Concrete Recycling in Pavement Applications

Update on the FHWA Concrete Recycling Initiative

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September 20, 2017
Concrete Recycling Initiative

TEAM
• Peter Taylor, Iowa State University, CP Tech Center Director
• Tom Cackler, Woodland Consulting, Inc.
• Dale Harrington, Snyder & Associates
• Mark Snyder, Pavement Engineering and Research Consultants
• Tara Cavalline, UNC Charlotte
• Gary Fick, Trinity Construction Management Services
• Steve Tritsch, CP Tech Center

FHWA
• Gina Ahlstrom, FHWA
• Tom Yu, FHWA
Concrete Recycling Initiative

Champion States

- California – Mehdi Parvini
- Illinois Tollway – Steve Gillen and Ross Bentsen
- Kansas – Will Lindquist, Rod Montney, Greg Scheiber
- Minnesota – Maria Masten
- North Carolina – Nilesh Surti and Brian Hunter
- Oklahoma – Kenny Seward
- Pennsylvania – Steve Kose
- Texas – Andy Naranjo
- Utah – Bryan Lee
- Washington – Jeff Uhlmeyer

AASHTO

- Cecil Jones, Diversified Engineering Services

THANK YOU!
Concrete Recycling Initiative

Industry and Association Representatives

- Tom Tietz, CNCement
- Charles Rea, CalCIMA
- Todd LaTorella, Missouri/Kansas Chapter, ACPA
- Greg Dean – Southeast Chapter, ACPA
- Brent Burwell – Oklahoma/Arkansas Chapter, ACPA
- Rich Jucha and John Becker – Pennsylvania Chapter, ACPA
- Jan Prusinski – Cement Council of Texas
- Mitzi McIntyre – Utah Chapter, ACPA
- Jim Powell – Northwest Chapter, ACPA
- Randy Riley – Illinois Chapter, ACPA
- Leif Wathne - ACPA
- Colin Lobo - NRMCA
- Steve Kosmatka and Wayne Adaska - PCA

THANK YOU!
FHWA Concrete Recycling Initiative

• Part of FHWA Sustainable Concrete Pavement Program
  – Program Goals: Encourage innovation and extended application of sustainable pavement technologies on projects

• *Concrete Recycling Initiative* – promote recycling of concrete pavement materials in cost-effective applications while optimizing the triple bottom line (social, environmental, economic)

44 of 50 states allow use of RCA in various applications
(FHWA, 2004 + new info)
RCA Survey Findings – DOT survey

Allow use of RCA in subbases, bases, shoulders, erosion control:

- YES (15 out of 15 respondents)

Allow use of RCA in concrete mixtures:

- 9 NO, 6 YES

![Bar chart showing percent of projects for different applications of RCA](chart.png)
<table>
<thead>
<tr>
<th>Application</th>
<th>Percentage (% use)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Granular subbase</td>
<td>40</td>
</tr>
<tr>
<td>Crushed products for other markets</td>
<td>18</td>
</tr>
<tr>
<td>Embankment (includes backfill)</td>
<td>12</td>
</tr>
<tr>
<td>Coarse concrete aggregate</td>
<td>9</td>
</tr>
<tr>
<td>Other (given to owner agency)</td>
<td>7</td>
</tr>
<tr>
<td>Chemically stabilized granular subbase (CTB, lean concrete etc.)</td>
<td>4</td>
</tr>
<tr>
<td>Haul road</td>
<td>3</td>
</tr>
<tr>
<td>Granular shoulder material</td>
<td>3</td>
</tr>
<tr>
<td>Fine concrete aggregate</td>
<td>2</td>
</tr>
<tr>
<td>Surplus fines</td>
<td>1</td>
</tr>
<tr>
<td>Erosion control applications</td>
<td>0</td>
</tr>
<tr>
<td>Plant site subbase</td>
<td>1</td>
</tr>
<tr>
<td>Slope stabilization materials</td>
<td>0</td>
</tr>
<tr>
<td>Underdrain filter material</td>
<td>0</td>
</tr>
<tr>
<td>Rip rap</td>
<td>0</td>
</tr>
</tbody>
</table>
## Survey Findings - Barriers

