ACI 201 – Guide to Durable Concrete
Updates to AAR Chapter 5

Reported by ACI Committee 201

Russell L. Hill
Chair

Kevin J. Folliard
Secretary

Dr. Jason H. Ideker
Assistant Professor
Oregon State University
Outline

Current version of ACI 201.2R-08, Ch 5

Proposed revisions to ACI 201.2R-08
- Improved technical information on ASR and ACR
- Test Methods – significant focus here
- Guidance for to Managing ASR following AASHTO approach - Benoit
- 47 references added

- Summary
Chapter 5: Alkali Aggregate Reaction

- Types of Reactions
- Evaluating Aggregates for Potential AAR
- Preventive Measures

Types of Reactions

- ACR – Alkali Carbonate Reaction
  - Little information
- ASR – Alkali Silica Reaction
  - More in-depth information referred to other documents within ACI

Evaluating Aggregates for Potential AAR

- Field Performance
- ASTM C 295 – Petrographic Exam
  - **ASR**
- ASTM C 227 – Mortar Bar Test
- ASTM C 289 – Quick Chemical Test
- ASTM C 1260 – Accelerated Mortar Bar Test
- ASTM C 1293 – Concrete Prism Test
  - **ACR**
- ASTM C 586 – Rock Cylinder Test
- CSA A23.2-26A – Chemical Comp.
- ASTM C 1105 – Concrete Prism Test
- Other tests

Preventive Measures

- Use of nonreactive aggregate
- Use of low-alkali cement
- Limits on alkali content (loading)
- Supplementary cementing materials
  - Fly ash and slag (together)
  - Silica fume
  - Natural pozzolans
- Tests for evaluating effect of pozzolans and slag on ASR
  - ASTM C 441
  - ASTM C 1293 - mentioned
  - ASTM C 1567 - mentioned
- Suitable chemical admixtures
  - Lithium salts
  - Other admixtures

Developing testing strategies and criteria
Chapter 5: Alkali Aggregate Reaction - PROPOSED UPDATES

Introduction
Types of reactions
Evaluating aggregates for potential alkali-aggregate reactivity
Preventive measures
Evaluating preventive measures
Approaches for managing AAR

Types of Reactions
- ACR – Alkali Carbonate Reaction
  History, Reaction mechanisms
- ASR – Alkali Silica Reaction
  History, Reaction mechanisms

Evaluating Aggregates for Potential AAR
- (R) Field Performance
- (R) ASTM C295 – Petrographic Exam
  ASR
- (NR) ASTM C227 – Mortar Bar Test
- (NR) ASTM C289 – Quick Chem Test
- (R) ASTM C1260 AMBT - cautions
- (R) ASTM C1293 – Concrete Prism Test
- (NR) Accelerated Concrete Prism Test
  also RILEM AAR 4 – Proposed
- (R) Concrete Microbar Test
  ACR
- (R) ASTM C 586 – Rock Cylinder Test
- (R) CSA A23.2-26A – Chemical Comp.
- (R) ASTM C 1105 – Concrete Prism Test
- (R) Concrete Microbar Test
- Other tests

Preventive Measures
- Use of nonreactive aggregate
- Limits on alkali content
- Supplementary cementing materials
  - Fly ash
  - Slag
  - Silica fume
  - Natural pozzolans
- Suitable chemical admixtures
  - Lithium salts
  - Other chemical admixtures

Evaluating Preventive Measures
- ASTM C 441 - precautions
- (R) ASTM C 1567
- (R) ASTM C 1293

Approaches for Managing AAR
Benoit Fournier addressed
Will reflect AASHTO/FHWA approach

ACI 201.2R - XX
Guide to Durable Concrete
Dr. Michael D.A. Thomas
Dr. Jason H. Ideker
Types of Reactions

• ACR – Alkali Carbonate Reaction
  History, Reaction mechanisms
• ASR – Alkali Silica Reaction
  History, Reaction mechanisms
Test Methods for AAR

Evaluating Aggregates for Potential AAR

- (R) Field Performance
- (R) ASTM C295–Petrographic Exam
- (NR) ASTM C227 – Mortar Bar Test
- (NR) ASTM C289 – Quick Chem Test
- (R) ASTM C1260 AMBT - cautions
- (R) ASTM C1293 – Concrete Prism Test
- (NR) Accelerated Concrete Prism Test
also RILEM AAR 4 – Proposed
- (R) Concrete Microbar Test

