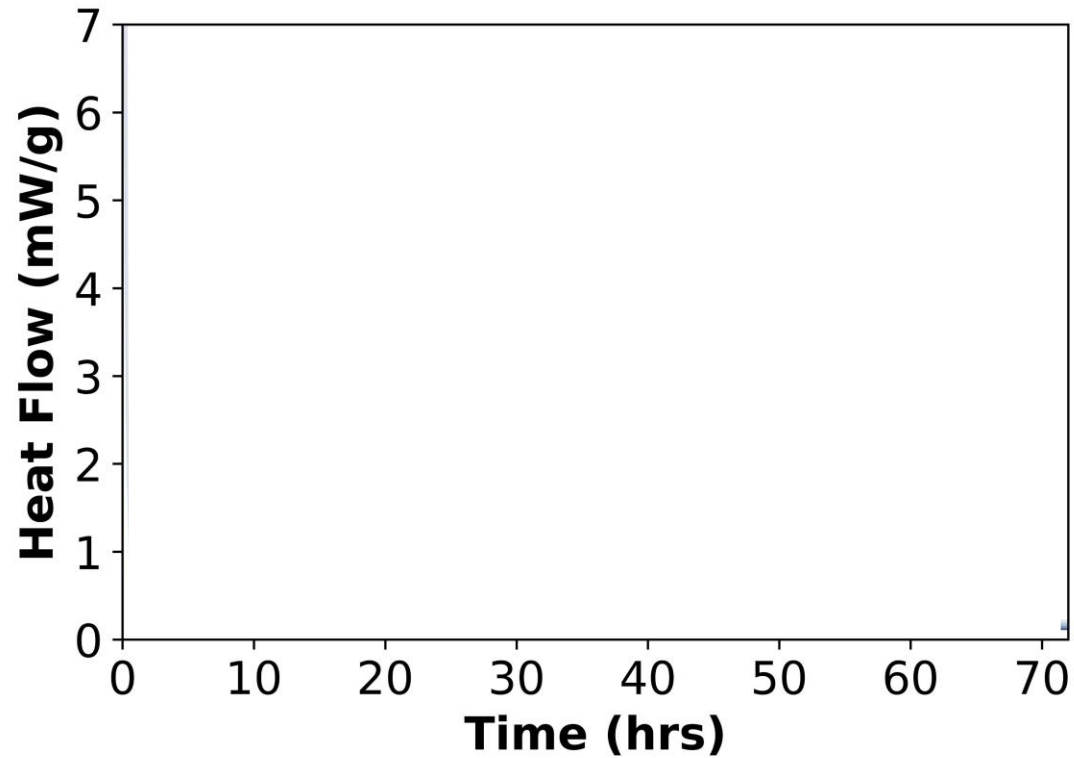
- 1) Recall the performance of commercial C-S-H seeds
- 2) AFt Seeds synthesis
- 3) AFt seeds performance

