The Usage, Storage and Testing of Recycled Materials - Results of Survey

TPF-5 (129) Recycled Unbound Materials

Mn/DOT Contract No. 89264 Work Order No. 2

CFMS Contract No. B14513

Addendum to Task 1A: Literature Review

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1. Introduction

The use of recycled material as base course in roadway construction has steadily increased for the past twenty years. Over time the methods associated with these practices continue to evolve, and therefore the data regarding the usage of recycled materials can quickly become outdated.[1] The University of Wisconsin-Madison has conducted a survey to better define the current state if practices involving the use, storage, and testing of materials used as granular base course in roadway applications. The survey focused on three materials: recycled asphalt pavement (RAP), recycled pavement material (RPM), and recycled concrete aggregate (RCA).

1.1. Recycled Asphalt Pavement (RAP)

The production of RAP material involves the removal and reprocessing of existing asphalt pavement from roadway structures. The top portion of the existing roadway is removed and either crushed on or off-site before being reused as a base course for the new roadway. The process of crushing and milling RAP material typically results in a high content of finer particles present within the recycled material. The aggregates in RAP materials typically display low water absorption properties due to a coating of asphalt cement preventing the water from reaching the individual particles of the material.[2,3]

1.2. Recycled Pavement Material (RPM)

The production of RPM material is similar to the production of RAP material, except that RPM production involves the pulverization and blending of the part or entire existing roadway rather than only the top HMA portion. The RPM production process may reclaim the existing roadway HMA, base, and part of the existing subgrade to a typical depth of approximately 300 mm. This process of excavating the entire roadway profile is commonly referred to as Full Depth Reclamation (FDR). RPM material typically has a lower strength and stiffness than RAP material due to the larger amount of fines contributed by the subgrade material.[4]

1.3. Recycled Concrete Aggregate (RCA)

Similar to the production of RAP and RPM materials, the production of RCA involves the removal and reprocessing of existing material. However, whereas the production of RAP involves the recycling of pavement almost exclusively, the production of RCA is expanded to include materials reclaimed from roadways as well as other demolition sources such as old buildings, airport runways, and the like. The RCA is initially crushed to break up the material and to allow any debris and steel reinforcement to be removed. Once the material is free from debris, the material is crushed again to a gradation typical of roadway base aggregate before being used in that capacity. Unlike the asphalt coating that retards water absorption in RAP material, the cementitious paste that coats the aggregate in RCA increases the water absorption of the material through hydration. In

addition, the hydration of residual cementitious paste present in the recycled material contributes to an increase in strength of the material.[3,5,6]

2. Survey Method

The University of Wisconsin-Madison conducted a survey to determine the extent of the use of recycled materials as a granular base course in roadway applications. The survey was conducted in the month of November, 2008, and was extended to individuals with a working connection to state and federal transportation agencies involved in roadway planning and construction. Those asked to take the survey were presented with thirteen (13) questions regarding the application, storage, and testing of recycled materials used as roadway base course.

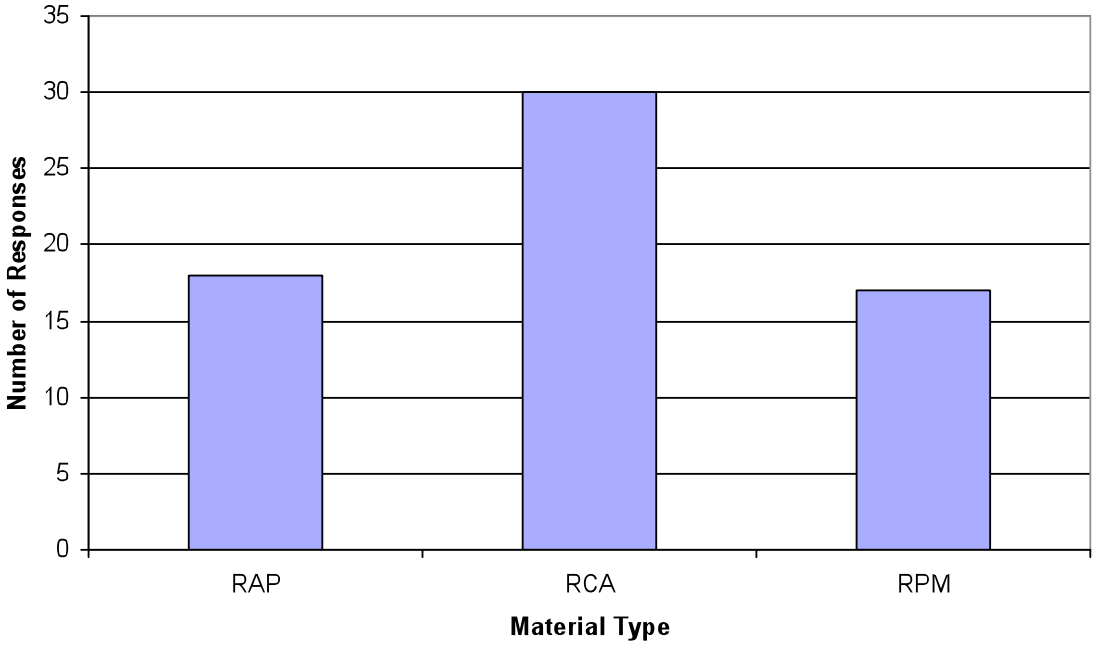
3. Survey Results and Discussion

3.1. Material Usage

Question 1

The first question asked in the survey was "Which of the following recycled materials do you use as a granular base course?" Each of the respondents had the opportunity to select one or more of the following options: Recycled Asphalt Pavement (RAP), Recycled Concrete Aggregate (RCA), and Recycled Pavement Material (RPM). There were 34 unique respondents to this question in the survey. The total responses to each option are represented in Figure 1.

Figure 1: Recycled Materials Used as Granular Base Course



Based on the survey information, the most commonly used recycled material type was RCA with 30 responses. RAP and RPM were the second and third most commonly used recycled material types with 18 and 17 responses, respectively. However, the combined RAP and RPM is 35% and slightly more than RCA.

Question #2

The second question presented in the survey was "When are the recycled materials used?" Each of the respondents had the opportunity to select one of the following options for each of the recycled material types: "Stockpiled and Used Later", "Used in Place Immediately" or "Both". There were 36 unique respondents to this question on the survey. The total distribution of responses to each option is represented in Figures 2 thru 4.

Figure 2: Placement Transition Time: RAP (Recycled Asphalt Pavement)

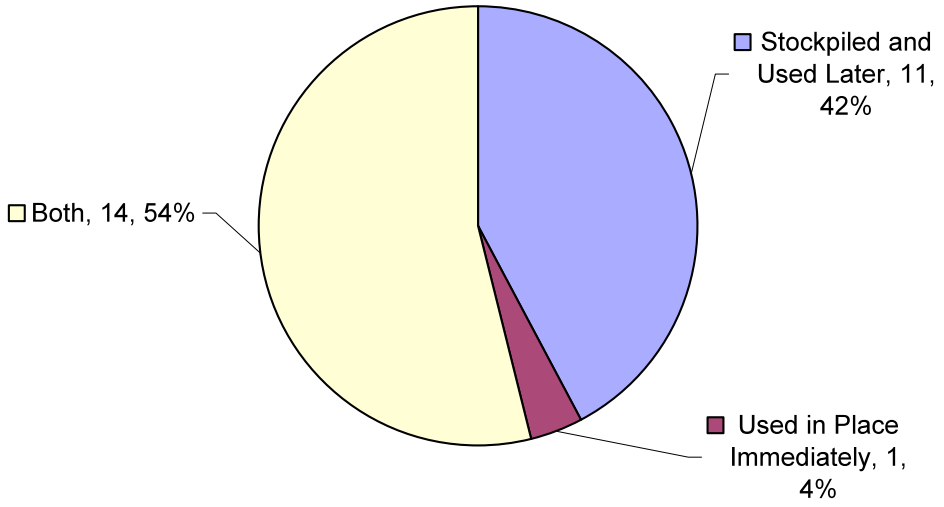


Figure 3: Placement Transition Time: RCA (Recycled Concrete Aggregate)

