

# Recycled Concrete Aggregate Usage in the US

**Summary Report  
January 2018**

National Concrete Pavement  
Technology Center



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IOWA STATE UNIVERSITY  
Institute for Transportation

## **About the National CP Tech Center**

The mission of the National Concrete Pavement Technology (CP Tech) Center at Iowa State University is to unite key transportation stakeholders around the central goal of advancing concrete pavement technology through research, tech transfer, and technology implementation.

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The author and reviewers would like to thank the many state highway agencies (SHAs) and contractors that took the time to respond to the benchmarking survey documented in this summary report. Maria Masten, chair of the National Concrete Consortium, and Leif Wathne, executive vice president of the American Concrete Pavement Association, made invaluable contributions with their assistance in collecting the data to support this survey.

The National Concrete Pavement Technology Center thanks the Federal Highway Administration (FHWA) for the partnership and support in developing technical materials that address the technical barriers and will enable the broader use of recycled concrete aggregate (RCA) in future projects.





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## Introduction/Background

Recycling of concrete pavements has been a common practice in most states for many years, dating back to at least the 1940s with the reconstruction of US Route 66 in Illinois, when the existing pavement was recycled back into the new project. It is with renewed interest that public agencies are now more closely examining the opportunities for recycling concrete pavements.

In 2015, the Federal Highway Administration (FHWA) published a manual on sustainable construction, *Towards Sustainable Pavement Systems: A Reference Document* (Van Dam et al. 2015). The document identifies the opportunities to increase the recycling of concrete pavements, and the abstract states: “All stakeholders in the pavement community—from owner/agencies to designers, and from material suppliers to contractors and consultants—are embracing the need to adopt more sustainable practices in all aspects of their work, and are continually seeking the latest technical information and guidance available to help improve those practices.”

Another reason for considering recycling is the diminishing quantity of good natural materials. According to the *Mineral Commodity Summaries 2017* from the U.S. Geological Survey: “The construction sand and gravel industry remained concerned with environmental, health, permitting, safety, and zoning regulations. Movement of sand and gravel operations away from densely populated regions was expected to continue where regulations and local sentiment discouraged them. Resultant regional shortages of construction sand and gravel would likely result in higher-than-average price increases in industrialized and urban areas.” (USGS 2017)

However, many states still have specification or policy restrictions that do not allow recycled pavements to be utilized to the extent that is possible. In addition, the contracting industry may overlook opportunities to use recycled concrete aggregates (RCAs) on projects due to a lack of familiarity with the technical requirements or an uncertainty of how RCAs will perform for a specific application.

To gather insight on the current national practice of recycling concrete pavements, a two-part benchmarking survey was conducted in 2016 with the following goals:

- Document the current usage of concrete pavement recycling
- Understand the real and perceived barriers preventing more use of recycled products and the existing opportunities to increase the amount of recycling
- Guide the development of technical products and educational materials that will promote greater consideration of using recycled concrete as a construction material

The survey was conducted by the National Concrete Pavement Technology (CP Tech) Center in cooperation with the state highway agency (SHA) members of the National Concrete Consortium (NCC) and the American Concrete Pavement Association (ACPA). This information will be updated with a biannual survey to track the use of RCA in paving applications on a state-by-state basis.

The National CP Tech Center has worked with the FHWA and others, including the ACPA, to produce an array of technology transfer products related to the recycling of concrete pavements. The products that are available online or are in progress or planned are summarized below and will assist SHAs and the

concrete paving industry with addressing the technical challenges and current barriers to the broader use of RCA.

## Webinar Series

- Introduction to Concrete Pavement Recycling
- Construction Considerations in Concrete Pavement Recycling
- Environmental Considerations in Concrete Pavement Recycling
- Case Studies in Concrete Pavement Recycling

## Tech Briefs

- CP Road Map: Concrete Pavement Recycling and the Use of Recycled Concrete Aggregate in Concrete Paving Mixtures
- Concrete Pavement Recycling Series: Quantifying the Sustainability Benefits of Concrete Pavement Recycling
- CP Road Map: Concrete Pavement Recycling—Project Selection and Scoping
- Concrete Pavement Recycling Series: Protecting Water Quality through Panning and Design Considerations
- Concrete Pavement Recycling Series: Protecting the Environment during Construction

Additional RCA tech briefs may be developed as deemed appropriate under the cooperative agreement.

## Manual of Practice

- Recycling Concrete Pavement Materials: A Practitioner's Reference Guide (in press/forthcoming)

These products, along with other technical resources, are available for free download from the National CP Tech Center's website at <http://www.cptechcenter.org/concrete-recycling/>.

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## Opportunities to Use Sustainable Material Practices with Concrete Pavements

Concrete pavements are typically built with materials that beneficially incorporate industrial waste streams as well as recycled pavement materials. These materials are used to enhance engineering properties, improve economics, and reduce environmental impacts. While not the focus of the survey documented in this report, it is important to note that other material components (in addition to RCA in bound and unbound applications) are being used to improve concrete pavement sustainability, as described below.

### Cementitious System

The cementitious system used in modern concrete pavements typically takes advantage of blended cements (blending ordinary portland cement [OPC] or portland limestone cements [PLCs] with fly ash, slag, and other pozzolans) to produce binary and ternary combinations (see Van Dam 2013).

From the initial project applications in the 1970s to today, there have been significant advancements in understanding how supplementary cementitious materials (SCMs) can enhance concrete properties and, at the same time, save money and reduce the environmental impacts.

## Reinforcing Elements

Currently, almost all reinforcing steel and dowel bar reinforcement products used in pavements are made with recycled steel.

The vast majority of reinforcing steel has recycled material content typically greater than 97 percent (ASTM A615 and A706). Specialty reinforcing steel products have a recycled material content typically greater than 75 percent (CRSI 2011).

## Aggregates

Aggregates make up the largest volume of material used in concrete. Using existing concrete to meet the aggregate needs for a concrete mixture has been a proven practice for many years. Concrete recycling has been used extensively in Europe since the 1940s and in the US since the 1970s (NHI 1998).

Concrete recycling for paving applications is now implemented in at least 41 states (FHWA 2004). Annual production of RCA in the US from all sources (both pavements and demolition debris) was recently reported as about 140 million tons (CDRA n.d.). Another source of RCA being used is crushed returned concrete from ready-mix plants (5 percent of the 455 million cubic yards annual production of ready-mixed concrete is returned to the plant) (Obla et al. 2007)).



One of the first uses of RCA in pavement construction was on US Route 66 in Illinois in the 1940s. Concrete from a portion of the existing two-lane concrete roadway was crushed and stockpiled for use as aggregate in the second two lanes of the highway when it was expanded to four lanes after World War II (Epps et al. 1980). Concrete recycling became more common in the years that followed, and the practice has been adopted extensively in the US since the 1970s (NHI 1998).

Two-lift concrete pavements have been utilized as a pavement design concept to allow maximum use of RCA in the lower lift while giving the flexibility to optimize the top layer to meet the project's service conditions. Two-lift paving is not a new concept; in fact the first concrete pavement built in the US in 1891 in Bellefontaine, Ohio used this concept. Two-lift pavements have been commonly used in Austria since the 1980s, and have been used on several recent projects in the US, including the Illinois Tollway's reconstruction projects on I-90.

Whether put back into the concrete paving mixture as aggregate or utilized in other applications, RCA is often selected over virgin material as an economical alternative to natural aggregate while offering comparable or better performance in many applications.

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## Survey on RCA Utilization in Roadway Applications

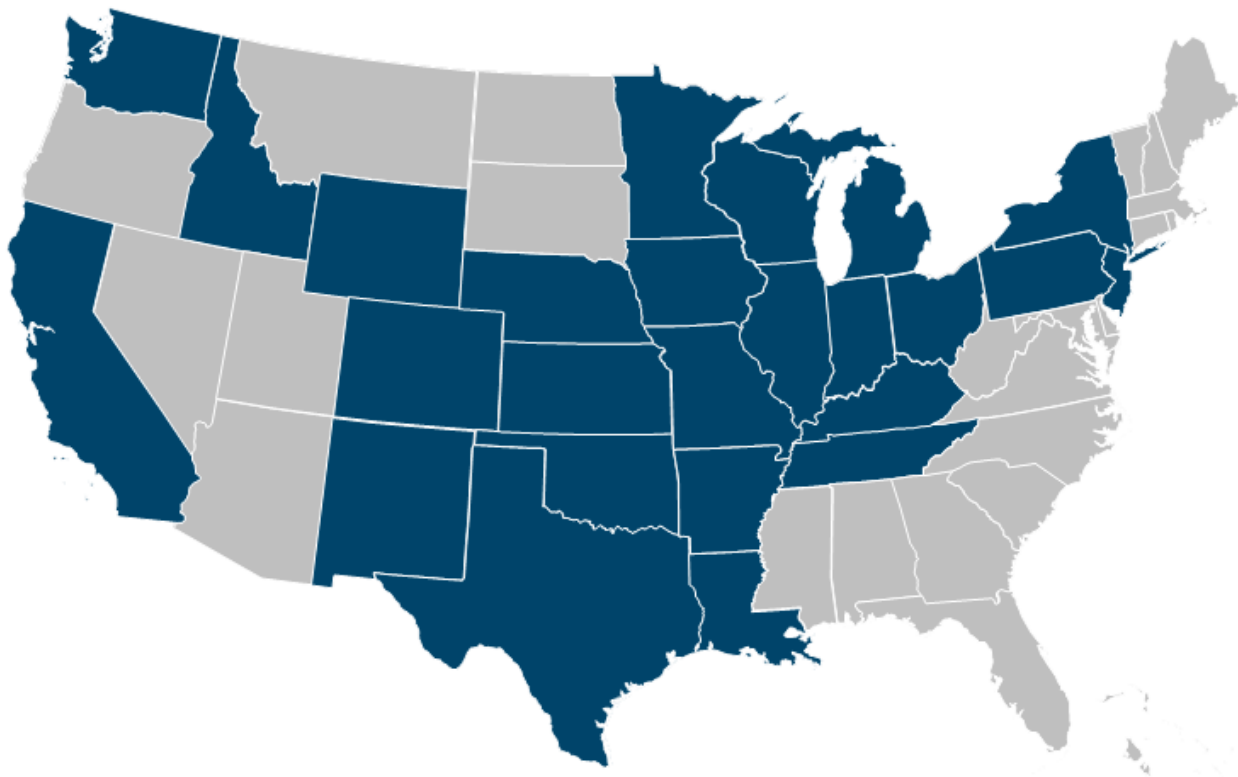
A two-part benchmarking survey was conducted during the first quarter of 2016 with the support of the ACPA. One set of survey questions was aimed at gathering information from SHAs while another set of questions was targeted to contractors who are involved with recycling concrete pavements on projects.

**Objective:** The objectives of the survey were to gather information on the utilization of RCA in the US concrete paving market and to identify persistent barriers to the use of RCA.

**Survey methodology:** The National CP Tech Center worked with the SHA members of the NCC to collect the agency responses (see Appendix A). The ACPA surveyed its members to gather the contractor input (see Appendix B). The results were combined for the assessment on RCA utilization and barriers.

### Summary of Key Findings

Figure 1 shows the states (in dark blue) represented by the survey findings, which included input from 14 DOTs plus the Illinois Tollway Authority and 24 contractor firms.