### Master X-Seed®

A commercial hardening accelerator from Master Builders



# Kinetics – Isothermal calorimetry

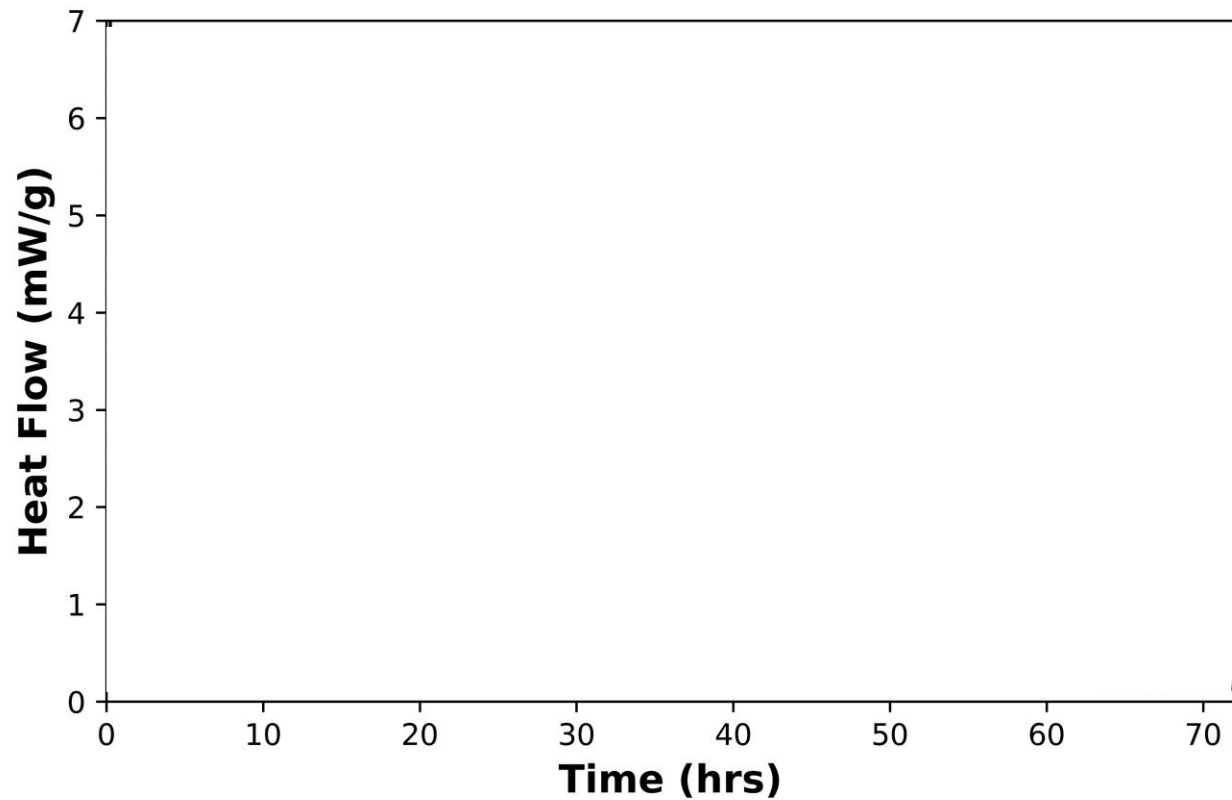


- Acceleration takes place
- Increases the degree of hydration

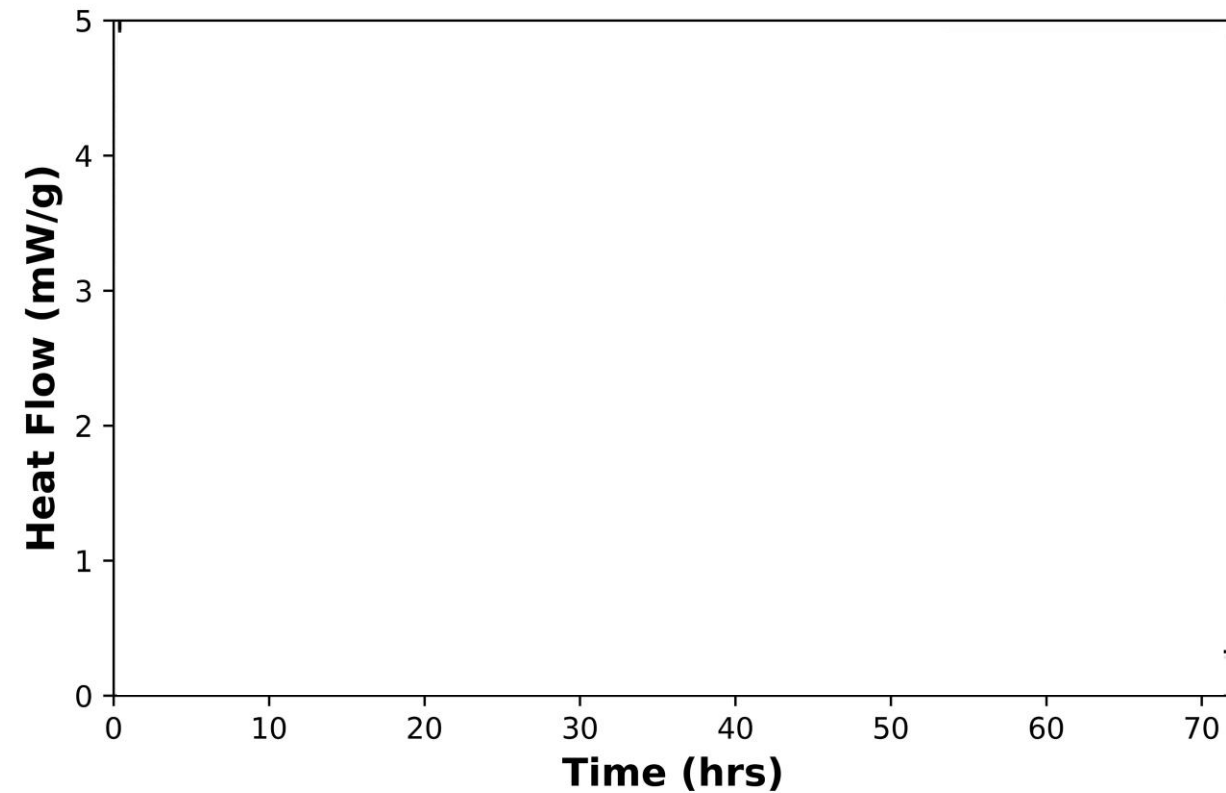
Qadri et al., *Mat. Today Com.* **2024**