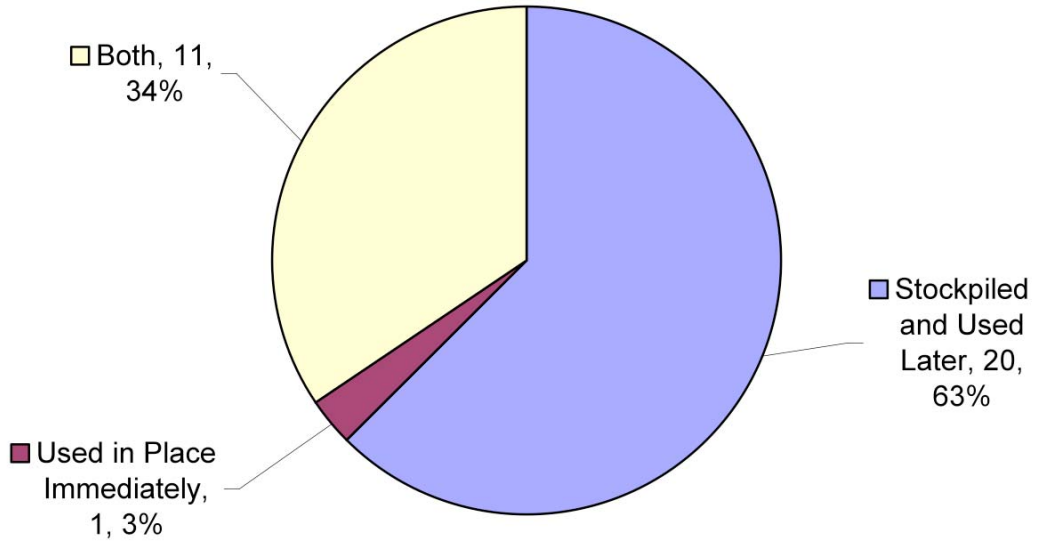
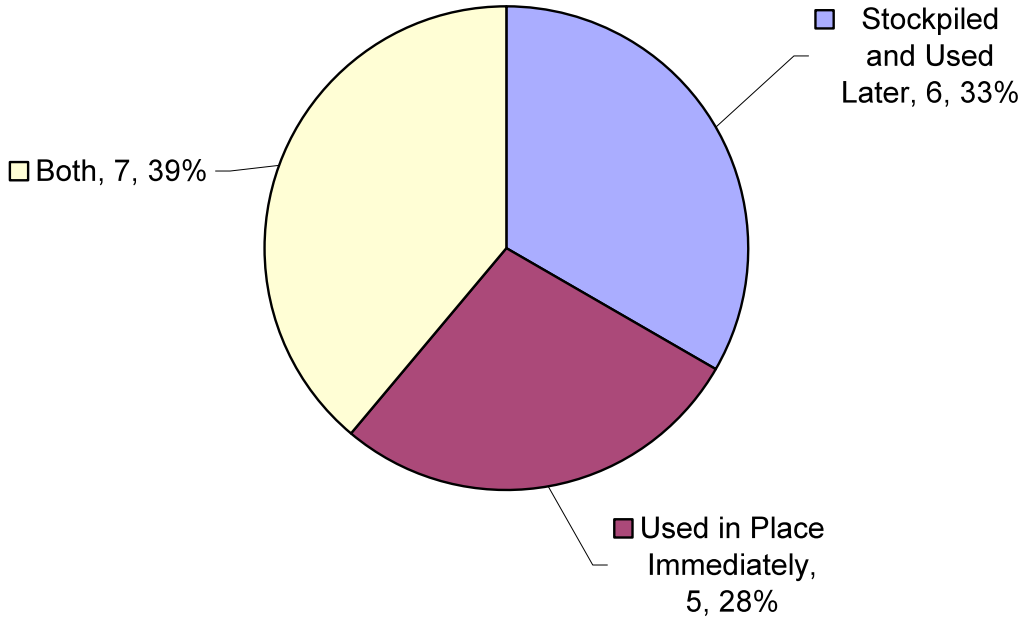


Figure 4: Placement Transition Time: RPM (Recycled Pavement Material)



Of the three materials considered in this report, RCA is most likely to be exclusively stockpiled for later use, followed by RAP and RPM. RAP is the most common material in situations where stockpiling and in-place use are both utilized, followed by RCA and RPM. With very little exception, RPM is the only material which is exclusively used-in-

place immediately after reclamation. This is most likely a reflection of construction practices associated with FDR techniques and the common use of RPM as aggregate in bituminous mixtures. The data would suggest that the practice of stockpiling materials is far more common than the practice of using the material in place immediately after reclamation.

Question 3

The third question presented in the survey was "In a given year, how much of the recycled material do you use?" Each of the respondents had the opportunity to select one of the following options for each of the recycled material types: "Less than 1,000 Tons", "1,000 to 5,000 Tons", "5,000 to 10,000 Tons", "10,000 to 25,000 Tons", "25,000 to 50,000 Tons", "50,000 to 75,000 Tons", and "More than 75,000 Tons". There were 33 unique respondents to this question on the survey. The distribution of responses to each option is represented in Figures 5 thru 7.

Figure 5: Annual Quantity Used: RAP (Recycled Asphalt Pavement)

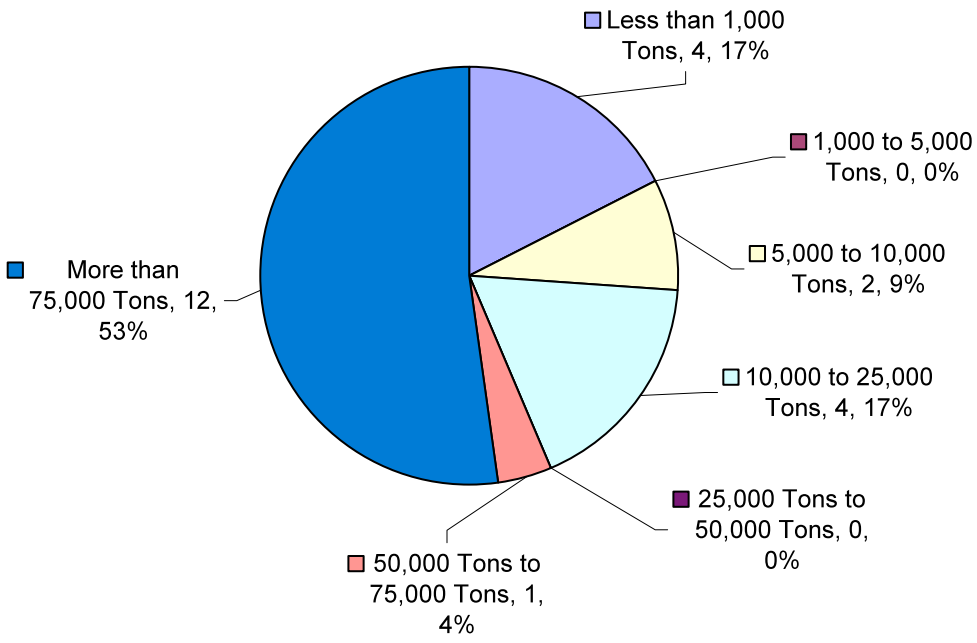


Figure 6: Annual Quantity Used: RCA (Recycled Concrete Aggregate)

