Information Series 138

Asphalt Pavement Industry Survey on

Recycled Materials and Warm-Mix Asphalt Usage 2014

NATIONAL ASPHALT PAVEMENT ASSOCIATION

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16. Abstract

A shared goal of the Federal Highway Administration (FHWA) and the National Asphalt Pavement Association (NAPA) is to support and promote sustainable practices, such as pavement recycling and warm-mix asphalt (WMA). The use of recycled materials, primarily reclaimed asphalt pavement (RAP) and reclaimed asphalt shingles (RAS), in asphalt pavements reduces the amount of new materials required to produce asphalt mixes, as well as the stream of material going to landfills. This is vital to the mission of environmental stewardship and extending the service life of the nation's infrastructure while lowering overall costs.

WMA technologies have been introduced to reduce the production and compaction temperatures for asphalt mixtures as a means of reducing the energy needed and emissions associated with mix production. Additional benefits include improved compaction of asphalt mixtures leading to improved pavement performance, as well as a longer paving season. As part of FHWA's Every Day Counts initiative, WMA was chosen for accelerated deployment in federal-aid highway, state department of transportation (DOT), and local road projects.

It is important for the industry to document the deployment of these technologies to understand where they are being used and where they may be underutilized. FHWA has established a mechanism for tracking the use of recycled materials and WMA in asphalt pavements. This mechanism has established a baseline for RAP, RAS, and WMA usage and has tracked the growth of the use of these sustainable practices in the highway industry since 2009.

The objective of this tracking is to quantify the use of recycled materials and WMA produced annually by the asphalt pavement industry. Results show significant growth in the use of RAP, RAS, and WMA technologies from 2009 through 2014. The asphalt industry remains the country's most diligent recycler by recycling asphalt pavements at a rate of over 99 percent. The average percentage of RAP used in asphalt mixtures has increased from 15.6 percent in 2009 to 20.4 percent in 2014. In 2014, the estimated RAP tonnage used in asphalt mixes was 71.9 million tons. Assuming 5 percent liquid asphalt in RAP, this represents over 3.6 million tons (20 million barrels) of asphalt binder conserved along with replacing some 68 million tons of virgin aggregate.

The combined saving of asphalt binder ($550/ton) and aggregate ($9.50/ton) by using RAP and RAS in asphalt mixes is more than $2.8 billion. This keeps asphalt pavement mixture costs competitive and allows owners to achieve more roadway maintenance and construction activities within limited budgets.

In 2014, WMA was about one-third of the total asphalt mixture market. WMA use increased by nearly 7 percent from 2013 to 2014, and about 577 percent since 2009. Plant foaming is used most often in producing WMA, with over 84 percent of the market. WMA additives accounted for about 16 percent of the market.

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List of Abbreviations

AASHTO	American Association of State Highway and Transportation Officials
CCPR	Cold Central Plant Recycling
CIR	Cold In-Place Recycling
CRM	Crumb Rubber Modifier
DOT	Department of Transportation
FDR	Full-Depth Reclamation
FHWA	Federal Highway Administration
GTR	Ground Tire Rubber
HIR	Hot In-Place Recycling
HMA	Hot-Mix Asphalt
MWAS	Manufacturing Waste Asphalt Shingles
NAPA	National Asphalt Pavement Association
NCAT	National Center for Asphalt Technology
NCAUPG	North Central Asphalt User/Producer Group
NEAUPG	North East Asphalt User Producer Group
NSA	National Slag Association
PCAS	Post-Consumer Asphalt Shingles
PCCAS	Pacific Coast Conference on Asphalt Specifications
RAP	Reclaimed Asphalt Pavement
RAS	Recycled Asphalt Shingles
RMA	Rubber Manufacturers Association
RMAUPG	Rocky Mountain Asphalt User/Producer Group
SAPA	State Asphalt Pavement Association
SEAUPG	Southeastern Asphalt User/Producer Group
UPG	User/Producer Group
WMA	Warm-Mix Asphalt

Asphalt Pavement Industry Survey on Recycled Materials and Warm-Mix Asphalt Usage: 2014

Executive Summary

The 2014 survey results demonstrate that the asphalt pavement industry continues to improve its outstanding record of sustainable practices by further increasing the use of recycled materials and warm-mix asphalt (WMA). The use of recycled materials, particularly reclaimed asphalt pavement (RAP) and reclaimed asphalt shingles (RAS), conserve raw materials and reduce overall asphalt mixture costs while WMA technologies improve conditions for ensuring pavement performance and long life, conserve energy, reduce emissions from production and paving operations, and improve conditions for workers.

The objective of this survey was to quantify the use of recycled materials, primarily RAP and RAS, and WMA produced by the asphalt pavement industry. The National Asphalt Pavement Association (NAPA) conducted a voluntary survey of asphalt mixture producers in the United States and of state asphalt pavement associations (SAPAs). The survey was broken into five sections: general information, RAP, RAS, WMA, and other recycled materials. Asphalt mix producers from all 50 states completed the 2014 survey. A total of 228 companies/branches with 1,185 plants were represented in the 2014 construction season survey.