# A tale of two admixtures

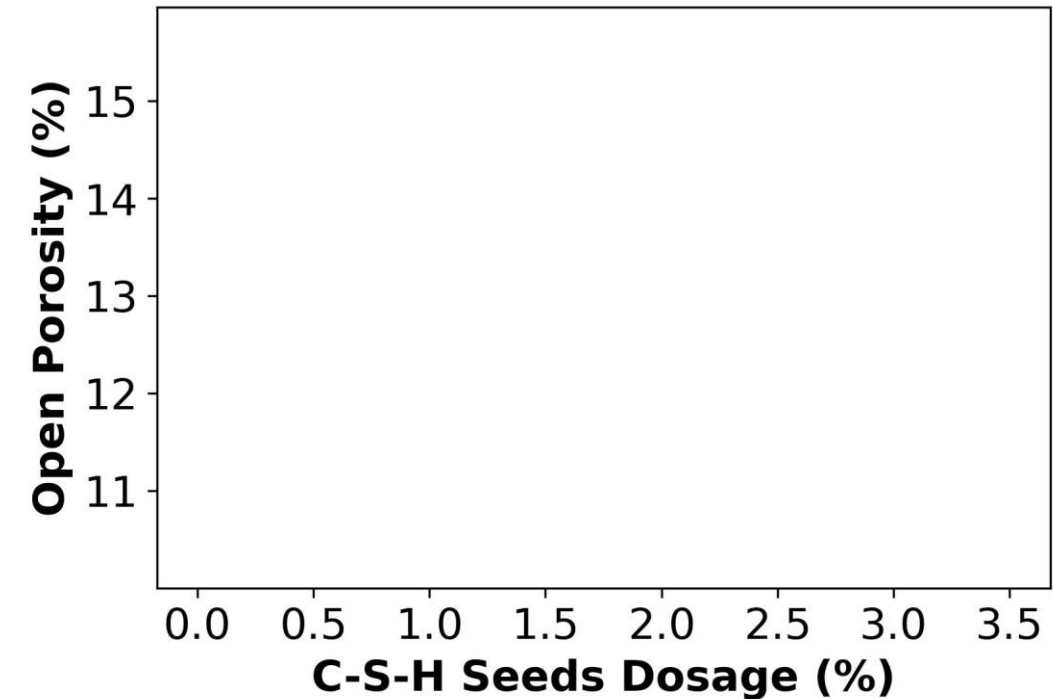
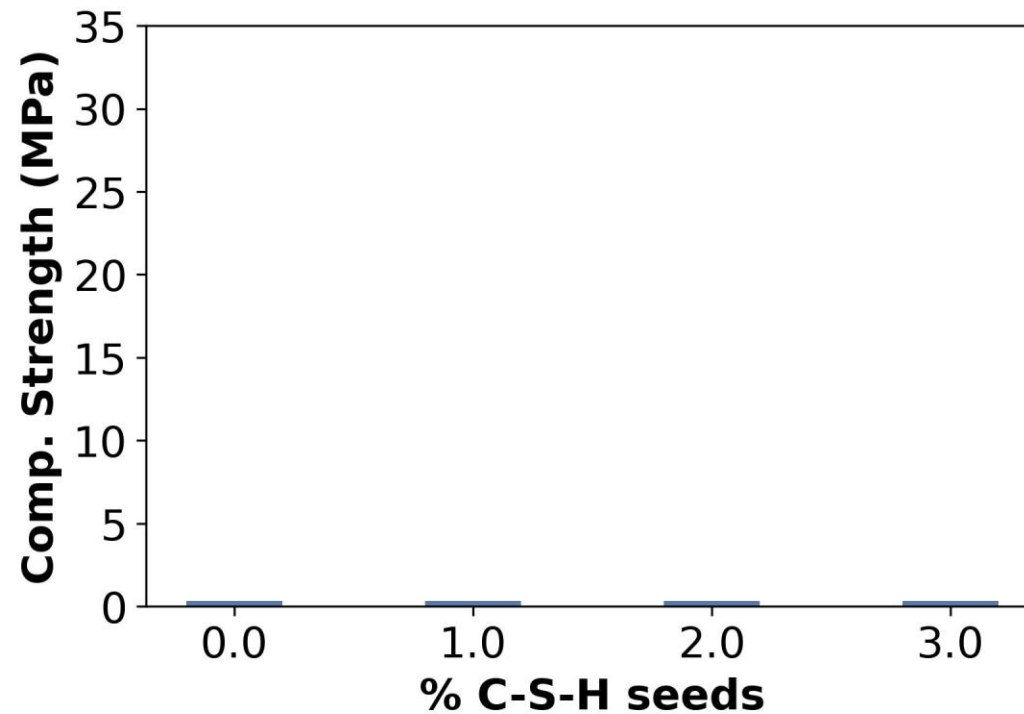
**X-Seed 44**



