PUTTING RESEARCH TO WORK

BRIEF

Evaluation of Curing Compound Application Time on Concrete Surface Durability

Roadways that are both durable and aesthetically pleasing are primary goals of Wisconsin Department of Transportation (WisDOT) paving projects. Recently, Portland Cement Concrete (PCC) pavement projects constructed by WisDOT have experienced increased amounts of scaling within the first two years of service life. Scaling is a form of surface damage that can lead to decreases in the aesthetic appeal, functionality and service life of a PCC pavement. Scaled pavements typically demonstrate symptoms including surface roughness, exposed aggregates, collection of loose scaled material on the surface and discontinuities in both the outward appearance and level of the top layer of the pavement. Membrane-forming curing compounds (MFCCs) are used in paving applications to properly ensure that the mix water within the mortar that comprises the top ¼ to ½ inch of the concrete pavement surface does not prematurely evaporate and inhibit hydration. However, pavement projects using any one of several different WisDOT-approved curing compounds still experienced scaling within a few years of construction.

What is the Problem?

In addition to increased concrete pavement scaling, instructions on most curing compounds indicate that application to the concrete surface should occur following final finishing efforts and after bleeding has ceased. Despite this common instruction, factors such as ambient relative humidity, ambient temperature, wind speed, solar radiation, total mix water, admixtures and supplementary cementitious materials can make it difficult to know when the bleeding process has finished. Elevated evaporation rates can lead to application prior to cessation of bleeding. Whereas depressed rates of evaporation due to high humidity can delay application due to the continued presence of water, despite bleeding cessation.

Objectives

The objectives of this study were to determine:

1. The impact of the application time of curing compounds on the scaling resistance of concrete.
2. The repeatability of curing compound performance.
3. A process that quickly and reliably identifies the optimal time for curing compound application based upon the extent of the bleeding process.

Decision Matrix for Curing Compound Providing the Earliest Application Time Likely to Provide Highest Levels of Durability

		Compounds Used				Preferred Compound/Time	Alternative Compound/Time
Aggregate	**Cement Type**	**Linseed Oil**	**Wax**	**PAMS**	**Acrylic**		
Limestone	**OPC**	30 Minutes	30 Minutes	30 Minutes	30 Minutes	PAMS at 30 Minutes	Acrylic at 30 Minutes
	30% Slag	2 Hours	4 Hours	30 Minutes	30 Minutes	Wax at 4 Hours	Linseed Oil at 2 Hours
	30% Fly Ash	4 Hours	4 Hours	30 Minutes	4 Hours	Acrylic at 4 Hours	PAMS at 30 Minutes
Gravel	**OPC**	2 Hours	30 Minutes	30 Minutes	4 Hours	Acrylic at 4 Hours	Wax at 30 Minutes
	30% Slag	2 Hours	30 Minutes	30 Minutes	4 Hours	Acrylic at 4 Hours	Linseed Oil at 2 Hours
	30% Fly Ash	4 Hours	30 Minutes	30 Minutes	4 Hours	Acrylic at 4 Hours	PAMS at 30 Minutes

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Methodology

A partial factorial experiment was designed to probe the effect of MFCC application time on scaling damage as measured using ASTM C672. Three emulsion-based curing compounds, linseed oil, wax, and poly-alpha-methyl-styrene (PAMS) were evaluated at three application times (30 minutes, 2 hours and 4 hours after finishing) on concrete specimens prepared with one of two sources of coarse aggregate and one of three cementitious materials. An acrylic solvent-based sealing compound was evaluated with respect to concrete scaling resistance at two application times. Untreated specimens from each mix type were cured in a wet room and tested as controls. Concrete mixes were designed and specimens were prepared according to WisDOT procedures. Freeze-thaw testing was performed and data recorded. Properties such as fresh concrete slump, air content, 28-day compressive strength, and curing compound application rates were also measured.

Results

Results from this study indicate that the influence of MFCC application time on the scaling resistance of concrete is dependent upon the selected compound and the concrete mix. The linseed oil and acrylic formulations displayed improved scaling resistance with an increase in time to application. The PAMS formulation was generally equally effective regardless of time to application. Adding time to application with the wax-based compound did not consistently yield improved scaling resistance. Results from the untreated wet room cured specimens indicate that curing compounds do not replicate scaling resistance levels that are comparable to wet room curing. Scaling resistance was also influenced by the composition of the concrete, especially with respect to the coarse aggregate and cementitious material choice. Elevated levels of ambient relative humidity at the time of specimen manufacture appeared to decrease the scaling resistance, regardless of application time

Based on statistical analysis of the scaling amounts associated with each condition, the shortest successful curing compound applications times were determined for each mix. They are summarized in table on the previous page. The two curing compounds and application times with the greatest degree of scaling resistance were identified as preferred and alternative options. In general, the researchers observed that later application times, within the 30-minute to 4-hour window, resulted in higher levels of durability.

The first generation humidity detection device was found to be unreliable for monitoring the presence of bleed water. Analysis of the data collected by the device showed that future modifications could be made to improve its operational capability.

Recommendations

A single optimal time to apply curing compounds to concrete pavements does not exist. Concrete mixes, curing compound formulations and environmental conditions, at laboratory and field sites, all influence when it will be most effective to apply the curing compound from a scaling resistance perspective. Finding or developing a method that assesses the surface conditions of the concrete, particularly the presence of bleed water, is recommended. In this study, time was a pseudo indicator of the presence of bleed water on the surface and it turned out that even in the relatively controlled conditions of the laboratory, it was not a particularly good indicator. Alternatively, a more empirical approach that expands upon the decision matrix could be taken. The researchers recommend that the decision matrix expand the dimensions of variables considered to include environmental factors. in addition to times, mix characteristics and curing compound types.

WisDOT could possibly discontinue the use of linseed oil and explore later application of curing compounds.

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