AGENDA

ACI Committee 555, Concrete With Recycled Materials

Sunday, September 28, 2003, 5:00 – 6:30 pm
Sheraton Boston Hotel, Boston, MA
Room: Beacon D

1. Introduction of Committee Members and Guests
2. Approval of Minutes and Agenda
3. TAC Contact’s Remarks
4. Status of Committee Membership
5. Status of ACI Special Publication
6. Status of Committee Reports
   i. Revision to ACI 555R-01
   ii. Concrete with Recycled Materials as Aggregate
7. Technical Sessions at Upcoming ACI Conventions
8. Technical Presentations by Members/Visitors
9. Old Business
10. New Business
11. Next Meeting
12. Adjournment
Members in Attendance:

Tony C. Liu, Chair        David L. Gress        Seamus F. Freyne
Christian Meyer          Tarun R. Naik        William Halczak
Herbert C. Hale           Arezki Tagnit-Hamou  Nabil Bouzoubaa
Charles E. Pierce         Erik K. Lauritzen

Visitors Present:

Raissa Douglas           Yoshio Kasai          Moncef Nehdi
Caijun Shi               Ewan Byars           Yixin Shao
V.M. Malhotra            Bruce W. Ramme

1. Call to Order and Introduction of Committee Members and Guests

Tony Liu called the meeting to order at 3:35 pm. All committee members and
guests introduced themselves.

2. Approval of Minutes and Agenda

The minutes of the meeting held at the ACI Fall Convention in Phoenix were
approved as distributed.

3. TAC Contact’s Remarks

TAC Contact, Dr. Randy Poston, was unable to attend because of scheduling
conflict.

4. Status of Committee Membership

As of March 20, 2003, the committee had 16 Voting Members, one Consulting
Member (Erik Lauritzen) and 5 Associate Members. During this meeting, three of
the visitors (Ewan Byars, Bruce Ramme, Moncef Nehdi) completed Applicant’s
Data Sheets and passed them on to the Chair to be appointed as new committee
members. Caijun Shi also expressed an interest in joining the committee.

The large increase in membership within a relatively short period is indicative of
strong interest and a vindication of the committee’s decision to expand its scope.
5. Technical Sessions at 2003 ACI Spring Convention

This committee has organized two sessions for this convention with six papers each, thereby constituting a mini-theme of the convention’s main theme “Concrete fit for its purpose”. In the morning session, three ad-hoc substitutions had to be made. Because of a health problem, Mason Brown was unable to make his presentation. Arezki Tagnit-Hamou was kind enough to fill in to report on his research. Also, Beatrix Kerkhoff was unable to attend, and David Gress volunteered to make a presentation in addition to the one originally scheduled. Also, Torben Hansen could not attend, but his co-author Erik Lauritzen was able to make the presentation in his place. For the afternoon session, all scheduled speakers were available to make their presentations.

(Comment of recorder: Both sessions, held on the Tuesday following this committee meeting, were very well attended, with the audience fluctuating between 25 and 50).

TAC has approved a Special Publication with the papers presented during these two sessions. Tony Liu and Christian Meyer will serve as editors. Ewan Byars, who had expressed an interest in joining the committee, inquired whether it is possible for him to contribute a paper to this volume. Tony Liu replied that he (or his successor) will look into this as a possibility, which would increase the total number of papers from 12 to 13. Tony Liu suggested an ambitious publication schedule: Complete all manuscripts and send to Tony Liu by April 30; select reviewers by April 30; complete all reviews by June 30 (ACI requires that each chapter be reviewed by two reviewers, who do not have to be committee members); authors will complete final manuscripts by July 31; all manuscripts will be submitted to ACI during August. Tony Liu will mail detailed instructions to all authors.

6. Status of Committee Reports

William Halczak reported that because he had to spend considerable time with his growing family, he did not have the time to do anything about a revision of Report 555R-01, but he is hopeful that he will get to it during the summer. The material contained in the report dates primarily from the late 1980s and needs to be updated. Ewan Byars volunteered to add a European perspective to the report.

For the planned new report, “Concrete with Recycled Material as Aggregate”, Christian Meyer and Dan Jansen had volunteered to take the lead. An outline of this report had been distributed together with the agenda.