**X-Seed 55**



## Enhancement in strength and open porosity

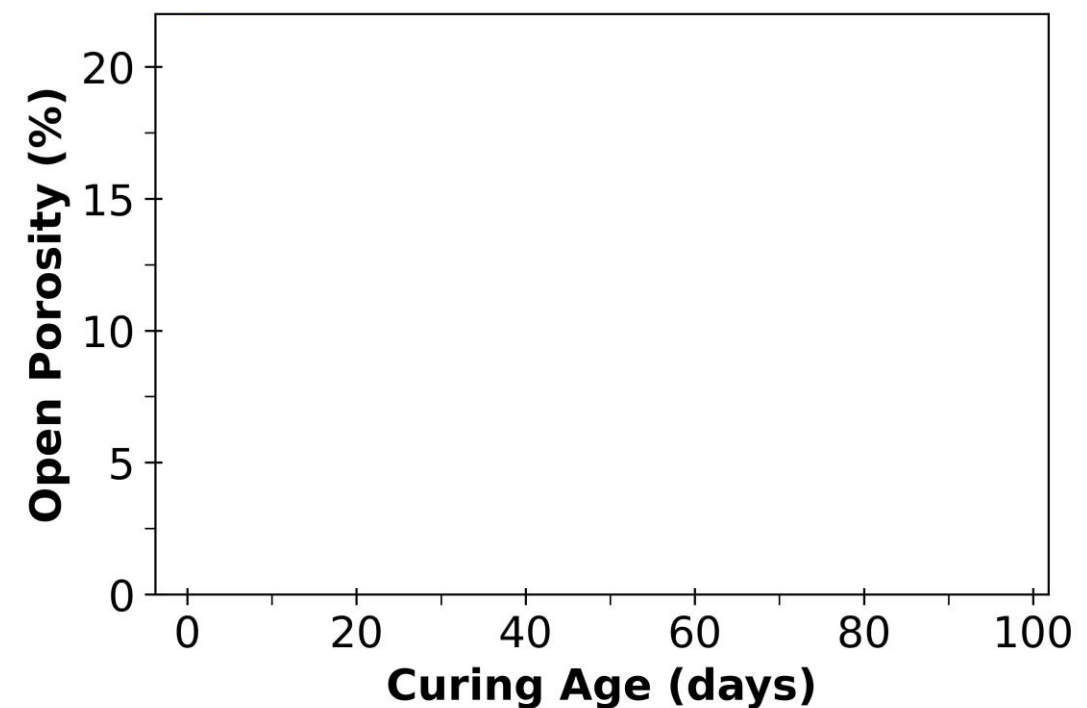
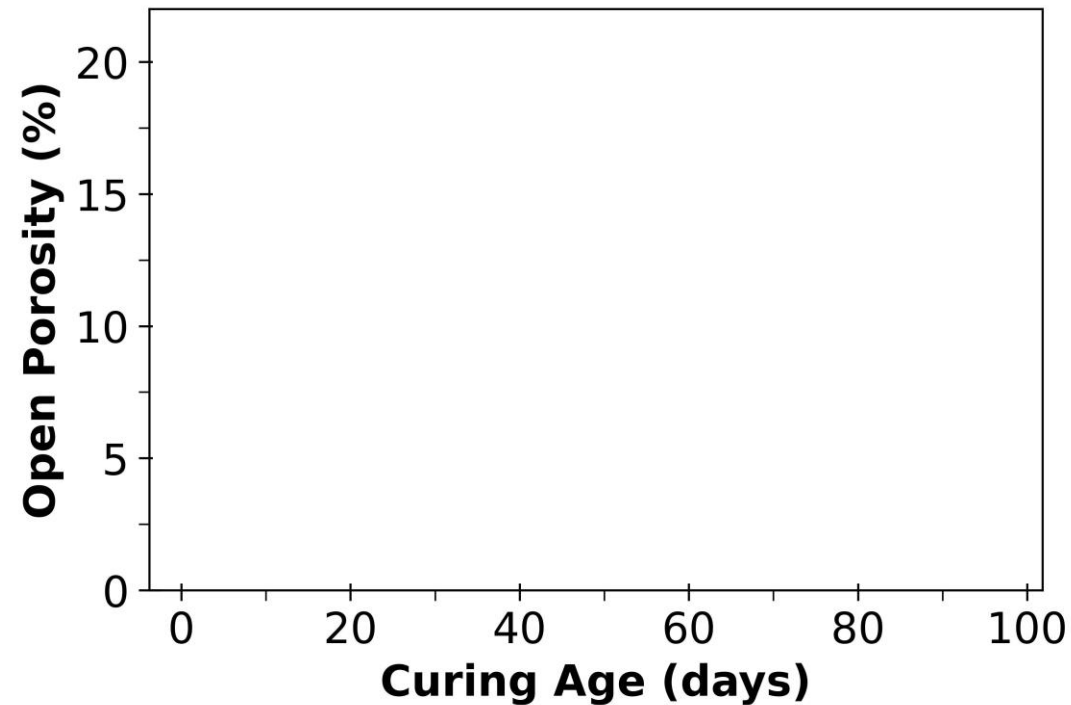


With C-S-H seeds:

- Strength increases (25 – 50%)
- Open porosity decreases (16% vs. 11%)