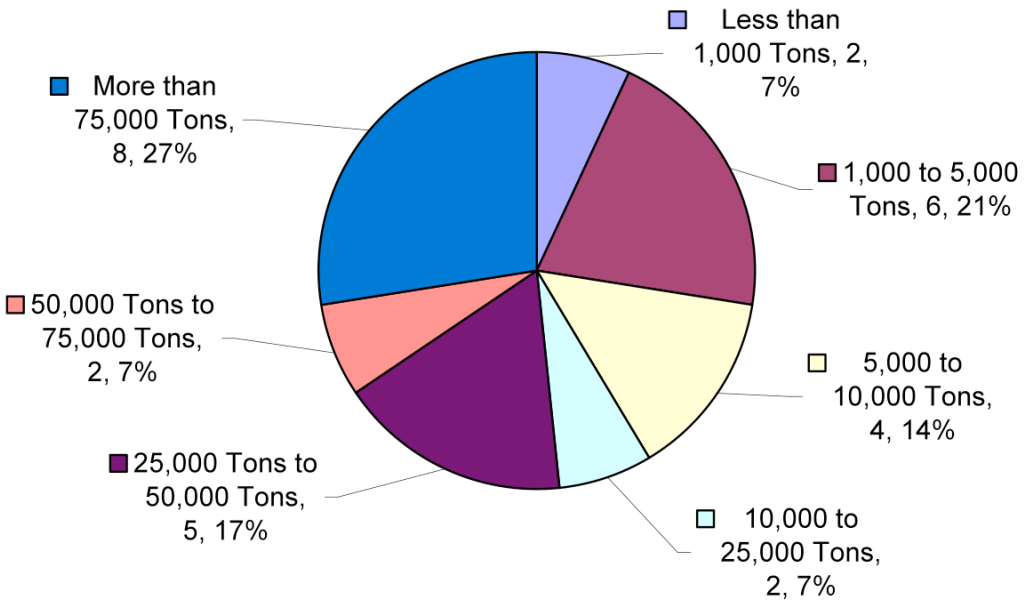
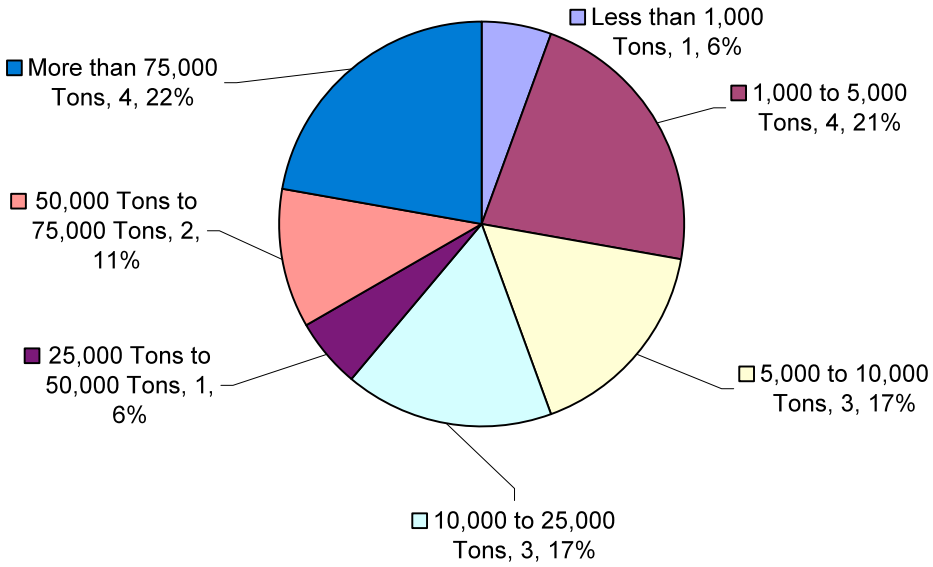


Figure 7: Annual Quantity Used: RPM (Recycled Pavement Material)

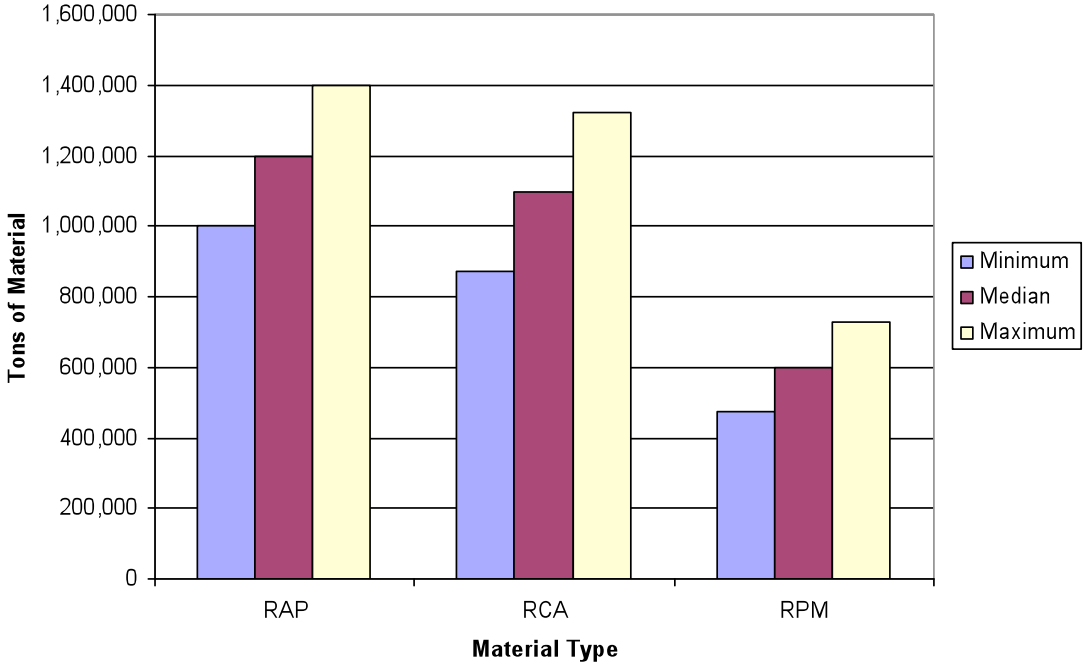


The most common response to the question for all three materials is “more than 75,000 tons” which would indicate that the use of recycled materials is significantly widespread. Of these materials, the use of RAP seems to be the most advanced it terms of quantity, with more than half of the respondents indicating that 75,000 tons of material or more was typically used. RCA is the second most advanced, with more than half the

respondents indicating that 25,000 tons of material or more was typically used. RPM seemed to be the least advanced; with more than half of the respondents indicating that 25,000 tons or less was typically used.

The data represented in Figures 5 thru 7 can be further understood if the total tonnage is considered. The total material used in each case was calculated and is represented in Figure 8. Three calculations were made for each material corresponding to the maximum, median, and maximum values of tons used for each of the quantity ranges. The maximum value for the "More than 75,000 Tons" option was assumed to be 100,000 tons.

Figure 8: Quantity of Each Material Used



The trends for all three materials represented in the survey can be seen to fall within a clearly visible trend, with RAP material being the most widely used in all three categories. The trend continues with RCA and RPM being the second and third most widely used, respectively. Contrasting this data with the data in Figure 1 seems to indicate that although more agencies are currently using RCA as a recycled fill, RAP material is being used in greater amounts. If RAP and RPM are combined, it appears flexible pavement recycling is far greater than RCA, which include rigid pavement recycling as well as building concrete. This is also reflective of the preponderance of flexible pavements compared to rigid pavements.

Question #4

The fourth question presented in the survey was "How long have you been using the recycled materials?" Each of the respondents had the opportunity to select one of the following options for each of the recycled material types: "Less than 1 Year", "1 to 2

Years", "2 to 5 Years", "5 to 10 Years" or "More than 10 Years". There were 34 unique respondents to this question on the survey. The distribution of responses to each option is represented in Figures 9 thru 11.

Figure 9: Number of Years Used: RAP (Recycled Asphalt Pavement)

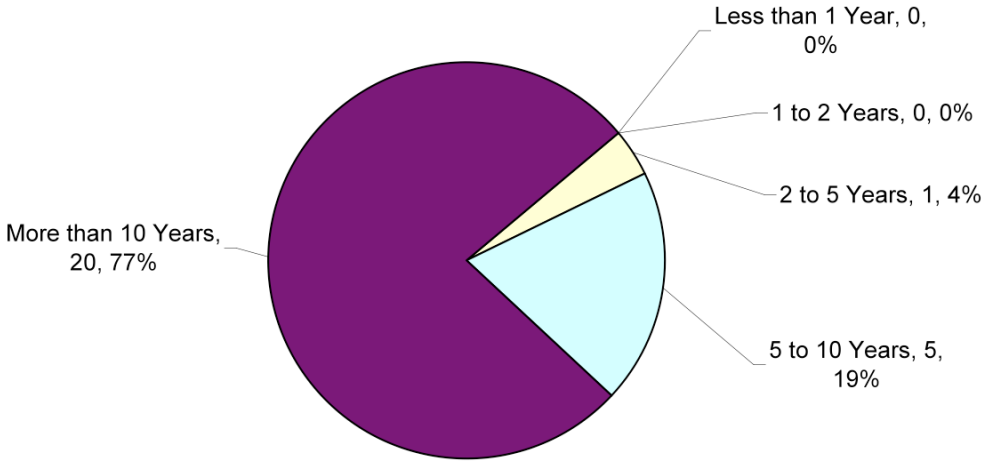


Figure 10: Number of Years Used: RCA (Recycled Concrete Aggregate)