**Figure 1. States represented by the SHAs and contractor firms that responded to the survey questions**

#### **SHA Responses (15 usable responses were received)**

- Current Utilization:
  - All agencies allowed use of RCA in a variety of products and two-thirds have the goal of increasing usage

- All of the SHAs that responded permit the use of RCA in unbound applications, such as subbases, bases, shoulders, and erosion control
- The most common RCA applications were in unbound bases and shoulder material
- Barriers:
  - General
    - Most SHAs simply give the contractor the responsibility to comply with state and federal environmental requirements (see contractor barriers)
    - In most cases, potential cost savings from using RCA are not considered in the economic analysis for a project, other than what is being reflected in the agency's historical unit bid prices
  - RCA used in paving mixtures
    - Only 40 percent (6 of 15 agencies) allow RCA in concrete mixtures. The barriers identified include the following:
      - Quality of the source concrete; typically material-related distress (MRD) concerns
      - Lack of technical guidance on mixture design and proportioning to achieve equivalent performance to virgin aggregate mixtures
      - Uncertainty of the economics of using RCA in paving mixtures when good natural aggregate sources are available
    - For those agencies that allow RCA in paving mixtures, no adjustments are made to the pavement design inputs
  - RCA used in unbound applications
    - Potential barriers of using RCA in pavement foundations were not perceived as significant
    - No adjustments were made to the structural value of RCA versus virgin material used in unbound applications
    - Most common environmental concern was water quality (pH and tufa/calcium carbonate precipitate)
- Recommendations:
  - Review specifications and remove restrictions on the use of RCA that lack technical basis
  - Increase knowledge of the national practice related to RCA
  - Provide contractors with flexibility on how to best utilize recycled materials on a project, depending on the products needed, available local material, project staging, and material availability for processing
  - Collaborate with state and federal regulatory agencies to clarify and streamline the permitting requirements
  - Provide guidance on appropriate means of mitigating potential environmental impacts, as well as allowable beneficial reuse applications for residuals

### **Contractor Responses (24 usable responses were received)**

- Current Utilization:
  - All respondents worked on state projects and about half also completed local and private contracts; the data represents 1,063 projects (awarded in 2014) in 19 states, which also represents approximately 15 percent of the national paving volume

- Most contractors relied on firms specializing in pavement removal and material processing to accomplish the recycling
- 54 percent of the contractors indicated they recycled 81 percent to 100 percent of the pavement removals
- 92 percent of the contractors indicated they recycled more than 20 percent of the pavement removals
- More than half of the concrete not recycled on the source project was stockpiled for future recycling
- Much of the concrete that was not recycled on the source project was utilized on other projects or marketed commercially
- RCA utilization was approximately:
  - 40 percent granular subbase
  - 15 percent concrete mixtures and stabilized bases
  - 19 percent other unbound applications
  - 18 percent crushed for other markets
  - 7 percent given to the owner agency
- Barriers:
  - General
    - The most common reason for not recycling was specification limitations followed by it being cost-prohibitive
    - About 20 percent of the contractors indicated that environmental concerns limited RCA utilization
    - The most commonly stated environmental barriers to recycling related to the following:
      - Permitting and unclear regulations
      - Dust generation
      - Noise generation
      - Wastewater runoff
    - The threshold that justifies recycling is low; 9 of the 24 firms indicated that they recycle all pavement removed, and 11 of the 24 indicated that the minimum quantity needed is less than 5,000 cubic yards
- Recommendations:
  - Communicate with SHAs on how to improve current specifications and designs to utilize more RCA in an economical manner
  - Train personnel on how to produce RCA to consistently meet agency specifications
  - Become proficient in concrete mixture proportioning and placement using RCA
  - Adopt a corporate philosophy of striving to use 100 percent of pavement removals in an RCA application

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## Conclusions

Incorporating RCA products into highway applications can provide benefits to owner agencies. A key to realizing these benefits and the intended design performance is to remember that RCA is an engineered material and that there are many effective ways to incorporate RCA into a project.

It is recommended that project requirements give the contractor flexibility to determine the most cost-effective use of RCA at the project level. Developing a project-level approach with the proper specifications, RCA material requirements, and a contractual framework to allow flexibility in the choice of the RCA applications on the project results in the best value proposition for the owner agency.

## Summary

- Agencies and contractors are interested in increasing the use of RCA
- Production and use of RCA is common on most projects involving concrete pavement removal
- There are opportunities to increase the total volume of RCA use
- The threshold for economical recycling appears to be relatively low (i.e., less than 5,000 cubic yards)
- Unbound applications of RCA are the most common, with bases being the predominant use
- Agencies rely on state and federal regulatory agencies for environmental compliance
- Most agencies have less stringent technical requirements for RCA when the RCA is obtained from the agency's own infrastructure
- There appears to be a lack of knowledge and experience on how to utilize RCA as an engineered material in concrete mixtures
- Barriers that appear to restrict the use of RCA include the following:
  - Restrictive specifications
  - Complex permitting regulations
  - Lack of knowledge on how to use RCA without compromising performance
  - Lack of knowledge on how to address potential environmental concerns related to RCA while in service

## Plans to Track/Keep an Inventory of Materials Removed in 2017

For projects where materials were removed in 2017, the ACPA intends to track the quantities of those materials that were then recycled by asking member contractors to complete an annual inventory on a project basis. The ACPA intends to work proactively to train member firms and to support the FHWA and SHAs in specification and policy development that enables the beneficial use of existing concrete pavements.

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## References

- CRSI. 2011. *Understanding USGBC and LEED 2009 – A Primer for CRSI Members*. Architectural Technical Note ATN-S-1-11. Concrete Reinforcing Steel Institute, Schaumburg, IL.  
<http://resources.crsi.org/index.cfm/api/render/file/?method=inline&fileID=2A070108-AFDE-AA98-A30AE7E817B43798>.
- CDRA. no date. *Good Economic Sense*. Construction & Demolition Recycling Association, Milwaukee, WI.  
<https://cdra.memberclicks.net/concrete-recycling>.
- Epps, J., D. Little, R. Holmgren, and R. Terrel. 1980. *NCHRP Report 224: Guidelines for Recycling Pavement Materials*. National Cooperative Highway Research Program, Washington, DC.
- FHWA. 2004. *Transportation Applications of Recycled Concrete Aggregate*. Federal Highway Administration, Washington, DC. <https://www.fhwa.dot.gov/pavement/recycling/applications.pdf>.
- NHI. 1998. *Techniques for Pavement Rehabilitation: A Training Course – Participant’s Manual*. FHWA-HI-99-006. National Highway Institute, Washington, DC.
- Obla, K., C. Lobo, and H. Kim. 2007. *Crushed Returned Concrete as Aggregates for New Concrete*. Final Report to the RMC Research Education Foundation. Project 05-13. RMC Research and Education Foundation, Silver Spring, MD.
- USGS. 2017. *Mineral Commodity Summaries 2017*. U.S. Geological Survey, Reston, VA.  
<https://minerals.usgs.gov/minerals/pubs/mcs/2017/mcs2017.pdf>.
- Van Dam, T. 2013. *Supplementary Cementitious Materials and Blended Cements to Improve Sustainability of Concrete Pavements*. National Concrete Pavement Technology Center, Ames, IA.
- Van Dam, T., J. Harvey, S. Muench, K. Smith, M. Snyder, I. Al-Qadi, H. Ozer, J. Meijer, P. Ram, J. Roesler, and A. Kendall. 2015. *Towards Sustainable Pavement Systems: A Reference Document*. FHWA-HIF-15-002. Federal Highway Administration, Washington, DC.  
<https://www.fhwa.dot.gov/pavement/sustainability/hif15002/hif15002.pdf>.



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# Appendix A: Recycled Concrete Aggregate (RCA) State Departments of Transportation Benchmarking Survey

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## Survey Objectives:

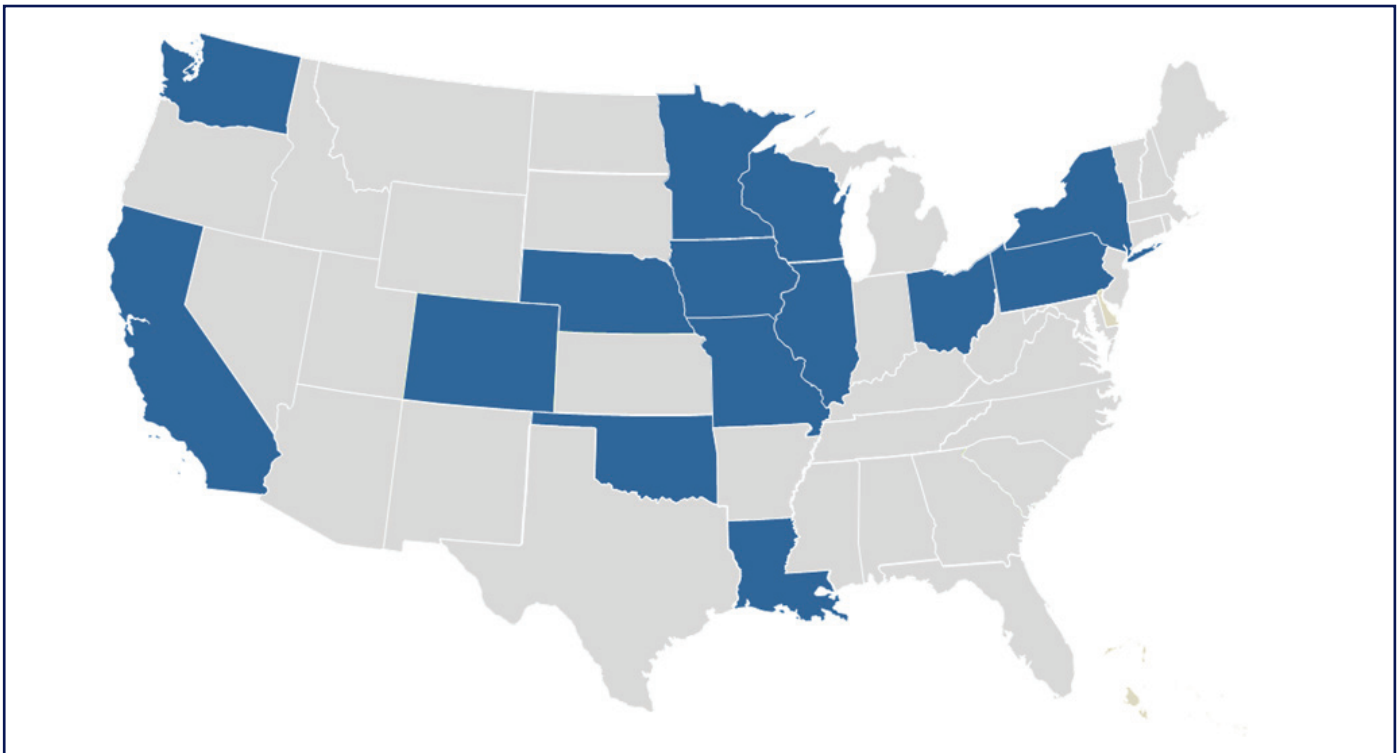
The information gathered through this survey will be used to estimate the utilization of RCA across the US as well as to identify persistent barriers to the use of RCA. Once compiled, this information will be available for sharing with agencies, consultant engineers, and contractors and will ultimately guide the development of strategies aimed at maximizing the use of RCA.

## Survey Instructions:

1. Read all questions before beginning the survey.
2. Answer all of the questions with respect to projects in the 2014 calendar year.
3. Include all projects that included any quantity for removal of existing concrete pavement and/or concrete pavement with an asphalt overlay.
4. For purposes of this survey, rubblization and/or crack and seat is not considered as a recycling process.