### Importance of potential barriers for RCA use in pavement foundations

<table>
<thead>
<tr>
<th>Barriers</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economics (cost of producing RCA)</td>
<td>2.0</td>
</tr>
<tr>
<td>Environmental impacts (runoff, leachate, etc.)</td>
<td>2.3</td>
</tr>
<tr>
<td>RCA foundation strength and/or stability</td>
<td>1.7</td>
</tr>
<tr>
<td>Gradation issues, particularly fines</td>
<td>2.5</td>
</tr>
<tr>
<td>ASR, D-cracking of source concrete</td>
<td>1.9</td>
</tr>
</tbody>
</table>

0 = Not a significant barrier  
5 = Critical barrier or very high importance
Survey Findings - Barriers

Importance of potential barriers for RCA use in new concrete mixtures

<table>
<thead>
<tr>
<th>Barriers</th>
<th>Importance Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good, inexpensive natural sources</td>
<td>3.3</td>
</tr>
<tr>
<td>Economics</td>
<td>2.9</td>
</tr>
<tr>
<td>Lack of guidance on mix designs</td>
<td>2.9</td>
</tr>
<tr>
<td>Strength</td>
<td>2.4</td>
</tr>
<tr>
<td>Workability</td>
<td>3.0</td>
</tr>
<tr>
<td>Shrinkage</td>
<td>2.6</td>
</tr>
<tr>
<td>ASR, D-Cracking</td>
<td>3.5</td>
</tr>
</tbody>
</table>

0 = Not a significant barrier  5 = Critical barrier or very high importance
KEY CONCRETE RECYCLING RESOURCES:

PRIOR TO THIS INITIATIVE
ACPA EB043P (2009)
Recycling Concrete Pavements

- RCA Production
- Properties and Characteristics of RCA
- Uses of RCA
- Properties of Concrete Containing RCA
- Performance of Concrete Pavements Constructed Using RCA
- Recommendations for Using RCA
- Appendices:
  - Guidelines for Removing and Crushing Existing Concrete Pavement
  - Guidelines for Using RCA in Unstabilized (Granular) Subbases
  - Guidelines for Using RCA in Concrete Paving Mixtures
  - Relevant AASHTO/ASTM Standards
  - Glossary of Terms and Index
CP Tech Center Deployment Plan

- Report outlines barriers to implementation (perceptions, lack of experience, risk, etc.) and recommends approaches to overcoming them.

- Also: FHWA Technical Advisory TT 5040.37: Use of Recycled Concrete Pavement as Aggregate in Hydraulic-Cement Concrete Pavement
NEW CONCRETE RECYCLING RESOURCES:
DEVELOPED AS PART OF THIS INITIATIVE
Webinars:
http://www.cp techcenter.org/webinars/

1) Introduction to Concrete Pavement Recycling (Mark Snyder and Tara Cavalline)

2) Environmental Considerations in Concrete Pavement Recycling (Tara Cavalline)

3) Construction Considerations in Concrete Pavement Recycling (Gary Fick)

4) Case Studies in Concrete Pavement Recycling (Mark Snyder)
Recycling Concrete Pavement Materials - Practitioner’s Reference Guide

Ch. 1: Introduction to Concrete Pavement Recycling
Ch. 2: Economics and Sustainability
Ch. 3: Project Selection and Scoping
Ch. 4: Using RCA in Pavement Base Products
Ch. 5: Using RCA in Concrete Paving Mixtures
Ch. 6: Using RCA in Unbound Aggregate Shoulders
Ch. 7: Mitigating Environmental Concerns

100+ pages of useful technical info and implementation guidance
Ch. 2 Economics and Sustainability