Qadri et al., *Mat. Today Com.* **2024**

# Microstructure refinement – blended cement



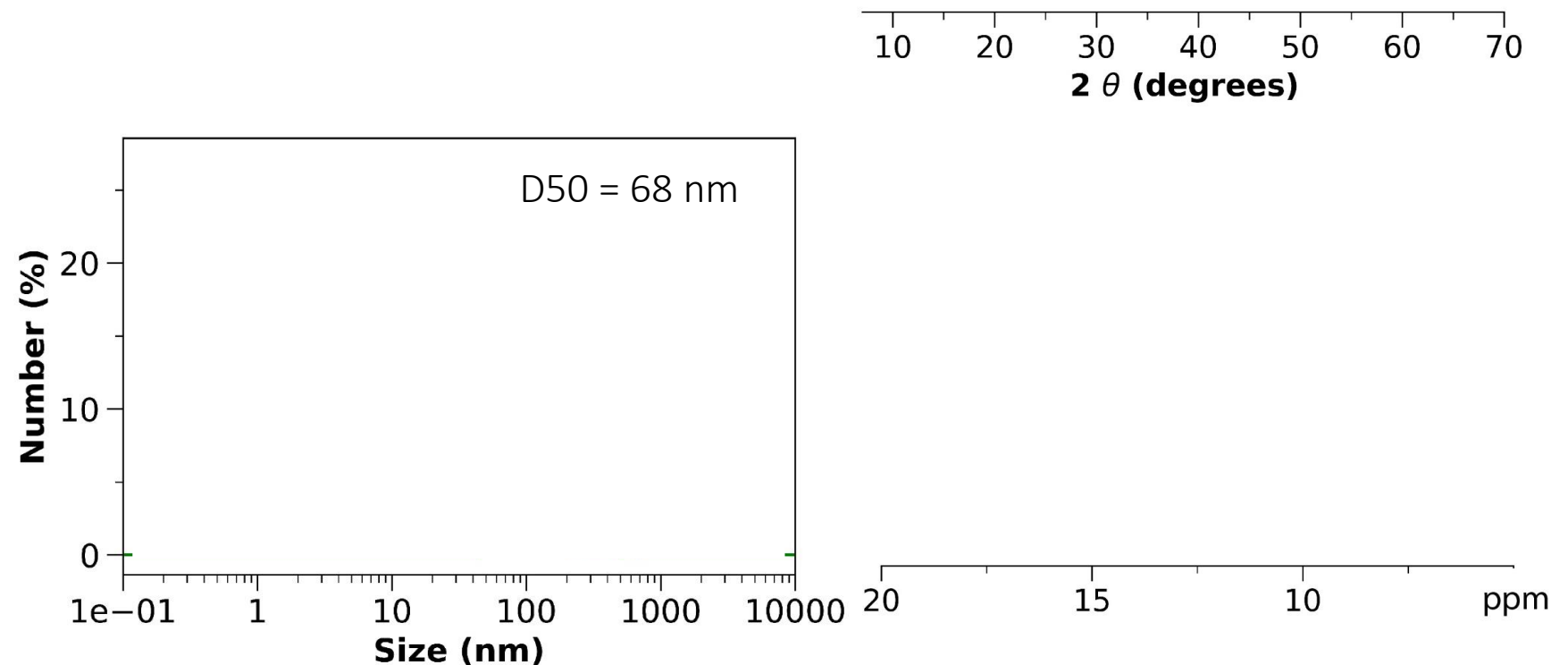
Porosity decreases at all ages

Qadri and Garg., *FHWA-ICT 2023*

