Research Brief

Wisconsin Highway Research Program
Project 0092-17-07
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# Evaluating Current Wisconsin Mixes Using Performance Engineered Mixture Testing Protocols

## Research Objectives

- Use performance-based testing on current WisDOT concrete mixtures
- Create a database of results on WisDOT mix designs and compare to PEM specifications
- Evaluate 1.5-inch aggregate in the Tarantula Curve and MinT consolidation versus rodding during SAM testing
- Test resistivity using multiple curing conditions

## Research Benefits

- Greater flexibility in the composition of concrete mixtures that can be used for projects due to increased reliability in testing measures and understanding of mixture performance

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## Background

Concrete specifications provided by state highway agencies (SHA) are typically prescriptive; that is, they describe the materials and methods that must be used to complete projects. The main concerns with this approach are that most of the risk and liability for the performance of the project is on the SHA, which limits the incentive for contractors to innovate. Performance-related specifications (PRS), those that describe expected concrete performance, offer an alternative that allows contractors flexibility and encourages innovation, leading to improved performance and lower costs. This research took place in two phases. In Phase I, the objectives were to:

- Use performance-based testing methods on current WisDOT mixtures, and
- Collect a comprehensive database of results on several WisDOT mix designs and assess how they compare to proposed Performance-Engineered Mixtures (PEM) specifications

In Phase II, the objectives were to:

- Evaluate the 1.5-inch aggregate in the Tarantula Curve and Miniature Vibration Table (MinT) consolidation compared to rodding during Super Air Meter (SAM) testing
- Test resistivity per AASHTO TP119-21 and AASHTO T358-21 using bucket curing in pore solution, accelerated curing, lime curing, and sealed sample.
- Perform field testing on Wisconsin mixtures to verify Phase I recommendations and perform additional resistivity conditioning.

## Methodology

In Phase I, the research team sampled concrete mixes used at eight construction projects sites across the state, representative of a variety of materials and methods. Samples were taken at the plant, before the paver and after the paver in the morning and afternoon of two consecutive days. Performance tests were conducted on each sample to measure strength, durability and workability properties.

**Strength properties:**

- Flexural vs. Compressive Strength

**Workability properties:**

- Box Test
- Vibrating Kelly Ball

“The results of this research will be integral in the direction of evaluating concrete performance.”
–Leslie Hidde, WisDOT

**Interested in finding out more?**

**Final report is available at:**
**WisDOT Research website**

**Durability properties:**

- Bulk resistivity
- Coefficient of thermal expansion
- Formation factor
- Hardened air voids
- Porosity
- Super Air Meter (SAM)
- Surface resistivity

Conducting a surface resistivity test

In Phase II, a large lab study was conducted to investigate performance using various aggregate sources and blends. The research team investigated the common use of 1.5-inch stone in Wisconsin as it pertains to the Tarantula Curve and performance properties. The various optimized blends were tested using slump, box test, shrinkage, and resistivity. Additionally, five more field projects were visited where testing was conducted using various consolidation methods for the SAM test, and various conditioning methods for resistivity testing.

## Results

Results demonstrate the value of using the optimized gradation curve (Tarantula Curve) by increasing workability and reducing cementitious products without sacrificing performance. Even though theoretical relationships between compressive and flexural strength have been developed, the mixtures tested in this study with the highest compressive strengths did not always have the highest flexural strengths. It was also found that air content is not a good indicator of Spacing Factor as results varied widely among samples with the same air content. However, SAM numbers remained similar indicating loss of largely coarse bubbles. Resistivity increased with all curing methods tested, but the 28-day accelerated curing had the benefit of being faster than other methods with little difference in outcome. The coefficient of thermal expansion varied across the types of mixtures tested, with Dolomite showing mid-range coefficients with less variability than other materials such as gravel.

## Recommendations for implementation

- Continued option to use 1.5-inch aggregate size in WisDOT mixtures
- Use of the Tarantula Curve with a warning band for all WisDOT mixtures where longevity is important
- Design and production targets for the SAM meter
- Using MinT for SAM consolidation and the accelerated curing method for resistivity


This brief summarizes Project 0092-17-07,
“Evaluation of Current WI Mixes Using Performance Engineered Mixture Testing Protocols”
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