**Note: DOT survey responses. 15 agencies responded to the survey. Not every questions was completed by all respondents.**

### 1. State Departments of Transportation Responding to the Survey (14 DOTs plus the Illinois Tollway Authority)

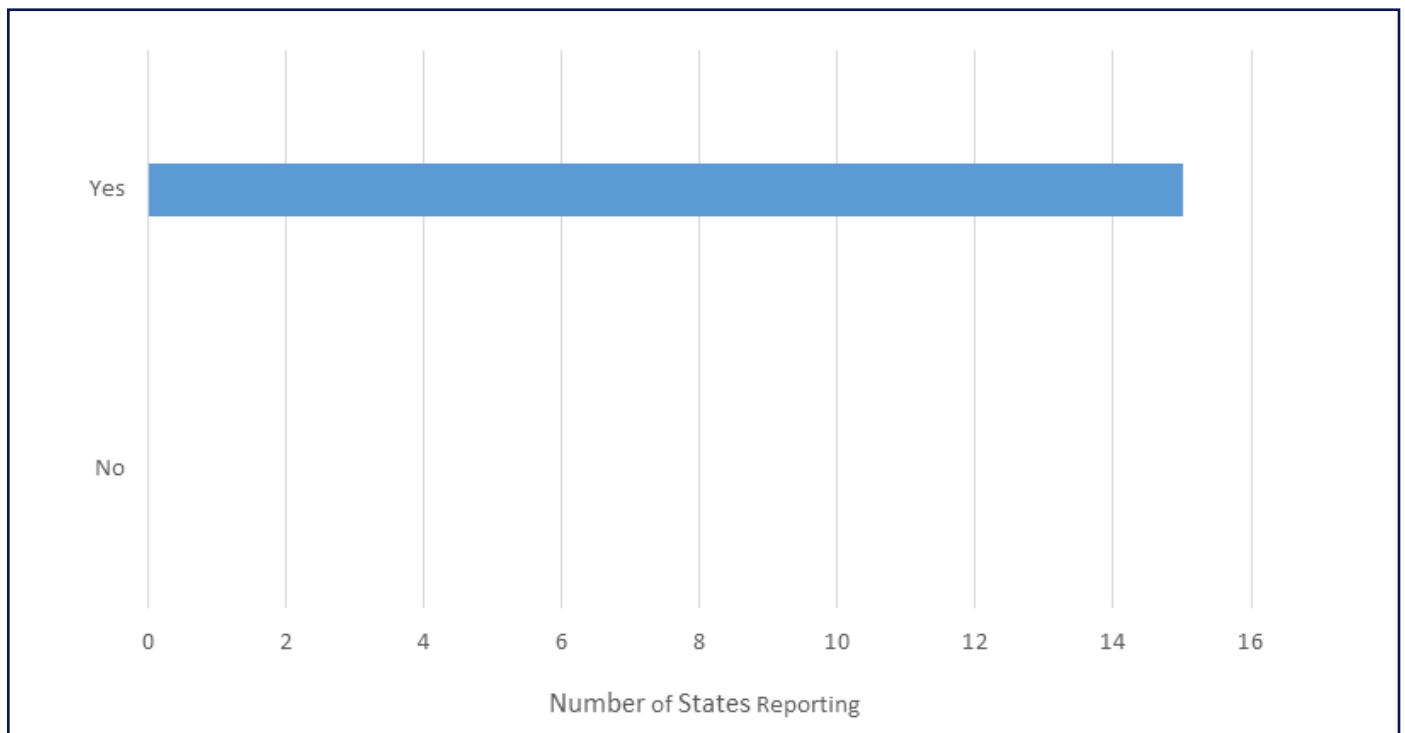


# Appendix A: Recycled Concrete Aggregate (RCA) State Departments of Transportation Benchmarking Survey

## 2. What are your agency's current goals regarding the use of recycled concrete aggregate (RCA)?

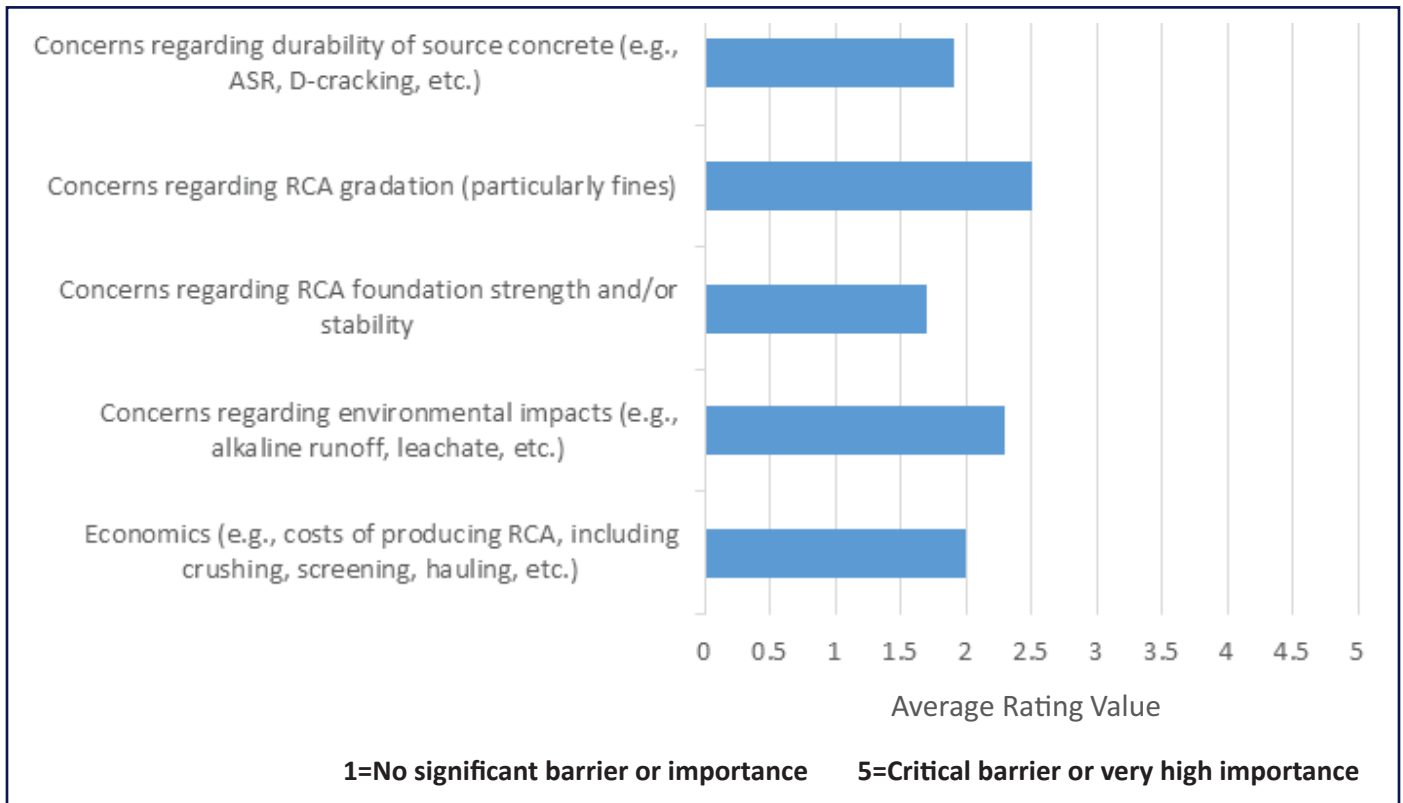
- No stated goals, but currently allow RCA usage: —2 responses
- Currently allow and goal is to increase usage in an environmentally sensitive way: —10 responses
- Currently allow where RCA will: —3 responses
  - perform similar to virgin material
  - save money

## 3. Do you permit the use of recycled concrete in subbases, bases, shoulders, and erosion control?

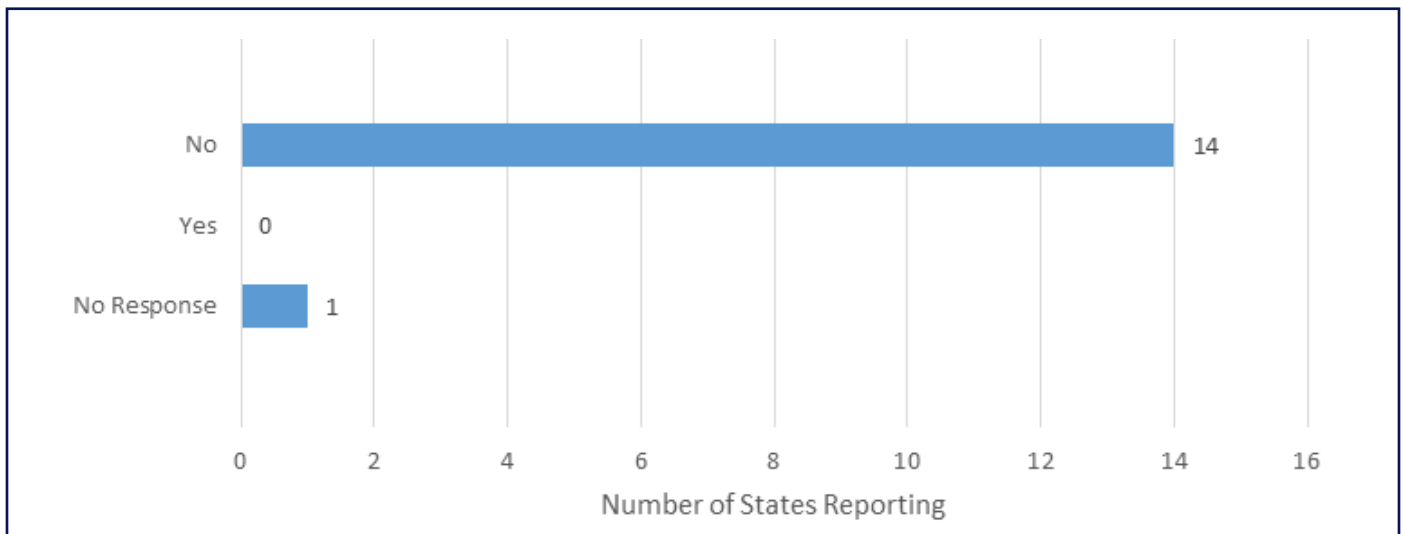


# Appendix A: Recycled Concrete Aggregate (RCA) State Departments of Transportation Benchmarking Survey

4. Rate the importance (or magnitude) of the following potential barriers within your agency to using recycled concrete aggregate (RCA) in pavement foundations.

