Research Brief

Wisconsin Highway Research Program
Project 0092-23-03
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Chemistry and Performance of Supplementary Cementitious Materials (SCMs) for Wisconsin Pavement

Objectives

- Identify traditional and non-traditional SCMs, and reclaimed ashes available
- Establish appropriate testing methodologies for SCMs
- Develop a database for SCM properties and characteristics
- Propose revisions to WisDOT manuals, standards and policies

Benefits

- Enhancing testing methods for screening new materials
- Results highlight potential for a new strength activity index for testing

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Background

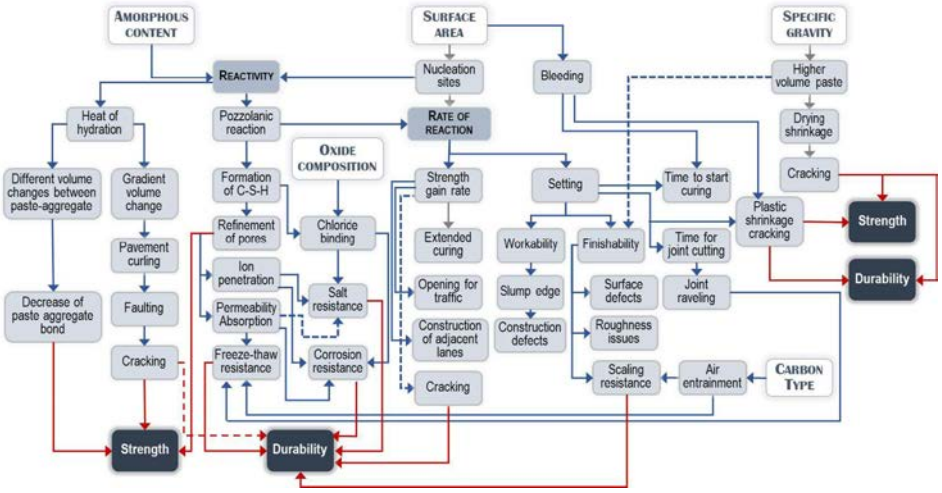
This study investigated the performance of supplementary cementitious materials (SCMs) and alternative supplementary cementitious materials (ASCM). Performance included materials characterization and concrete performance.

Most transportation agencies use SCMs in their concrete pavement mixtures, especially fly ashes, as a partial replacement for portland cement. SCMs are materials that react either with calcium hydroxide at high pH (pozzolanic) and/or with water at high pH (latent hydraulic), within a concrete mixture. SCMs contribute to long term performance, especially durability because they promote densification of the matrix.

The concrete industry faces two challenges. The supply of standard SCMs is insufficient to fulfill the current needs and there is an increasing demand to develop a more sustainable infrastructure without sacrificing performance.

Methodology

Ten materials were studied. Characterization included chemical composition, x-ray diffraction, density, setting time, water requirement, particle size, a modified version of the strength activity index, a modified version of the foam index, and reactivity. Concrete performance included slump, the box test, air content, super air meter, compressive and flexural strengths, freezing and thawing resistance, surface resistivity and length change due to shrinkage.



SCMs main effects on concrete properties. Specific deterioration mechanisms such as alkali-silica reaction and sulfate resistance, among others. Red arrows indicate the ultimate effect on concrete strength and durability.

"The results from this study are going to improve WisDOT's specifications for using SCMs and ASCMs in concrete mixtures. This will allow for greater testing efficiency and better performance of Wisconsin pavements." –

Tirupan Mandal, WisDOT

Results

Results showed that some of these materials (Micron3, Opus, PozzSlag, Liquid ASCM) either did not meet the requirements of the American Society for Testing and Materials (ASTM)'s specifications or did not meet the definition of the material in these specifications.

However, all concrete mixtures containing the SCM or ASCM in this study showed good performance, sometimes, at later ages, better than the control mixture, with exception of the liquid ASCM, which showed similar performance as the control.

The validity of the reactivity tests (ASTM C1897) was confirmed, and it was recommended to be implemented when evaluating a material with no performance history or alternative SCMs.

The modified foam index was unable to correlate with concrete AEA demand but was found to be a good indicator of potential air entrainment problems, and the modified strength activity index (SAI) was found to be a good screening tool.

Loss on ignition (LOI) did not correlate with the AEA demand or with the foam index and the current 2% requirement for fly ashes is too restrictive.

Recommendations for Implementation

Based on the results of the study, the researchers had several recommendations including:

- Removing the requirement for LOI and reword WisDOT specification 501.2.4.2.2.1
- Eliminating the APL for Class F fly ashes and allow the use of up to 30% of Class F fly ashes that comply with ASTM C618, with the exception of SAI. Replace SAI with the modified SAI performed in this study
- Removing the need for individual constituents to comply with their applicable specification, as long as the blended SCM does – with the exception of the SAI which should be replaced by the modified SAI
- Increasing the qualification age to 90 days, if the results at 28 days do not meet the requirements
- Adding a qualification requirement of low penetrability at 90 days, according to WRM T358
- Performing comprehensive research on shrinkage behavior, including estimation of field performance and cracking probability
- Introducing a framework for evaluating ASCMs and guidance on acceptability requirements

Interested in finding out more?
Final report is available at:
WisDOT Research website

This brief summarizes Project 0092-23-03
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