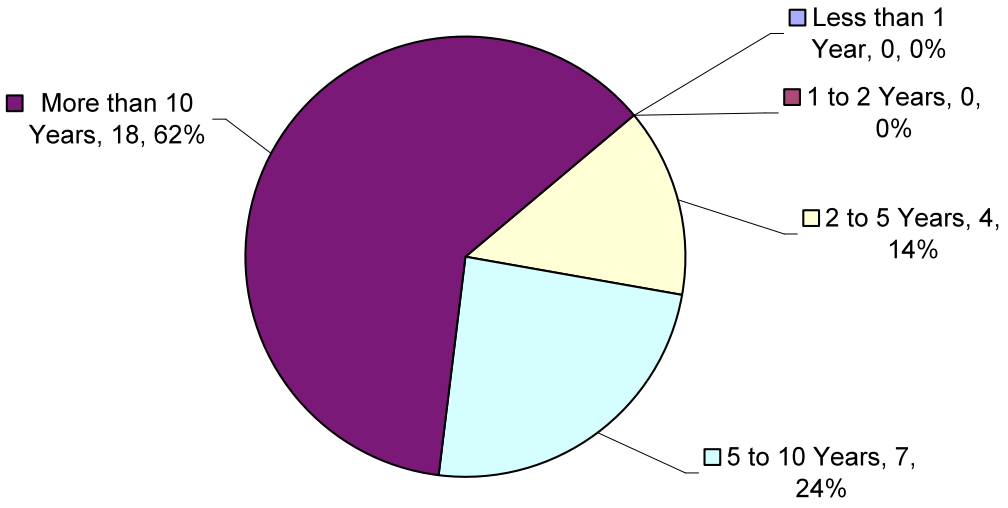
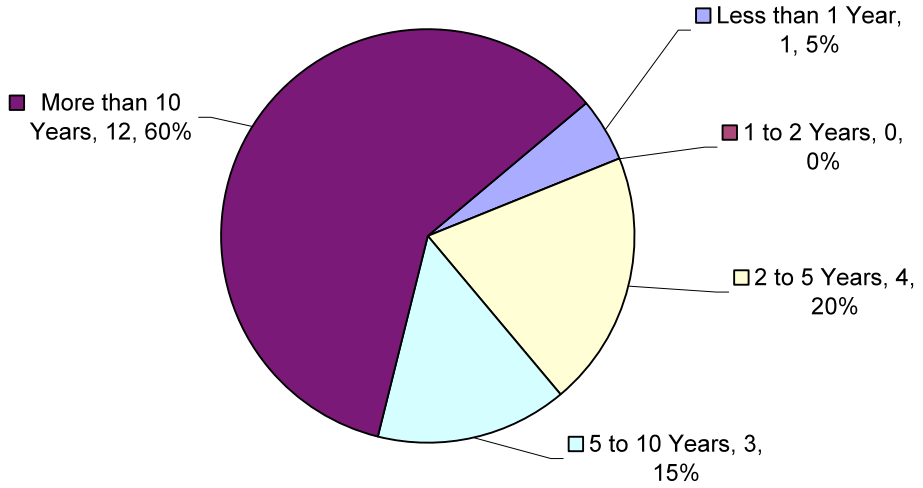


Figure 11: Number of Years Used: RPM (Recycled Pavement Material)



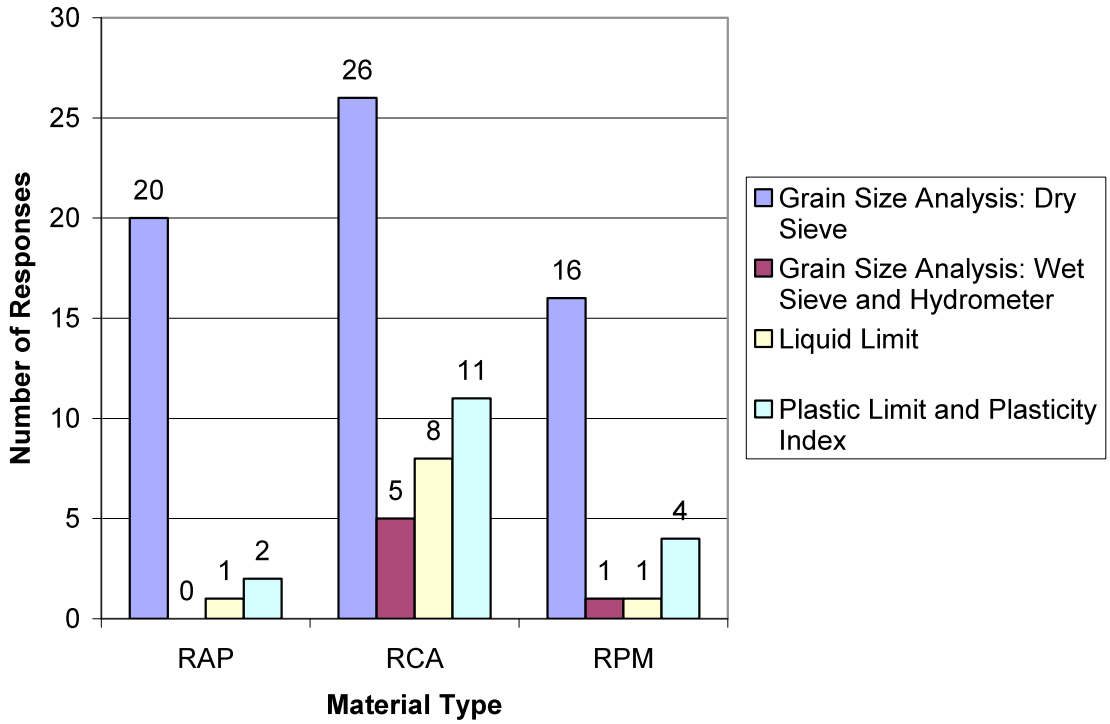
The overall results indicate that the use of recycled materials has been established for a considerable amount of time. For each of the given materials, more than half of the respondents indicated that the material had been used for more than 10 years. All but one response (for RPM) indicated that each responding agency had used the given material for more than 2 years.

3.2. Aggregate Specification and Quality

Question #5:

The fifth question presented in the survey was "Are any of the following tests used in specifications for the material?" Each of the respondents had the opportunity to select any of the following options for each of the recycled material types: "Grain Size Analysis: Dry Sieve", "Grain Size Analysis: Wet Sieve and Hydrometer", "Liquid Limit", and "Plastic Limit and Plasticity Index". There were 32 unique respondents to this question on the survey. The distribution of responses to each option is represented in Figure 12.

Figure 12: Specification Tests Used by Material Type

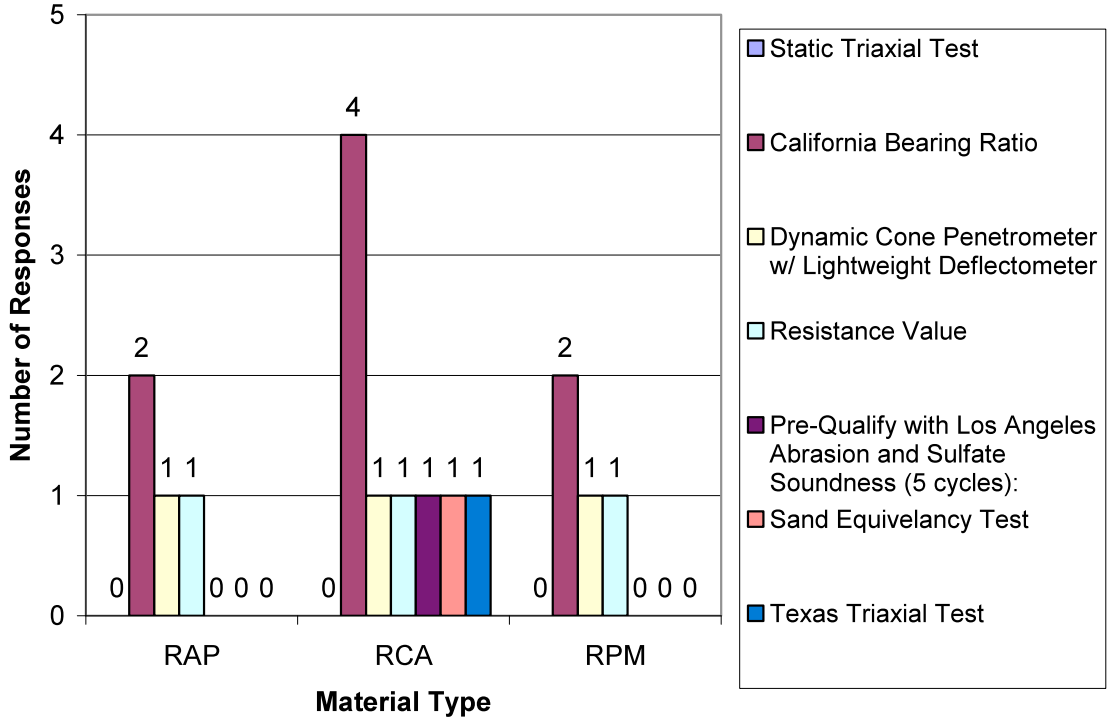


It can be seen from Figure 12 that the dry sieve method of grain size analysis is by far the most common test used to establish specification compliance for the given material, with plastic limit and plasticity index determinations ranking second by a wide margin. The wet sieve and hydrometer method of grain size analysis and the determination of liquid limits rank third and fourth most common, respectively. From Figure 12 it seems that the RCA material is the most rigorously tested of the three materials, with the greatest response totals for all three test methods.