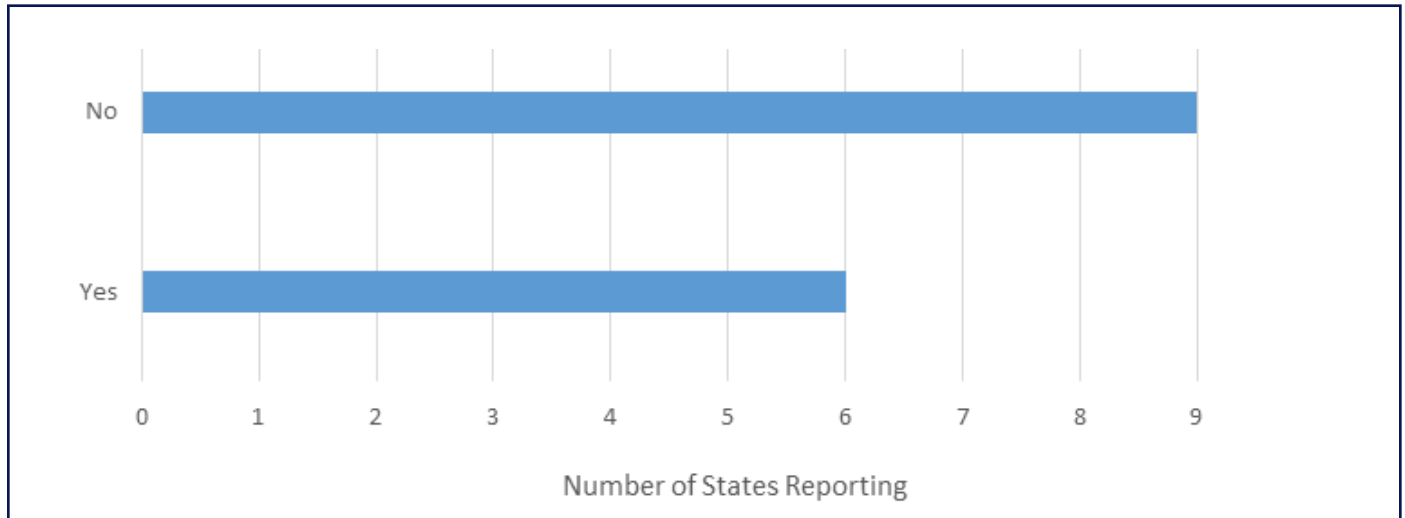


5. If your agency allows the use of RCA in pavement foundation layers, are any adjustments made to the foundation design inputs in the state pavement design procedures for determining the thickness of the pavement surface layer (e.g., different structural layer coefficients, different effective k-values, different E values, etc. when compared to typical unbound aggregate foundation layers)?

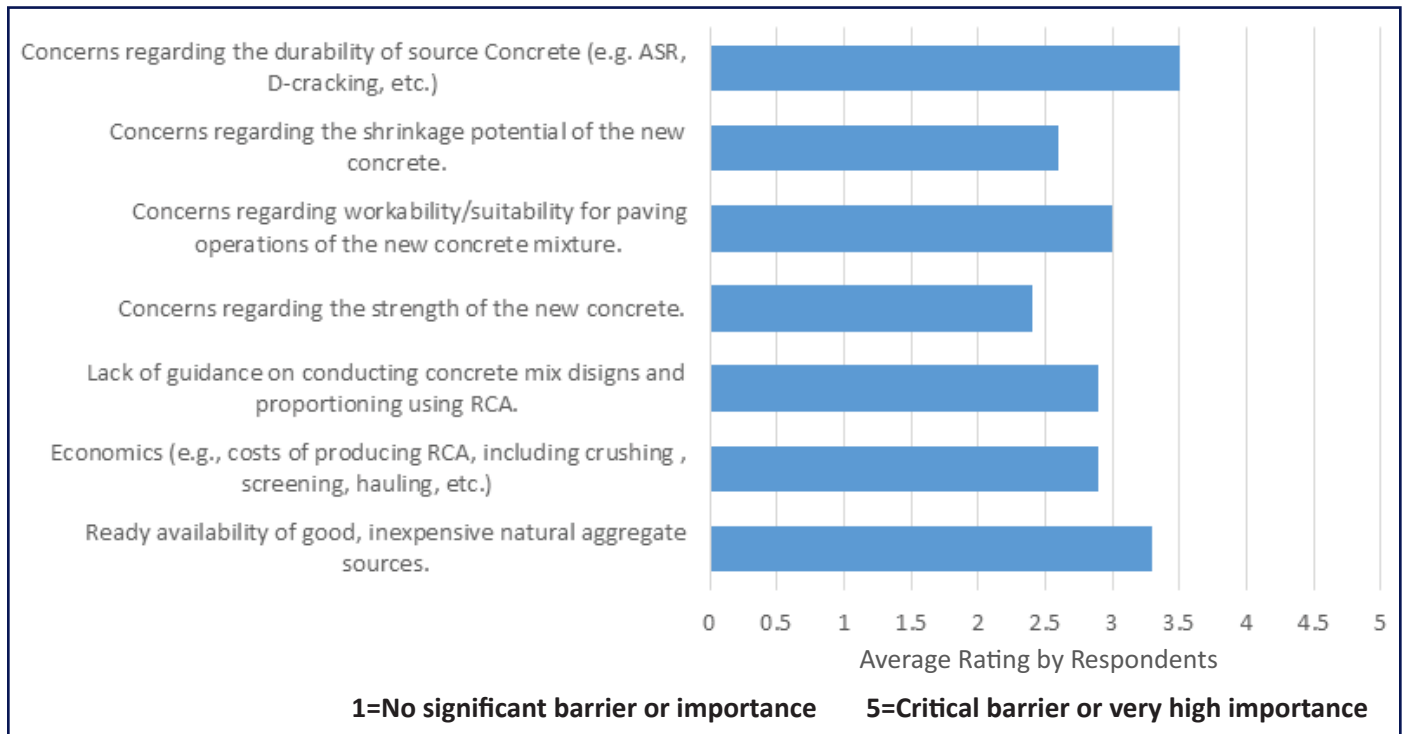


# Appendix A: Recycled Concrete Aggregate (RCA) State Departments of Transportation Benchmarking Survey

6. Do you permit the use of recycled concrete aggregate (RCA) in concrete mixtures?

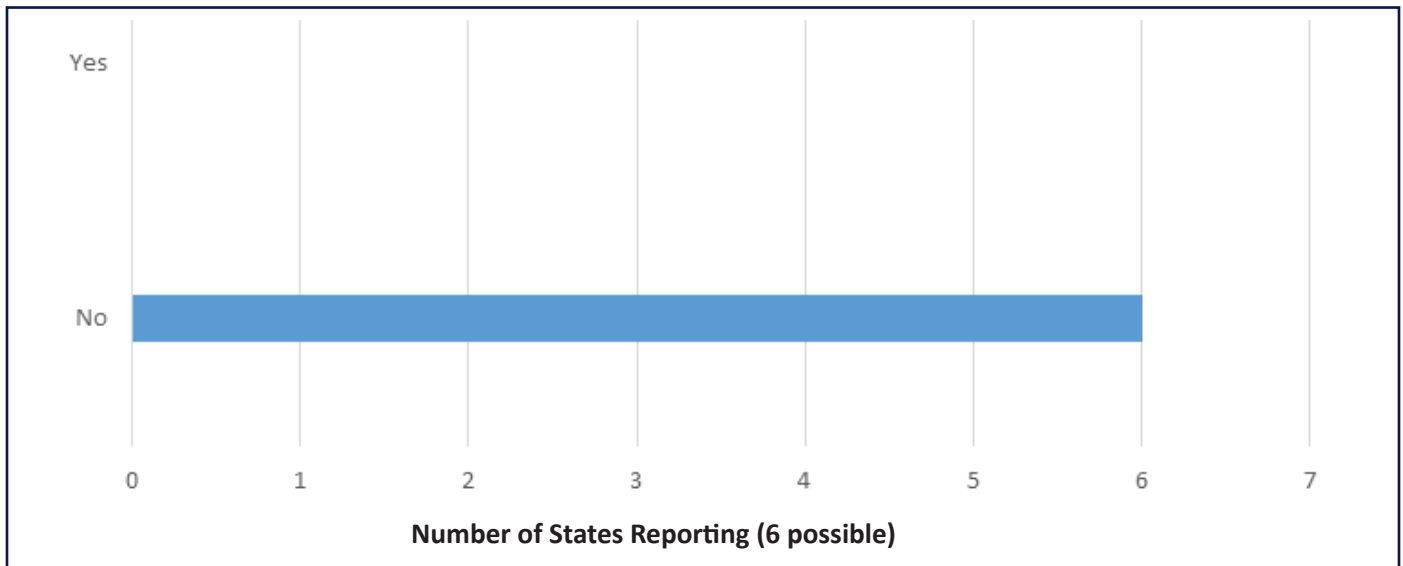


7. Rate the importance (or magnitude) of the following potential barriers within your agency to using recycled concrete aggregate (RCA) in new concrete mixtures.

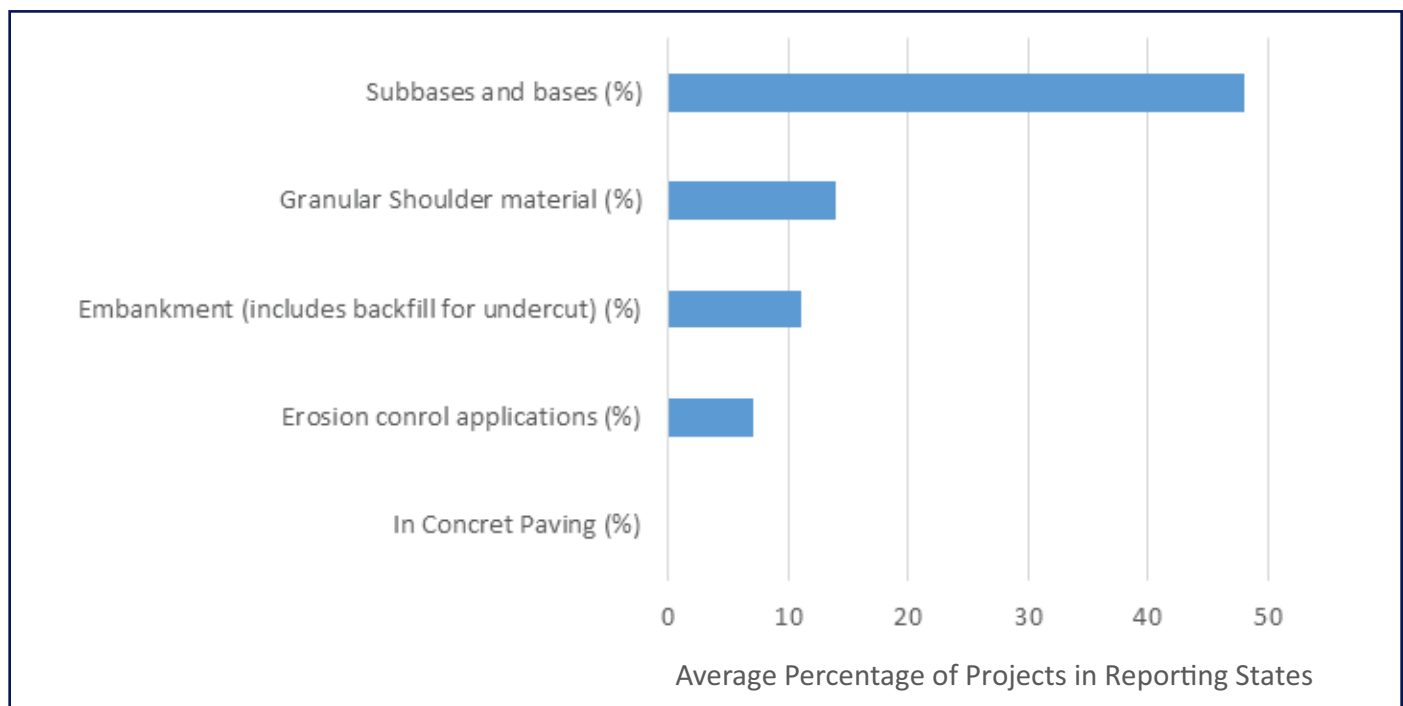


## Appendix A: Recycled Concrete Aggregate (RCA) State Departments of Transportation Benchmarking Survey

8. If your agency allows the use of RCA in new concrete pavement surface materials, are any adjustments made to the design inputs in the state pavement design procedures for determining the thickness of the pavement surface layer (e.g., different structural layer coefficients, different E value, different design strength, different coefficient of thermal expansion, etc.) when compared to the values used when the concrete comprises only natural aggregate?

