

Evaluation of ASR Potential of Aggregates in Presence of Deicing Chemicals

Revised EB70 Protocol



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Background

- Premature deterioration of concrete runways and taxiways was observed in some airports, ex: Colorado Springs Airport (COS)
- Alkali-Silica Reaction (ASR) in concrete was suspected.
- Distress was observed to be more pronounced in sections treated with deicers, ex: Cryotech E 36

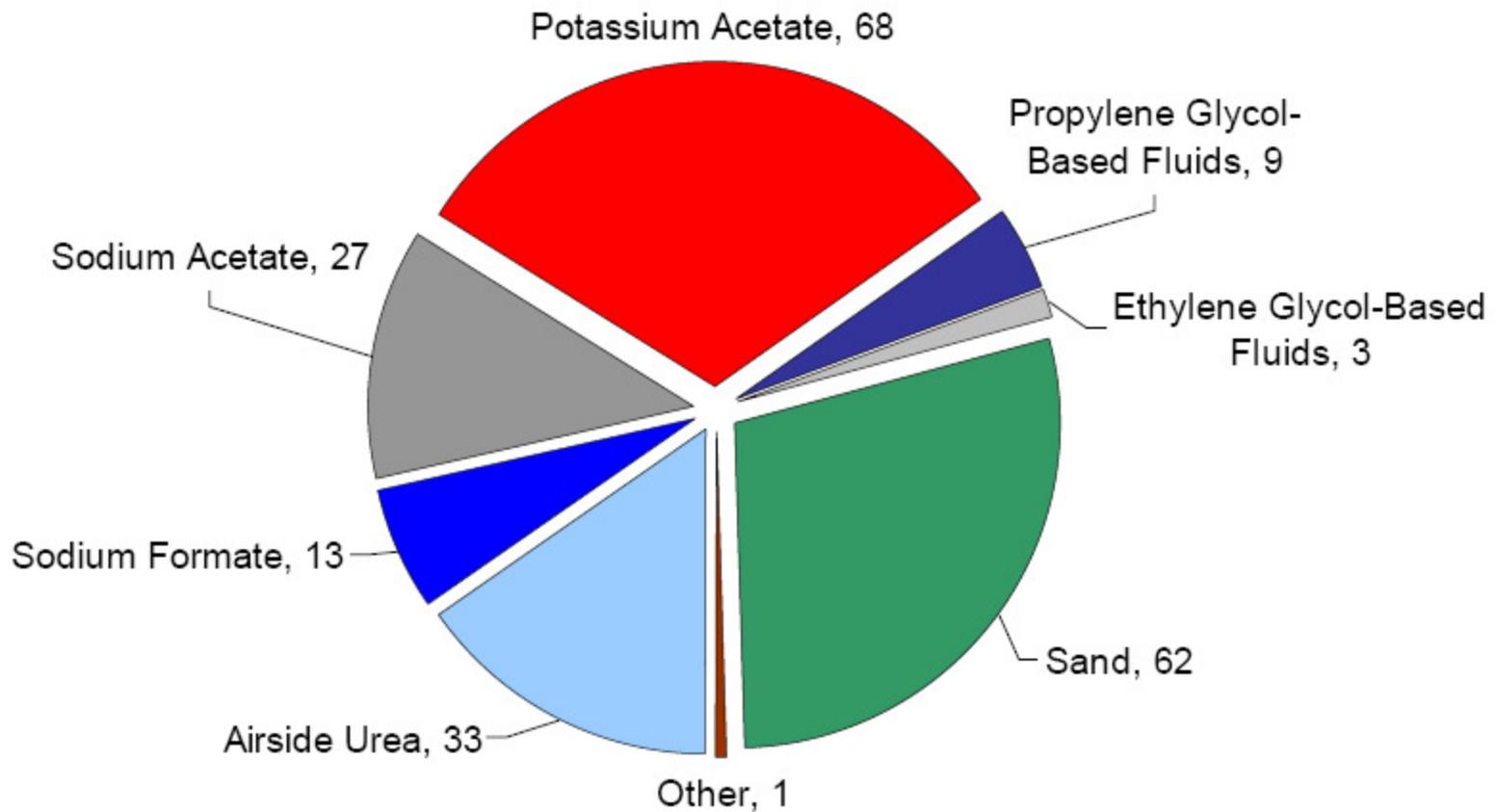
Impact of Deicers on Concrete Pavements

Colorado Springs Airport, Colorado



Deicer and Anti-Icer Usage on U.S. Airfield Pavements

(Survey of 95 Airports, 2004/5)



