Final Report

Materials Management Section Project
Project 0092-25-52
January 2026

Use of Phoenix Test to Evaluate Concrete Performance

Objectives

- Timely and accurate evaluation of w/cm ratio in Class I concrete mixes in Wisconsin using Phoenix equipment.

Benefits

- Assess the effects of variations in the w/cm ratio on concrete performance-based tests to provide specific guidance and recommendations regarding acceptable fluctuations in the w/cm ratio for WisDOT projects.

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Background

Wisconsin Department of Transportation (WisDOT) Standard Specifications (SS) has upper limits on water-to-cementitious material (w/cm) ratio for concrete mixes; however, currently there is currently no method to verify this value in the field. The w/cm ratio is a proven predictor of concrete strength, workability, permeability and durability. Given that water is one of the most variable components in concrete and considering current practices, it is challenging to accurately measure the precise amount, particularly when unrecorded mix water is included in the concrete prior to hardening. The Phoenix equipment (Figure 1) is a specially designed oven that is capable of accurately measuring the water in fresh concrete in approximately 15 minutes and it can be used to evaluate w/cm ratio in concrete mixes during placement.

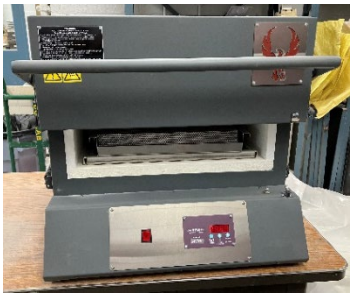

Figure 1: Phoenix equipment

Methodology

The Phoenix test allowed the WisDOT Bureau of Technical Services' central laboratory to evaluate w/cm ratio of concrete mixes in real-time in Wisconsin using the batch weights and the total water content in the fresh concrete. Two concrete mixtures with the same proportions were tested. To determine the w/cm ratio of the concrete mixtures, the Minnesota DOT *Standard Method of Test for Measuring the Water Content in Fresh Concrete by Rapid Evaporation (Phoenix Test Method)* procedure was used, including the following steps:

- A rigid container of a fixed volume was used; the mass of the container was measured before and after filling, and after emptying the concrete sample.
- The sample was transferred to a pan and the mass of the pan was measured before and after filling with the sample.
- The pan is then placed into the furnace and heated between the temperatures of 1,450°F and 1,500°F for approximately 15 minutes.
- The mass of the sample-filled container was measured again to ensure that the water evaporated.
- The difference in the mass of the specimen before and after the test determines the water content of the specimen.

"Phoenix equipment will allow WisDOT to accurately measure the w/cm ratio of concrete mixes used across Wisconsin." –

–Tirupan Mandal, WisDOT

Results

With the Phoenix equipment, the central laboratory was able to determine w/cm ratio of two concrete mixtures in real-time using the same mixture proportions.

Batched w/cm ratio of 0.44 was used for both test samples and the results for the actual w/cm ratio were the following:

- Test #1: 0.40
- Test #2: 0.42

The software application provided with the equipment was used to calculate the results as shown in Figure 2.

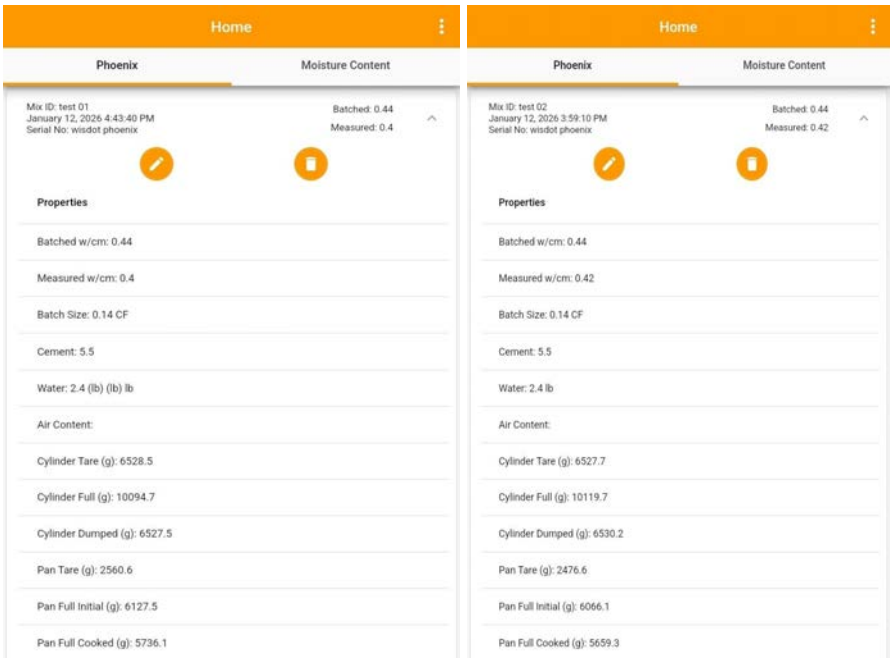

Figure 2: Batched vs. actual w/cm ratio for Test #1 (left) and Test #2 (right)

Final test results (Test #1 and Test #2) indicate that actual w/cm ratio can be different for concrete mixtures batched using the same material proportions and batching process proving material inconsistencies observed with concrete mixtures on WisDOT projects over the years.

Recommendations for Implementation

Timely and accurate evaluation of w/cm ratio will allow for concrete mixes to be adjusted in real-time. The BTS Concrete Unit is planning to test various concrete mixes in-house and during placement on different pavement projects in different regions using Phoenix equipment to ensure that the concrete mixtures used in Class I concrete pavements and structures are meeting WisDOT SS requirements.

Additionally, WisDOT is planning to analyze, correlate and validate the w/cm ratio against performance-based tests conducted on freshly mixed concrete and provide specific guidance and recommendations regarding acceptable fluctuations in the w/cm ratio for WisDOT projects.

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

This brief summarizes Project 0092-25-52
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