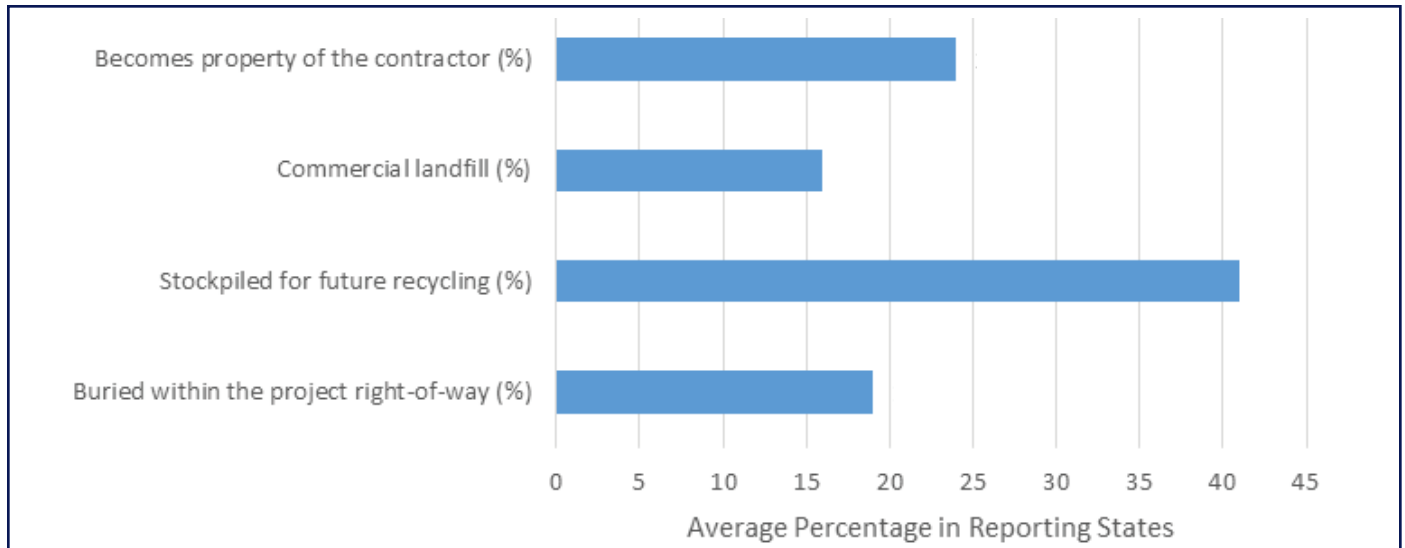


9. What percentage of projects in your state DOT makes use of RCA in...?  
*10 states provided data.*



## Appendix A: Recycled Concrete Aggregate (RCA) State Departments of Transportation Benchmarking Survey

**10. For concrete pavement removed and not recycled or reused in any manner, how was it disposed of?**  
*Eight states responded.*



**11. Overall, are environmental concerns cited as barriers to use of RCA in pavement, foundation base layers, and/or other concrete mixtures? Please briefly describe the actual or perceived barriers as related to permitting, mitigation efforts, costs, training, etc.**

*11 states responded. Specific concerns are noted below. The balance responded that the environmental concerns are not barriers and can be addressed.*

- Water quality (alkaline runoff, leachate, transported sediments, etc.)
  - Plugging Drains—3 responses
  - High pH—3 responses
  - Concern in high quality drainage areas—2 responses
  - Perceived permitting barrier—1 response
- Air quality (equipment emissions, dust)
  - Perceived permitting and cost barrier
- Noise (processing)
- Waste generation and disposition (solids, wastewater, slurries, etc.)
  - Large concern
  - High pH

**12. If specific environmental concerns or barriers actually prevented use of RCA in pavements, foundation base layers, or other concrete mixtures in one or more of your projects, what were the reasons?**

*Ten states reported no projects were prevented in using RCA because of environmental concerns. Of the five states that reported restrictions that prevented use of RCA on projects the following reasons were cited:*

- a. Water quality concerns associated with stockpile runoff—0 responses
- b. Water quality concerns associated with leachate from new use—3 responses

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## **Appendix A: Recycled Concrete Aggregate (RCA) State Departments of Transportation Benchmarking Survey**

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- c. Other water quality concerns (please describe)—1 response (Tufa, calcium carbonate participate)
- d. Air quality concerns associated with processing/handling—0 responses
- e. Noise concerns associated with processing/handling—0 responses
- f. Waste generation and disposition concerns (solids, wastewater, slurries, etc.)—2 responses
- g. Lack of guidance associated with environmental regulations—2 responses
- h. Delays and/or cost associated with environmental permitting and/or mitigation efforts—1 response
- i. Other environmental concerns (please briefly describe)—0 responses

### **13. If your agency is currently utilizing RCA:**

**What measures (if any) do you require to address environmental concerns related to water quality (stockpile management, testing for alkalinity/chemical contaminants, etc.)?**

- Compliance with state and federal requirements—13 responses
- In addition
  - Pre-approval of equipment and processing site—1 response
  - Restrict use around metal pipes and near plantings—1 response

**What measures (if any) do you require to address environmental concerns related to air quality (dust control, handling techniques, testing, etc.)?**

- Compliance with state and federal requirements—14 responses
- In addition
  - Restrict recycling in residential areas—1 response

**What measures (if any) do you require to manage waste generation and disposition (solids, slurries, wastewater, etc.)?**

- Compliance with state and federal requirements—14 responses
- In addition
  - Regulations under development—1 response

### **14. Are strategies to mitigate environmental impacts associated with RCA production and use currently incorporated into your current specifications, special provision, or permitting requirements?**

- Yes—3 responses
- No, Just require compliance with state and federal requirements—12 responses

### **15. Do you consider potential savings from the use of recycled material in your economic analysis for projects?**

- No—10 responses
- Unknown—1 response
- Yes, reflected in unit prices used for project cost estimating—2 responses
- Yes—2 responses





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## Appendix B: Recycled Concrete Aggregate (RCA) Paving Industry Benchmarking Survey

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### Survey Objectives:

The information gathered through this survey will be used to estimate the utilization of RCA across the US as well as to identify persistent barriers to the use of RCA. Once compiled, this information will be available for sharing with agencies, consultant engineers, and contractors and ultimately guide the development of strategies aimed at maximizing the use of RCA.

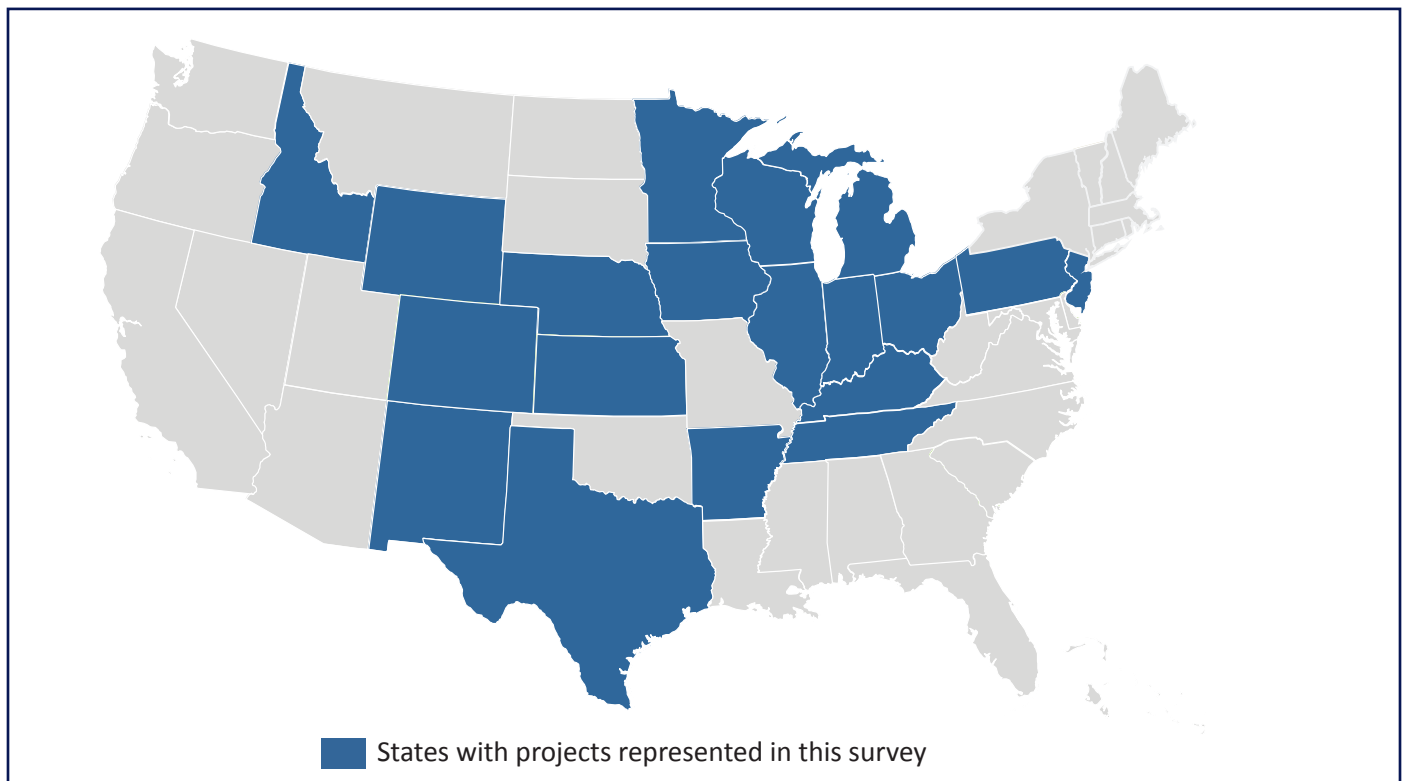
### Survey Instructions:

1. Read all questions before beginning the survey.
2. Answer all of the questions with respect to projects awarded to your firm in the 2014 calendar year.
3. Include all projects that included any quantity for removal of existing concrete pavement and/or concrete pavement with an asphalt overlay.
4. For purposes of this survey, rubblization and/or crack and seat is not considered as a recycling process.

### Survey Questions:

Answers represent 24 firms with work in the following states in 2014.

1,063 projects were represented by the survey responses.