Chapter 1 serves as a brief introduction, and Christian Meyer is writing this. Chapter 2 will summarize the use of recycled concrete, and Bill Halczak will provide a brief summary of Report 555R-01. In Chapter 3, Christian Meyer will
summarize the research at Columbia University and elsewhere that had been performed on the use of waste glass as an aggregate. Moncef Nehdi volunteered to assume responsibility for Chapter 4 on the utilization of tires. For Chapter 5 on the use of wood, no chapter author has been found yet, but Christian Meyer promised to inquire with Prof. Natterer in Lausanne whether one of his coworkers might be willing to take the lead. Chapter 6 on the use of pulp and paper mill residuals was suggested by Tarun Naik, who volunteered to assume responsibility for this chapter. Dan Jansen had volunteered to write Chapter 7 on plastics.

A long discussion followed on Chapter 8, which was proposed to deal with filler materials, both inert and pozzolanic, as well as toxic and hazardous materials such as fly ash from waste-to-energy facilities or dredged material. The discussion benefited from the European and more specifically Danish experience (Erik Lauritzen) and the Japanese perspective (Y. Kasai). Also Mohan Malhotra referred to some of the CANMET experience. No consensus could be reached on whether to include toxic materials, but it appeared to be counterproductive at this time because of the numerous issues (public health and safety, economics, public acceptance, etc) that would have to be addressed.

In the originally proposed outline, Chapter 9 would deal with “other” materials, such as foundry sands and bottom ashes, with which Tarun Naik has gained experience. Also synthetic lightweight aggregates are under consideration. In this regard, it was fortunate that Bruce Ramme, Chairman of Committee 213, was present as a guest and expressed an interest in joining our committee.

The discussion showed that the scope of the report requires further thought before serious writing commences.

7. Technical Presentations by Members/Visitors and General Discussion

David Gress mentioned that the Federal Highway Administration is conducting a national review of recycled concrete aggregate. He asked that the Committee provide guidance for this study. He provided the Chair with a diskette, which contains detailed information about this review. It is intended to post this information on our committee website, from which members are able to download it. Anyone interested in this study should contact David Gress.

Bruce Ramme reported that Committee 213 (Lightweight Aggregate) has a subcommittee on industrial byproducts, which has partial overlap with our committee. To avoid duplicate efforts and foster cooperation and coordination between the two committees, he volunteered to join our committee as liaison.

Caijun Shi mentioned that the Federal Highway Administration does have guidelines for the use of recycled concrete, dated 1998, with Warren Chessman being a major contributor. He will provide the committee with more information.
Arezki Tagnit-Hamou reported that CSA has requirements for alternate cementitious material.

Erik Lauritzen presented a comparison between the European and North American state of the art in the use of recycled materials. Whereas Europe used to be far ahead of us, this gap is narrowing, primarily because the Europeans are now concentrating on hazardous materials and environmental issues, which is slowing down the increased use of recycling. In Denmark, there does not seem to be a market for recycled material that contains hazardous substances. He appreciates the work our committee is doing. He recommended that the committee make an effort to recruit members from demolition contractors and recyclers. The present membership of the committee is overly academic, and in any case we should seek input from practitioners in the field for our reports.


Tony Liu pointed out that there will be an “International Workshop on Sustainable Development and Concrete Technology” in Beijing, September 14-15, 2003, and he distributed fliers for that meeting.

9. Chair’s Announcement and Remarks

Tony Liu reported that his three-year term as Committee Chairman expired at this Convention, and he felt it was time to resign and give someone else the opportunity to give the committee new directions. He was delighted to report that TAC had appointed Christian Meyer to be the incoming Chairman, effective as of today. With these words he yielded the podium to his successor.

Christian Meyer expressed the honor he felt of having been given the opportunity to chair this committee. The rapidly increasing membership was an indication that the committee’s decision to expand its scope was the right one. He expressed his conviction that issues of recycling and sustainable development will become of increasing concern to the concrete industry. He is a member of the ACI Task Group on Sustainable Development. At this Group’s last meeting, outgoing President Terry Holland had voiced serious concerns that the concrete industry is in danger of losing market share if it only paints itself “green” and does not undertake major efforts to make the industry more compatible with the tenets of sustainable development. Our Committee is clearly the one most suited to spearhead such efforts. By building on our connections with Europe and Japan, we should be able to point the way.

10. Next Meeting

For some administrative reasons, the Fall Convention in Boston is being advanced by one day, i.e. instead from the usual Sunday through Thursday, it
will take place from Saturday through Wednesday. Thus, if we were to stick to our “traditional” Monday time slot, we would have to meet on Sunday this time. Thus, the next meeting will be scheduled tentatively for Sunday, September 28, with second choice being Monday, September 29. To avoid conflicts with other committee meetings, the time slot requested is from 5 till 6:30 pm.