The following are highlights of the 2014 survey:

- The asphalt industry remains the country's most diligent recycler, recycling asphalt pavements at a rate of greater than 99 percent. All contractors/branches responding to the survey reported using RAP in 2013 and 2014. The average percent of asphalt used for all mixes has seen a steady increase of about 1 percent per year since 2009. The total estimated amount of RAP used in asphalt mixtures was 71.9 million tons in 2014, a 28 percent increase over the tons used in 2009 (56 million tons). This is a 6 percent increase over the tons used in 2013 (67.8 million tons). Assuming 5 percent liquid asphalt in RAP, this represents over 3.6 million tons (20 million barrels) of asphalt binder conserved. Use of RAP also reduced the need for some 68 million tons of virgin aggregate. The amount of RAP landfilled was only 0.17 percent, which is in line with previous years.
- Use of both manufacturing waste and post-consumer shingles in asphalt mixtures increased to an all-time high of nearly 2 million tons in 2014, nearly a 20 percent increase from 2013 (1.6 million tons). Assuming a conservative asphalt content of 20 percent for the RAS that may be used to replace virgin binder, this represents 400,000 tons (2.2 million barrels) of asphalt binder conserved, along with 982,000 tons of aggregate. Since the 2012 survey, the amount of scrap shingles collected has been less than the amount used. Contractors contacted on this issue have reported that they either have shingles stockpiled or are buying RAS from shingle processors.
- The combined saving of asphalt binder ($550/ton) and aggregate ($9.50/ton) by using RAP and RAS in asphalt mixes is more than $2.8 billion. This keeps asphalt pavement mixture costs competitive and allows owners to achieve more roadway maintenance and construction activities within limited budgets.
- Information on other recycled materials was obtained for the third time in this year's survey. The most commonly used other recycled materials in asphalt mixtures were blast furnace slag, steel slag, ground tire rubber, and cellulose fibers. Less commonly used recycled materials included fly ash and foundry sand.
- Total tonnage of WMA was estimated at 113.8 million tons during 2014. This is nearly a 7 percent increase over 2013 WMA tonnage (106.4 million tons). As of 2014, WMA is now about one-third of the total asphalt mixture market. Plant foaming is used most often in producing WMA, with more than 84 percent of the market; additives accounted for about 16 percent of the market.

Asphalt Pavement Industry Survey on Recycled Materials and Warm-Mix Asphalt Usage: 2014

Background

A shared goal of the Federal Highway Administration (FHWA) and the National Asphalt Pavement Association (NAPA) is to support and promote sustainable practices, such as incorporating recycled materials in pavement mixtures and the use of warm-mix asphalt (WMA). Reclaimed asphalt pavement (RAP) is recycled at a higher rate than any other material in the United States and is vital to the mission of extending the performance and service life of the nation's infrastructure while lowering overall costs. Another recycled material used in asphalt mixtures is reclaimed asphalt shingles (RAS) from both manufacturing waste (MWAS) and post-consumer asphalt shingles (PCAS). The use of RAP and RAS in asphalt pavements can reduce the amount of new asphalt binder and aggregates required in mixes, which can help stabilize the price of asphalt mixtures and save natural resources. Other recycled materials being incorporated into asphalt pavements include ground tire rubber (GTR), steel slag, blast furnace slag, and cellulose fibers, among others. By putting waste materials to a practical use, the asphalt pavement industry helps reduce the amount of material going to landfills while improving the sustainability of asphalt mixtures.

WMA technologies reduce the mixing and compacting temperatures for asphalt mixtures. Environmental benefits include reductions in both fuel consumption and air emissions. Construction benefits include the ability to extend the paving season into the cooler months, haul material longer distances, improve compaction, and use higher percentages of RAP (Prowell et al., 2012). As part of FHWA's original group of Every Day Counts initiatives, WMA was chosen in 2010 for accelerated deployment in federal-aid highway, state department of transportation (DOT), and local road projects (FHWA, 2013). In 2013, WMA was honored with the Construction Innovation Forum's NOVA Award for its engineering, economic, and environmental benefits (CIF, 2013).

FHWA works closely with the pavement industry through associations and other stakeholders to promote pavement recycling technologies and WMA. Since 2007, the American Association of State Highway and Transportation Officials (AASHTO) has conducted a biennial survey of state DOTs' use of recycled materials (Copeland, 2011; Copeland et al., 2010; Pappas, 2011). The results of the AASHTO survey are typically presented at FHWA Expert Task Group meetings. FHWA partners with NAPA to document industry use of RAP, RAS, other recycled materials, as well as WMA technologies used by asphalt mix producers. These efforts have established a baseline for RAP, RAS, and WMA usage, and have tracked the growth of the use of these sustainable practices in the highway industry since 2009.

The industry survey first collected data for the 2009 and 2010 construction seasons and with follow up surveys for the 2011, 2012 and 2013 construction season. These surveys have shown significant growth in the use of RAP, RAS, and WMA technologies from 2009 to 2013 (Hansen & Newcomb, 2011; Hansen & Copeland, 2013a; 2013b; 2014). To continue tracking the use of these technologies, FHWA again partnered with NAPA to capture RAP, RAS, and WMA use for the 2014 construction season. This report documents the results of the 2014 industry survey, including the survey methodology, results, trends, and changes from 2009 through 2014. Since 2012, the survey has also asked about the use of other recycled materials used in asphalt mixtures. The survey questions and data by state are included in the appendices.

Objective and Scope

The objective of this effort is to quantify the use of recycled materials and WMA technologies by the asphalt pavement industry. NAPA conducted a voluntary survey of asphalt mixture producers in the United States, along with a survey of state asphalt pavement associations (SAPAs). While keeping specific producer data confidential, NAPA staff compiled the amount of asphalt mixtures being produced; the amount of RAP, RAS, and other recycled material used; and the amount

of WMA produced in the United States. The data are broken out on a state-by-state basis in Appendix B. To keep specific producer data confidential, no state specific information is provided in the tables or appendix if fewer than three producers from a state responded to the survey. Information from states with fewer than three responding companies is used to estimate national values, however.