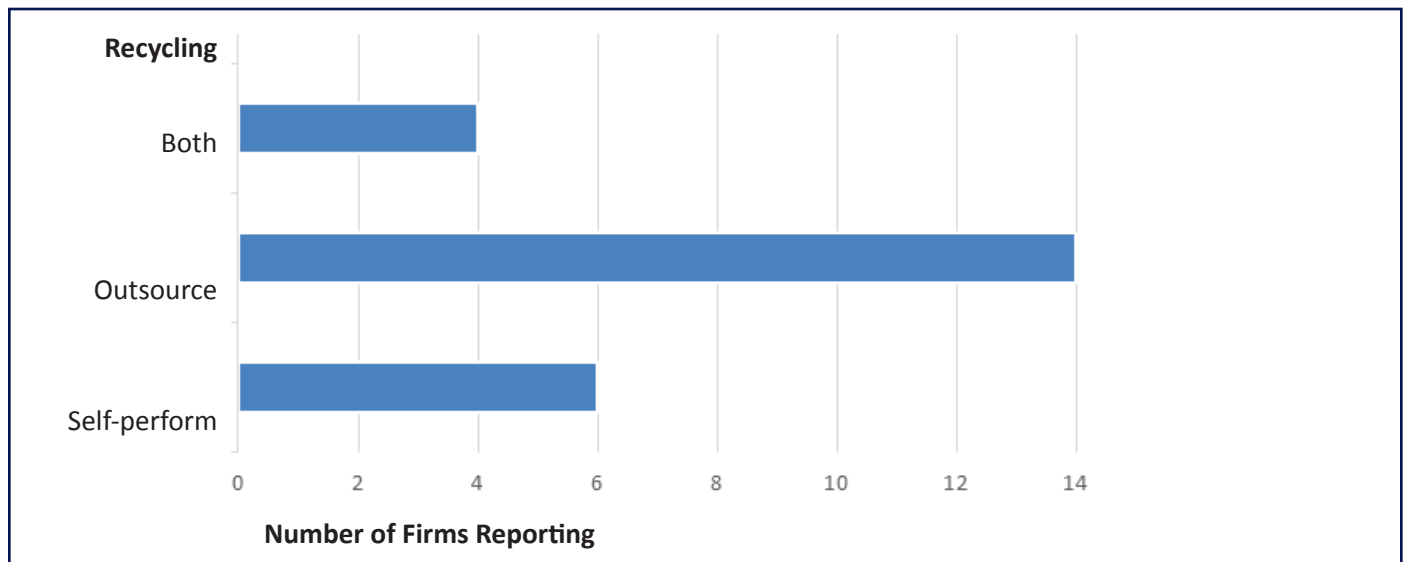
## Appendix B: Recycled Concrete Aggregate (RCA) Paving Industry Benchmarking Survey

1. Answers reflect projects with (check all that apply) \_\_\_State; \_\_\_County; \_\_\_City; \_\_\_Private

Types of projects represented				
Number of firms	State	County	City	Private
8 Firms	X			
7 Firms	X	X	X	X
4 Firms	X	X	X	
2 Firms	X		X	
1 Firm	X			X
1 Firm	X	X		
1 Firm	X	X		X
<b>Total 24 Firms</b>	<b>24</b>	<b>13</b>	<b>12</b>	<b>9</b>

2. Does your firm (check all that apply):

- a. Self-perform concrete recycling?
- b. Outsource (subcontract) concrete recycling?
- c. Other (specify)?



## Appendix B: Recycled Concrete Aggregate (RCA) Paving Industry Benchmarking Survey

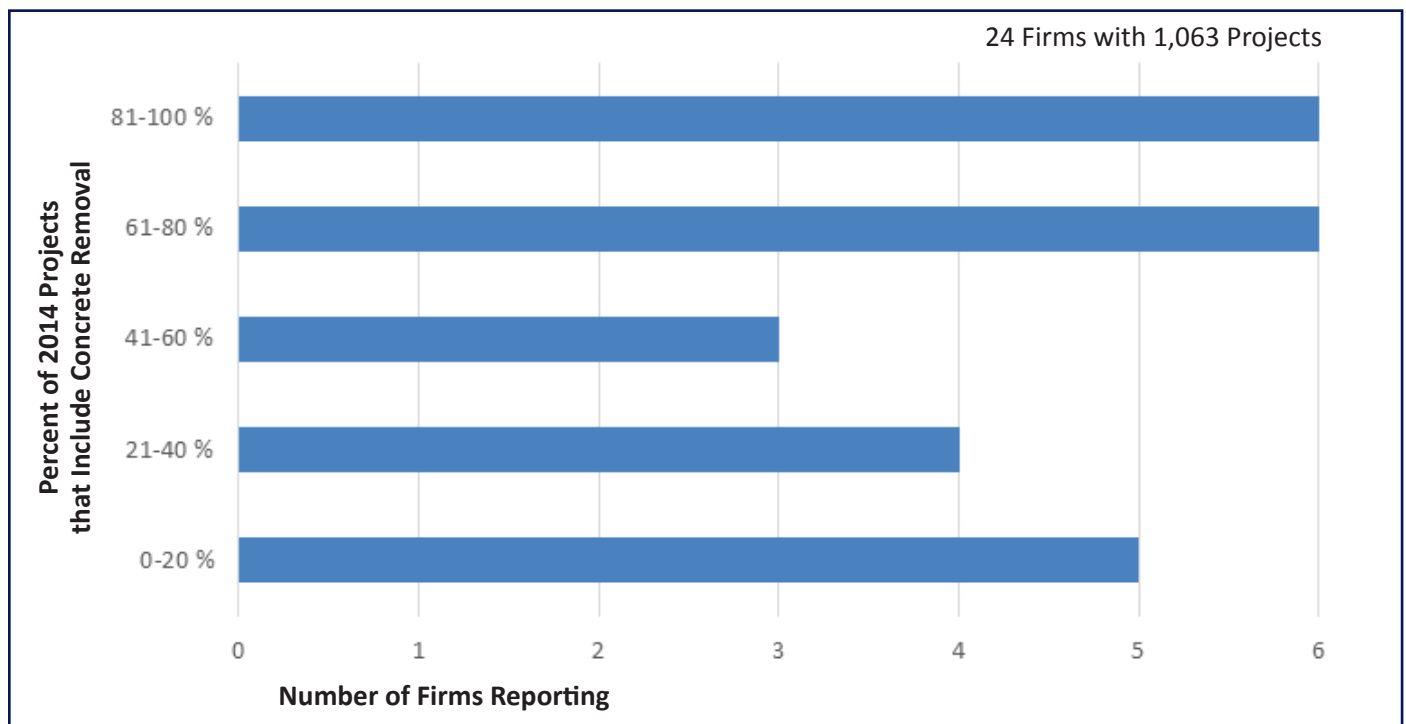
### 3. How many paving projects was your firm awarded in 2014?

1,063 projects represented

Approximately 15% of the national volume

### 4. What percentage of the paving projects awarded to your firm in 2014 included removal of concrete pavement and/or removal of concrete pavement with an asphalt overlay?

- a. 0% to 20%
- b. 21% to 40%
- c. 41% to 60%
- d. 61% to 80%
- e. 81% to 100%

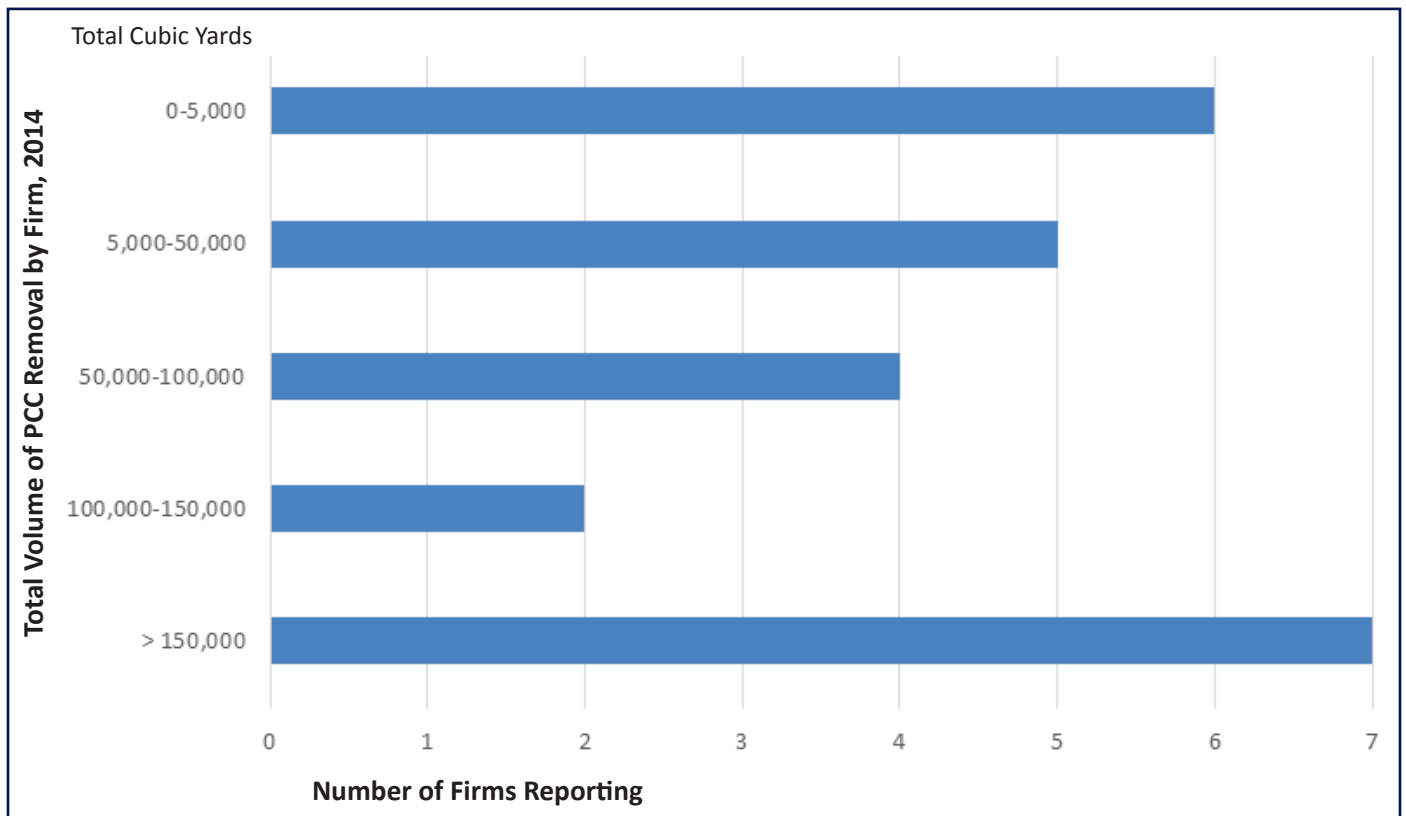


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## Appendix B: Recycled Concrete Aggregate (RCA) Paving Industry Benchmarking Survey

