New performance-based concrete mix testing technologies lead to more durable and sustainable pavements.

RESEARCH SOLUTIONS

Increasing concrete durability with new test methods and specifications

Concrete pavement durability is a priority for state transportation agencies. Test methods typically ensure the strength of concrete mixtures, but durable, high-quality pavement depends on many other properties. A comprehensive pooled fund effort led by Iowa DOT implemented new performance-engineered mixture (PEM) methods for concrete testing that resulted in improved specifications for sustainable pavement in Iowa and other states.

THE NEED

Transportation agencies, including Iowa DOT, are always looking to improve the performance and sustainability of concrete pavement. Traditional methods of evaluating concrete mixes rely on measures such as strength and air content. Concrete strength remains crucial for pavement quality, but durability and sustainability are also dependent on environmental conditions, traffic loading, and other external factors.

Recently developed testing technologies can measure characteristics of a concrete mix that directly relate to long-term pavement performance. Rather than specifying materials or mixing methods, performance-based specifications identify desired concrete pavement function over its life cycle.

Agencies needed methods to understand concrete mix properties that are predictive of pavement sustainability. Iowa DOT led a pooled fund effort to disseminate and deploy new testing technologies and support states in adopting concrete pavement specifications suitable for their road construction and maintenance needs.

RESEARCH APPROACH

During a five-year, multifaceted project, Iowa DOT and other pooled fund states implemented PEM for durable concrete pavement.

(continued)

"We now have a better handle on concrete mix test methods — before the concrete gets to the field — to ensure durable performance while reducing cement content."

— **TODD HANSON,**
Iowa DOT PCC Materials Engineer

Researchers facilitated training and project-level assistance through workshops, webinars, and guidance documents. Educational components focused on the benefits of the PEM method, tests used, and setting appropriate specification limits.

Iowa DOT and six other states received incentive funding from the Federal Highway Administration to field-test new PEM tests, including the Vibrating Kelly Ball (VKelly), super air meter, and box test. Data was collected on properties such as shrinkage, freeze-thaw resistance, and workability. State transportation agencies also shared feedback on PEM implementation with industry representatives.

WHAT IOWA LEARNED

While concrete specifications vary among transportation agencies, Iowa DOT and other pooled fund states successfully implemented PEM through multiple project activities, including coordination and communication among states and industry, training for and practicing new test methods, and contractor support and use of PEM tools. Contractors for Iowa DOT's first pilot project, in fact, have continued to use the PEM approach in several projects.

Field testing results and feedback from pooled fund states prompted researchers to propose refinements to test methods, including measuring the moisture content of fresh concrete and conducting thermodynamic modeling to predict performance and indicate carbon footprint and pavement sustainability. Additionally, manufacturers improved the energy efficiency and ease of use of the VKelly machine.

The National Concrete Pavement Technology Center's PEM website, which is hosted by project researchers at Iowa State University's Institute for Transportation, compiles all project information, including:

- An interactive map of pilot project locations and project reports.
- Instructional videos and summaries on test methods.
- A database of PEM test results from pilot projects and other pavement core sampling.
- Newsletters, resources, and other project reports.

Finally, the project produced the AASHTO Standard Practice for Developing Performance Engineered Concrete Pavement Mixtures (R 101), which provides test methods for PEM properties relating to strength, shrinkage, freeze-thaw durability, transport, aggregate stability, and workability.

PUTTING IT TO WORK

PEM resulted in improved, more sustainable concrete mixes with reduced cement content. Iowa DOT and 19 other pooled fund states have either modified concrete mix specifications or are considering doing so. Iowa DOT will continue to incorporate PEM mix design and testing into paving projects and will explore its use in large bridge structures.

Iowa DOT is also leading the next related pooled fund effort on construction techniques: Performance Centered Concrete Construction. A focus on actions including concrete mixture transport, handling, vibration, curing, and cutting will support Iowa DOT and other states in selecting effective performance-based specifications for pavements and overlays to function sustainably over their design life cycles.

ABOUT THIS PROJECT

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Final Report | Technical Brief

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PROJECT CHAMPION:
Todd Hanson, P.E.
PCC Materials Engineer
Iowa DOT
todd.hanson@iowadot.us
515-239-1933

PROJECT MANAGER:
Khyle Clute, P.E.
SPR Research and Pooled Fund Programs Manager
Iowa DOT
khyle.clute@iowadot.us
515-239-1646

PRINCIPAL INVESTIGATOR:
Peter Taylor
Iowa State University
ptaylor@iastate.edu

IOWA DOT RESEARCH:
iowadot.gov/research
ideas.iowadot.gov