The data are analyzed and summarized in this report. In order to accomplish this work, the following tasks were conducted:

1. Develop an online survey similar to the 2009–2013 surveys that enables an analysis of the quantities of recycled materials being used in asphalt mixtures, as well as the total amount of WMA produced nationally.
2. Conduct a voluntary survey of asphalt mix producers throughout the United States and follow up with verbal requests for information in locations where responses were low.
3. Estimate the total asphalt mixture market in each state or territory by using data provided by SAPAs and the U.S. Department of Transportation federal-aid highway apportionment to determine a weighting factor for each state and reconcile the total U.S. asphalt mix tonnage with national estimates.
4. Analyze and summarize the information nationally and by state and prepare a final report.

Survey Methodology

The survey was conducted using an online survey platform, SurveyMonkey®. Sections 1 through 4 of the survey for 2014 were identical to the surveys used for 2009 through 2012 (Hansen & Newcomb, 2011; Hansen & Copeland, 2013a; 2013b; 2014). Section 5 was first added in 2012 to collect information on the use of other recycled material in asphalt mixtures. A copy of the 2014 survey is included as Appendix A. Table 1 summarizes the questions asked in each section.

Producers were notified of the survey through several forums and electronic media. A notice was posted in NAPA's e-newsletter, *ActionNews*, informing members of the survey and asking for their participation. SAPAs participated by placing notices on their websites and in their newsletters. Announcements were made at NAPA meetings, as well as at several state asphalt conferences. A press release was sent to construction industry trade media, and republished in print and online. Notices of the survey and links were shared through social media channels, including Twitter, Facebook, and LinkedIn. Asphalt mixture producers then went to the SurveyMonkey website to complete the survey form. Some producers submitted PDF forms and the data were entered into SurveyMonkey by NAPA. One multistate producer submitted data using a spreadsheet developed by NAPA. After the initial data was gathered and analyzed, anomalies in individual producer records were identified and reconciled.

Table 1: Survey Questions Summary

Section 1: General Information	Sections 2 and 3: RAP & RAS	Section 4: WMA	Section 5: Other Recycled Materials
Number of Plants	Tons Accepted	Average % Produced for DOT Tons	Other Recycled Materials Used
DOT Tons	Tons Used in HMA/WMA	Average % Produced for Other Agency Tons	Tons of HMA/WMA Produced Using Each Recycled Material
Other Agency Tons	Tons Used in Aggregate	Average % Produced for Commercial & Residential Tons	Tons of Other Recycled Product Used
Commercial & Residential Tons	Tons Used in Cold Mix	Chemical Additive %	
	Tons Used in Other	Additive Foaming %	
	Tons Landfilled	Plant Foaming %	
	Average % for DOT Mixes	Organic Additive %	
	Average % for Other Agency Mixes		
	Average % for Commercial & Residential Mixes		

To determine the total amount of RAP and RAS used and WMA produced in each state and in the nation, the total amount of asphalt mix produced in each state needed to be determined. Total tonnage of asphalt mix produced represents commercial (i.e., private sector) and government (i.e., DOT and Other Agency) tonnages. Estimated tonnages were provided by SAPAs in 35 states/territories, which totaled about 291 million tons. This included one SAPA that supplied DOT-estimated tonnages. For this state, the total tonnage was estimated by dividing the DOT tonnage by the percent of DOT tons provided by asphalt mix producers in that state who completed the survey. To estimate the total tons in states where a SAPA estimate of total tonnage was not available, the total asphalt mixture tonnage was estimated through a relationship developed by examining states where SAPA-estimated tons were available compared to their federal-aid highway apportionment. This is the same methodology used to estimate tonnage in the previous versions of this survey; for more details see Hansen & Newcomb (2011).This resulted in the following power curve relationship:

$$\text{Total Estimated Tons} = 0.2359 \times (\text{State Federal Apportionment})^{0.843} \quad [1]$$

Equation 1 is used to estimate the tonnage for states with no SAPA estimate based on the state's federal apportionment.

Survey Results

Asphalt mix producers from all 50 states completed the 2014 survey, which is two fewer jurisdictions than in 2013, but higher than in other survey years. No plants in the District of Columbia or any U.S. insular area contributed data for 2014. A total of 228 companies/branches with 1,185 plants are represented in the 2014 survey. This is down slightly from the 2013 survey responses, but more than in previous survey years. While the number of companies/branches and plants represented by this survey decreased, the total tons reported increased from 147.6 to 151.0 million tons. This may be due to a slight increase in total asphalt mix production and contractors shutting down less efficient plants. Table 2 summarizes the number of companies/branches and the number of plants reporting for each state. Table 3 summarizes the total responses from previous years.

Table 2: No. of Companies/Branches Completing 2014 Survey by State

State	Cos.	Plants	State	Cos.	Plants	State	Cos.	Plants
Alabama	5	37	Kentucky	7	47	Ohio	7	102
Alaska	*	*	Louisiana	*	*	Oklahoma	6	16
American Samoa	NCR	NCR	Maine	3	17	Oregon	5	14
Arizona	3	6	Maryland	5	13	Pennsylvania	6	27
Arkansas	6	19	Massachusetts	4	16	Puerto Rico	NCR	NCR
California	6	61	Michigan	6	36	Rhode Island	*	*
Colorado	5	21	Minnesota	7	26	South Carolina	6	18
Connecticut	3	16	Mississippi	5	21	South Dakota	*	*
Delaware	*	*	Missouri	4	29	Tennessee	7	53
District of Columbia	NCR	NCR	Montana	*	*	Texas	11	61
Florida	7	38	Nebraska	3	7	U.S. Virgin Islands	NCR	NCR
Georgia	4	22	Nevada	3	4	Utah	8	19
Guam	NCR	NCR	New Hampshire	4	14	Vermont	*	*
Hawaii	*	*	New Jersey	3	16	Virginia	7	33
Idaho	4	14	New Mexico	*	*	Washington	4	30
Illinois	9	29	New York	9	59	West Virginia	3	14
Indiana	4	32	North Carolina	7	32	Wisconsin	*	*
Iowa	8	18	North Dakota	*	*	Wyoming	*	*
Kansas	5	24	N. Mariana Islands	NCR	NCR			

