Hybrid Concrete for Advancing Pavement Performance

tech transfer summary

A newly developed hybrid concrete made with asphalt (flexible) pervious concrete and filled with Portland cement (rigid) mortar shows promising signs of reducing rutting in wheel paths, among other benefits.

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RESEARCH PROJECT TITLE
Hybrid Concrete for Advancing Pavement Performance

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The Midwest Transportation Center (MTC) is a regional University Transportation Center (UTC). Iowa State University, through its Institute for Transportation (InTrans), is the MTC lead institution.

MTC's research focus area is State of Good Repair, a key program under the 2012 federal transportation bill, the Moving Ahead for Progress in the 21st Century Act (MAP-21). MTC research focuses on data-driven performance measures of transportation infrastructure, traffic safety, and project construction.

Goals and Objectives

The goals of this project were to explore the advantages, challenges, and feasibility of using a hybrid, semi-flexible, semi-rigid concrete for highway pavements, bridge decks, and overlays. Specifically, the objectives were as follows:

- Develop a hybrid concrete, a casting cement asphalt mixture (CCAM), using raw materials sourced locally in Iowa
- Evaluate key engineering properties, including rutting, shrinking, and freeze-thaw resistance, for the hybrid concrete in Iowa's environment and for its transportation needs
- Provide insights and recommendations to develop guidelines for applying the CCAM in practice

Problem Statement

Although this hybrid concrete has been adopted in warmer climates in Europe and Asia, its uses in the US have not been well understood or studied.

Background

CCAMs were first designed in the 1950s to protect the surface course from oils and fuels. It has been used since that time throughout Europe and Asia, and the asphalt mixture has performed well in withstanding stress induced from heavy traffic loads and sudden braking. In particular, research has demonstrated that CCAMs can significantly improve rutting resistance on flexible pavements.

While the asphalt mixture has worked well on pavements in warmer climates, methods utilizing grouting materials are currently being developed to improve its low-temperature performance and moisture susceptibility.

IOWA STATE UNIVERSITY
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Project Description

To develop a CCAM using Iowa materials, the research team performed the following tasks:

1. Collected and characterized the general properties of local coarse and fine aggregates, asphalt, cement, and admixtures

2. Designed an asphalt pervious concrete with porosity levels of 25 percent, and examined its basic properties, such as density, air void, draindown, and Cantabro abrasion

3. Designed a highly flowable Portland cement grout with high stability based on the concept of self-consolidating concrete, and tested its fluidity and strength

4. Achieved the optimal mix proportions for a porous asphalt mixture and cement-based grout using the local Iowa raw materials

Furthermore, the research team evaluated the key engineering properties and microstructure of the CCAM, which included conducting tests on compressive strength, shrinkage behaviors, and freeze-thaw durability.

Key Findings

- CCAMs can be successfully produced with a pervious concrete of 25 percent porosity and a highly flowable, rapid set cement grout

- The CCAM is strengthened with the addition of grouting material, particularly calcium sulphoaluminate cement grouting, as well as by utilizing a combination of fly ash and silica fume

- A high modulus grouting material can make a CCAM less susceptible to rutting

Implementation Readiness and Benefits

The hybrid concrete mixture has potential benefits not seen in traditional counterparts, including opening to traffic sooner than on a conventional cement concrete pavement, and a longer service life, a higher resilient modulus, and better rutting performance than traditional asphalt mixtures. This hybrid concrete uses Iowa materials and shows promising signs of reducing rutting in wheel paths, among other benefits.

While the research team successfully developed a CCAM that is designed for use on Iowa roadways and other cooler climate environments, further study is needed on its key properties, particularly freeze-thaw durability, before it can be applied to Iowa pavements.

Recommendations for Future Research

Because the CCAM was newly developed for Iowa roadways, more research is needed to understand its properties, particularly its freeze-thaw durability. The research team used ASTM C666-B for this test, but new test methods may be needed.

The grouting materials used contained a large portion of fine particles, which made proper air entrainment and a stable air system in the grout pastes very challenging. As a part of the freeze-thaw durability study, development of another technology to introduce a proper air system in the grout of the CCAM is also necessary.

Further research is also needed to prevent segregation and water bleeding, which in turn could adversely affect the formation of the microstructure and compressive strength due to overuse of superplasticizer to improve flowability.