Deicer Scaling Resistance of Concrete Pavements, Bridge Decks, and Other Structures Containing Slag Cement

Pooled Fund Project TPF-5(100)

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Overview

- Describe the purpose and goals of the project
- Summarize the field sites and the test results obtained from cores extracted from those sites
- Suggestions for Phase 2

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Thanks to the Participants !

- Pool States Include: Iowa (lead), Connecticut, New York, Ohio and Kansas
- Additional States Include: Delaware and Michigan

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Background

- Concrete containing slag cement tends to have good to excellent field performance
- ASTM C 672 test results suggest that concrete mixtures containing slag cement are prone to scaling especially at replacement levels >35-50%
- The purpose of this research project is to study why this anomalous relationship exists between field concrete and laboratory test methods

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Caveat

- There are a lot of pavements and bridges made with slag cement that are in excellent condition.
- In this study, we focused on sites where some damage was observed so this is not representative of the vast majority of concrete.

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Background (continued)

- Pooled fund approach utilizing two phases
  - **Phase 1** - Field study that concentrates on existing concrete containing slag cement
  - **Phase 2** - Lab study that concentrates on scaling test methods

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Summary of Phase 1 Sites

- Inspected about 28 potential sites in six different states (IA, NY, MI, DE, KS and CT). Many sites contained fly ash as well as slag
- Cores were received from all but one of the requested sites (final tally = 6 bridge decks and 6 pavements)
- Three sub-sites were also selected for coring (all pavements) – this was done to provide precision information

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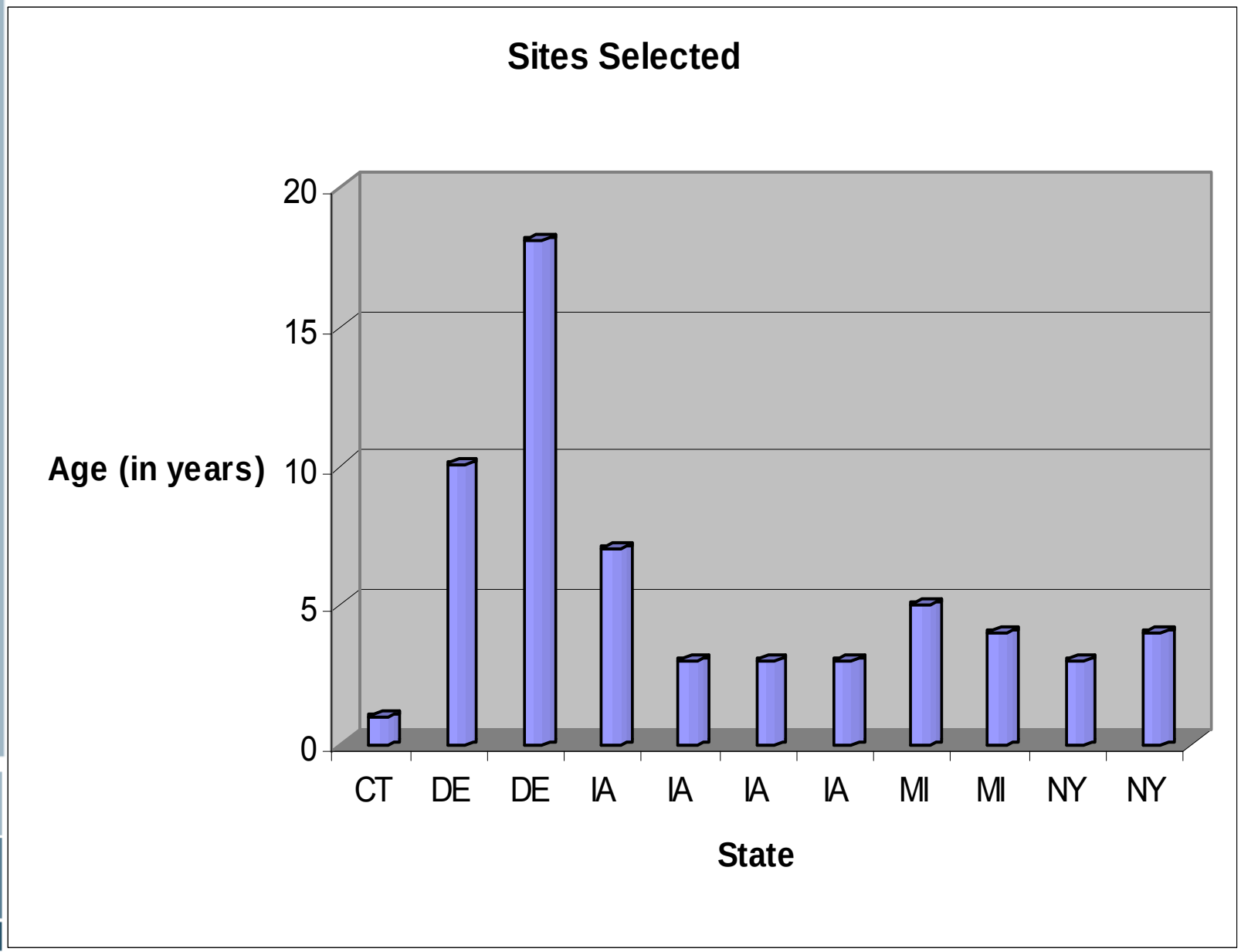
Sites Selected
Age (in years)
20
15
10
5
0
CT
DE
DE
IA
IA
IA
IA
MI
MI
NY
NY
State