NCR = No Contractors Reporting * = Fewer than 3 contractors reporting

Table 3: Summary of Jurisdictions, Companies/Branches, and Plant Represented in 2009–2014 Surveys

Year	No. Jurisdictions Reporting	No. of Companies/Branches Reporting.	No. of Plants Represented in Survey	Average Tons Produced per Plant
2009	48	196	1,027	121,000
2010	48	196	1,027	117,000
2011	49	203	1,091	121,000
2012	49	213	1,141	122,000
2013	52	249	1,281	115,000
2014	50	228	1,185	127,000

Table 4 includes the estimated tonnage for each state as estimated by the SAPA or estimated from the federal apportionment using Equation 1, as well as the reported tonnage for each state from the survey results and the ratio of the tons reported in each state to the total estimated tons for 2014. The closer a state's ratio is to 100 indicates that the reported tonnage from the survey matches the estimated tonnage provided by the SAPA or the tonnage estimated from the federal apportionment. The data reported in the survey represent about 43 percent of total estimated U.S. tonnage for 2014.

Table 4: Summary of 2014 Estimated and Reported Plant Mix Asphalt Tons by State

State	Tons, Millions	Reported % of Estimated		State	Tons, Millions	Reported % of Estimated	
		Estimated	Reported			Estimated	Reported
Alabama	7.50	4.04	54%	Montana	4.18	*	*
Alaska	4.76	*	*	Nebraska	3.17	0.81	26%
Arizona	6.63	0.84	13%	Nevada	3.65	0.52	14%
Arkansas	5.10	1.67	33%	New Hampshire	1.93	1.57	81%
California	23.09	10.23	44%	New Jersey	5.00	3.31	66%
Colorado	7.00	2.86	41%	New Mexico	3.81	*	*
Connecticut	4.69	2.14	46%	New York	16.30	5.13	31%
Delaware	1.46	*	*	North Carolina	12.00	4.22	35%
District of Columbia	1.88	NCR	NCR	North Dakota	5.00	*	*
Florida	13.30	6.51	49%	Ohio	14.80	13.54	91%
Georgia	4.50	2.32	52%	Oklahoma	4.60	2.20	48%
Hawaii	1.89	*	*	Oregon	4.89	1.45	30%
Idaho	3.06	1.03	34%	Pennsylvania	17.70	3.23	18%
Illinois	13.80	3.49	25%	Puerto Rico	1.60	NCR	NCR
Indiana	9.20	4.76	52%	Rhode Island	2.44	*	*
Iowa	3.60	2.19	61%	South Carolina	4.89	1.96	40%
Kansas	4.00	2.37	59%	South Dakota	2.10	*	*
Kentucky	9.00	4.37	49%	Tennessee	7.36	4.44	60%
Louisiana	6.25	*	*	Texas	18.00	9.74	54%
Maine	2.07	1.36	66%	Utah	3.40	2.94	86%
Maryland	6.80	2.52	37%	Vermont	2.27	*	*
Massachusetts	6.50	2.62	40%	Virginia	9.75	5.24	54%
Michigan	11.30	7.39	65%	Washington	4.90	2.60	53%
Minnesota	13.00	5.55	43%	West Virginia	2.60	1.49	57%
Mississippi	3.50	2.41	69%	Wisconsin	13.00	*	*
Missouri	6.10	1.89	31%	Wyoming	2.75	*	*
				Total	352.04	150.98	43%

NCR No Companies Reporting

* Fewer than 3 companies/branches reporting

SAPA Estimated Tons

Figure 1 shows the number of plants as well as the average tons produced per plant separated by User/Producer Group (UPG) region. While the number of plants represented in each UPG decreased in 2014, the tons per plant for all UPGs increased significantly from 2013 to 2014 with both the North Central Asphalt User/Producer Group (NCAUPG) and Southeastern Asphalt User/Producer Group (SEAUPG) reaching all-time high production levels since the survey began in 2009.