11. Adjournment

The meeting was adjourned at 5:00 pm.

Action Items

<table>
<thead>
<tr>
<th>Liu</th>
<th>Check with ACI whether we can include a paper by Ewan Byars in our SP.</th>
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<tbody>
<tr>
<td>Liu</td>
<td>Mail instructions to all authors of papers presented during the two Vancouver sessions.</td>
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<tr>
<td>Liu, Meyer</td>
<td>Select reviewers for all papers and send papers out for review.</td>
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<tr>
<td>Meyer, Hansen</td>
<td>Refine outline and scope of report.</td>
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<td>Meyer</td>
<td>Post FHWA project information on Committee website.</td>
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<tr>
<td>Shi</td>
<td>Provide Committee with information on FHWA guidelines prepared by Warren Chessman.</td>
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<tr>
<td>Byars</td>
<td>Add European perspective to update of Report 555R-01.</td>
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<tr>
<td>Meyer</td>
<td>Contact demolition companies and recyclers to recruit committee members.</td>
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Respectfully Submitted,
Christian Meyer
July 14, 2003
Concrete with Recycled Materials as Aggregate

Committee 555, Concrete with Recycled Materials

Outline
(For discussion at Boston Meeting, 9/28/03)

1. Introduction (Meyer)

Scope and objective of report; not included are cement substitutes; background information; need for sparse utilization of natural resources; depletion of natural resources; characteristics which provide for good recycled materials as an aggregate in concrete (must be economically beneficial, result in improved concrete performance, or be aesthetically pleasing); government regulations and incentives to use of recycled materials in construction; problems associated with recycling hazardous waste materials

2. Recycled Concrete (Halc扎k)

Topic of separate committee report; here only brief summary of ACI 555R-01

3. Waste Glass (Meyer)

3.1 Secondary markets for post-consumer glass
3.2 Processing of waste glass (washing, crushing, color-sorting, grading, shipping)
3.3 ASR problem, tests, remedies;
3.4 Special properties of glass;
3.5 Concrete products involving wet technology (tiles, precast); mechanical properties, durability, esthetics
3.6 Concrete products using dry technology (paving stones, masonry blocks); mechanical properties, durability, esthetics
3.7 Architectural concrete; production technology
3.8 Economic aspects

4. Tires (Nehdi)

4.1 Secondary markets for used tires
4.2 Processing of used tires
4.3 Special properties of rubber
4.4 Concrete with rubber aggregate; mechanical properties, durability, leaching of contaminants
4.5 Rubber concrete pavements, processing, properties, case studies, practical experience
4.6 Economic aspects
5. Wood (Natterer?)

5.1 Wood wastes, secondary markets
5.2 Wood chemistry and mechanical properties
5.3 Wood concrete products, mechanical and thermal properties, durability
5.4 Applications, case studies, experience here and abroad
5.5 Economic aspects

6. Pulp and Paper Mill Residuals (Naik)

6.1 Pulp and paper mill residuals, secondary markets
6.2 Pulp chemistry
6.3 Pulp concrete products, mechanical and thermal properties, durability
6.4 Leaching of contaminants
6.5 Applications, case studies, experience here and abroad
6.5 Economic aspects

7. Plastics (Jansen)

7.1 Recycled Plastics; types of recycled plastic; recycling and processing of Plastics; economics (secondary markets, volumes of recycled plastics)
7.2 Plastics in concrete; physical and mechanical properties of plastics related to use in concrete; mechanical and durability performance of concretes containing recycled plastics
7.3 Problems and limitations
7.4 Applications, sub-base concrete (work by Ray Krizek and Khaled Sobhan); other applications (potential?)

8. Other Materials (Naik/Ramme)

8.1 Synthetic lightweight aggregates (SLAs) made from combining recycled plastic and fly ash (production of aggregates, properties of concrete containing the SLAs)
8.2 Foundry Sands
8.3 Bottom Ashes
Recycled Concrete Aggregate
Federal Highway Administration National Review

Purpose/Objectives:
The purpose of this review is to capture for technical deployment the most advanced uses of recycled concrete aggregate and then transfer the knowledge with all State Transportation Agencies (STA). Through this sharing of information, we intend to showcase how other STAs overcame barriers and advanced the routine use of recycled concrete as aggregate. Specific uses or applications will be identified along with their barriers and benefits to implementation. Specifications, construction practices and implementation challenges will also be documented. This information will then be disseminated to all STAs through technical guidance, training, and guide specifications, as necessary.