ACR

- (R) ASTM C 586 – Rock Cylinder Test
- (R) CSA A23.2-26A – Chemical Comp.
- (R) ASTM C 1105 – Concrete Prism Test
- (R) Concrete Microbar Test
- Other tests

- Stronger language and recommendations about test methods
- Generally the tests of longer duration (e.g. the concrete prism test) are found to produce more reliable results than shorter duration, highly aggressive tests e.g. standard mortar bar test and even the accelerated mortar bar test
  - High temperature
  - Sample size
  - Mass loss
  - Leaching (loss of alkalies)
  - Non-reactive aggregate issues
- Addition of new testing methods
Test Methods (2)

**ASTM C 227** – Not recommended for identifying ASR or for cement aggregate combinations excessive leaching, trouble identifying slow reacting aggregates

**ASTM C 289** – Not recommended for detecting potentially deleterious alkali-silica reaction in aggregate samples

loss of reactive phases during crushing/sieving temperatures during test change reaction kinetics from that seen in field concrete
Test Methods (3)

Accelerated Concrete Prism Test – not a recommended test (NEW)

excessive leaching due to temperature mass loss (drying) of prisms, especially at early-age (e.g. up to 7 days)
temperature (60C) changes reaction kinetics
sulfate drawn into solution preferrentially non-reactive fine aggregates play increasingly important role (alkali leaching)
ASTM C 1260 – caution given to following test method carefully (volume of soak solution, bars of only one mixture type stored together, prevent evaporation, others)

Limit of 0.10% at 14 days recommended based on correlation to field performance

Precautions given to false negatives
Concrete Prism Test – recommended test, most reliable
real-scale concrete tested, reduced leaching over mortar bar tests (ASTM C 227)
duration of 1 or year is still of concern
Concrete Microbar Test (NEW)

- 40 x 40 x 160 mm prism
- 2.5-5 mm aggregate
- 1260 storage conditions
- 14 day test with an expansion limit ~ 0.90%

Identified aggregates with false negatives in 1260. Recommend running in conjunction with ASTM C 1260.
ACR Test Methods

Rock Cylinder Method (ASTM C 586)
Chemical Composition (CSA A23.2-26A)
Concrete Prism Test (ASTM C 1105)
Concrete Microbar Test (CMT) (NEW)
  2.5-5.0 mm aggregate and 5.0-10.0 mm
  28 day testing period for reactivity
  proposed limit of 0.10% at 28 days
Preventive Measures

- Low alkali cements – removed
  - Alkali content focus
- SCMs – rearranged
  - Fly ash and slag treated separately
  - Silica fume: long-term effectiveness issues, ternary blends encouraged
- Lithium salts
  - Lithium covered more in depth with inclusion of recent findings
  - Dosage needed depends highly on reactive aggregate type

Preventive Measures

- Use of nonreactive aggregate
- Limits on alkali content
- Supplementary cementing materials
  - Fly ash
  - Slag
  - Silica fume
  - Natural Pozzolans
- Suitable chemical admixtures
  - Lithium salts
  - Other chemical admixtures
Evaluating Preventive Measures

• New section
• Precautions added in relation to ASTM C 441
  • Need to test combinations of SCMs and/or chemical admixtures with reactive aggregate
  • Still acceptable for comparing efficacy of SCMs
• ASTM C 1567 – AMBT added
• ASTM C 1293 – language about 2 year extension for testing preventive measures added.
Tests for Evaluating Preventive Measures

- ASTM C 441 – added precautions about testing efficacy on aggregates
- ASTM C 1567 (NEW)
- ASTM C 1293 (NEW)
  - language to relate to limits in CSA standards for running to 2 years
Approaches for Managing AAR

Benoit Fournier addressed new AASHTO specifications
Will be reflected in new AAR Chapter
Summary

Improved technical information on ASR and ACR
Test methods – stronger language, recommendations given, new methods discussed
Improved technical information on preventive measures
Evaluating preventive Measures – test methods
Approaches for managing AAR

ICAAR – Held in Austin, Texas
May 2012