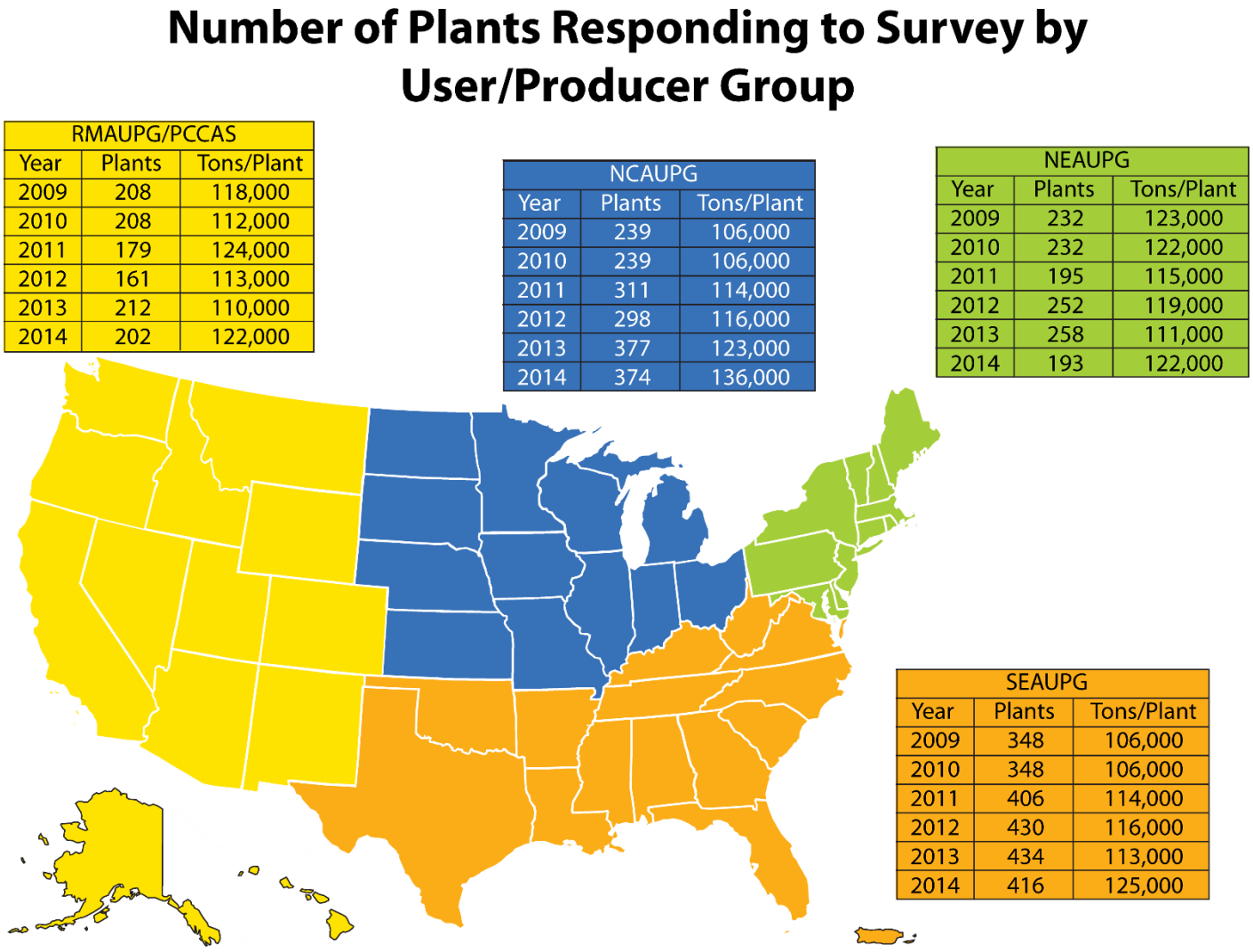


Figure 1: Number of Plants Responding to Survey by User/Producer Group Regions and Estimated Tonnage, 2009–2014

Table 5 summarizes the RAP, RAS, and WMA data from the 2014 survey alongside data from the 2013 survey (Hansen & Copeland, 2014) for comparison. The information requested in the survey is summarized in Table 1 and detailed in Appendix A. Reported Values in Table 5 are national summaries of the values from asphalt mix producers completing the survey. Estimated values for the Tons of HMA/WMA Produced were determined as outlined above in Survey Methodology.

For the amount of RAP accepted contractors were asked “How many tons of removed asphalt pavement and asphalt millings were accepted/delivered to your facilities in the state in 2014?” For the amount of RAS accepted producers were asked “How many tons of unprocessed shingles (manufacturers waste and tear-offs) were accepted/delivered to your facilities in the state in 2014?” Therefore, for RAS, this quantity would not include processed RAS acquired from shingle processors. For each state, the tons of RAS and RAP reported as accepted and used were multiplied by the ratio

of estimated production to total production, and these values were summed to arrive at the national estimated tons for these materials.

To understand the average percentage of recycled material used in mixes, producers were asked to report the average recycled content of mixes produced for each sector (DOT, Other Public Agencies, Commercial & Residential) and to use their best estimate if data was not available. These were averaged to determine the National Average All Mixes Based on % Reported for Different Sectors. In this case, it is evident that many producers provided the average percent when either product was used in a mix, resulting in a likely overestimate of the percentage for each sector as not all mixes would necessarily contain recycled product. To account for this, a National Average All Mixes Based on RAP/RAS Tons Used in HMA/WMA was calculated based on reported tons of material used in HMA/WMA mixes divided by total reported tons produced. Because RAP is more commonly used in mixes than RAS, the differences in the percentages for each sector and the National Average All Mixes Based on RAP/RAS Tons Used in HMA/WMA show less of a disparity in the RAP values. The better estimate of the average percentage for either product is the percentage based on reported tons used. Producers were not asked about allowable RAP or binder replacement requirements, which can have an effect on demand for mixes that incorporate these materials.

Producers were asked to give their best estimate of the percent of WMA produced for each sector when the technology resulted in temperature reduction of 10°F to 100°F. These percentages were multiplied by the total mix production for each sector to determine the total estimated tons of WMA produced for each sector. The survey methodology was designed so that only mixes produced at reduced temperatures are reported. Because some WMA additives are used for construction benefits unrelated to the goal of reducing production temperatures, the use of some WMA additives in HMA production may not be captured in this question.

2014 RAP Study Tour of Japan

In 2014, NAPA led a study tour of Japanese asphalt mix producers and road construction projects to learn about the use of high levels of RAP in that country. The tour included U.S. asphalt mix producers, state department of transportation officials, and representatives from FHWA. On average, Japan uses about 47 percent RAP in its asphalt pavements, and in some prefectures the average is around 51 percent. Through analysis of pavement performance on hundreds of projects and experimentation in the lab and field, Japan has developed standards and practices that have proven to provide equal performance for high RAP content mixes and virgin mixes. Although some of these factors and practices are unique to the Japanese pavement industry, the tour gained many insights that can be applied in the U.S. These are detailed in the NAPA publication *High RAP Asphalt Pavements: Japan Practice — Lessons Learned* (West & Copeland, 2015).