Summary of Phase 1 Site Details

- Slag content varied from 20% to 50%, but was most commonly used at about 30 to 35% replacement
- Ternary mixtures with fly ash and silica fume were most common – only five sites contained binary mixtures of slag and portland cement
- Construction dates ranged from 1990 to 2005 (age from about 2 to 17 yrs)

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Condition of field sites

- The majority of the sites looked good to excellent – all were in service
- Scaling was noted on four of the six bridge decks and one of the six pavement sites that were cored
- Scaling was not observed on any of the sub-sites (all pavements) that were cored

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Extent of Scaling

- On site 3 the scaling traversed the gutter on the deck
- On site 4 the scaling was only evident in the gutter- the driving lane and passing lanes looked excellent
- Site 5, the scaling was widespread
- On site 8 the scaling progressed across the pavement (10-20% of area)
- Sites 12 and 13 had limited scaling but showed signs of re-tempering.

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Site 2: NY, Taconic St. Parkway, SB

Scaling on shoulder but less on driving lanes.

Effect of Curing

- The curing compound projects appeared to have no problems with scaling.
- The wet-curing projects did not fare so well especially in late season construction where there was no drying period .

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Summary of Lab Tests

- Petrographic exams and water-cement ratio determinations
- Deicer depth profiling and rapid chloride permeability tests
- Scaling tests were conducted on cores extracted from specific sites – deicer depth profiling was repeated on the samples after the scaling tests

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Petrographic Exams

- Only one field site exhibited marginal air void parameters (spacing factor >0.008”, hardened air content ≤3.5%) – all of the other sites had good to very good air void systems
- Water-cement ratios ranged from 0.35 to 0.51 (bridge decks) and 0.38 to 0.50 (pavements)