Question #6

The sixth question presented in this survey was "Which of the following aggregate quality tests for shear strength do you perform on the material prior to placement?" Each of the respondents had the opportunity to select any of the following options for each of the recycled material types: "Static Triaxial Test (AASHTO T 296, ASTM D 2850)", "California Bearing Ratio (AASHTO T 193, ASTM D 1883)", "Dynamic Cone Penetrometer (ASTM D 6951)", or "Other". If "Other" was selected, the respondent was requested to indicate the optional test performed. There were 11 unique respondents to this question on the survey. The distribution of responses to each option is represented in Figure 13.

Figure 13: Aggregate Quality Tests for Shear Strength

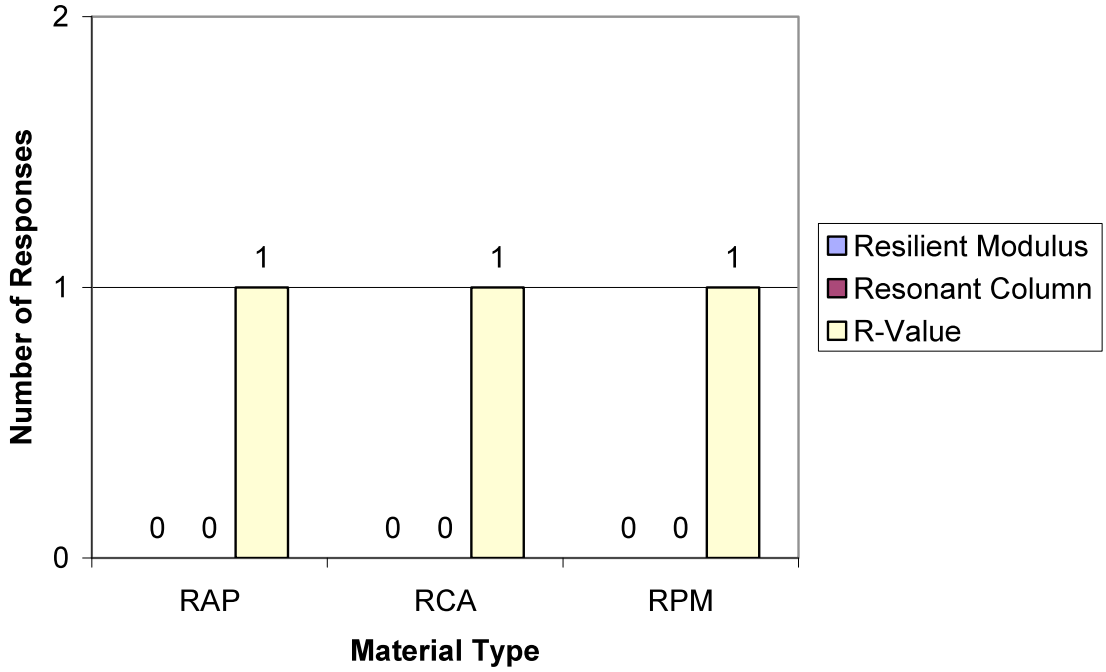


Despite the limited amount of response to the question, the California Bearing Ratio test stood out as the most commonly used test to determine shear strength for each of the recycled materials. Four of the respondents chose "other", indicating that their particular agencies used additional tests for shear strength. The collected data indicated that one agency used the Resistance Value test for each of the three materials, and three separate agencies respectively used the following three tests for RCA: "LA Abrasion Test and Sulfate Soundness (Pre-Qualify)", "Sand Equivalency Test", and "Texas Triaxial Test".

Question 7

The seventh question presented in the survey was "Which of the following aggregate quality tests for stiffness do you perform on the material prior to placement?" Each of the respondents had the opportunity to select any of the following options for each of the recycled material types: "Resilient Modulus (AASHTO T 307)", "Resonant Column (ASTM D 4015)", or "Other". If "Other" was selected, the respondent was requested to indicate the optional test performed. There was only 1 unique respondent to this question on the survey. The distribution of responses to each option is represented in Figure 14.

Figure 14: Aggregate Quality Tests for Stiffness



There was only one response to the question, so the data is inconclusive. Neither of the provided options was chosen in response to the question. The sole respondents chose "other" and indicated that their particular agency used the R-Value test as an additional test for stiffness on all three material types. However, based on the data, it appears that the testing of materials for stiffness prior to placement is not common.

Question 8

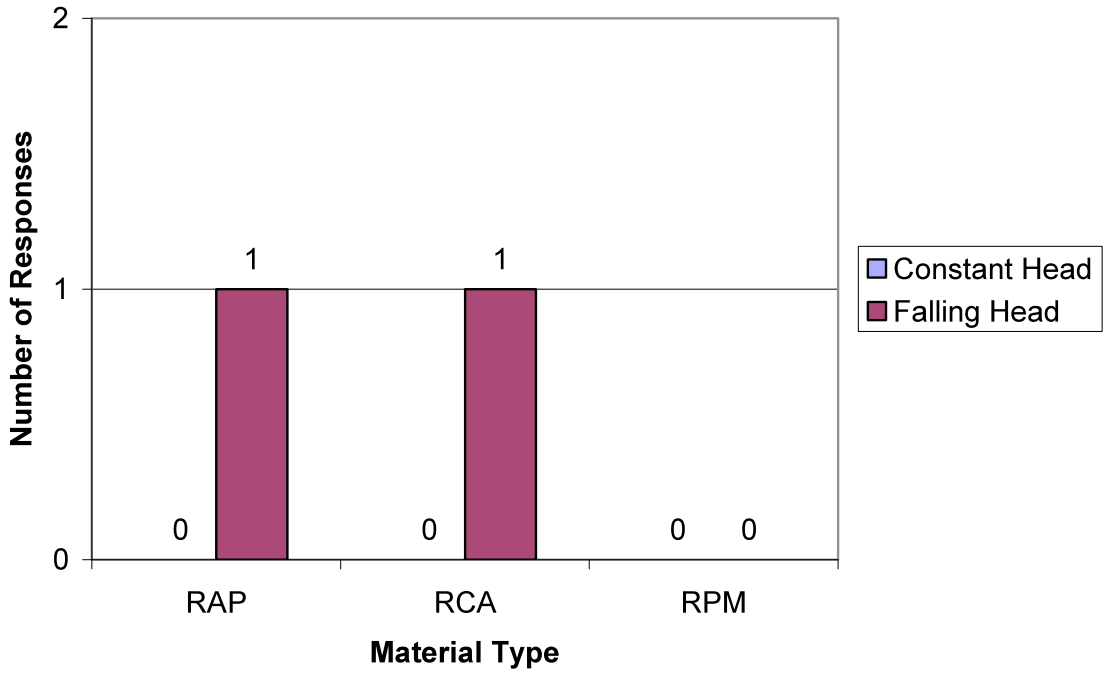
The eighth question presented in the survey was "Which of the following aggregate quality tests for frost susceptibility do you perform on the material prior to placement?" Each of the respondents had the opportunity to select any of the following options for each of the recycled material types: "Tube Suction Test (Texas Method 144E)", or "Other". If "Other" was selected, the respondent was requested to indicate the optional test performed. There were no respondents to this question on the survey, and therefore it appears that the testing of materials for frost susceptibility prior to placement is not common.

Question 9

The ninth question presented in the survey was "Which of the following aggregate quality tests for permeability do you perform on the material prior to placement?" Each of the respondents had the opportunity to select any of the following options for each of the recycled material types: "Constant Head (AASHTO T 215, ASTM D 2434)", "Falling Head", or "Other". If "Other" was selected, the respondent was requested to indicate the

optional test performed. There was only 1 unique respondent to this question on the survey. The distribution of responses to each option is represented in Figure 15.