• Benefits associated with concrete recycling
  – economic
  – sustainability

• Assessment tools and techniques
  – economic analysis
  – environmental assessment
  – rating systems

• Table providing guidance for using sustainability assessment tools for concrete recycling projects
  – general considerations
  – considerations specific to concrete recycling
Ch. 2 Economics and Sustainability

- Benefits associated with concrete recycling
  - economic
  - sustainability

- Assessment tools and techniques
  - economic analysis
  - environmental assessment
  - rating systems

- Table providing guidance for using sustainability assessment tools for concrete recycling projects
  - general considerations
  - considerations specific to concrete recycling

Photos: Phillip Lamoureux, FHWA Western Federal Lands (top), Steven Theisen, WisDOT (below)
Ch. 3 Project Selection and Scoping

- Potential Recycling Project Identified
- Characterization of the Source Concrete
- Production Options for RCA
- Economics
- Other Factors
- Project Scoping Completed

Structured around a flowchart showing typical project selection and scoping process

- Includes checklist of considerations for use of RCA in different applications
  - Materials considerations
  - Production considerations
  - Other considerations
Ch. 4 Using RCA in Pavement Base Products

**Unbound aggregate base applications**
- Performance concerns
  - Structural issues
  - Drainage issues
- Qualification testing
  - General
  - Gradation
  - Other tests (abrasion, soundness, etc.)
- Subbase design and construction considerations
- Concrete pavement design considerations
- Environmental considerations

**Bound (stabilized) base applications**
- Lean concrete subbase and cement-stabilized subbase
- Asphalt concrete and asphalt-stabilized subbase

Includes example projects for each application
Ch. 5 Using RCA in Paving Mixtures

- Constructability considerations
  - Fresh properties

- Pavement design considerations
  - Hardened properties

- Developing concrete mixture designs using RCA
  - Qualification Testing
  - Proportioning

- Examples and Case Studies
  - D-cracking aggregate
  - ASR
  - Continuously reinforced concrete pavement
Ch. 6 Using RCA in Unbound Aggregate Shoulders

- Assessing potential economic benefits
- Estimating environmental benefits
- Constructability considerations
  - particle degradation during roll-down
  - moisture-density control
  - other concerns
- Qualification testing
  - gradation
  - Absorption
  - LA abrasion/MicroDeval
  - unconfined compression
  - Other tests
- Examples and Case Studies
Ch. 7 Mitigating Environmental Concerns

• Legislative and regulatory considerations

• Overview of potential environmental concerns
  – water quality
  – air quality
  – noise/local impacts
  – waste generation

• **Mitigating environmental concerns during project planning and design**
  – Focus on water quality issues

• **Mitigating environmental concerns during construction**
  – Strategies for mitigating issues on-site

Photo: Dwayne Stenlund, MnDOT
Tech Briefs

**Available Now:**
- Introduction to Concrete Recycling
- Quantifying the Sustainability Benefits of Concrete Pavement Recycling

**Coming Very Soon:**
- Project Selection and Scoping

**Coming Soon:**
- RCA in Unbound Aggregate Shoulders
- RCA in Concrete Paving Mixtures
- Mitigating Environmental Concerns During Project Planning and Design
- Mitigating Environmental Concerns During Construction
Website

http://www.cptechcenter.org/concrete-recycling/

Resources available:

- Practitioner’s Guide
- Webinars
- Tech Briefs
- Other Publications
- Results of Industry/State Survey

Photo: CDRA
On a related note:

ACI 555: Concrete with Recycled Materials
ACI 555R-01: Removal and Reuse of Hardened Concrete

Major revisions and updates to document in process!

- Chapter 1: Introduction
- Chapter 2: Types of Concrete and Degree of Removal
- Chapter 3: Concrete Removal Methods
- Chapter 4: Production of Recycled Concrete Aggregate –
- Chapter 5: Use of RCA in Unbound Applications
- Chapter 6: Production of Concrete with RCA
- Chapter 7: Case Studies
- Chapter 8: References
Questions?