Source: ACRP Synthesis 11-03/Topic S10-03

Principal Findings from IPRF 03-8 and IPRF 04-9 Studies

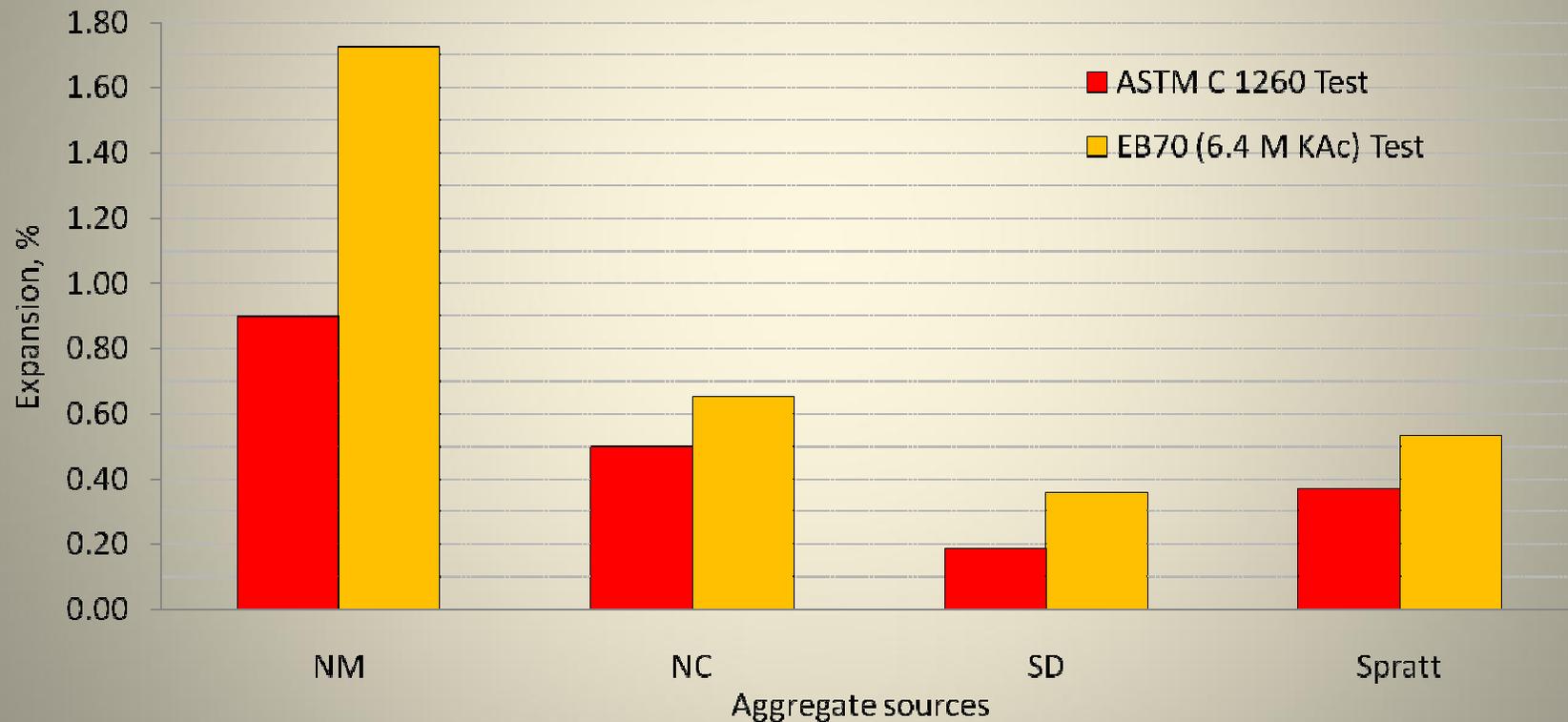
- Alkali-acetate and alkali-formate deicers have **significant** potential to cause ASR in concrete in lab studies.
- Traditional ASR mitigation measures such as **Class F fly ash** can successfully mitigate the ASR damage in the presence of deicing chemicals.

