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putting research to work

BRIEF

RESEARCH DEVELOPMENT & TECHNOLOGY TRANSFER

Aggregate Coatings Effects on Concrete Pavement

Wisconsin Department of Transportation specifications require coarse aggregates used in concrete mixes to be "clean" and "free of adherent coatings, which could be considered injurious." WisDOT limits to 1.5 percent by mass the fine materials – materials that pass a No. 200 sieve – in coarse aggregate.

What's the Problem?

Since at least the early 1980s, a perception has grown in Wisconsin that fine aggregate coatings can impede the finished strength and durability of concrete by weakening the aggregate-cement paste bond. Aggregate coatings have been cited as a potential factor in unusually stiff concrete mixtures, in cracking, and in low-strength concrete at sites around the state.

Of particular concern are clay fines that persist in aggregate even after washing. Clay coatings cling to aggregate through electrostatic bonds; if that bond proves weaker than that of cement paste to clay coating, weak zones may develop in the coating-aggregate interface, chinks in the cement-strength armor.

However, little hard data has been developed to support or refute this concern over the impact of aggregate coatings on concrete performance, and the efficacy of the common practice of washing aggregates to remove coatings is unknown.

Research Objectives

This study seeks to investigate the nature of aggregate coatings in Wisconsin and determine their effect on concrete strength and durability, following these objectives:

1. Determine the mineralogy of aggregate coatings found in this state.
2. Measure the effects of coatings on concrete strength and durability.
3. Evaluate the effectiveness of aggregate washing.
4. Identify test methods to monitor aggregate cleanliness.

The specific hypothesis put to task was that WisDOT specifications should distinguish between clay and non-clay coatings, regulating the content of clay coatings more rigorously than that of stone dust or carbonate material.

Research Methodology

Investigators approached the research in the following steps:

- Literature search.
- Survey of 19 district supervisors, engineers and contractors to identify aggregate sources with susceptible coating characteristics.
- Gather and examine the mineralogy of aggregate from 10 sources around the state.
- Select three representative sources from this group for making concrete samples from washed and unwashed aggregates.
- Test finished concrete for compressive strength, tensile strength, drying shrinkage, freeze-thaw durability, rapid chloride-ion permeability, air void, and bond quality and micro-cracking via petrographic examination.

The published report grouped these into three phases. Phase I, literature survey and determination of mineralogy tests; Phase II, aggregate coating mineralogy examinations; Phase III, concrete sample examinations.

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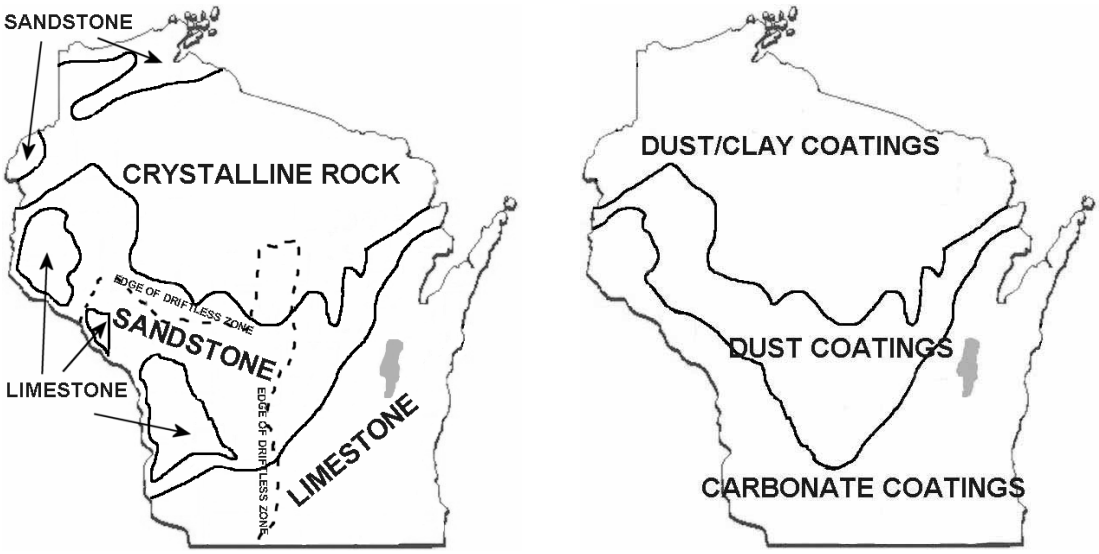
The minerology of aggregate coatings is thought to be closely related to the types of aggregate found in different parts of Wisconsin, as shown in the two maps (Figure 5, p.19).



"This study showed that clay aggregate coatings can have a negative impact on concrete strength and durability. A new study for 2003-2005 will establish a database of statewide coatings information and help us select tests and limits to prevent the problem in the future."

- David Larson, Technology Advancement Supervisor, WisDOT Pavements Section

Research Results

Specific findings with regard to objectives include:

1. The mineralogy of coatings carries regional propensities. Dust/clay coatings, a byproduct of igneous rock deposits, were more common in the north of the state; dust coatings were the norm in central Wisconsin, and carbonate coatings in the south.
2. Aggregate coatings from dust and carbonate had little negative impact on concrete performance, but were able at times to offset the negative impact of clay coatings.
3. Washing of aggregate in limited lab tests showed little efficacy.
4. WisDOT's current standard for testing aggregate cleanliness was less effective than the California Cleanness Test.

Investigators concluded that most aggregate coatings in Wisconsin are innocuous. While aggregate coatings provided no evidence of disruption of the aggregate-cement paste bond, clay coatings showed tendencies near the p200 threshold of 1.5 percent to concentrate air voids around coarse aggregate particles, disrupting the air void system. Clay coatings also significantly impact workability and require field additions of water with potential to weaken concrete performance. Furthermore, clay coatings at similarly high levels increased drying shrinkage by around 65 percent and also produced noticeable differences in slump and durability.

Hence, researchers concluded mineralogy of coatings to be a more significant factor in concrete performance than quantity of the fine materials. The team determined that the California Cleanness Test offers a more promising measure of mineralogy and quantity than the WisDOT standard, p200, which can assess quantity but not quality.

Implementation and Further Research

This project supports a reconsideration of the current WisDOT standard for testing aggregate coating mass, the p200 test. Because certain types of coatings have more impact on concrete performance than other types, the mineralogy of the fines should be considered more important to performance than quantity alone.

However, this project employed only small sample sizes, and more research will be necessary before implementing the suggestion of instituting the California Cleanness Test as a new aggregate coating measuring standard. A follow-up study, "Expanded Study on the Effects of Aggregate Coatings and Films on Concrete Performance," will consider a broader range of aggregate sources in the state.

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Effects of Aggregate Coatings and Films on Concrete Performance

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