# Validation of synthesized AFt seeds

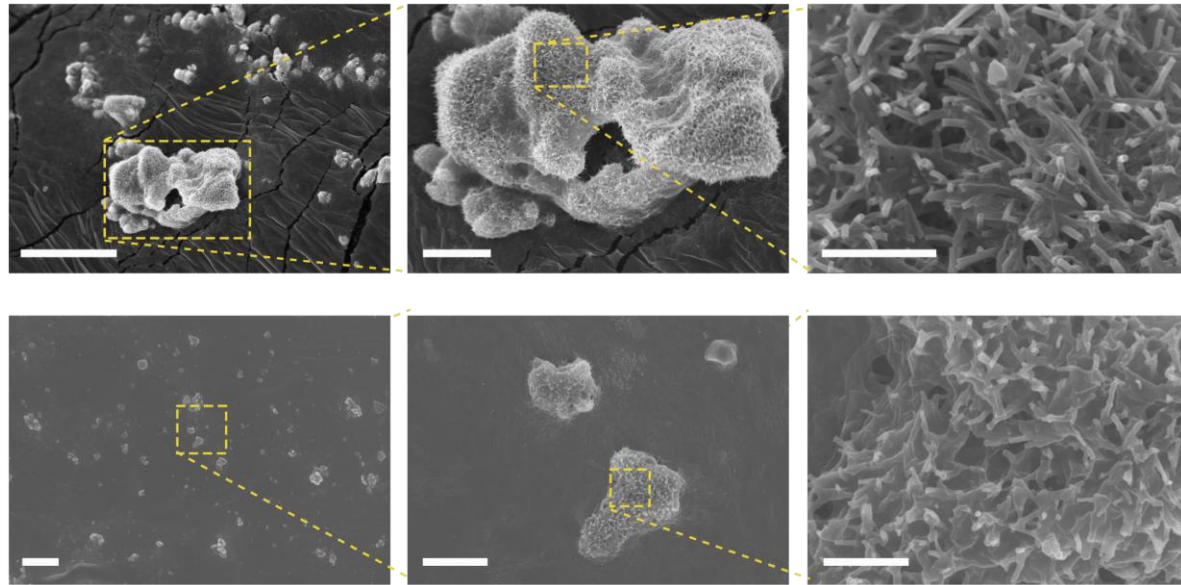
High purity AFt can be synthesized

Very small particle size compared to the previous works

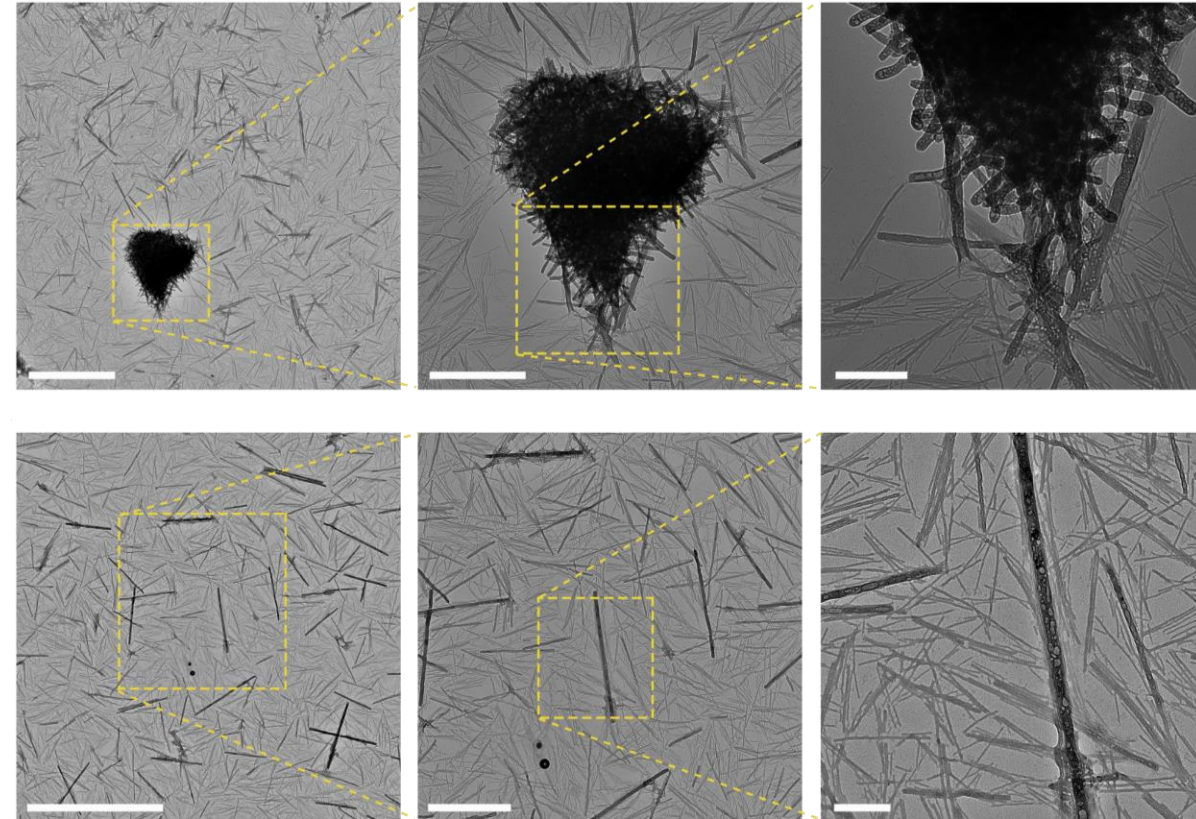


# AFt seeds – morphology

SEM



