Early Age Properties of Zeolite Cementitious Materials

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Background
- Between 900 to 1000 kg of CO₂ emissions for producing every 1000 kg of portland cement [1].
- Use of supplementary cementitious materials (SCMs) as the replacement of portland cement can lower the CO₂ emissions & also have other environmental benefits.
- Need to make durable concrete structures for reducing service cost using relatively cheap SCMs.

About Zeolite
- Clinoptilolite content of zeolite is a natural pozzolanic having 97% purity.
- Hydrated alumna-silica based minerals with surface area of 35-45 m²/g and specific gravity is 1.89.
- Good cation exchange capacity without changing its properties.
- Increase durability properties of concrete against sulfate attack, alkali silica reaction, shrinkages, etc. [2-3].
- Relatively cheap & available, using benefit outweigh the costs.

Objective of study
- To determine the early age properties of zeolite blended cementitious paste i.e. workability, setting time and heat of hydration.
- Applicability of using natural zeolite as SCM with the replacement of cement for producing durable concrete.

Methodology
Natural zeolite replaced portland cement at 0, 5, 10, 15, and 20% by mass namely Control, NZ 5, NZ 10, NZ 15, NZ 20 respectively.
- For measuring workability, mortar was prepared without chemical admixtures with a water-to-cementitious materials (w/cm) ratio of 0.485 according to ASTM C 109 and tested as per ASTM C 1437.
- For measuring setting time, cementitious paste was made with w/cm ratio = 0.40. An automatic Vicat apparatus machine having 1 mm penetration needle was used with 10 mins of penetration interval to accomplish the test method B by ASTM C191-18a.
- Samples were prepared with w/cm ratio of 0.45 and placed in sealed glass vials for monitoring at least 72 hours at 25 °C in a TAM Air Isothermal calorimeter. Heat of hydration calculations were done according to ASTM C1679-17.

Research Results

Conclusion
- According to Fig. 10, water demand for workability was relatively high for mortar made with 5%-20% zeolite compared to control case. Use of up to 20% zeolite in the cementitious mortar, can reduce the workability of up to 10 to 20% due to higher surface area of zeolite particles.
- Using very little dosages of high range water reducing admixtures, workability of zeolite samples can be made same as like as control case without segregation as shown in Fig. 11.
- As per Fig. 12, replacement of portland cement with zeolite (5-20%) by mass can reduce the initial setting time by 50-80 mins and final setting time by 30-80 minutes of cementitious pastes, Zeolite can accelerate the setting time of pastes due to nucleation sites effects on C-S-H precipitation.

Future studies
- A detailed investigation will be conducted on the durability properties of zeolite cementitious materials i.e. alkali-silica reaction, chemical shrinkage, drying shrinkage, autogenous shrinkage, compressive strength.
- Additionally, finding out the factors that influence the modification of its properties by cation exchange, acid treatment, or calcination.

References