Genesis of EB-70 Protocol

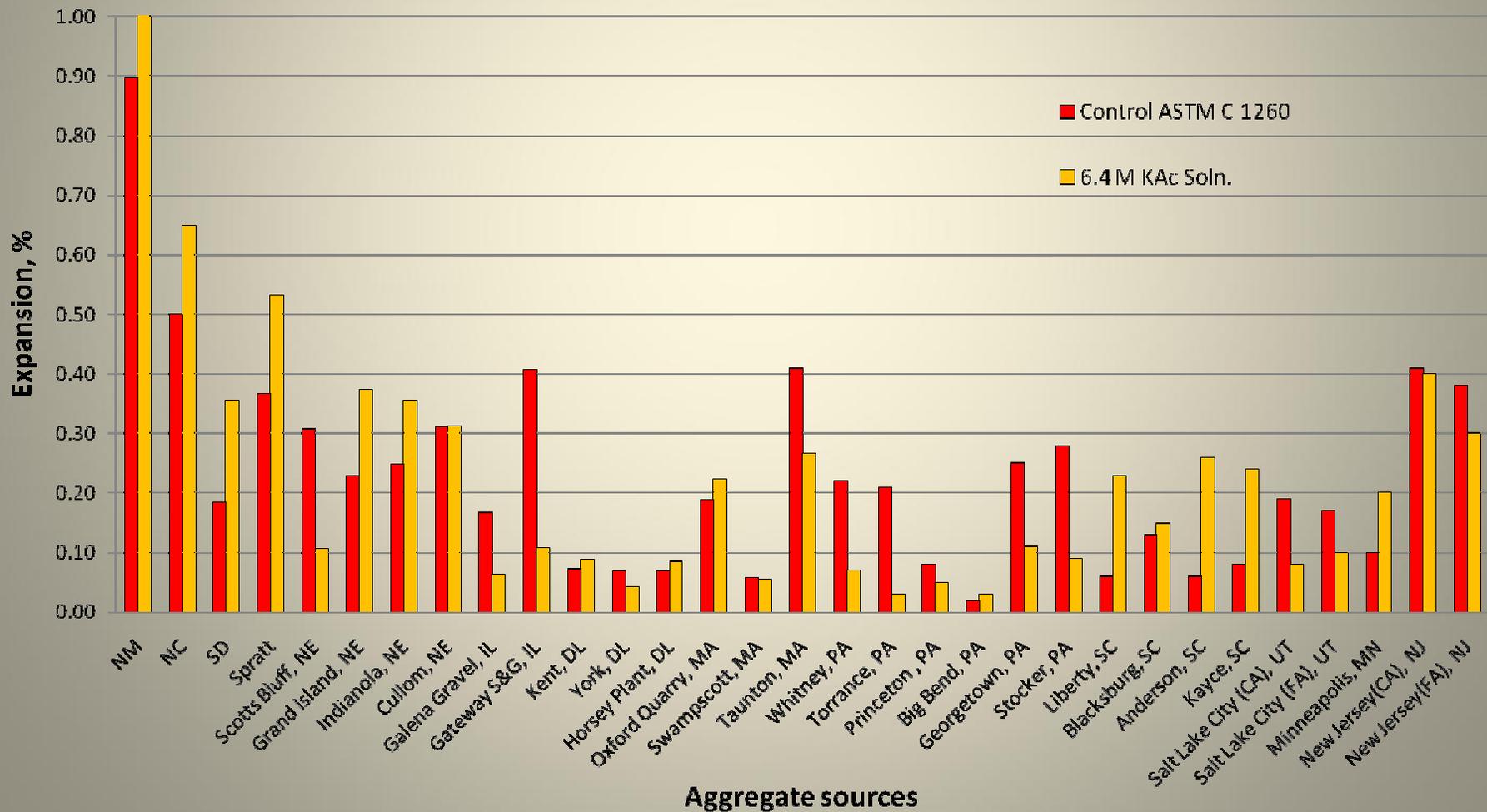
- Based on findings from IPRF 03-9 and 04-8 studies, a KAc deicer-based mortar bar test was proposed to screen aggregates that are sensitive to deicers.
- In 2005 the deicer-based test was adopted in FAA EB-70 as one of the two standard protocols to screen aggregates for ASR. The other standard protocol is ASTM C 1260 test.