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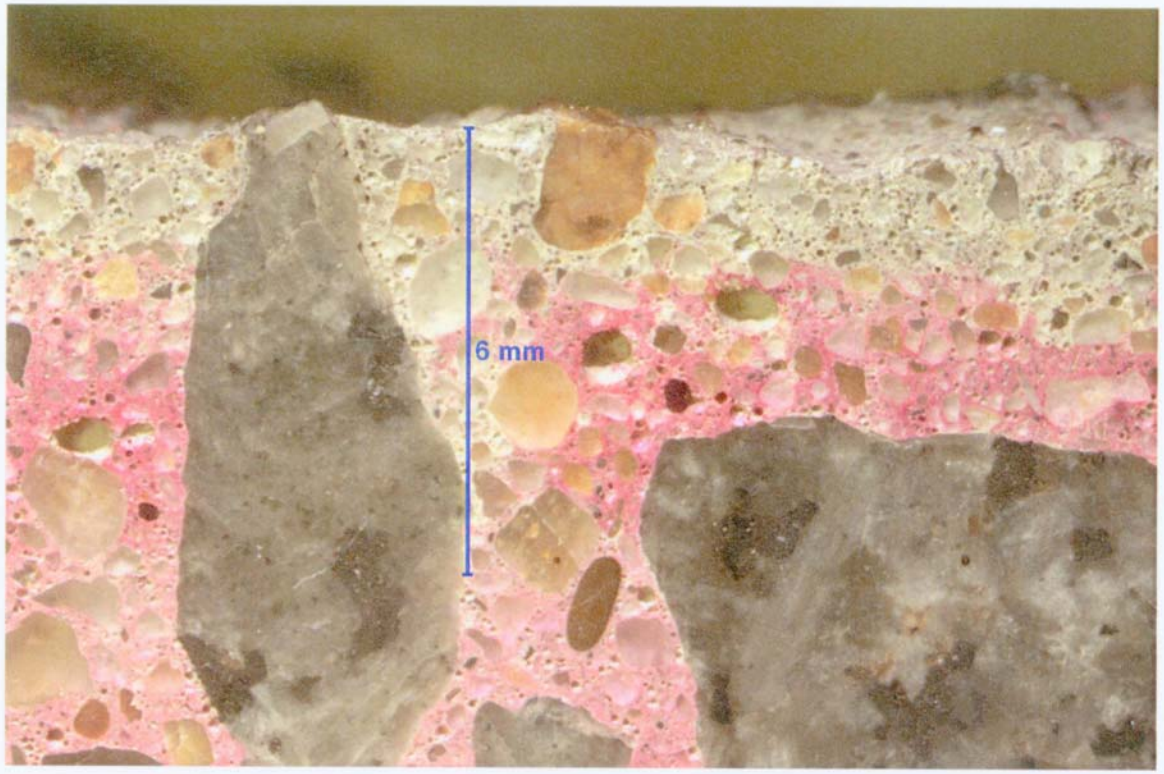
Depth of carbonation (2-year old concrete—worst case)



SAMPLE ID: N #7
MAG: 10x

DESCRIPTION: Carbonation (unstained) proceeds up to 6 mm (1/4") depth from the top surface along subvertical microcracking.

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Carbonation Depth - results

- Carbonation depth was not excessive on most of the cores (typically about 0 to 0.05” in most instances)
- Some of the sites that exhibited scaling did tend to have slightly deeper carbonation depths; however, this could be related to the scaling induced surface damage

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Construction Related Issues

- Several of the sites that exhibited scaling also contained petrographic evidence of construction-related issues such as:
  - Retempering or multi-stage batching
  - Petrographic water-cement ratio approximately 0.1 units higher than site batching documentation