Scope:
Minnesota, Utah, Virginia, Texas, and Michigan were the states chosen for an in-depth review of their recycled concrete aggregate program. These states were chosen because of their experience with recycling concrete aggregate. For each state visited, the review team will consist of 5 members. One individual from the leadership team will be present at all reviews to assure consistency. The other members of the review team will include individuals from the Federal Highway Administration (FHWA), Environmental Protection Agency (EPA), American Concrete Institute (ACI), or American Association of State Highway Transportation Officials (AASHTO).

For each state visited, the team will review recycled concrete aggregate applications utilized by that particular state for the purpose of developing a consolidated report at the completion of all the state visits that addresses the objectives listed above. It is intended that the final report be widely circulated to assist other states that may consider utilizing these applications. Additionally, a technology deployment package will be distributed to the FHWA Resource Center for further deployment.

Background:
STAs were surveyed to determine their use of recycled concrete aggregate. The following five figures depict the extent of use for recycled concrete aggregate.

Figure 1 Recycling concrete as aggregate
Figure 2 Base aggregate
Some conclusions that can be drawn from the figures are as follows:

- Concrete is routinely being recycled into the highway environment in the United States.
- The principal application of recycled concrete aggregate in the United States has been as a base material.
- The utilization of recycled concrete aggregate as aggregate in hot mix asphalt (HMA) and concrete is not as widely accepted in the United States.

Further issues were identified in the survey, but will be saved for further clarification and discussion by the review team in the final report.

**Team Members:**
Bryan Cawley, Materials Engineer, FHWA Resource Center Midwest  
Jason Harrington, Asphalt Pavement Engineer, FHWA Headquarters  
Cathy Nicholas, Highway Engineer, FHWA Washington Division  
Walter Waidelich, Assistant Division Administrator, FHWA New Hampshire Division  
Connie Hill, Environmental Protection Specialist, FHWA Headquarters  
Gary Crawford, Concrete Quality Engineer, FHWA Headquarters  
Randal Looney, Environmental Engineer, FHWA Arkansas Division  
Tom Byron, Florida Department of Transportation (AASHTO)  
John Sager & Paul Ruesch, US Environmental Protection Agency  
David, Gress, University of New Hampshire (ACI)

**Approach:**
1. A leadership team will be established to perform a majority of the administrative work for the review. This team will coordinate the compilation of research, writing reports, and overall organization of the team’s activities. Bryan Cawley, Materials Engineer, Resource Center Midwest will be the principal contact and focal point of review activities.

All members will be involved with the actual reviews, obtaining data and information for the reviews, and in formulation of all products produced from this review. These members bring knowledge and prospective from different disciplines and organizations.

2. A literature review will be conducted, paying particular attention to the applications and uses of recycled concrete aggregates in the states where an in-depth review will occur. This activity will be ongoing as documents are discovered during the review.

3. A written guide will be developed to assist the reviewers in asking appropriate questions and observing the necessary function of the DOT. It will consist of standardized questions and observation check sheets to help provide consistency of data collection between individual state reviews.

4. The individual state reviews will be comprised of several different subparts that are anticipated to take 4 to 5 working days to complete. The subparts are as follow:

   a. An initial meeting to discuss applications used in that particular state with the STA headquarters/central office staff.
   b. Interviews with STA environmental, design, materials, construction, and maintenance staff involved with the use of the material.
   c. Interviews with other state regulatory agencies that may have an impact on usage of recycled concrete aggregate.
   d. Interviews with contractor forces.
   e. Construction site visits.
   f. Review closeout meeting in each state visited prior to leaving.

At the conclusion of each review, a summary report will be written to help compile the overall knowledge obtained from that review.

5. A final report will be written that compiles all information gathered and provides a nationally perspective on the use of recycled concrete as aggregate.

6. Guide specifications, technical guidance or any other item developed as a result of this review will be further developed and distributed.
7. A deployment package of presentations, reports, and other documentation will be provided to the Resource Center for further deployment of the technologies identified from this review.

Output:
The direct output from this review will be experienced staff and documentation of the most advanced uses of recycled concrete aggregate. The team will develop a systematic deployment plan at the conclusion of the national review. The FHWA Office of Pavement Technology will review this deployment plan for concurrence. The experienced staff will then be used to deploy the use of recycled concrete aggregate in its most cost effective form to other STAs.