Comparison of Mortar Bar Expansions ASTM C 1260 *versus* EB 70 Protocol

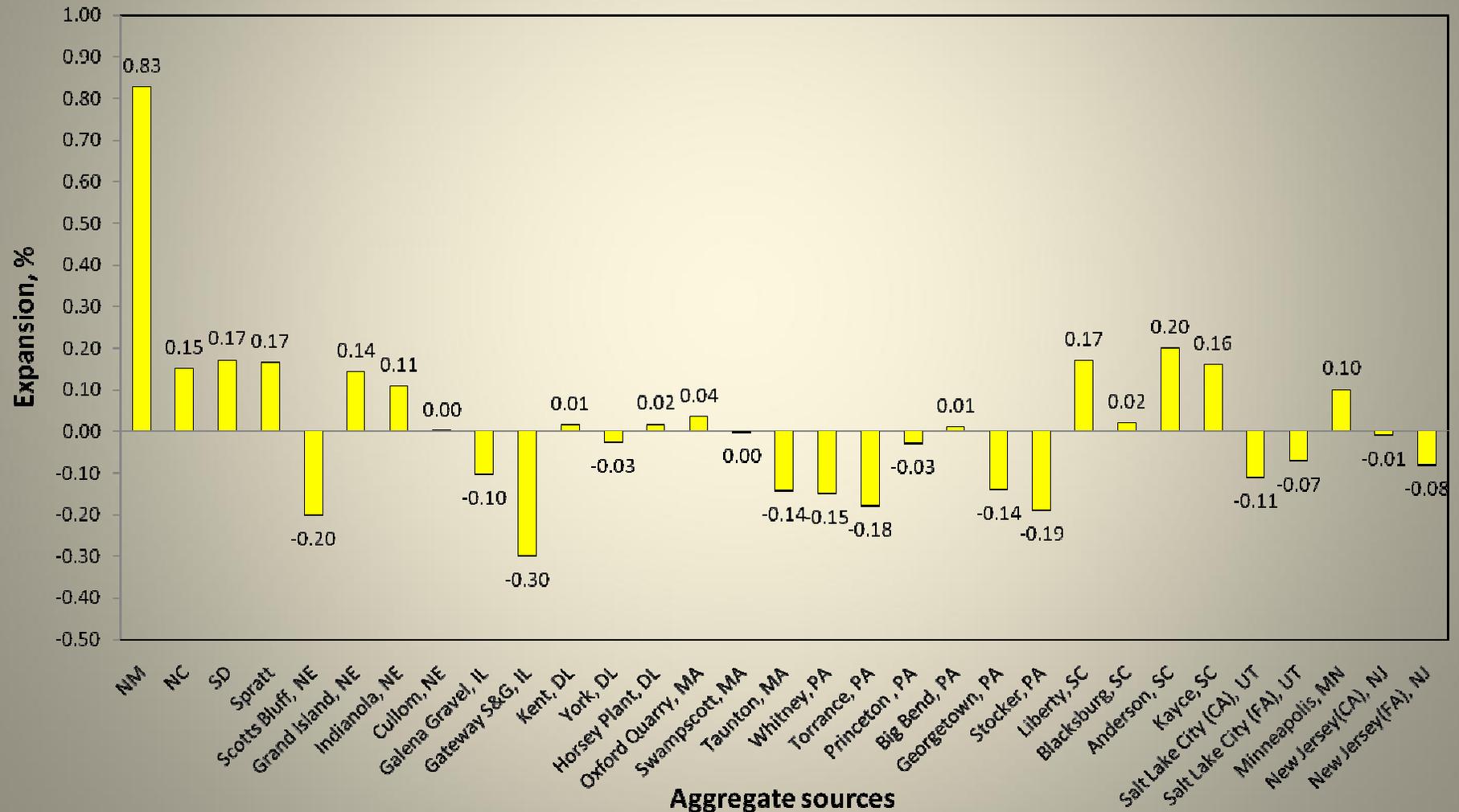
14-Day Expansion of Mortar Bars



Upon further testing with additional aggregates...



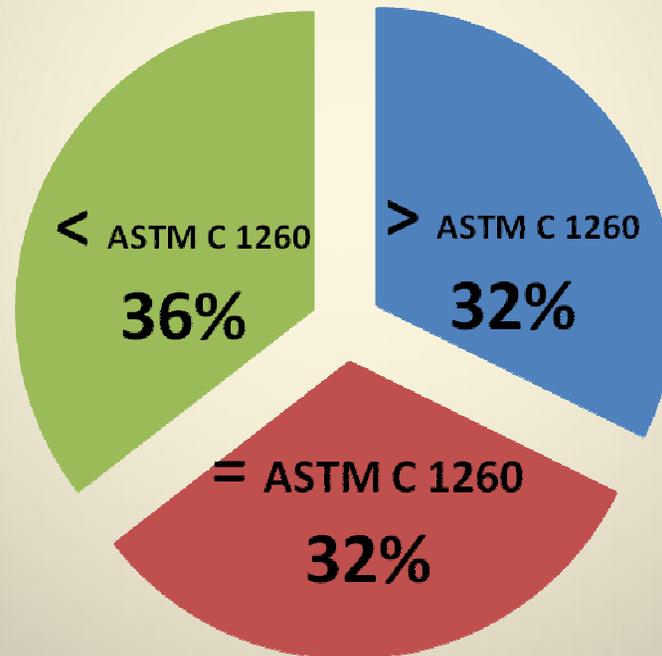
Mortar Bar Expansion in EB 70 Protocol relative to ASTM C 1260 Test



EB 70 versus ASTM C 1260 Test Results

Comparison of Mortar Bar Expansions	# of Aggregates
EB 70 > ASTM C 1260	10
EB 70 = ASTM C 1260	10
EB 70 < ASTM C 1260	11