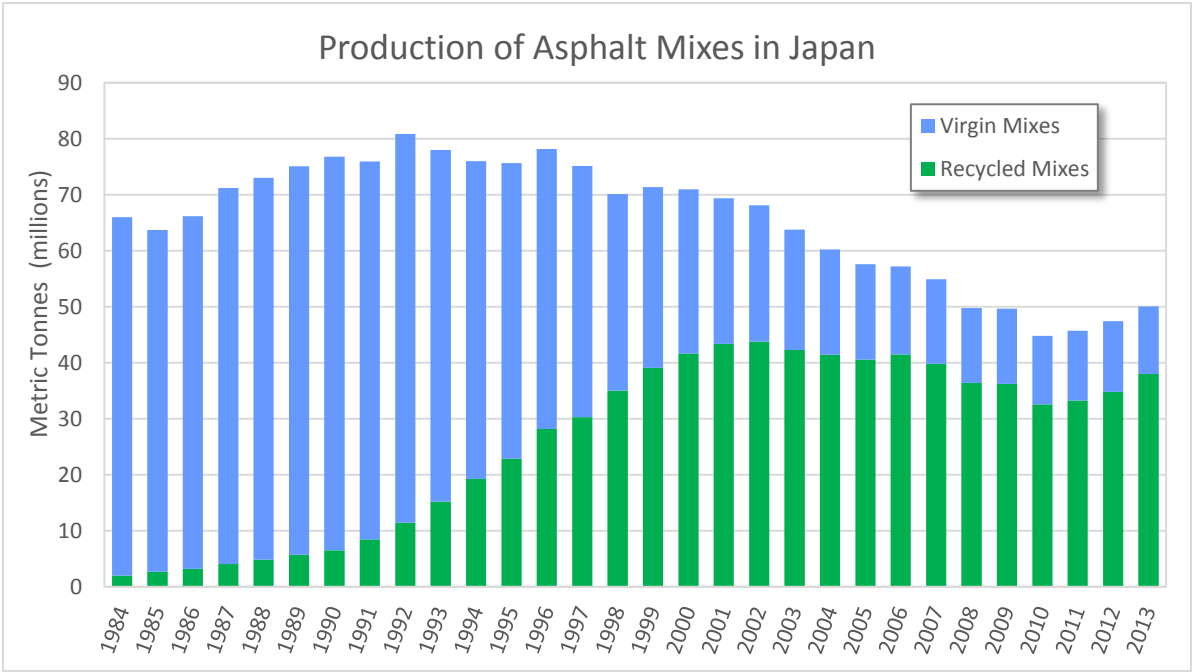


Table 5: Summary of RAP, RAS, WMA Data

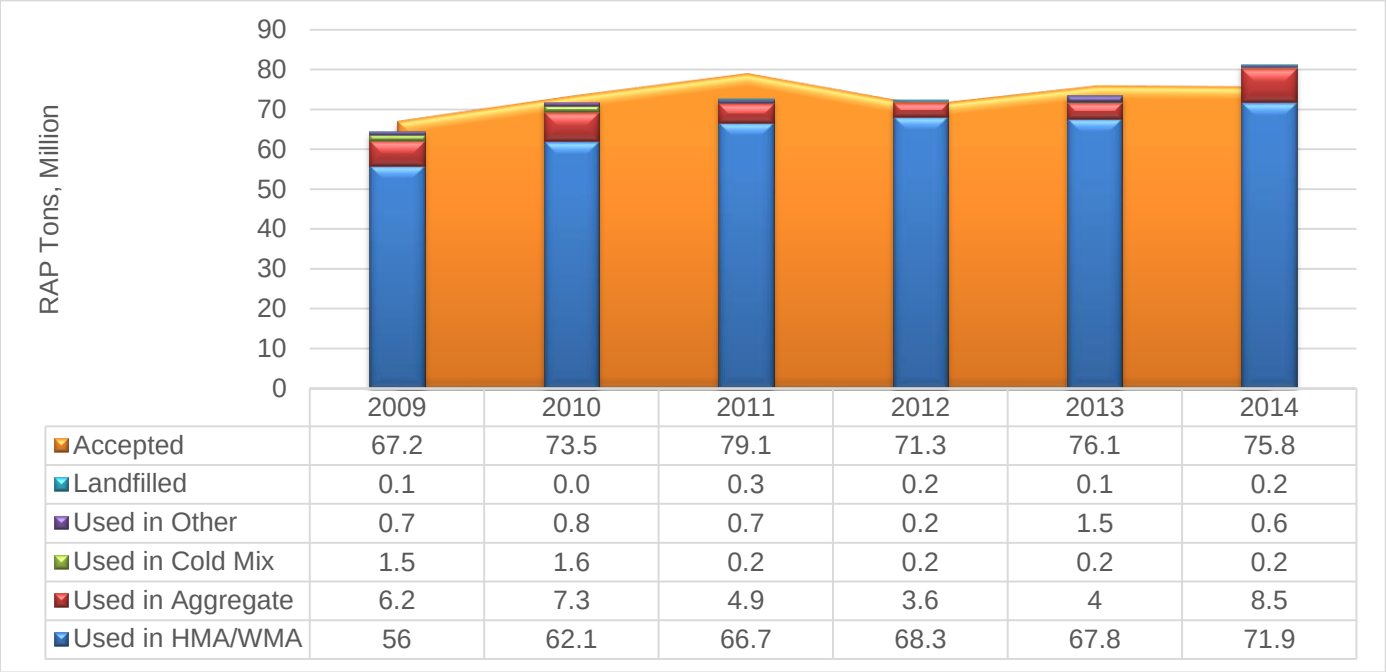
	Reported Values		Estimated Values	
	2013	2014	2013	2014
Tons of HMA/WMA Produced	Tons, Millions		Tons, Millions	
Total	147.6	151.0	350.7	352.0
DOT	67.4	68.7	160.1	160.2
Other Agency	40.6	38.9	96.5	90.7
Commercial and Residential	39.6	43.3	94.1	101.1
Companies/Branches Reporting	249	228		
RAP	Tons, Millions		Tons, Millions	
Accepted	34.9	33.8	76.1	75.8
Used in HMA/WMA	29.5	32.2	67.8	71.9
Used in Aggregate	1.7	2.9	4.0	8.5
Used in Cold Mix	0.1	0.1	0.2	0.2
Used in Other	0.3	0.2	1.5	0.6
Landfilled	0.1	0.1	0.1	0.2
	Average % Used in Mixes			
Average % for DOT Mixes[1]	19.5%	19.6%		
Average % for Other Agency Mixes[1]	19.3%	19.8%		
Average % for Commercial & Residential[1]	22.7%	22.7%		
National Average All Mixes Based on % Reported for Different Sectors[1]	19.3%	20.4%		
National Average All Mixes Based on RAP Tons Used in HMA/WMA[2]	20.0%	21.3%		
Companies/Branches Reporting Using RAP	249	228		
RAS	Tons, Millions		Tons, Millions	
Accepted	0.685	0.692	1.599	1.664
Used in HMA/WMA	0.718	0.809	1.647	1.964
Used in Aggregate	0.028	0.018	0.082	0.043
Used in Cold Mix	0	0	0	0
Used in Other	0.002	0.002	0.005	0.006
Landfilled	0	0	0	0
	Average % Used in Mixes			
Average % for DOT Mixes[1]	0.85%	0.72%		
Average % for Other Agency Mixes[1]	1.08%	0.95%		
Average % for Commercial & Residential[1]	1.24%	1.47%		
National Average All Mixes Based on RAS Tons Used in HMA/WMA[2]	0.49%	0.54%		
Companies/Branches Reporting Using RAP	97	87		
WMA	% of Total Production		Tons, Millions	
DOT	37.3%	37.8%	55.7	56.9
Other Agency	32.4%	34.9%	27.9	28.4
Commercial and Residential	25.9%	29.4%	22.8	28.5
Total			106.4	113.8
	% of Market			
Chemical Additive %	12.1%	15.0%		
Additive Foaming %	0.3%	0.0%		
Plant Foaming %	87.0%	84.5%		
Organic Additive %	0.7%	0.5%		
Companies/Branches Reporting Using WMA	193	174		