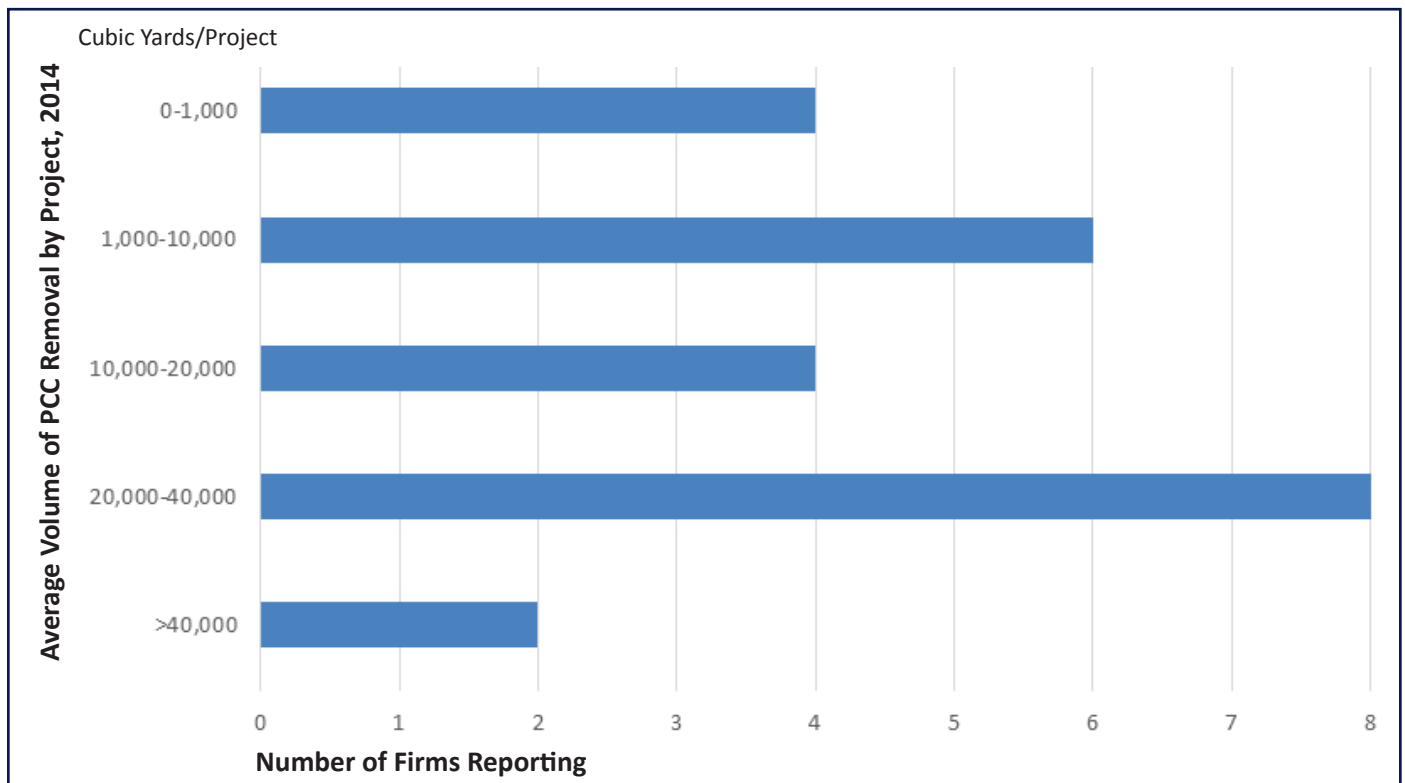
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5. Of the projects that included removal of concrete pavement and/or removal of concrete pavement with an asphalt overlay, what was the total volume of concrete removals awarded to your firm in 2014?
- a. 0 to 5,000 cy
  - b. 5,001 to 50,000 cy
  - c. 50,001 to 100,000 cy
  - d. 100,001 to 150,000 cy
  - e. Greater than 150,000 cy



## Appendix B: Recycled Concrete Aggregate (RCA) Paving Industry Benchmarking Survey

6. Of the projects that included removal of concrete pavement and/or removal of concrete pavement with an asphalt overlay, what was the average volume of concrete removals per project awarded to your firm in 2014?
- a. 0 to 1,000 cy
  - b. 1,001 to 10,000 cy
  - c. 10,001 to 20,000 cy
  - d. 20,001 to 40,000 cy
  - e. Greater than 40,000 cy

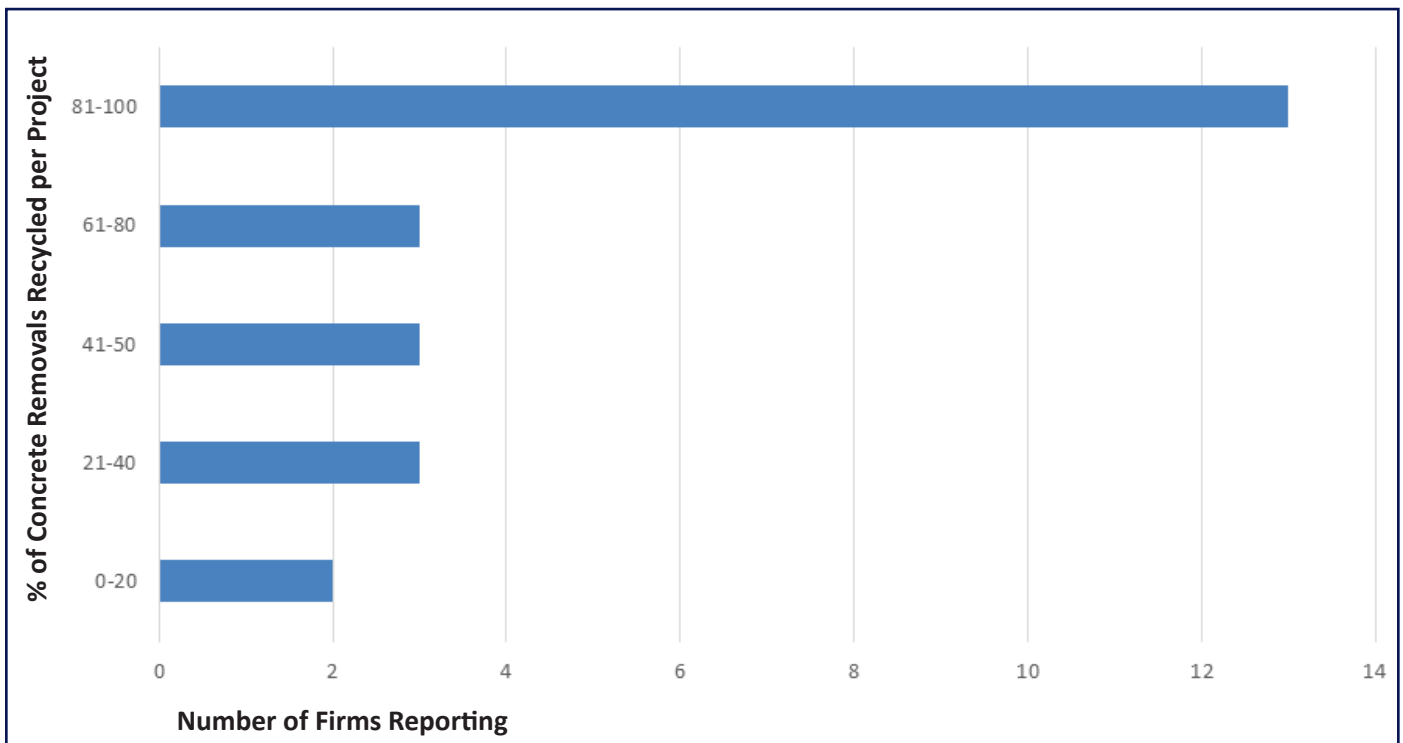


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## Appendix B: Recycled Concrete Aggregate (RCA) Paving Industry Benchmarking Survey

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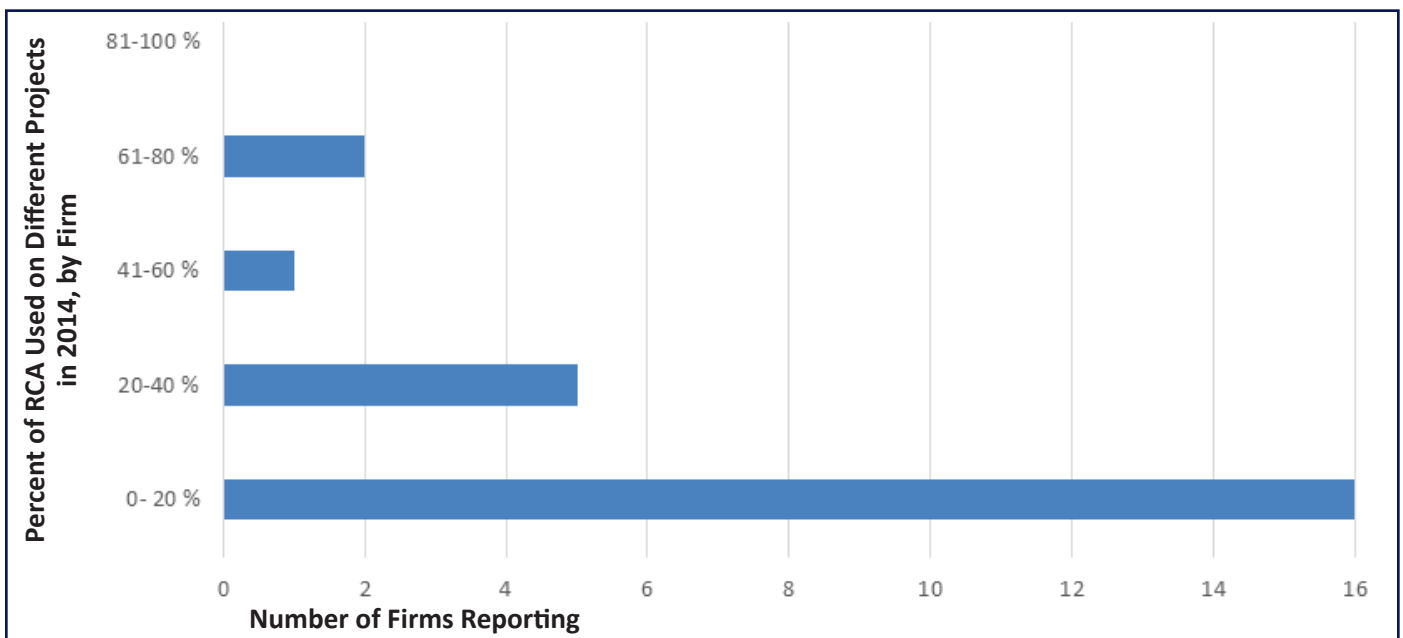
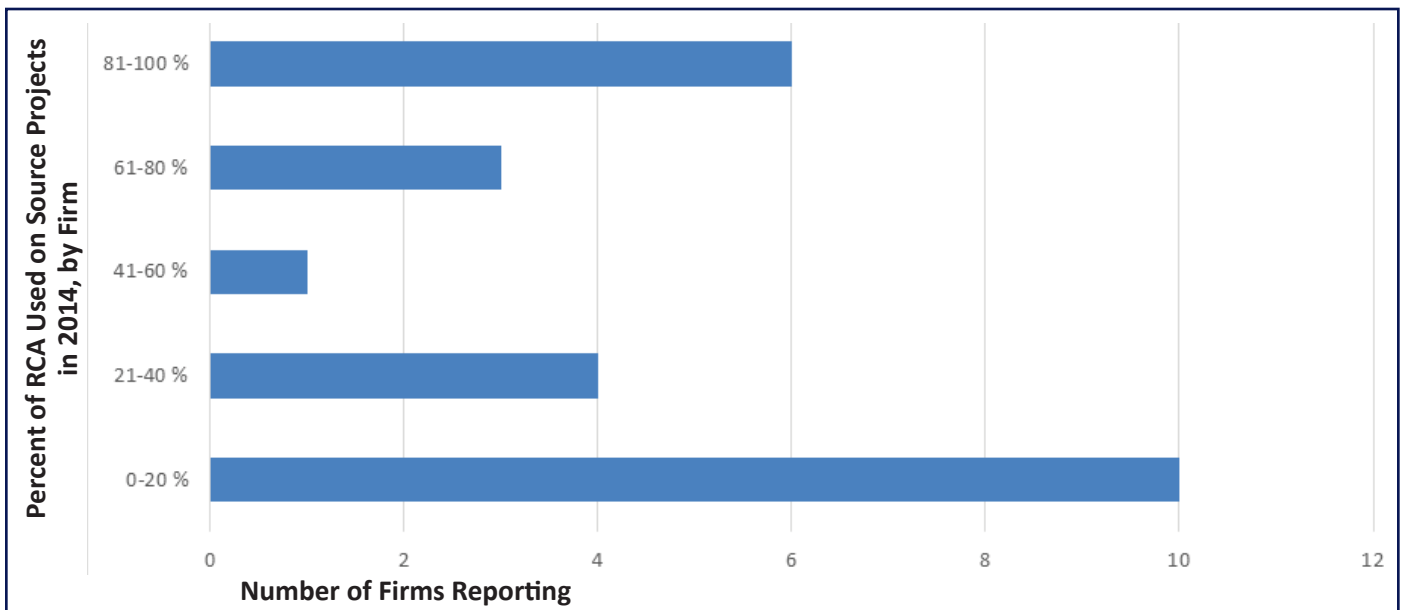
7. For all projects awarded to your firm in 2014, what percentage of concrete removals was recycled in any manner (e.g., crushed on-site, hauled to a commercial recycling facility, recycled for use on another project, etc.)?
- a. 0% to 20%
  - b. 21% to 40%
  - c. 41% to 60%
  - d. 61% to 80%
  - e. 81% to 100%