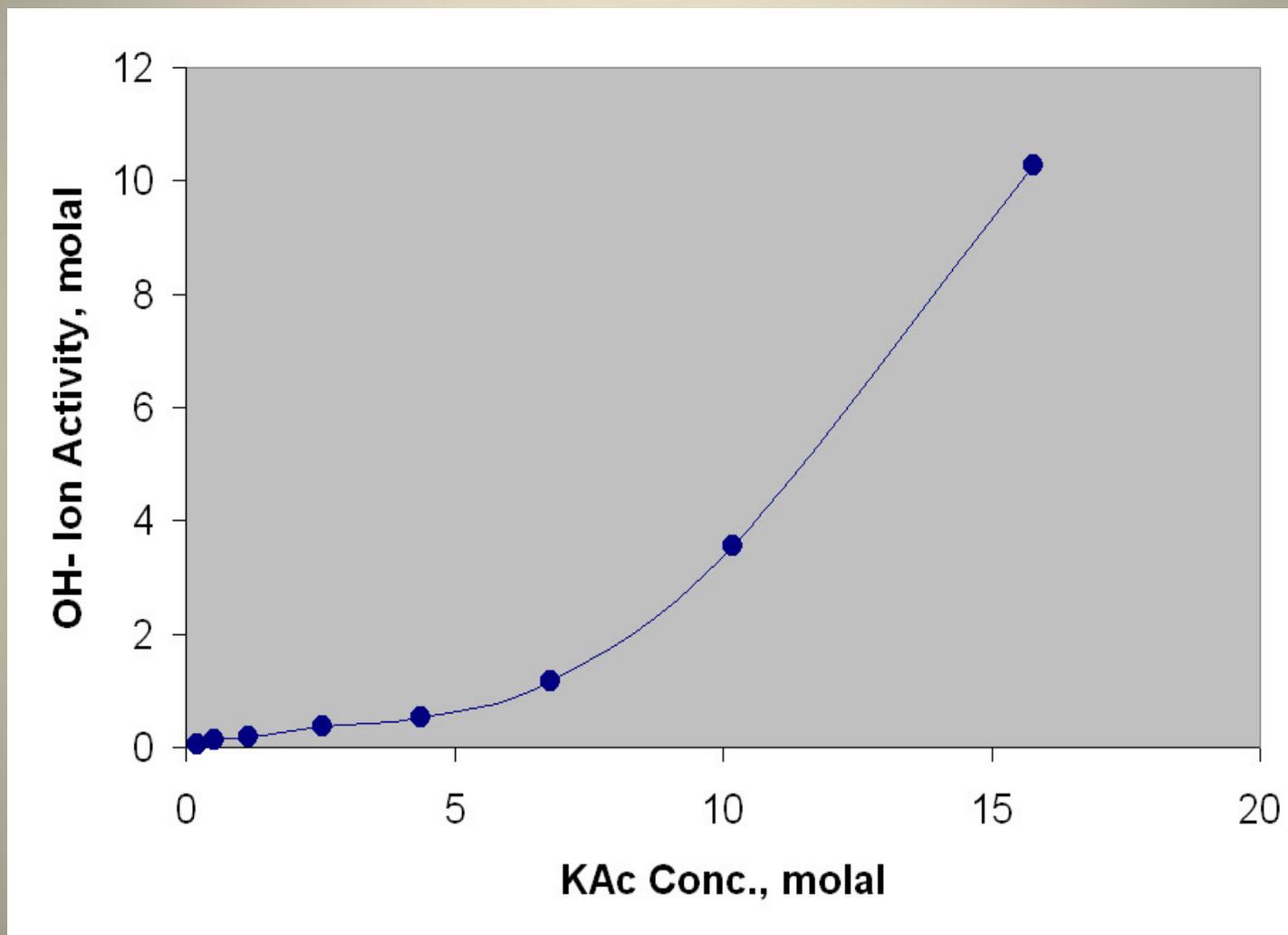
Comparison of Expansion Data
Margin of Error = +/- 0.05%



Mechanism for Deicer-Induced ASR Distress

- One of the principal findings from IPRF 03-9 and 04-8 studies was the **“pH jump”** phenomenon in deicer solution interacting with portland cement pastes.
- The underlying mechanism for such “pH jump” was determined to be due to increase in **OH⁻ ion activity coefficient** in concentrated deicer solutions.