Figure 15: Aggregate Quality Tests for Permeability

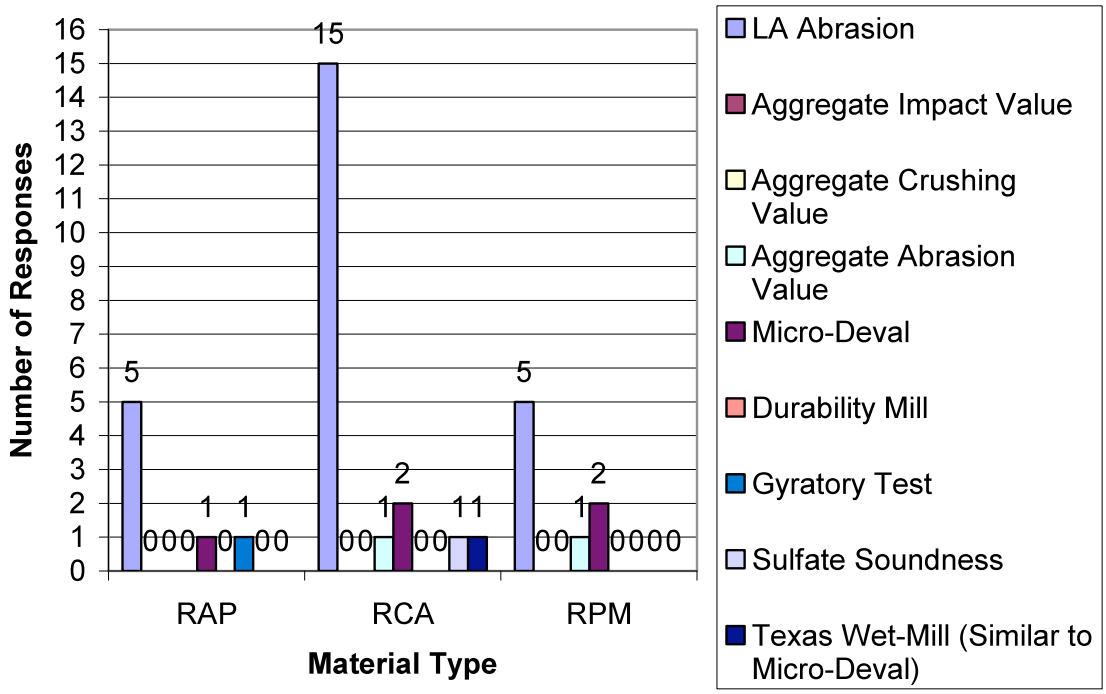


The only response to the question indicated that the Falling Head test was typically used for permeability determinations. However, the limited response to this question renders the data inconclusive. It appears that the testing of materials for permeability prior to placement is not common.

Question 10

The tenth question presented in the survey was "Which of the following aggregate quality tests for toughness do you perform on the material prior to placement?" Each of the respondents had the opportunity to select any of the following options for each of the recycled material types: "LA Abrasion (AASHTO T 96, ASTM C 131)","Aggregate Impact Value (BS 812)", "Aggregate Crushing Value (BS 812)", "Aggregate Abrasion Value", "Micro-Deval (AASHTO TP 58 and T 327, ASTM D 6928)", "Durability Mill (Sampson and Netterberg 1989)", "Gyratory Test", or "Other". If "Other" was selected, the respondent was requested to indicate the optional test performed. There were 21 unique respondents to this question on the survey. The distribution of responses to each option is represented in Figure 16.

Figure 16: Aggregate Quality Tests for Toughness



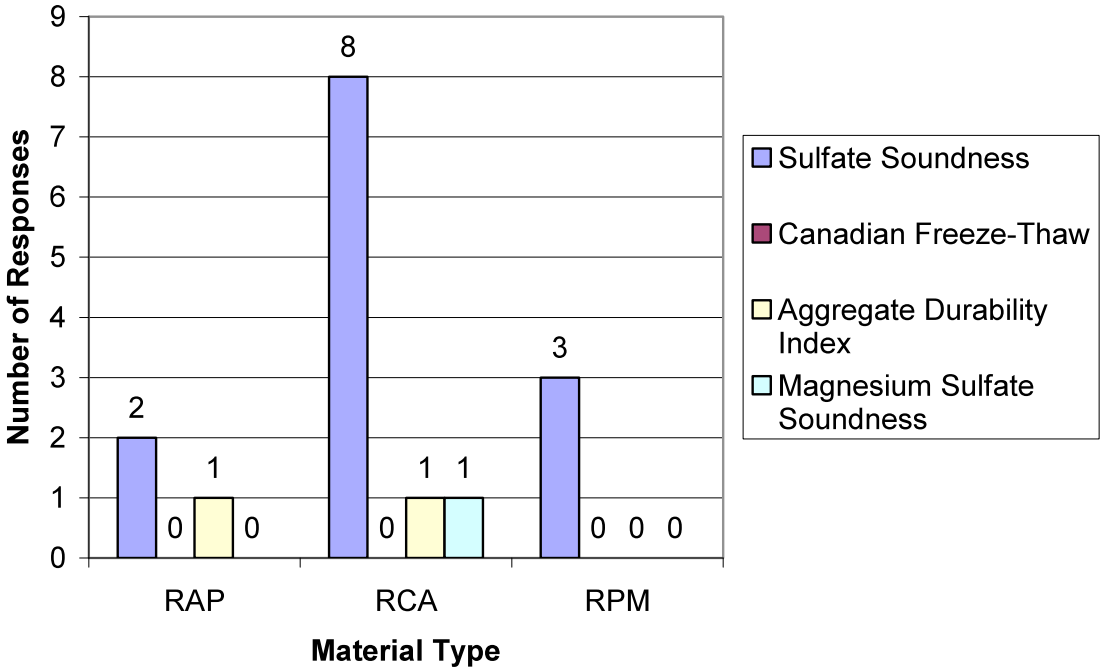
It is clear from Figure 16 that the LA Abrasion test is the most commonly used test for the toughness of a material prior to placement and is frequently used for all three material types, but most commonly when RCA material is considered. Despite the minimal data available for the other test methods, the Micro-Duvall test for all materials, the Aggregate Abrasion Value test for RCA and RPM, and the Gyratory Test for RAP were each indicated as being marginally used. None of the respondents indicated that the Aggregate Impact Value, Aggregate Crushing Value or Durability Mill Tests were used.

Two of the respondents chose "other", indicating that their particular agencies used additional tests for toughness. The Sulfate Soundness test and Texas Wet-Mill test were respectively used by two different agencies for toughness testing on RCA material. The Texas Wet-Mill test was described as "similar to the idea of Micro-Deval."

Question 11

The eleventh question presented in the survey was "Which of the following aggregate quality tests for durability do you perform on the material prior to placement?" Each of the respondents had the opportunity to select any of the following options for each of the recycled material types: "Sulfate Soundness (AASHTO T 104, ASTM C 88)", "Canadian Freeze-Thaw (MTO LS-614)", "Aggregate Durability Index (AASHTO T 210 and T 176, ASTM D 3744)", or "Other". If "Other" was selected, the respondent was requested to indicate the optional test performed. There were 12 unique respondents to this question on the survey. The distribution of responses to each option is represented in Figure 17.

Figure 17: Aggregate Quality Tests for Durability

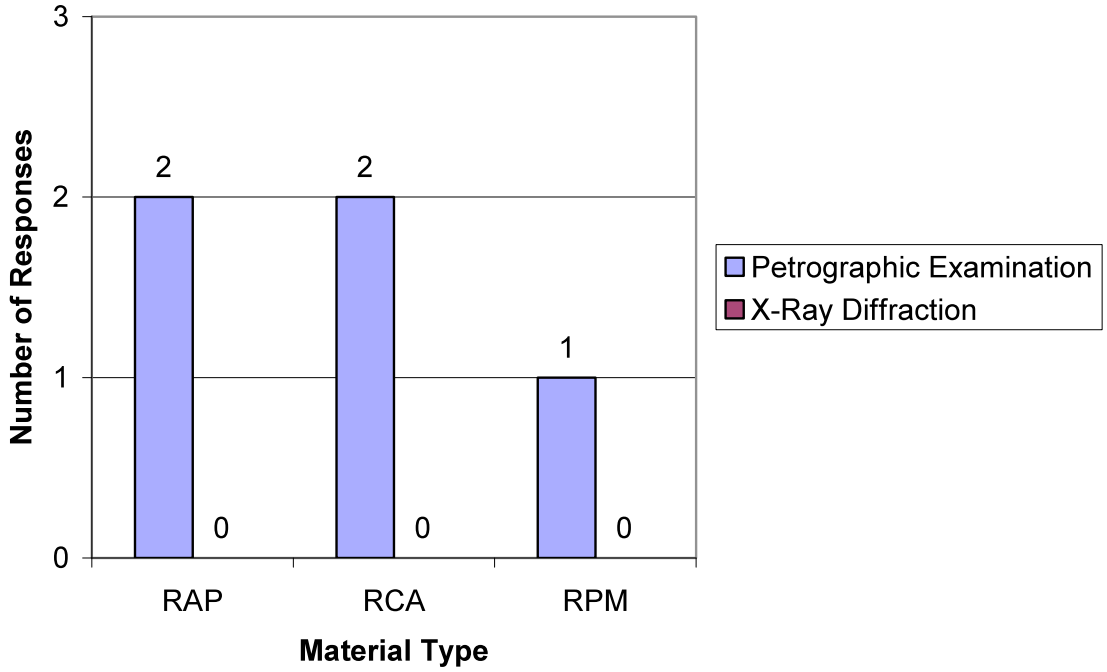


From Figure 17 it can be seen that the Sulfate Soundness test is the most commonly used test for the durability of a material prior to placement, and is frequently used for all three material types. Despite the minimal data available indicating other test methods, the Aggregate Durability Index test for RAP and RCA was indicated as being marginally used. None of the respondents indicated that the Canadian Freeze-Thaw test was used. One of the respondents chose "other", indicating that their particular agency used the Magnesium Sulfate Soundness test as an additional durability test for RCA.