TEM



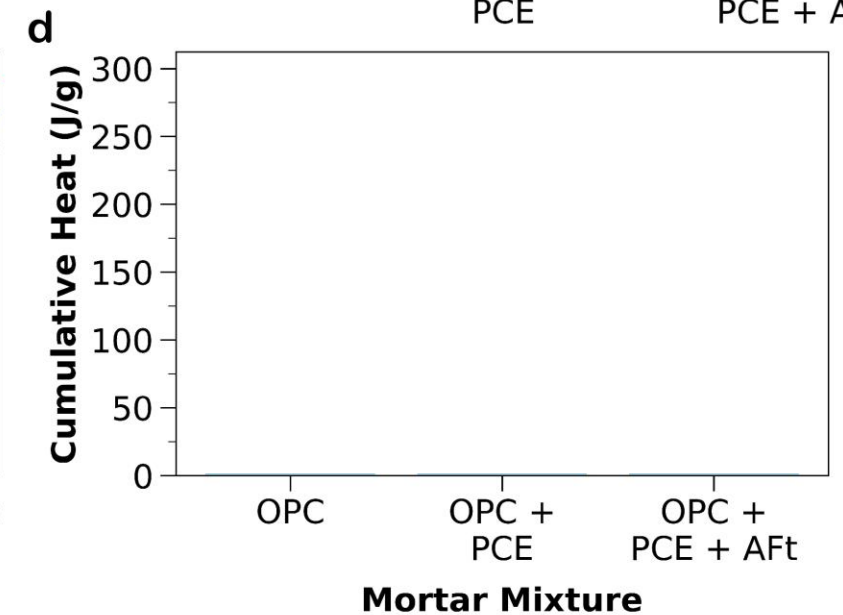
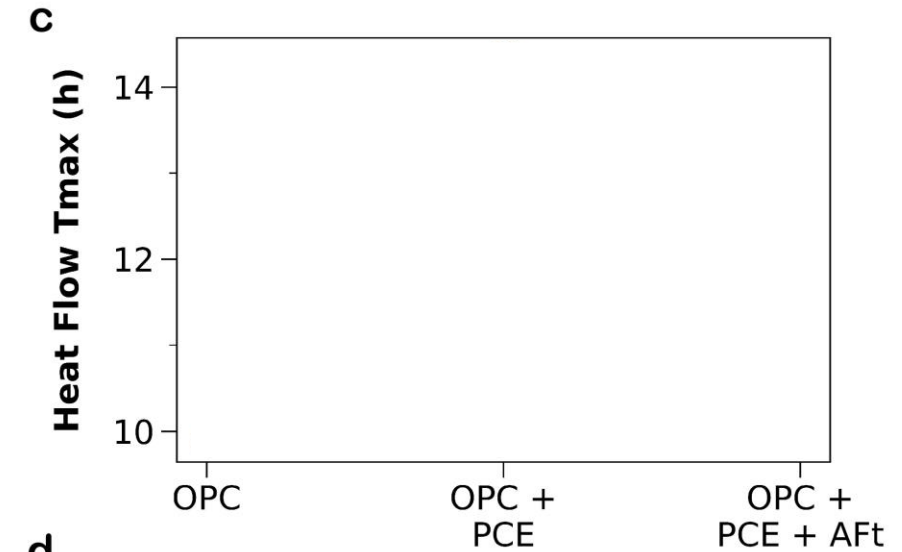
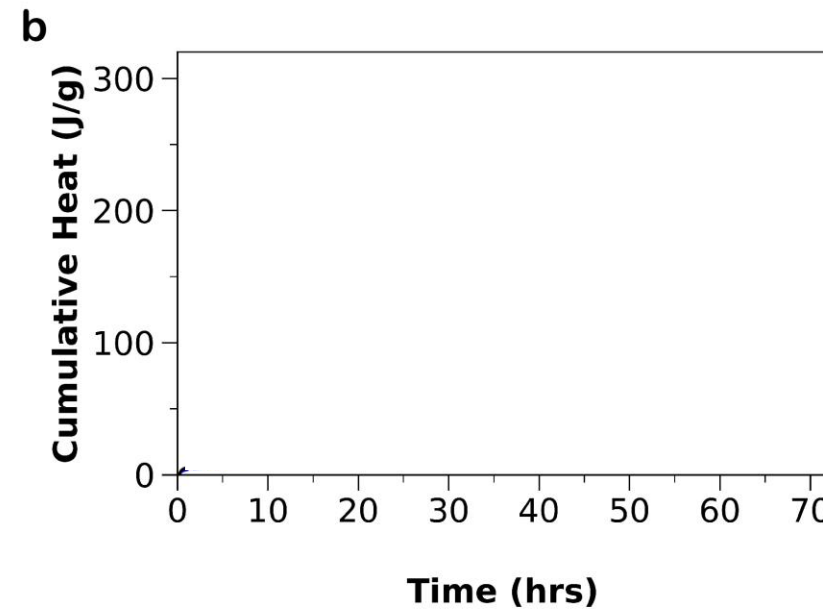
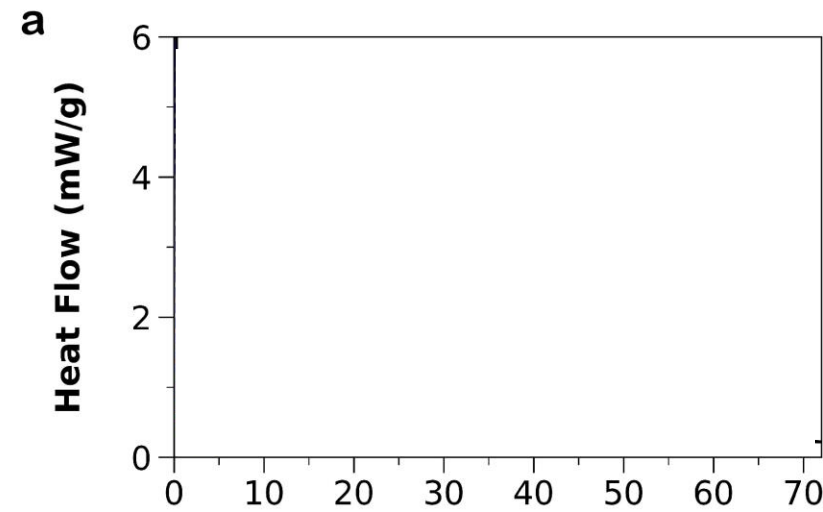
Spatially distributed needles with some cluster