KAc Solutions Containing Saturated $\text{Ca}(\text{OH})_2$
Measured OH Ion Activity vs. KAc Concentration
(*Prof. Diamond and Prof. Olek, Purdue University; IPRF 03-9 Project)



Comparison of Soak Solutions Characteristics

Solution	Avg. pH @ ~ 21°C	OH - ion Conc.	OH- ion Activity Coeff.
6.4M KAc with Sat. Ca(OH) ₂	10.76	Low	Very High
1N NaOH	13.69	Very High	Low
1N NaOH + 3M KAc	14.47	Very High	Very High

Proposed Test Method

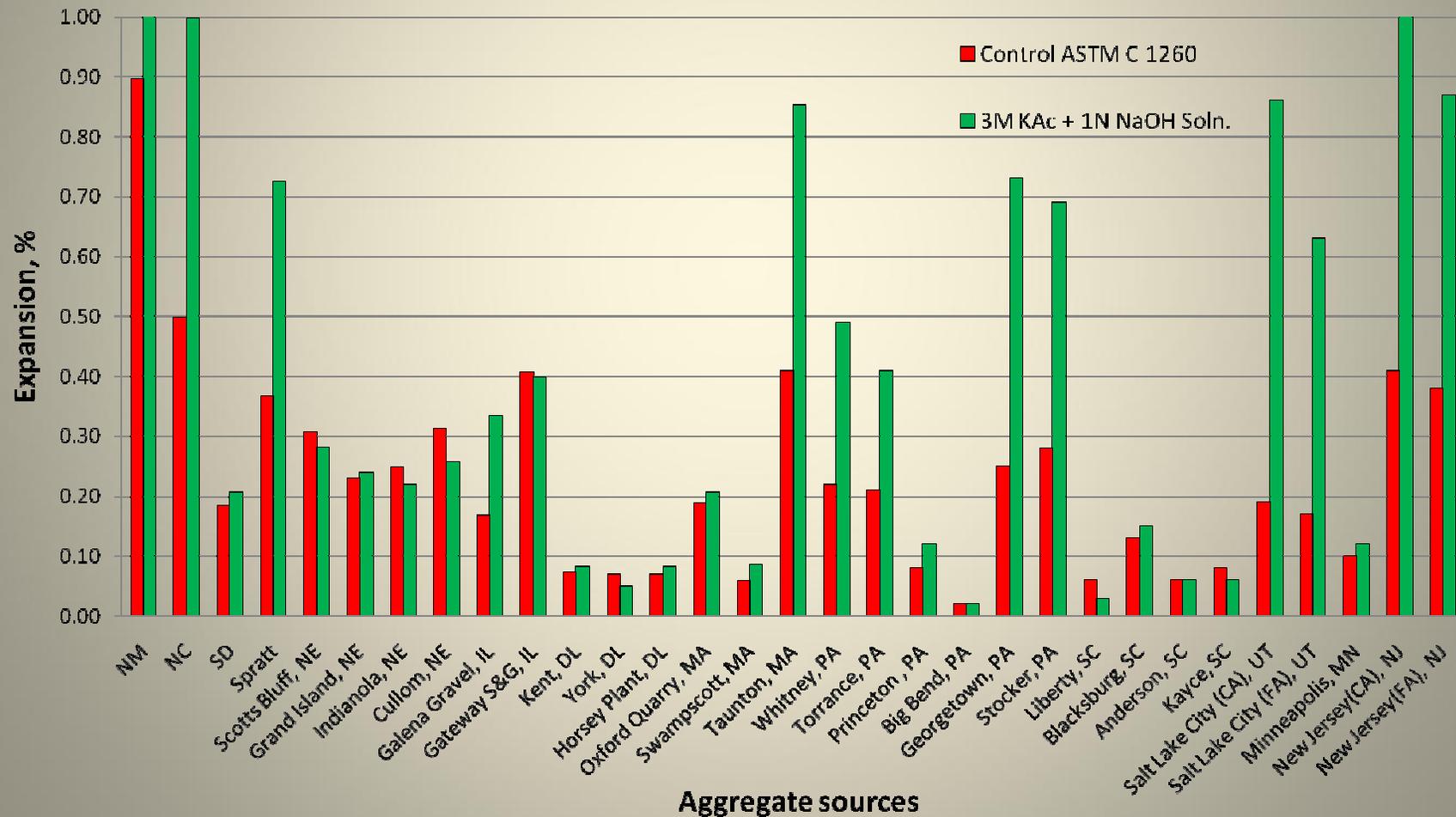
- Combination of KAc deicer with NaOH solutions appear to provide ample “pH Jump” effect along with high enough concentration of OH⁻ ions.
- Comparative testing using **1N NaOH** solution and **1N NaOH+3M KAc** solutions has potential to identify reactive aggregates, and their sensitivity to KAc deicer solution.