[1] Average percent based on contractor's reported percentage for each sector.

[2] Average percent based on total reported tons of RAP or RAS used in HMA/WMA divided by reported total tons HMA/WMA produced.

Reclaimed Asphalt Pavement

Table 5 includes the summary of RAP data from the 2014 survey. The information requested in the survey is detailed in Appendix A and summarized in Table 1. Figure 2 is a visual representation of the estimated total tons of RAP used in asphalt mixes, aggregate, cold mix, other uses, and landfilled compared to the RAP tons accepted from 2009 to 2014. The overwhelming majority of RAP is used in asphalt mixtures, which is the most optimal use of RAP. For 2014, as in 2012, more RAP was used for all purposes than was received. This is primarily due to increased use of RAP in asphalt mixtures. Discarding RAP in construction and demolition landfills is rare. Since the beginning of the survey in 2009, the average amount of RAP landfilled is less than 150,000 tons per year, or 0.20 percent. For 2014 the amount of RAP landfilled was 0.22 percent.



	2009	2010	2011	2012	2013	2014
Accepted	67.2	73.5	79.1	71.3	76.1	75.8
Landfilled	0.1	0.0	0.3	0.2	0.1	0.2
Used in Other	0.7	0.8	0.7	0.2	1.5	0.6
Used in Cold Mix	1.5	1.6	0.2	0.2	0.2	0.2
Used in Aggregate	6.2	7.3	4.9	3.6	4	8.5
Used in HMA/WMA	56	62.1	66.7	68.3	67.8	71.9

Figure 2: Comparison of Tons of RAP Accepted and Tons of RAP Used (Million Tons)

Figure 3 shows the total estimated amount of RAP used in the different industry sectors. These values were calculated using the average percentages of RAP reported for the different sectors and adjusted to account for differences between reported RAP tonnage and tons calculated from the percentage by sector.

The sectors are divided into Commercial & Residential (private sector) and DOT and Other Agency (public sector). The Other Agency grouping includes mix produced for public works agencies, city and county transportation departments, and the U.S. military, and federal agencies, such as the Federal Aviation Administration.

Figure 4 shows the average percentage of RAP used by each sector and total percentage RAP used. The average percent RAP used by all sectors has seen variable growth from 2009 to 2014. However, the change in the total percentage of RAP use by all sectors has increased steadily since 2009 at a rate of about 1 percent per year. Fluctuations in RAP tonnages used by each sector, as is illustrated in Figure 5, are primarily due to changes in the total tonnage used by each sector. It is interesting that while total tonnage for the DOT sector decreased in 2014, the percentage of RAP used DOT mixes increased, indicating that states and contractors are making greater use of RAP in their mixes.