Question 12

The twelfth question presented on the survey was "Which of the following aggregate quality tests for mineralogical composition do you perform on the material prior to placement?" Each of the respondents had the opportunity to select any of the following options for each of the recycled material types: "Petrographic Examination (ASTM C 295)", "X-Ray Diffraction", or "Other". If "Other" was selected, the respondent was requested to indicate the optional test performed. There were 4 unique respondents to this question on the survey. The distribution of responses to each option is represented in Figure 18.

Figure 18: Aggregate Quality Tests for Mineralogical Composition

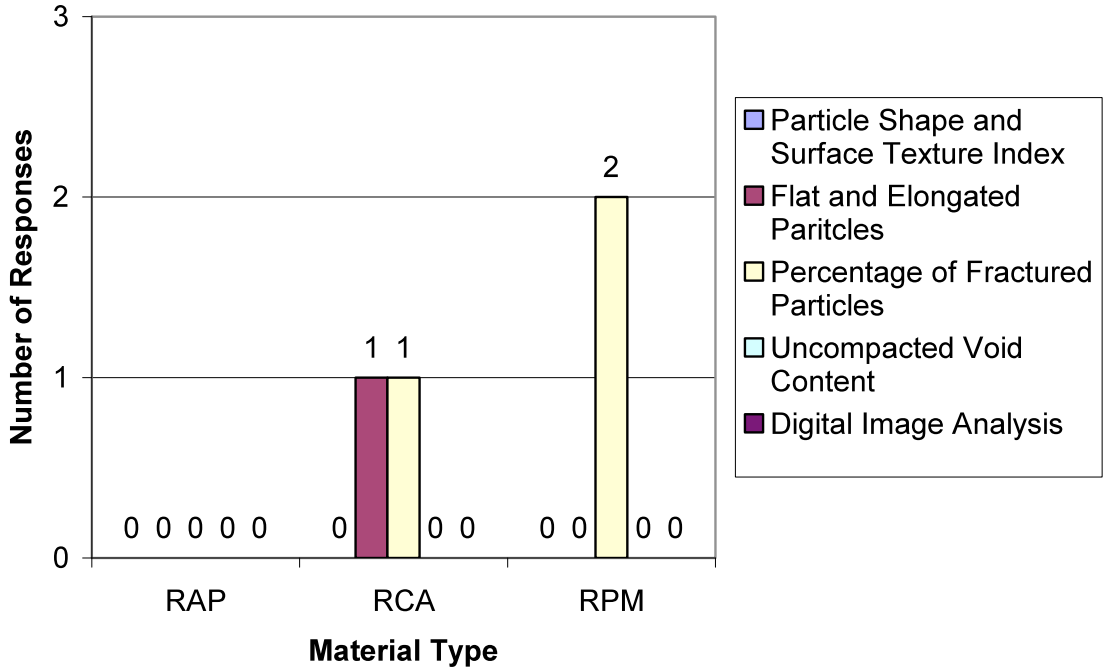


The only response to the question indicated that the Petrographic Examination test method was the only test typically used for the determination of mineralogical composition in recycled materials. However, the limited response would indicate that the data is inconclusive, and therefore it appears that the testing of materials for mineralogical composition prior to placement is not common.

Question 13

The thirteenth and final question presented on the survey was "Which of the following aggregate quality tests for particle geometric properties do you perform on the material prior to placement?" Each of the respondents had the opportunity to select any of the following options for each of the recycled material types: "Particle Shape and Surface Texture Index (ASTM D 3398)", "Flat and Elongated Particles (ASTM D 4791)", "Percentage of Fractured Particles (ASTM 5821)", "Uncompacted Void Content (AASHTO T 326, ASTM C 1252)", "Digital Image Analysis", or "Other". If "Other" was selected, the respondent was requested to indicate the optional test performed. There were 4 unique respondents to this question on the survey. The distribution of responses to each option is represented in Figure 19.

Figure 19: Aggregate Quality Tests for Particle Geometric Properties



The minimal data available for question thirteen indicates that tests for Particle Geometric Properties are marginally used. The usage of the Percentages of Fractured Particles test was slightly more common than that of the Flat and Elongated Particles test, with the former used for RCA and RPM materials and the latter used for RCA materials only. None of the other three tests were selected for the survey. Based on the results of this survey, it appears that the testing of materials for particle geometric properties prior to placement is not common.

4. Conclusion

A survey was conducted by the University of Wisconsin-Madison to determine the extent of use of recycled materials as granular base course in roadway applications. The survey found that of the three recycled materials considered, recycled concrete aggregate (RCA) was the most commonly used material, followed by recycled asphalt pavement (RAP) and recycled pavement material (RPM). However, if RAP and RPM are combined, recycling of flexible pavements is more common both in terms frequency and quantity. Following reclamation operations, it is more common for a recycled material to be stockpiled and used later than to be used immediately after reclamation. However, RPM materials, common to full-depth reclamation efforts, are more likely to be used immediately after reclamation than the other materials considered. In terms of quantity, RAP material represents the greatest total tonnage used, followed by RCA and RPM, respectively. Although RCA is the most common material used, RAP material is used in greater amounts.

The most common test used to determine specification compliance for a recycled material was Grain Size Analysis using dry sieve, followed by Plastic Limit and Liquid Limit determinations and Grain Size Analysis using a wet sieve and hydrometer. The survey indicated that the most common tests for aggregate quality are the California Bearing Ratio test for aggregate shear strength, the LA Abrasion test for aggregate toughness, and the Sulfate Soundness test for aggregate durability. Less common to uncommon tests for aggregate quality were found to be the R-Value test for stiffness, the Falling Head Method test for permeability, the Petrographic Examination test for mineralogical composition, and either the Percent of Fractured Particles test or Flat and Elongated Particles test for particle geometry. The results of the survey gave no indication that frost susceptibility tests were performed for summative quality. It is apparent from the survey that there is limited data for structural properties. For instance, resilient modulus needed for the Mechanistic-empirical design procedure is not performed. Developing a database of such properties for these recycled materials is needed.

5. Bilbliography

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APPENDIX

SURVEY RESULTS

WebSurvey@UW

Survey Results -- Overview

Export Data | Individual Responses

Recycled Material

Respondents: 41 displayed, 41 total **Status:** Open

Launched Date: 11/06/2008 **Closed Date:** N/A

Display: Display all pages and questions

Manage Filters 0 filters

Share Results Disabled

1. Q1

	Response Total	Response Percent
Recycled Asphalt Pavement (RAP)	**18**	**53%**
Recycled Concrete Aggregate (RCA)	**30**	**88%**
Recycled Pavement Material (RPM) (Mixture of HMA and Base Course)	**17**	**50%**
Total Respondents	**34**	
(skipped this question)	7	

2. When are the recycled materials used?

	Stockpiled and Used Later	Used in Place Immediately	Both	Response Total
Recycled Asphalt Pavement (RAP)	42% (11)	4% (1)	54% (14)	**26**
Recycled Concrete Aggregate (RCA)	65% (20)	3% (1)	35% (11)	**31**
Recycled Pavement Material (RPM)	33% (6)	28% (5)	39% (7)	**18**
Total Respondents				**36**
(skipped this question)				5