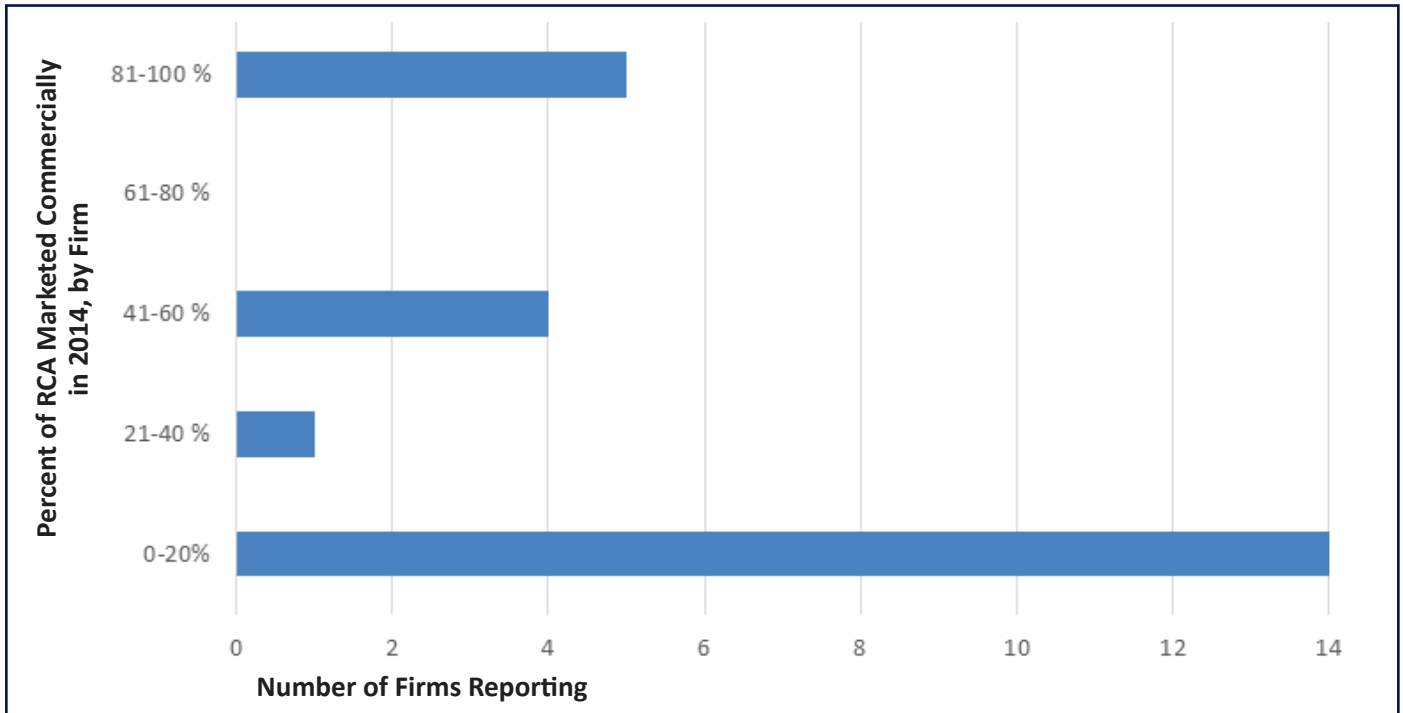
## Appendix B: Recycled Concrete Aggregate (RCA) Paving Industry Benchmarking Survey

### 8. What percentage of RCA was:

- a. Utilized on the project it was sourced from?
- b. Utilized on a different project?
- c. Marketed to other users?
- d. Other (specify)?
  - o Granular subbase for industrial use
  - o All removed concrete pavement was wasted
  - o Left for future use by the owner agency
  - o Pavement as used in fill



## Appendix B: Recycled Concrete Aggregate (RCA) Paving Industry Benchmarking Survey



**9. Of all RCA produced from projects awarded in 2014, estimate the percentage by product/application:**

- a. Granular subbase
- b. Chemically stabilized granular subbase (cement treated base, lean concrete, etc.)
- c. Coarse concrete aggregate
- d. Fine concrete aggregate
- e. Granular shoulder material
- f. Embankment (includes backfill for undercut)
- g. Underdrain filter material
- h. Rip Rap
- i. Slope stabilization materials
- j. Erosion control applications
- k. Plant site subbase
- l. Haul road
- m. Crushed products for other markets
- n. Surplus fines
- o. Other (please specify)

**If you entered a percentage for Other in the previous question, please specify the type or application.**

- Given to owner agency for their use



## Appendix B: Recycled Concrete Aggregate (RCA) Paving Industry Benchmarking Survey

Application	Percentage
Granular subbase	40
Crushed products for other markets	18
Embankment (includes backfill for undercut)	12
Coarse concrete aggregate	9
Other (Given to owner agency)	7
Chemically stabilized granular subbase (cement treated base, lean concrete, etc.)	4
Granular shoulder material	3
Haul road	3
Fine concrete aggregate	2
Plant site subbase	1
Surplus fines	1
Erosion control applications	0
Rip Rap	0
Underdrain filter material	0
Slope stabilization materials	0

**10. For the projects where recycling of concrete pavement was not performed, what was the primary reason?**

- a. The quantity of concrete removals was not large enough to justify mobilizing a crusher or hauling to a commercial recycling facility—7 Firms
- b. Specifications limited potential uses of RCA—12 Firms
- c. Cost prohibitive—8 Firms
- d. Concerns over quality of the RCA—1 Firm
- e. Locally available aggregate sources are less expensive—5 Firms
- f. Permitting—1 Firm
- g. Other (Haul time to recycling facility)—1 Firm

**11. For the percentage of concrete pavement removed and not recycled or reused in any manner, how was it disposed of?**

- a. Commercial landfill—27%
- b. Stockpiled for future recycling—55%
- c. Buried within the project right-of-way—10%
- d. Other—8%

**If you entered a percentage for Other in the previous question, please describe the other manner(s) in which the concrete was disposed.**

- Commercial facility—4%
- Off-site fill—4%

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## **Appendix B: Recycled Concrete Aggregate (RCA) Paving Industry Benchmarking Survey**

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**12. For your firm, on average, what is the minimum quantity of concrete removal that justifies on-site recycling?**

- a. Other (please specify)
  - i. 300,000 cy—1 Firm
  - ii. 75,000 cy—1 Firm
  - iii. No minimum, recycle all products—2 Firms
  - iv. Depends on the location—1 Firm
  - v. Depends on the cost of local materials—1 Firm
  - vi. Do not recycle on site—1 Firm
- b. 5,000 cy—9 Firms
- c. 10,000 cy—3 Firms
- d. 15,000 cy—1 Firm
- e. 20,000 cy—4 Firms

**13. For your firm, on average what is the minimum quantity of concrete removal that justifies hauling to a commercial recycling facility?**

- a. Other (please specify)
  - i. Recycle all products—9 Firms
  - ii. 1,000 cy—1 Firm
  - iii. Varies with geographic location—2 Firms
- b. 5,000 cy—11 Firms
- c. 10,000 cy—2 Firms
- d. 15,000 cy—0 Firms
- e. 20,000 cy—0 Firms

**14. For your firm, on average what is the maximum distance that justifies hauling concrete removal to a commercial recycling facility?**

- a. Other (please specify)
  - i. Recycle all products—3 Firms
  - ii. Varies depending on project—1 Firm
- b. 5 miles—4 Firms
- c. 10 miles—9 Firms
- d. 15 miles—4 Firms
- e. 20 miles—2 Firms

## Appendix B: Recycled Concrete Aggregate (RCA) Paving Industry Benchmarking Survey

15. In your market as a whole, what environmental concerns related to processing/handling/construction are cited as barriers to use of RCA in pavement foundations and or concrete mixtures? Any additional comments or feedback on these impediments is welcomed, and can be provided in the space below the table.

		Please check one	
		Yes	No
<b>Water Quality</b>	Alkaline runoff (pH)	4	20
	Leachate (other contaminants)	4	20
	Transported Sediments	2	21
	Other (Please describe below)		20
<b>Air Quality</b>	Equipment emissions	6	18
	Dust generation	11	13
	Other (Please describe below)	2	10
	Vehicle emissions		8
<b>Noise</b>	During processing/handling	8	15
<b>Waste Generation and Disposal/Reuse</b>	Solids	3	21
	Wastewater/stormwater runoff	6	18
	Slurries	5	18
<b>Permitting/Regulation</b>	Unclear requirements	8	15
	Cost of permitting and/or addressing regulations	9	14
	Time required for permitting and/or addressing regulations	12	12
	Lack of decision support tools	5	18
<b>Other</b>	Training of personnel	3	20
<b>Comments</b>	Lack of research on RCA in concrete mixes	2	

16. Which of the following circumstances, if any, limit RCA utilization? (Check all that apply)

- Material specifications—20 Firms
- Unknown source material—12 Firms
- ASR, D-Cracking Concerns—10 Firms
- Permitting—4 Firms
- Uncertain impact on quality—1 Firm

## Appendix B: Recycled Concrete Aggregate (RCA) Paving Industry Benchmarking Survey

17. If you have been involved in projects utilizing RCA, what measures (if any) do you utilize to address environmental concerns related to:

- Water quality

	Yes	No
Stockpile management (site selection/upkeep)	10	4
Runoff control	9	4
Runoff testing for alkalinity/chemical contaminants	3	10
Other (please describe below)	0	6

- Air quality in processing/handling RCA

	Yes	No
Dust control during production	13	1
Dust control during transport/handling	6	5
Air quality monitoring/testing	4	4
Other (please describe below)	0	1

18. Did environmental concerns or barriers (either actual or perceived) actually limit or exclude RCA utilization on one or more of you projects? If yes, please briefly describe.

- No—16 Firms
- Yes—4 Firms
- Noise in residential areas—1 Firm

19. Do you utilize any specific measures to manage or mitigate waste generation and disposal (e.g., solid waste, wastewater, slurries) associated with RCA?

- No—10 Firms
- Yes—9 Firms
- Steel is sold—1 Firm