National Concrete Pavement Technology Center

Material Thermal Inputs of Iowa Materials for MEPDG

tech transfer summary

The thermal properties of Iowa concrete materials must be tested to help implement the MEPDG in Iowa effectively.

OBJECTIVES

- Investigate the thermal properties of Iowa pavement concrete and study the effects of Iowa aggregates on those thermal properties
- Help implement the Mechanistic-Empirical Pavement Design Guide (MEPDG) effectively in Iowa

PROBLEM STATEMENT

The thermal properties of concrete materials, such as coefficient of thermal expansion (CTE), thermal conductivity, and heat capacity, are required by the MEPDG program as the material inputs for pavement design. However, a limited amount of test data is available on the thermal properties of concrete in Iowa. The default values provided by the MEPDG program may not be suitable for Iowa concrete, since aggregate characteristics have significant influence on concrete thermal properties.

LABORATORY INVESTIGATION

The CTE and thermal conductivity of Iowa concrete samples were investigated in the laboratory. CTE tests were conducted at the Iowa Department of Transportation (Iowa DOT) and Iowa State University using 28 portland cement concrete (PCC) samples made with limestone, quartzite, and dolomite in various mix proportions. Thermal conductivity values for typical Iowa concrete mix samples were measured according to ASTM C177-04 at Concrete Technology Laboratory (CTL) in Skokie, Illinois. Typical mixes of Iowa asphalt cement concrete (ACC) with limestone as coarse aggregate were also tested for thermal conductivity.

Test setup for measuring coefficient of thermal expansion

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RESEARCH PROJECT TITLE
Task 6: Material Thermal Input for Iowa Materials

SPONSOR
Iowa Department of Transportation

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The mission of the National Concrete Pavement Technology Center is to unite key transportation stakeholders around the central goal of advancing concrete pavement technology through research, tech transfer, and technology implementation.

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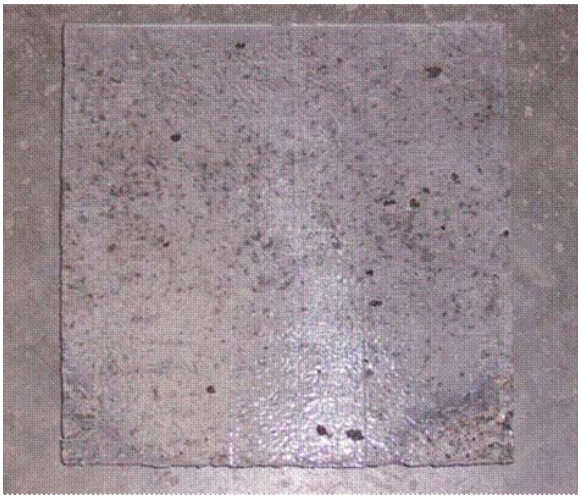
KEY FINDINGS AND RECOMMENDATIONS

- A literature review indicated that the thermal properties of concrete vary largely. The most significant factors that contribute to this variability include concrete materials (especially aggregate), mix proportion, moisture condition, and age.
- The average CTE values for concrete made with limestone, dolomite, and quartzite were 10.25x10^{-6}/°C (5.69 x10^{-6}/°F), 12.03x10^{-6}/°C (6.68x10^{-6}/°F), and 12.35 x10^{-6}/°C (6.86 x10^{-6}/°F), respectively.
- In the MEPDG, the default CTE value for PCC is 9.9x10^{-6}/°C (5.5 x10^{-6}/°F). This value is close to that of Iowa concrete made with limestone. Different values should be used in the MEPDG for concrete made with aggregate other than limestone.
- The thermal conductivity values were reported to be 9.25 Btu•in/hr•ft^2•°F for PCC and 14.5 Btu•in/hr•ft^2•°F for ACC. Both values were significantly different than the default inputs in the MEPDG, 15 Btu•in/hr•ft^2•°F for PCC and 8.04 Btu•in/hr•ft^2•°F for ACC. These differences may be caused by the different testing methods used.

IMPLEMENTATION READINESS

- This study tested and analyzed a small number of samples. A larger study of the effects of mix design and aggregate type on thermal properties is necessary, especially for CTE, thermal conductivity, and specific heat.
- A larger study would help update the typical Iowa material input values for the MEPDG and would provide rational predictions using the MEPDG for concrete pavement design.
- Some of the factors that contribute to the variability of concrete thermal properties have already been considered in many concrete CTE prediction equations. However, the prediction equations were not more comprehensively calibrated due to the lack of a complete set of CTE data for Iowa concrete.
- The test method for pavement concrete thermal conductivity recommended by the MEPDG may need to be further evaluated and modified.

Mold for PCC thermal conductivity samples


PCC thermal conductivity test sample


Test setup for thermal conductivity