Revised EB-70 Protocol

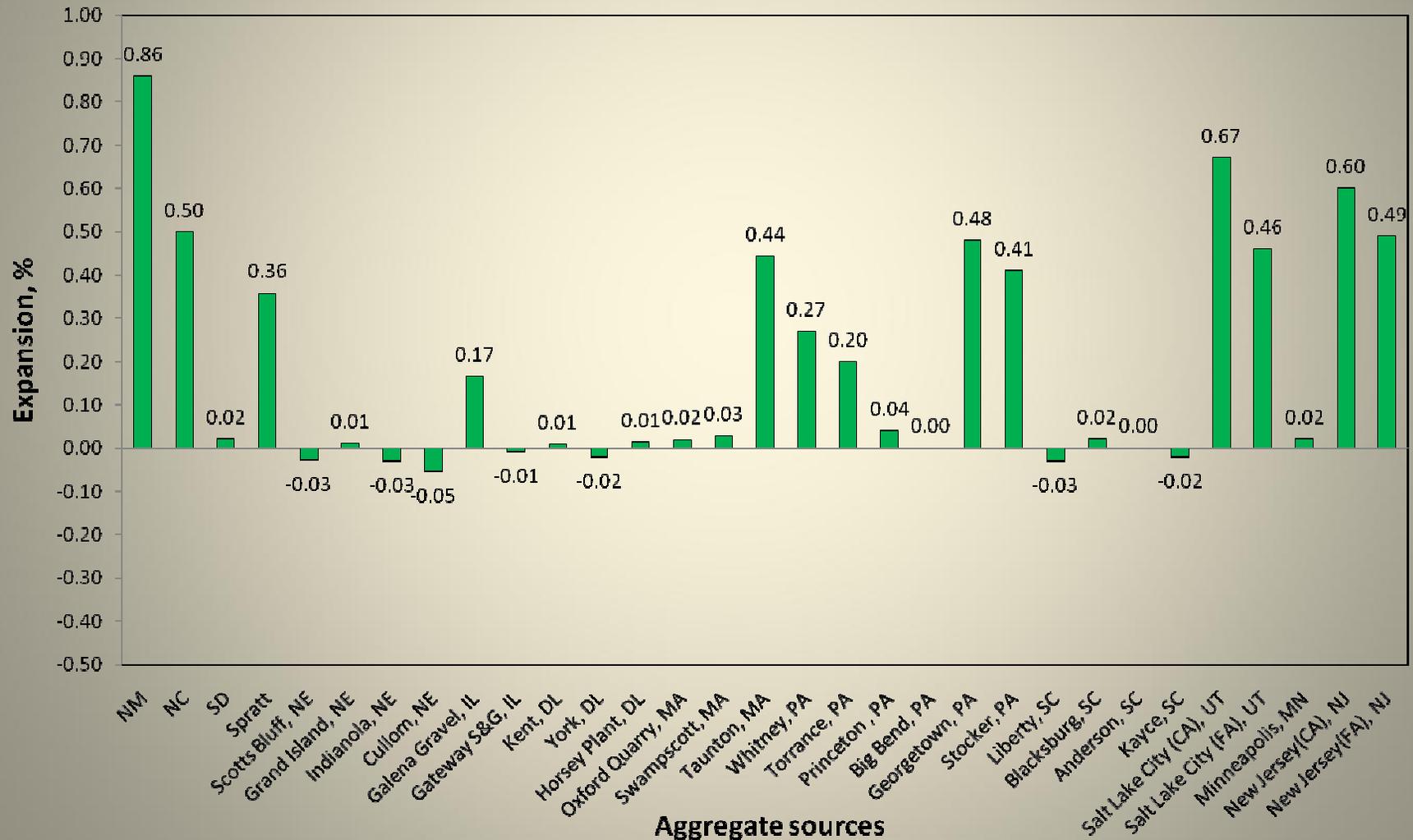
- Test method is similar to EB-70 Protocol, with exception of soak solution composition.
- Proposed soak solution is:
1N NaOH + 3M KAc solution
- Test duration and expansion limits are similar to the standard ASTM C 1260 test

Comparison of Mortar Bar Expansion

Std. ASTM C 1260 *versus* Revised EB – 70 Protocol



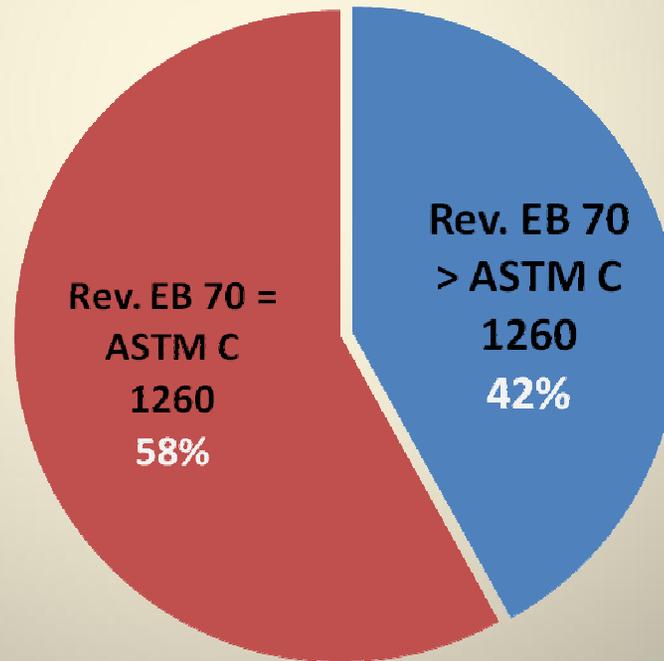
Mortar Bar Expansion in Revised EB 70 Protocol relative to ASTM C 1260 Test