Resources:

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<th>Activity</th>
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<th>Money</th>
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<td>Travel for Reviews</td>
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<td>Deployment Materials Preparation</td>
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<td>Speakers Travel for 2003</td>
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<td>Administrative</td>
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Schedule:

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<th>End</th>
<th>Duration</th>
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<th>Q3 02</th>
<th>Q2 03</th>
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<th>Q4 03</th>
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<th>Q2 03</th>
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<td>9/25/2002</td>
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<td>7/18/2003</td>
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<td>10/22/2003</td>
<td>10/22/2003</td>
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<td>7</td>
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<td>9/8/2003</td>
<td>11/14/2003</td>
<td>50d</td>
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<td>8</td>
<td>Deployment plan development</td>
<td>9/8/2003</td>
<td>11/14/2003</td>
<td>50d</td>
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Recycled Concrete Aggregate
Federal Highway Administration National Review
Review Guide

Purpose
The purpose of this review is to capture for technical deployment the most advanced uses of recycled concrete aggregate (RCA) and then transfer the knowledge to all State Transportation Agencies (STA). Through this sharing of information, we intend to showcase how other STAs overcome barriers and advance the routine use of RCA. Specific uses or applications will be identified along with their barriers and benefits to implementation. Specifications, construction practices and implementation challenges will also be documented. This information will then be disseminated to all STAs through technical guidance, training, and guide specifications, as necessary.

Review Methodology
The RCA review will involve visiting several different states, meeting with state and industry personnel and some site visits. It is anticipated that the review will be completed in fiscal year 2003 with a final report published in 2004. The Recycled Concrete Aggregate (RCA) review team consists of FHWA, EPA, an AASHTO representative from the subcommittee on materials, and a representative of the American Concrete Institute technical committee on recycling (555).

The state visits will generally follow the same agenda. The Review Guide will be sent to the selected states 30 days before arrival. The local FHWA and STA representative will assist in arranging meetings and site visits.

Discussion Groups
Discussion groups will be used to gain knowledge about different activities and operations. Attached is a list of questions and issues that will be discussed at each discussion group. The following is a list of discussion groups and requested representation from the STA, FHWA, and other organizations:

- **Leadership** – Director of Transportation, Division Administrator, State EPA Director, State Environmental Assistance Agency.
- **Planning & Environmental** – Environmental Specialist and Planning Specialist, and State EPA/Environmental Assistance Agency.
- **Performance, Design, Materials and Research** – Pavement Management Engineer, Maintenance Engineer, Materials Engineer, Pavement Design Engineer, Structural Engineer, Materials, Specification, and Research Engineer.
- **Project Administration** (with first-hand experience using RCA) – Project Engineer, Prime Contractor, Aggregate Producer, Inspections Staff, and Laboratory Technicians.
- **Industry** - Local Association of General Contractors (AGC) Chapter, American Concrete Pavement Association (ACPA), Asphalt Industry, Crushed Concrete Industry and Aggregate Industry.
Site Visits
Site visits will be used to gain further insight into the overall operation and performance of projects with RCA, if possible. State Review Coordinators should limit site visits only to those where the visit will add value to the review. The following are examples of sites that may be desirable to visit:

- Previously constructed pavements & structures that utilized RCA.
- Current construction projects that are using RCA.
- Recycling facilities that process concrete rubble into RCA.
- Ongoing experimental research project sites involving RCA.

Materials
We would like to obtain specific documents that are related to the STA’s use of RCA. The following are examples of documents we would like to obtain:

- Vision, mission and strategic plan
- Environmental assessments & plans
- Environmental permits
- Pavement management performance data/curves
- RCA usage trends
- Design procedures
- Specifications
- Test Reports
- Demonstration/Research reports

Conclusion
A closeout meeting will be held on the last day of the review for all interested and available parties. When the reports from all state reviews are completed and compiled into a draft final report, a copy of the draft report will be mailed to the FHWA and STA Coordinators for their review and comment.
Leadership

1. What is your agency’s vision regarding the use of recycled concrete aggregate (RCA)? What is the driving force behind this vision?

2. What policies or practices have changed to support this vision? Do you foresee any changes in the next 5 years related to the use of RCA?