3. In a given year, how much of the recycled material do you use?

	Less than 1,000 Tons	1,000 to 5,000 Tons	5,000 to 10,000 Tons	10,000 to 25,000 Tons	25,000 to 50,000 Tons	50,000 to 75,000 Tons	More than 75,000 Tons	Response Total
Recycled Asphalt Pavement (RAP)	17% (4)	0% (0)	9% (2)	17% (4)	0% (0)	4% (1)	52% (12)	**23**
Recycled Concrete Aggregate (RCA)	7% (2)	21% (6)	14% (4)	7% (2)	17% (5)	7% (2)	28% (8)	**29**

Recycled Pavement Material (RPM)	6% (1)	22% (4)	17% (3)	17% (3)	6% (1)	11% (2)	22% (4)	**18**
							Total Respondents	**33**
							(skipped this question)	8

4. How long have you been using the recycled materials?

	Less than 1 year	1 to 2 years	3 to 5 years	5 to 10 years	More than 10 years	Response Total
Recycled Asphalt Pavement (RAP)	0% (0)	0% (0)	4% (1)	19% (5)	77% (20)	**26**
Recycled Concrete Aggregate (RCA)	0% (0)	0% (0)	14% (4)	24% (7)	62% (18)	**29**
Recycled Pavement Material (RPM)	5% (1)	0% (0)	20% (4)	15% (3)	60% (12)	**20**
					Total Respondents	**34**
					(skipped this question)	7

5. Are any of the following tests used in specifications for the material?

	Grain Size Analysis: Dry Sieve	Grain Size Analysis: Wet Sieve and Hydrometer	Liquid Limit	Plastic Limit and Plasticity Index	Response Total
Recycled Asphalt Pavement (RAP)	87% (20)	0% (0)	4% (1)	9% (2)	**23**
Recycled Concrete Aggregate (RCA)	76% (26)	15% (5)	24% (8)	32% (11)	**34**
Recycled Pavement Material (RPM)	76% (16)	5% (1)	5% (1)	19% (4)	**21**
				Total Respondents	**32**
				(skipped this question)	9

6. Which of the following aggregate quality tests for shear strength do you perform on the material prior to placement?

	Recycled Asphalt Pavement (RAP)	Recycled Concrete Aggregate (RCA)	Recycled Pavement Material (RPM)	Response Total
Static Triaxial Test (AASHTO T 296, ASTM D 2850)	0% (0)	0% (0)	0% (0)	**0**
California Bearing Ratio (AASHTO T 193, ASTM D 1883)	50% (2)	100% (4)	50% (2)	**4**
Dynamic Cone Penetrometer (ASTM D 6951)	50% (1)	50% (1)	50% (1)	**2**
Other	33% (3)	67% (6)	33% (3)	**9**
			Total Respondents	**11**
			(skipped this question)	30

7. If "Other", please indicate what additional aggregate quality tests you perform for shear strength.

View responses to this question view

Total Respondents	**11**
(skipped this question)	30

8. Which of the following aggregate quality tests for stiffness do you perform on the material prior to placement?

	Recycled Asphalt Pavement (RAP)	Recycled Concrete Aggregate (RCA)	Recycled Pavement Material (RPM)	Response Total
Resilient Modulus (AASHTO T 307)	0% (0)	0% (0)	0% (0)	**0**
Resonant Column (ASTM D 4015)	0% (0)	0% (0)	0% (0)	**0**
Other	75% (3)	75% (3)	75% (3)	**4**
			Total Respondents	**4**
			(skipped this question)	37

9. If "Other", please indicate what additional aggregate quality tests you perform for stiffness.

View responses to this question view

Total Respondents **12**

(skipped this question) 29

10. Which of the following aggregate quality tests for frost susceptibility do you perform on the material prior to placement?

	Recycled Asphalt Pavement (RAP)	Recycled Concrete Aggregate (RCA)	Recycled Pavement Material (RPM)	Response Total
Tube Suction Test (Texas Method 144 E)	0% (0)	0% (0)	0% (0)	**0**
Other	67% (2)	67% (2)	67% (2)	**3**
			Total Respondents	**3**
			(skipped this question)	38

11. If "Other", please indicate what additional aggregate quality tests you perform for frost susceptibility.

View responses to this question view

Total Respondents **11**

(skipped this question) 30

12. Which of the following aggregate quality tests for permeability do you perform on the material prior to placement?

	Recycled Asphalt Pavement (RAP)	Recycled Concrete Aggregate (RCA)	Recycled Pavement Material (RPM)	Response Total
Constant Head (AASHTO T 215, ASTM D 2434)	0% (0)	0% (0)	0% (0)	**0**
Falling Head	100% (1)	100% (1)	0% (0)	**1**
Other	67% (2)	67% (2)	67% (2)	**3**
			Total Respondents	**4**
			(skipped this question)	37

13. If "Other", please indicate what additional aggregate quality tests you perform for permeability.

View responses to this question view

Total Respondents	**11**
(skipped this question)	30

14. Which of the following aggregate quality tests for toughness do you perform on the material prior to placement?

	Recycled Asphalt Pavement (RAP)	Recycled Concrete Aggregate (RCA)	Recycled Pavement Material (RPM)	Response Total
LA Abrasion (AASHTO T 96, ASTM C131)	26% (5)	79% (15)	26% (5)	**19**
Aggregate Impact Value (BS 812)	0% (0)	0% (0)	0% (0)	**0**
Aggregate Crushing Value (BS 812)	0% (0)	0% (0)	0% (0)	**0**
Aggregate Abrasion Value (BS 812)	0% (0)	50% (1)	50% (1)	**2**
Micro-Deval (AASHTO TP 58 and T 327, ASTM D6928)	25% (1)	50% (2)	50% (2)	**4**
Durability Mill (Sampson and Netterberg 1989)	0% (0)	0% (0)	0% (0)	**0**
Gyratory Test	100% (1)	0% (0)	0% (0)	**1**
Other	33% (1)	67% (2)	0% (0)	**3**
			Total Respondents	**21**
			(skipped this question)	20

15. If "Other", please indicate what additional aggregate quality tests you perform for toughness.

View responses to this question	view
Total Respondents	**9**
(skipped this question)	32

16. Which of the following aggregate quality tests for durability do you perform on the material prior to placement?

	Recycled Asphalt Pavement (RAP)	Recycled Concrete Aggregate (RCA)	Recycled Pavement Material (RPM)	Response Total
Sulfate Soundness (AASHTO T 104, ASTM C 88)	20% (2)	80% (8)	30% (3)	**10**
Canadian Freeze-Thaw (MTO LS-614)	0% (0)	0% (0)	0% (0)	**0**
Aggregate Durability Index (AASHTO T 210 and T 176, ASTM D 3744)	100% (1)	100% (1)	0% (0)	**1**
Other	67% (2)	67% (2)	67% (2)	**3**
			Total Respondents	**14**
			(skipped this question)	27

17. If "Other", please indicate what additional aggregate quality tests you perform for durability.

View responses to this question	view
Total Respondents	**8**
(skipped this question)	33

18. Which of the following aggregate quality tests for mineralogical composition do you perform on the material prior to placement?

	Recycled Asphalt Pavement (RAP)	Recycled Concrete Aggregate (RCA)	Recycled Pavement Material (RPM)	Response Total
Petrographic Examination (ASTM C295)	50% (2)	50% (2)	25% (1)	**4**
X-Ray Diffraction	0% (0)	0% (0)	0% (0)	**0**
Other	100% (2)	50% (1)	100% (2)	**2**
			Total Respondents	**6**
			(skipped this question)	35

19. If "Other", please indicate what additional aggregate quality tests you perform for mineralogical composition.

View responses to this question view

Total Respondents	**8**
(skipped this question)	33

20. Which of the following aggregate quality tests for particle geometric properties do you perform on the material prior to placement?

	Recycled Asphalt Pavement (RAP)	Recycled Concrete Aggregate (RCA)	Recycled Pavement Material (RPM)	Response Total
Particle Shape and Surface Texture Index (ASTM D 3398)	0% (0)	0% (0)	0% (0)	**0**
Flat and Elongated Particles (ASTM D 4791)	0% (0)	100% (1)	0% (0)	**1**
Percentage of Fractured Particles (ASTM 5821)	0% (0)	33% (1)	67% (2)	**3**
Uncompacted Void Content (AASHTO T 326, ASTM C 1252)	0% (0)	0% (0)	0% (0)	**0**
Digital Image Analysis	0% (0)	0% (0)	0% (0)	**0**
Other	100% (2)	50% (1)	100% (2)	**2**
			Total Respondents	**6**
			(skipped this question)	35

21. If "Other", please indicate what additional aggregate quality tests you perform for particle geometric properties.

View responses to this question view

Total Respondents	**9**
(skipped this question)	32