Project Summary

Texas Department of Transportation

0-5106: Evaluation of Curing Membranes Effectiveness to Reduce Evaporation

Background

Hydraulic cement requires adequate moisture and temperature to develop cement hydration for a sufficient period of time. If moisture content in concrete is not sufficient or temperature is too low, hydration will not proceed and the concrete may not have the desired strength and durability. Proper curing of concrete is crucial to obtain design strength and maximum durability, especially for concrete exposed to extreme environmental conditions at an early age. The Texas Department of Transportation (TxDOT) has recently experienced cases of spalling and delamination failure that may be related to a high rate of evaporation under extreme field conditions, such as high temperature, low humidity, and strong wind.

It is not easy to evaluate whether the current requirements in curing (quality and application rate of curing compounds, and the timing of their application) are met in the field. In most projects, the importance of curing has not been recognized and strictly enforced. This problem is partly due to a lack of any compliance testing for the evaluation of curing effectiveness. For this reason, TxDOT requested that the researchers identify a simple test procedure that can evaluate the effectiveness of various curing compounds and eventually the compliance with the specification requirements.

What the Researchers Did

The primary objective of this research is to identify appropriate compliance testing for curing effectiveness. To this end, material parameters and devices that are relevant to the curing effectiveness were selected through a literature survey. An experimental program, which included the laboratory and field tests, was developed and conducted. Parameters, such as penetration resistance, initial surface absorption, surface temperature, reflectance, relative humidity (RH), and dielectric constant (DC) were investigated. Different applications of curing compound, including the application rate and time, were simulated during the testing. Based on the measured data, material parameters were tested to identify the appropriate compliance testing method for curing effectiveness, and its limitations were discussed in this research.

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What They Found

Since the Windsor probe system is relatively small, the penetration depth is significantly affected by the aggregate. The effect of aggregate may be more than strength under different curing conditions. Additionally, an inconsistency of measurement would occur if the probe doesn't penetrate perpendicularly to the surface of concrete pavement.

Measuring surface temperature may detect the difference of evaporation heat which is caused by different curing effectiveness. However, surface temperature also changes depending on the various weather conditions. It may not be objective to express the surface temperature in terms of curing effectiveness.

The test on initial surface absorption is not simple and easy to implement due to the difficulty in sealing the interface between the instrument and concrete surface.

Reflectance has potential for the field compliance testing to identify the application rate of curing compound. However, it requires a lot of technical improvements to make this approach feasible in the field.

The technology on the internal RH of early age concrete is still being developed and various types of humidity sensors have been tried. In order to obtain the accurate RH in fresh concrete, there are still a lot of improvements to be made. Measurement of RH may not be a practical field compliance testing method for curing effectiveness.

What This Means

Even though various material parameters were tested to identify appropriate compliance testing for curing effectiveness, each had their own limitation for the application. It is considered that the investigation of material properties may not be a simple and easy-to-use compliance testing procedure for curing effectiveness. Therefore, a more practical approach is necessary to improve the current curing operation.

One practical issue in the curing operation is to ensure that a sufficient amount of curing compound is applied uniformly. Currently, there are no good compliance tests available that enable TxDOT to accurately estimate the application rate of a curing compound and its uniformity. It is difficult to keep track of how much curing compound is applied. The rate of curing compound and its uniformity mainly depend on cart speed, pump pressure, nozzle spacing, and degree of nozzle damage. Retrofit of a curing machine with hardware for speed and pressure measurements may improve the current curing operation and eventually the curing effectiveness in concrete pavement.

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