3. Is recycling an integral part of your strategic plan, annual plan, or other?

4. What is your agency’s current policy regarding the use of RCA?

5. What is your agency’s role in promoting the use of RCA?

6. What barriers have you overcome to increase the use of RCA?

7. Does your agency have dedicated staff for the purpose of implementing recycling programs and technology? If so, how many, and where are they located in your organization?

Estimated Time: 90 minutes
Planning & Environmental

1. How do you support the use of RCA (or recycled materials in general)?

2. What barriers have you overcome to increase the use of recycled concrete as aggregate (RCA)?

3. What barriers currently exist that prevent further use of RCA?

4. Provide a brief description of various uses of RCA in your state and usage trends.

5. Please describe your RCA quality requirements?

6. Please describe any challenges that have occurred at processing facilities or sites using RCA? What corrective action was performed?

7. Detail any major differences between site-specific or general procedures (i.e., sourcing, permits, specifications, approvals) for use of RCA and virgin aggregate material. Detail how these procedures and the associated information are coordinated within the department and other agencies.

8. What further research, laboratory work, or policy initiatives would be necessary to advance the use of RCA.

9. Provide details of any ongoing, completed or compiled research and demonstration projects regarding RCA.

10. Describe any instances where the use of RCA was precluded in a project and the circumstances or basis of the decision.

11. Specify any major differences between operating criteria (i.e., permits, approvals, testing, dust control, surface water and wash water management, sediment controls, stockpile management) for processing or use of RCA and virgin aggregate material. Detail how these procedures and relevant information are coordinated within the department and other agencies.
12. Does environmental documentation identify potential recycled materials that could be utilized on projects?

13. Are there any restrictions that recognize the previous use of contaminated or borderline contaminated recycled materials that may be present in the RCA (example: flyash with high metal content)?

14. What type of waste product is RCA defined as?

15. Are there any statutes or regulations that pertain to the use of RCA?

16. Do the statutes or regulations contain definitions concerning RCA?

17. Is there a permitting process for the use of RCA?

18. Are there any compliance evaluations performed on the use of RCA?

19. Are there any special considerations for transporting RCA?

20. Is disposal of RCA allowed in municipal solid waste landfills?

21. Is there any air emission standards specifically designed for the use of RCA?

22. What notification is required prior to destruction/construction activities associated with RCA?

23. Are there requirements to assure that there is no adverse impact to ground water or surface waters?

24. Describe the closure and post-closure monitoring and maintenance requirements applicable to construction activities with RCA.
Planning

1. During the development of your long-range plan, do you consider the use of recycling as part of the seven broad planning factors identified in TEA-21 to be considered in the planning process (economic, environmental, or system preservation). If not, when?

2. Is there an attempt to balance recyclable materials when identifying projects within the planning process?

3. Do you see benefits in considering RCA in the planning process?

Estimated time: 3 hours
Performance, Design, Materials, & Research

General
1. How do you support the use of RCA (or recycled materials in general)?

2. What was the driving force to decide to recycle?

3. What barriers have you overcome to increase the use of recycled concrete as aggregate (RCA)?

4. What barriers currently exist that prevent further use of RCA?

5. What further research, laboratory work, or policy initiatives would be necessary to assist you overcoming barriers?

6. Provide a brief description of various use trends of RCA in your state.

7. Please describe your RCA quality requirements?

8. Please describe any problems that have occurred at processing facilities or sites using RCA? What corrective action was performed?

9. When is the decision made about the use of RCA on a particular project?

10. Who determines the pavement type selection?

11. Does the STA consider the use of RCA in their reconstruction and/or rehabilitation pavement designs?

12. When determining the pavement type selection and then the detailed design, is RCA considered in a life cycle cost analysis? If so, what dollar values are used for construction and residual cost?
13. Are existing concrete sources, which are planned for removal and owned by the STA, reviewed to determine how the RCA could be used on future projects when removed? When does this occur?

14. Does the STA consider abutting land uses and local drainage characteristics when considering the use of RCA as part of the pavement structure?

15. Has anything in design limited the use of RCA in a project?

Pavement Thickness Design:

1. In which pavement layers are RCA’s allowed?

2. What design process do you use (i.e., AASHTO or mechanistic design)?

3. Are any adjustments made to structural coefficients, layer thicknesses, stiffness values or other parameters in the STA pavement design procedures because RCA is utilized?

4. If RCA is utilized as a surface course, have skid characteristics been investigated? Is there an effect on the micro-texture, and is it acceptable?

