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LRRB
LOCAL ROAD RESEARCH BOARD

TECHNICAL SUMMARY

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LRRB PROJECT COST:
$99,998

Researchers cast and cured concrete samples to test hardened air content, compressive strength and freeze-thaw durability.

MINNESOTA DEPARTMENT OF TRANSPORTATION

RESEARCH SERVICES

OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

Extending the Delivery Time of Concrete Mixtures

Extending the allowable delivery time of concrete mixtures would make some construction projects less costly. Before changing MnDOT specifications, it was important to verify that the use of additives to delay setting would not compromise concrete performance.

What Was the Need?

To transport concrete from mixing plants to construction projects, workers use trucks with large rotating drums, which keep the plastic concrete agitated, maintain its workability and delay the process of setting. Setting occurs as water reacts with portland cement, which then gradually hardens and binds the aggregates together.

Agitating concrete in transit delays setting but does not halt it altogether. The longer this process goes on, the less the concrete is workable enough to be placed and finished during construction. While workability can be restored by adding water, doing so decreases the final product's strength and durability.

Setting can be delayed by using chemical additives, including water reducers, retarding admixtures and hydration stabilizers. Water reducers lower the amount of water necessary in a mixture, making it possible to extend the setting time without compromising workability and durability. Retarding admixtures—which are usually also water reducers, called water-reducing retarders—slow the reaction of water with cement. Hydration stabilizers delay the onset of setting. Concrete mixtures typically also contain air-entraining agents, detergent-like additives that increase the durability of hardened concrete by promoting the formation of a matrix of air bubbles within the concrete.

MnDOT limits the transport time of concrete mixtures containing air-entraining agents to 60 minutes. However, other states allow transport times as long as 90 minutes for similar concrete mixtures. Research was needed to verify whether hauling times for concrete mixtures used in Minnesota could likewise be extended without compromising concrete performance.

What Was Our Goal?

The objective of this project was to evaluate how the performance of air-entrained concrete mixtures containing water reducers, water-reducing retarders or hydration stabilizers would be affected by extending their transit time from 60 to 90 minutes, with a potential for additional testing up to a 120-minute delivery time.

What Did We Do?

Researchers began by batching 23 concrete mixtures using the same mix design with various kinds and combinations of cement, fly ash, water reducer, water-reducing retarder, hydration stabilizer and air-entraining admixtures. Then they conducted laboratory tests to evaluate the consistency and plastic air content of these mixtures directly after initial mixing and after 30, 60, 90 and 120 minutes.

The compressive strengths of concrete cast directly after initial mixing were then compared to concrete cast after waiting 120 minutes. Compressive strengths were determined for all mixes at one, seven and 28 days. Similarly, a portion of the concrete was used to cast a set of two 15-inch-long rectangular beams to compare the freeze-thaw durability of the samples cast directly after initial mixing to concrete cast after waiting 120 minutes. In addition, researchers compared the hardened air content of the mixes.

continued

"As MnDOT is planning reconstruction of many bridges in less accessible rural areas, extending the delivery time for concrete will potentially allow more flexibility for the contractor, making these and similar projects less costly."

–Maria Masten,
Concrete Engineer,
MnDOT Office of
Materials

"One unanticipated benefit of this project came from getting out into the field and communicating with ready-mix concrete suppliers to exchange ideas and resolve other issues."

–Dan Vruno,
Senior Engineer,
American Engineering
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Researchers measured workability using the slump test (left), in which an inverted cone-shaped mold is removed from soft concrete and the resulting slumping measured. They measured plastic air content by using a pressure gauge (right) to calculate the percentage of the soft mixture composed of air bubbles.

Researchers then batched four mix designs at a single ready-mix concrete control plant in the field, using laboratory results from the first 23 batches to refine the use of chemical additives. Researchers supervised the mixing process and then repeated tests from the laboratory phase of this project.

Researchers oversaw seven additional ready-mix plants located throughout Minnesota design and produce similar mixtures using locally available materials and repeated the same testing on these samples.

Finally, researchers conducted a statistical analysis of data from laboratory, control plant and regional testing to determine how the performances of concrete mixtures was affected both by their ingredients and by extending their delivery time from 60 to 120 minutes.

What Did We Learn?

Final field results showed that extending the delivery time of air-entrained concrete mixtures from the current 60 minutes to 120 would not significantly affect compressive strength or freeze-thaw durability, and researchers recommend updating MnDOT specifications to allow a longer delivery time. This adjusted specification, however, must offset expected losses in plastic air content and slump, as results showed small decreases in some concrete properties with the additional time.

What's Next?

In the final report, researchers recommend that suppliers be required to develop a quality control plan for plastic concrete testing to make sure mixtures meet MnDOT specifications prior to being placed on a project. This plan should include slump and air content testing at the concrete plant and delivery location, and a mix modification procedure at the delivery location if the concrete does not meet specification requirements after being transported.

This Technical Summary pertains to the LRRB-produced Report 2011-26, "Concrete Delivery Time Study," published November 2011. The full report can be accessed at http://www.lrrb.org/PDF/201126.pdf.