Clusters with less than 100 nm in diameter

# Does AFt seeds affect kinetics?

Compensate the retardation from PCE

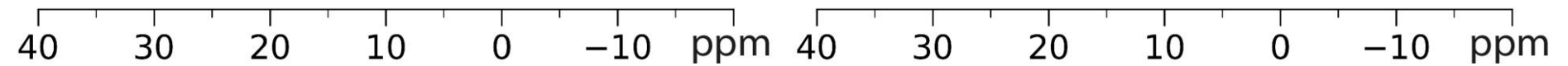
Degree of hydration



# Phase assemblage development

100% OPC

Seeded with AFt seeds

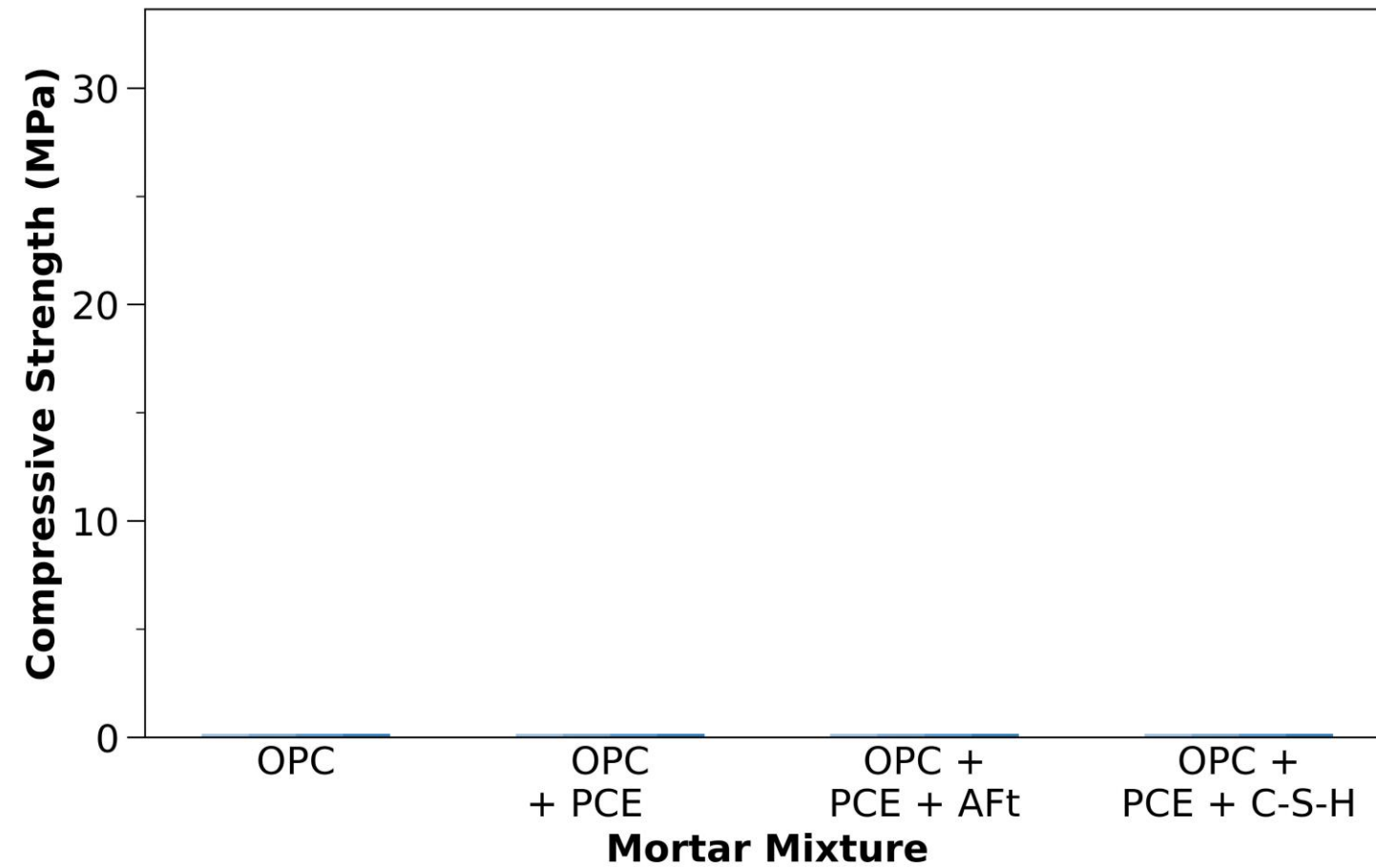


Early formation AFm and AFt phases

# Does AFt seeds affect strength development?

Strength boosting

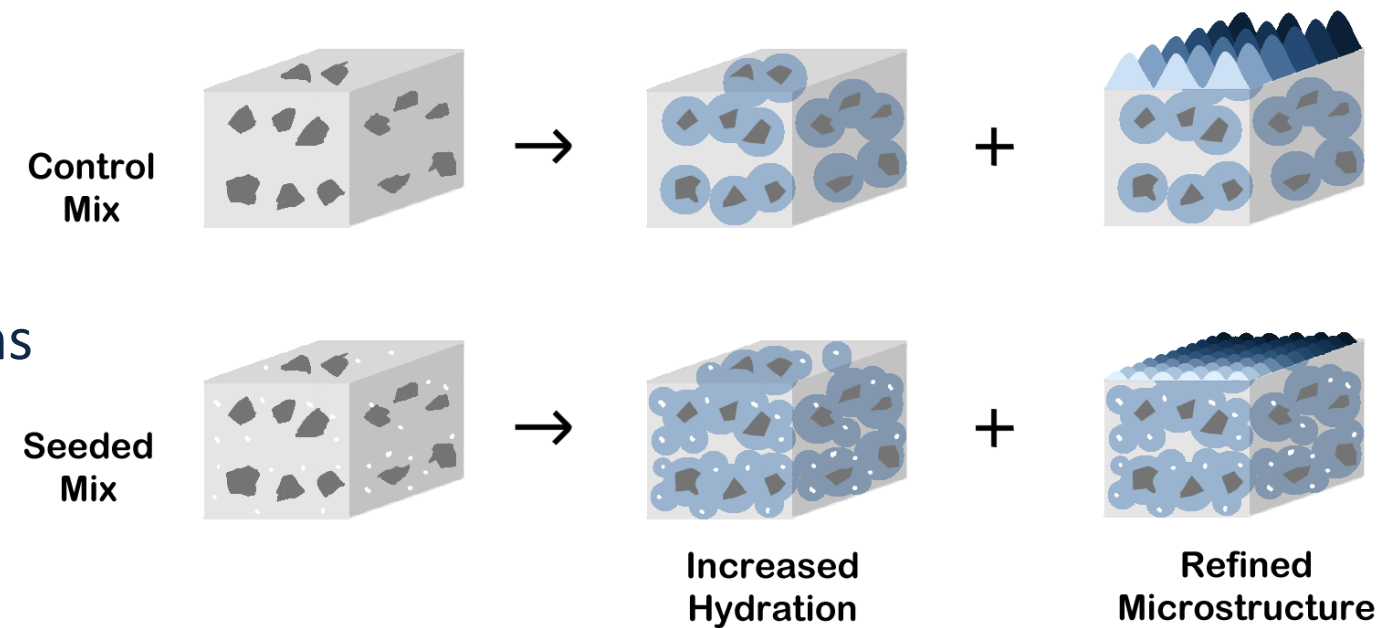
Comparable to the commercial  
C-S-H seed



# Contributions & Future Outlook

- C-S-H seeds affect the kinetics depending on the dispersion medium. Excess of PCE may cause set time retardation.

- AFt seeds synthesized in a small particles size and some agglomerations are less than 100 nm in diameter



- AFt seeds showed a promising nano seeds based on the results obtained

Qadri and Garg., *FHWA-ICT* **2023**

Qadri et al., *Mat. Today Com.* **2024**

Qadri and Garg, *Case Studies of Con. Mat.* **2023**

# Acknowledgements