5. Does the method of construction and manufacturing of RCA impact the design of the pavement section?

Specifications

1. What are the differences in requirements for virgin aggregates and RCA materials?
   a. Characterization (i.e., method, end-result)
   b. Physical properties
   c. Acceptance (i.e., percent within limits, incentive disincentive)
   d. Etc.

2. Do the specifications provide enough latitude for contractors to bid RCA as an option? Explain answer and why.
3. Has the STA ever offered an incentive or value engineering proposal for the use of RCA?

4. Has alternate bidding been used with RCA?

5. Are contractors provided the flexibility to make the decision to utilize RCA when the material meets standard specification requirements, or does the state require additional approvals and testing? What are the differences?

Materials
1. Do you use source approval for the RCA? What is the acceptance criterion?

2. Do you approve stockpiles of RCA for use? What is the acceptance criterion?

3. Are the fines used in the new mixture? Are they stockpiled separately?

4. How do you monitor the moisture of the coarse and fine aggregates?

5. Have you performed any resilient modulus testing on materials with RCA incorporated?

6. Do you ever reuse RCA that was known to have exhibited D cracking? Where?

7. Have you ever reused RCA that was known to be alkali silica reactive? In what capacity was it used and how did it perform?

8. Have you observed any changes in constructability as a result of the usage of RCA as compared to virgin aggregates?

9. Do you perform a hardness test on the RCA? If so, which one? Are the results comparable to virgin aggregates?
**Base/Subbase**
1. What type of aggregate durability test is performed on RCA? Are the results comparable to tests performed on virgin aggregates?

2. Have you observed degradation in the gradation as a result of the use of RCA as compared to virgin aggregates?

**Hot Mix Asphalt**
1. Is freeze thaw testing (ASTM C 666) performed on the original and the proposed RCA mix? What method of testing is used?

2. What type of aggregate durability test is performed on RCA? Are the results comparable to tests performed on Virgin mixes?

3. How does the use of RCA impact the asphalt demand of the mix?

4. Have you investigated the impact of RCA on the HMA’s stripping potential?

5. Does the use of RCA impact the volumetric properties of the HMA mix?

6. Have there been any issues during paving that have had an adverse effect on achieving placement, consolidation, and finishing of the RCA concrete?

**Concrete**
1. Is a petrographic analysis (ASTM C 856) performed on the existing concrete to assess its potential use as a RCA?

2. Is a petrographic analysis (ASTM C 856) performed on PCC samples that have incorporated RCA to determine its microstructure?

3. Is freeze thaw testing (ASTM C 666) performed on the original and the proposed RCA mix? What method of testing is used?

4. What air content and air void distribution (ASTM C 457) criteria are required for concrete made with RCA?

5. Is D cracking reduced in RCA concrete compared to virgin concrete?
6. What type of aggregate durability test is performed on RCA? Are the results comparable to tests performed on virgin mixes?

7. Is the mortar bar test (ASTM C 1260 or ASTM C1293) performed on the RCA mixes?

8. Do the locally available portland cements typically have high alkali contents?

9. Is the total alkali content of a concrete mixture restricted in concrete made with virgin as well as RCA?

10. If deicers have been utilized, are the NaCl and the equivalent alkali content (Na₂O + .658K₂O) determined for both the RCA fines and coarse particles? Are these tests done as a function of depth from the surface?

11. What has your experience been with achieving a desired compressive or flexural strength for RCA mixes? Are you required to change the w/c ratio or admixtures as compared to virgin mixes?

12. What moisture state is specified for the RCA aggregates during batching and mixing? Has control of uniform moisture been an issue?

13. Have there been any observations on increased or decreased shrinkage for RCA concrete compared to virgin?

14. Do RCA concretes have similar workability as conventional concrete?

15. Have there been any issues during paving that have had an adverse effect on achieving placement, consolidation, and finishing of the RCA concrete?

16. Have you performed any studies on aggregate interlock performance with RCA as compared to virgin aggregates?

17. Are you aware of any environmental concerns, which have an effect on the materials properties of the RCA concrete?
**Pavement Management**

1. Have you perform any FWD testing to measure resilient modulus on RCA projects?

2. What are the typical resilient modulus values for RCA and virgin materials in similar situations?

3. Are their any particular distresses observed or not observed on projects that have used RCA as compared to virgin materials? (Do you have data to support this and can I have a copy?)

4. What is the typical form of distress that triggers rehabilitation or reconstruction of typical versus RCA pavement sections?

