



## Tech Brief

### Examination of Curing Criteria for Cold In-place Recycling

(Phase 3: Calibration of Moisture Loss Indices and Development of Stiffness Gain Model)

December 2011

#### RESEARCH PROJECT TITLE:

Examination of Curing Criteria for Cold In-place Recycling (Phase 3: Calibration of Moisture Loss Indices and Development of Stiffness Gain Model)

#### SPONSOR:

Iowa Highway Research Board (TR-609)

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## Objectives

The main objectives of the study are to: 1) measure the moisture contents and temperature throughout a CIR layer from six CIR project sites, 2) calibrate the developed moisture loss indices using the field measurement from six CIR project sites, and 3) develop stiffness/density gain model to supplement (or possibly replace) the moisture criteria.

## Problem Statement

The previous research performed laboratory experiments to measure the impacts of the curing on the indirect tensile strength of both CIR-foam and CIR-emulsion mixtures. However, a fundamental question was raised during the previous research regarding a relationship between field moisture content measured using a nuclear gauge and the laboratory moisture content in gyratory compacted specimens. Therefore, it is critical to measure moisture and temperature at different depths of the CIR layer in the field, which can be related to the laboratory test results.

## Research

To develop moisture loss indices, the moisture contents and temperatures of CIR layers were monitored from seven project sites. The moisture content was measured by embedding capacitance moisture sensors at two inches below the surface and compared against the moisture content measured by a nuclear gauge. Moisture loss indices were developed based on the initial moisture content and temperature of the CIR layer. In addition, the in-situ stiffness was measured using a geo-gauge during the curing time. The stiffness changes during the curing time were also examined.

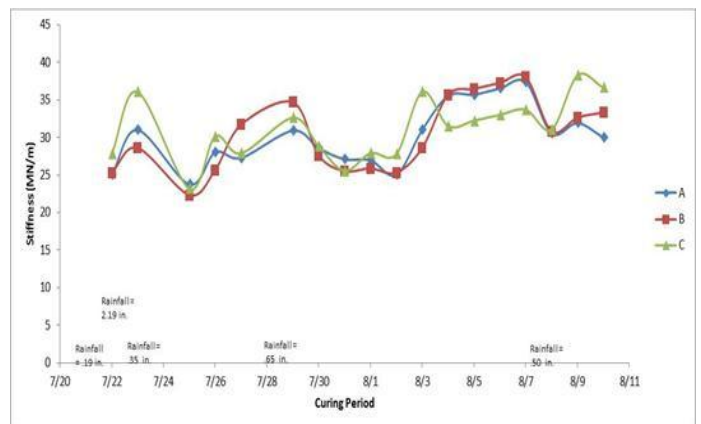
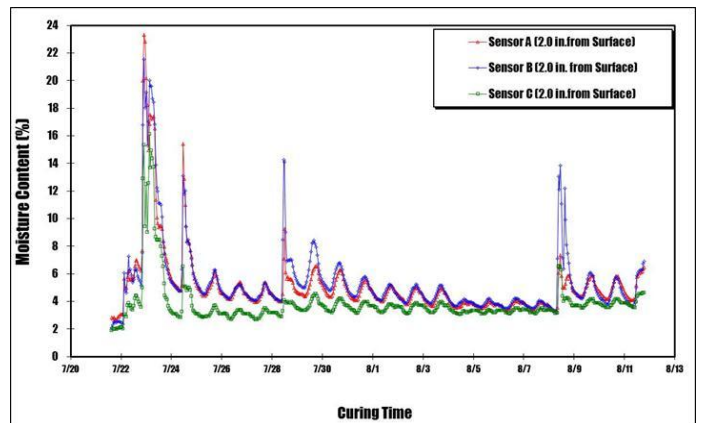
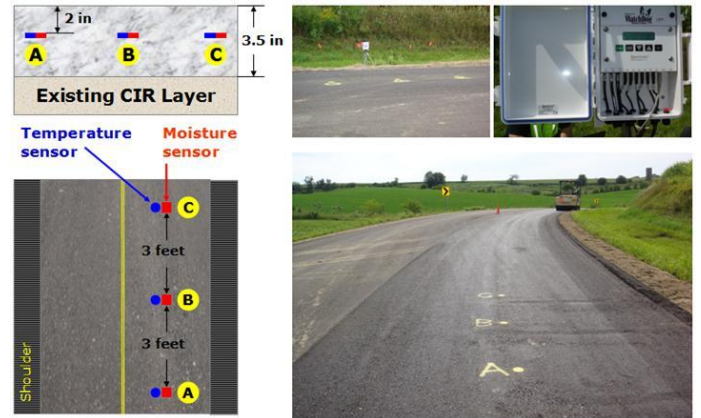
## Benefits

Use of moisture loss indices in conjunction with the stiffness of CIR layer measured using geo-gauge will help pavement engineers determine an optimum timing of an HMA overlay without continually measuring moisture conditions in the field using a nuclear gauge. This will increase the life of CIR pavements.

# Key Findings

The following conclusions are derived:

1. In some cases the in-situ stiffness remained constant and, in other cases, despite rainfalls, stiffness of the CIR layers steadily increased during the curing period.
2. The stiffness was affected by a significant amount of rainfall. The stiffness would decrease for around 1-2 days after the rainfall before beginning to increase again.
3. The moisture indices can be used for predicting moisture level in a typical CIR layer. The initial moisture content and temperature were the most significant factors in predicting the future moisture content in the CIR layer.
4. The stiffness of a CIR layer is an extremely useful tool for contractors to use for timing their HMA overlay.
5. To determine the optimum timing of an HMA overlay, it is recommended that the moisture loss index should be used in conjunction with the stiffness of the CIR layer.



# Recommended Refinements through Additional Research

The long-term performance of the CIR pavement sections should be monitored if the performance would be affected by the moisture condition when the overlay was applied. To better understand the curing process of CIR-emulsion, more CIR-emulsion sites should be monitored. A more in-depth study should be performed to determine if there is a direct correlation between stiffness and moisture content of the CIR layer. The influence of temperature on the stiffness gain should be also investigated. A step by step implementation guideline of using the moisture loss index in conjunction with the stiffness of the CIR layer should be developed.



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