Revised EB 70 *versus* ASTM C 1260 Results

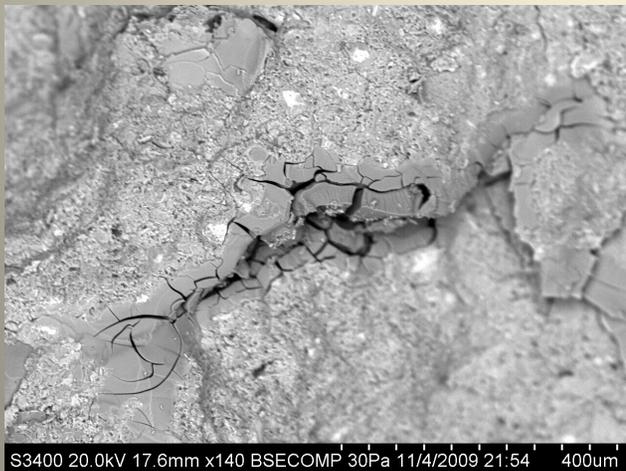
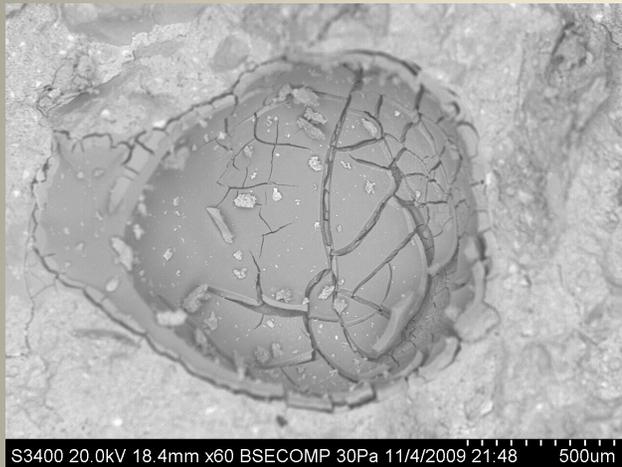
Comparison of Mortar Bar Expansions	# of Aggregates
Revised EB 70 > ASTM C 1260	13
Revised EB 70 = ASTM C 1260	18
Revised EB 70 < ASTM C 1260	0

Comparison of Expansion Data
Margin of Error = +/- 0.05%

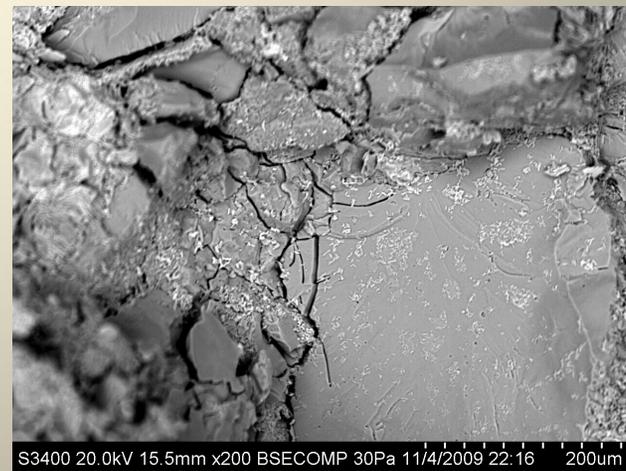


Microscopic Evidence of Damage Taunton Aggregate, MA

Std. ASTM C 1260 Test



Rev. EB-70 Test



Conclusions

- The revised EB70 test protocol for evaluating ASR potential of aggregate in presence of deicing chemicals **corrects** the deficiencies of the existing EB70 method.
- The proposed soak solution in the revised EB70 test method, i.e. 1N NaOH + 3 M KAc solution, captures the interaction between KAc deicer solution and cement alkalis more accurately than KAc deicer solution alone.
- 100% of aggregates evaluated in the revised EB70 protocol are shown to be either similarly or much more reactive as compared to the results from the standard ASTM C 1260 test method. Thus, **both tests show a consensus** in assessing aggregate reactivity.

On-Going Research

- Determine the influence of aggregate mineralogy on interaction with KAc deicer solutions.
- Evaluation of conventional ASR mitigation measures in revised EB-70 test method.

Questions?

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