5. Have you developed any performance curves for RCA? If yes, how do I obtain a copy?

**Research**

1. Have you had any issues that have resulted into a research project?

2. What demo or research projects have been performed?

Estimated time: 4 hours
1. How do you support the use of RCA (or recycled materials in general)?

2. What barriers have you overcome to increase the use of recycled concrete as aggregate (RCA)?

3. What barriers currently exist that prevent further use of RCA?

4. What further research, laboratory work, or policy initiatives would be necessary to assist you overcoming barriers?

5. Provide a brief description of various use trends of RCA in your state.

6. Describe the different RCA operations you have experienced.
   a. What was the destruction process?
   b. What was the source of the material?
   c. What type of crushing operation was used (stockpiles and equipment)?
   d. Is there a specification that describes this process? Can we have a copy?

7. If steel or rebar is present, how is this removed?

8. What is your typical source of RCA (i.e., pavement, bridges, buildings)?

9. Discuss the fines content of the recycled material. Does the material need to be cleaned prior to stockpiling?

10. Are the fines restricted or limited in mixtures with RCA?
    a. Base
b. Asphalt  
c. Concrete

11. Please describe your feed system into concrete or HMA plants for RCA?

12. Source approval for recycled material and other virgin material?

13. What type of mixer is used, central mixer, truck mixer or portable mixer?

14. What types of admixtures are typically used? Any special considerations with the recycled concrete?

15. Does the use of pozzolans impact the use of RCA?

16. Provide a brief description of various markets for RCA in your service area and recent production, usage and pricing trends.

17. Provide details of any ongoing, completed or compiled research and demonstration projects regarding RCA.

18. Describe any instances where the use of RCA was precluded in a project and the circumstances of the situation.

19. Provide details on any problems that have occurred at your facility or a project site using RCA. Describe any corrective actions, monitoring and follow-up employed to address any problems or concerns.

20. What quality assurance procedures are employed to monitor the process and product of RCA?

21. Are there any construction issues different for RCA and virgin aggregates?

Estimated time: 2 hours
INDUSTRY

1. How do you support the use of RCA (or recycled materials in general)?

2. What barriers have you overcome to increase the use of recycled concrete as aggregate (RCA)? State and private work?

3. What barriers currently exist that prevent further use of RCA?

4. What further research, laboratory work, or policy initiatives would be necessary to assist you overcoming barriers?

5. Provide a brief description of various use trends of RCA in your state.

6. Please describe your RCA quality requirements.

7. Please describe any problems that have occurred at processing facilities or sites using RCA. What corrective action was performed?

8. What was the driving force to decide to recycle?

9. What product is the most desirable: coarse or fines? What do you do with the excess?

10. Are their any environmental policies, permits, or statutes that impact the way you process and handle RCA?

11. Do STA specifications provide enough latitude for contractors to bid RCA as an option? Explain answer and why.

12. Are contractors provided the flexibility to make the decision to utilize RCA when the material meets standard specification requirements, or does the state require additional approvals and testing?
13. Describe feed system into plant for recycled materials?

14. Source approval for recycled material and other virgin material?

15. What type of mixer is used, central mixer, truck mixer or portable mixer?

16. What types of admixtures are typically used? Any special considerations with the recycled concrete?

17. Use of other recycled materials such as fly ash, foundry sand, and GGBF slag in this mixture?

18. Any other types of special considerations at the plant when using a recycled concrete material?

19. Provide a brief description of various markets for RCA in your service area and recent production, usage and pricing trends.

20. Provide details of any ongoing, completed or compiled research and demonstration projects regarding RCA.

21. Describe any instances where the use of RCA was precluded in a project and the circumstances of the situation.

22. Provide details on any problems that have occurred at your facility or a project site using RCA. Describe any corrective actions, monitoring and follow-up employed to address any problems or concerns.

23. Detail any ongoing concerns or barriers regarding the use of RCA in the various applications that would benefit from further laboratory work, field testing, or policy clarification.

24. What barriers have you overcome and how was that achieved?
25. Are there any construction issues different for RCA and virgin aggregates?

26. Describe the closure and post-closure monitoring and maintenance requirements applicable to construction activities with RCA.
Estimated Time: 2 hours
# Recycled Concrete as Aggregate Review

## Schedule

<table>
<thead>
<tr>
<th>Location</th>
<th>Date</th>
<th>Review Team</th>
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<th>State Coordinator</th>
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