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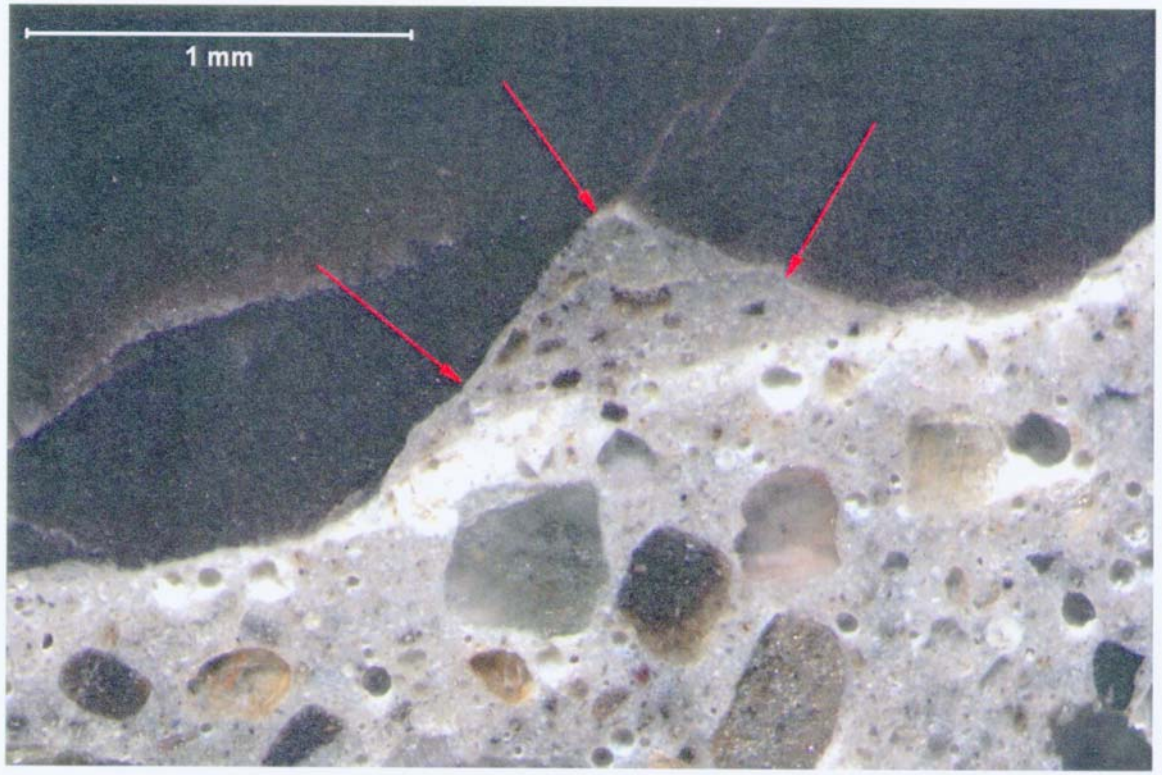
Example of retempering



SAMPLE ID: RT 378 4
MAG: 50x

DESCRIPTION: Darker colored, denser paste was observed in the notches of the carbonate coarse aggregate particles.

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Scaling Test Results

- Visual ratings tended to stay the same during the scaling tests (most ratings were 0 to 1) with one exception
- Mass loss values ranged from 0.0 to 0.7 lb/yd2 with one exception
- One site exhibited significant change in visual rating and mass loss (visual rating 2+, mass loss 1.95 lb/yd2)

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Chloride Profiling Test Results

- Indicated that the concrete was dense and nearly impenetrable
- Cl diffusion coefficients ranged from about 10E-12 to 10E-13 m2/s
- The scaling tests had little influence on the measured diffusion coefficients

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Rapid Cl Permeability Test Results

- Values ranged from a low of 590 to a high of 1580
- These values correspond to low or very low ratings as per ASTM C1202
- Slag content appeared to play a role in the observed test results (higher replacements gave lower values)

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Summary

- The purpose of this project is to evaluate if slag cement has a major impact on surface scaling of concrete pavements and bridge decks
- Phase 1 consisted of the evaluation of concrete from 13 field sites
- The large majority of the sites that were visited during this project exhibited good field performance - all of the sites were currently in service

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Summary (continued)

- Petrographic examinations plus RCP, Cl Profile and actual scaling tests indicated that the concrete cores extracted from the field sites generally tended to exhibit good to excellent performance
- Scaling most commonly appeared to be related to field construction issues (retempering, batch discrepancies, etc.) rather than simply slag content

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Suggestions for Phase 2

- Need to study scaling resistance of lab concrete mixtures containing 560 and 660 pcy of cement – this would cover nominal pavement and bridge deck mixtures
- Need to evaluate three different levels of slag replacement (e.g. 20%, 35% and 50%)
- Only a single source of coarse aggregate is needed
- A minimum of two different curing strategies need to be studied

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The lab.

versus the field

Alternative Lab Tests: eg. BNQ Scaling Test

- Like ASTM C 672 with the following differences:
- Finishing: wood float only
- Slab cast on filter fabric to allow drainage
- Salt solution ponded at 28d, but freezing only starts at 35d.

- Appears to better relate to field performance especially with slag and fly ash concretes

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Any Questions?