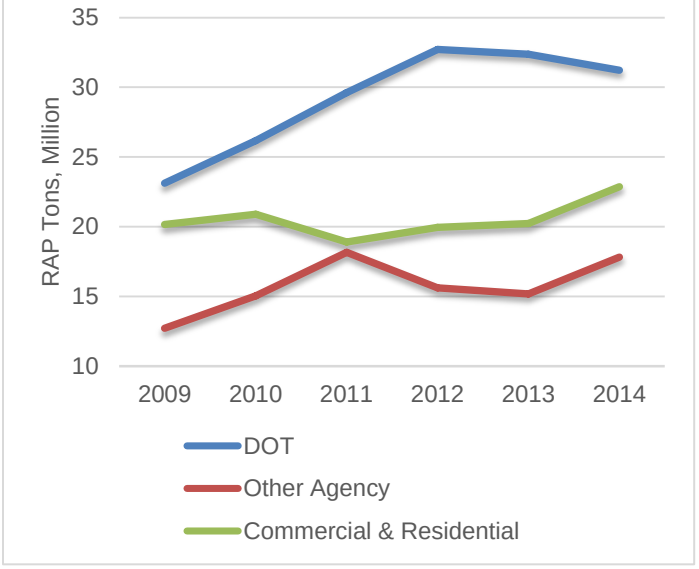


Figure 3: RAP Use by Sector (Million Tons)

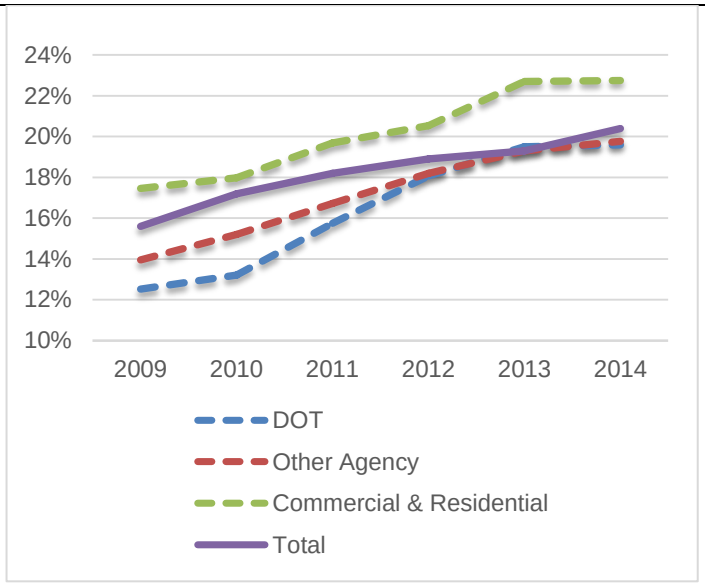


Figure 4: Average Percent RAP Used by Sector

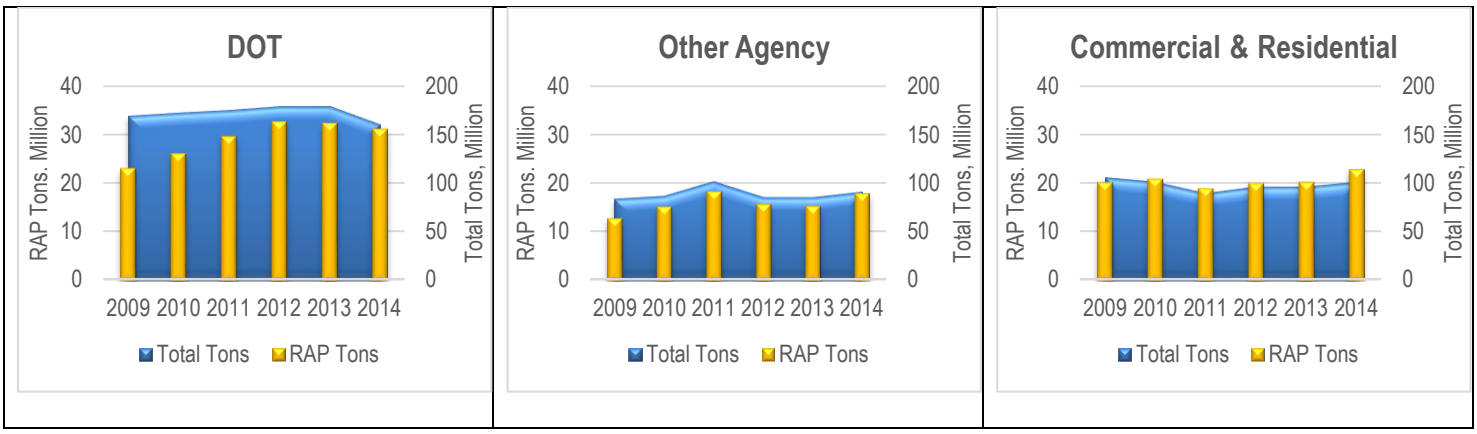


Figure 5: RAP Tons and Total Mix Tons Comparison (Million Tons)

Figure 6 and Table 6 show the average percent of RAP used in each state based on reported RAP and total tonnage. It should be noted that the accuracy of data for individual states will vary depending on the number of responses received from each state and the total number of tons accounted for in the responses. Comparing the maps in Figure 6, the number of states averaging more than 20 percent RAP in HMA/WMA (colored green and dark green) increased steadily from seven states in 2009 to 23 states in 2014. The use of increased amounts of RAP has spread quickly in the Midwest and West. For example, average percent RAP in Idaho increased steadily from 6 percent in 2009 to 25 percent or more since 2012.

For 2013 and 2014, all (100 percent) of the contractors/branches responding to the survey reported using RAP, and more than 91 percent of contractors reported having excess RAP on hand in 2014. In 2011 and 2012, 98 percent of respondents reported using RAP. From 2013 to 2014, the amount of RAP used in HMA/WMA increased from 67.8 million to 71.9 million tons. The average percent RAP used in mixes increased from 19.3 percent in 2013 to 20.4 percent in 2014.

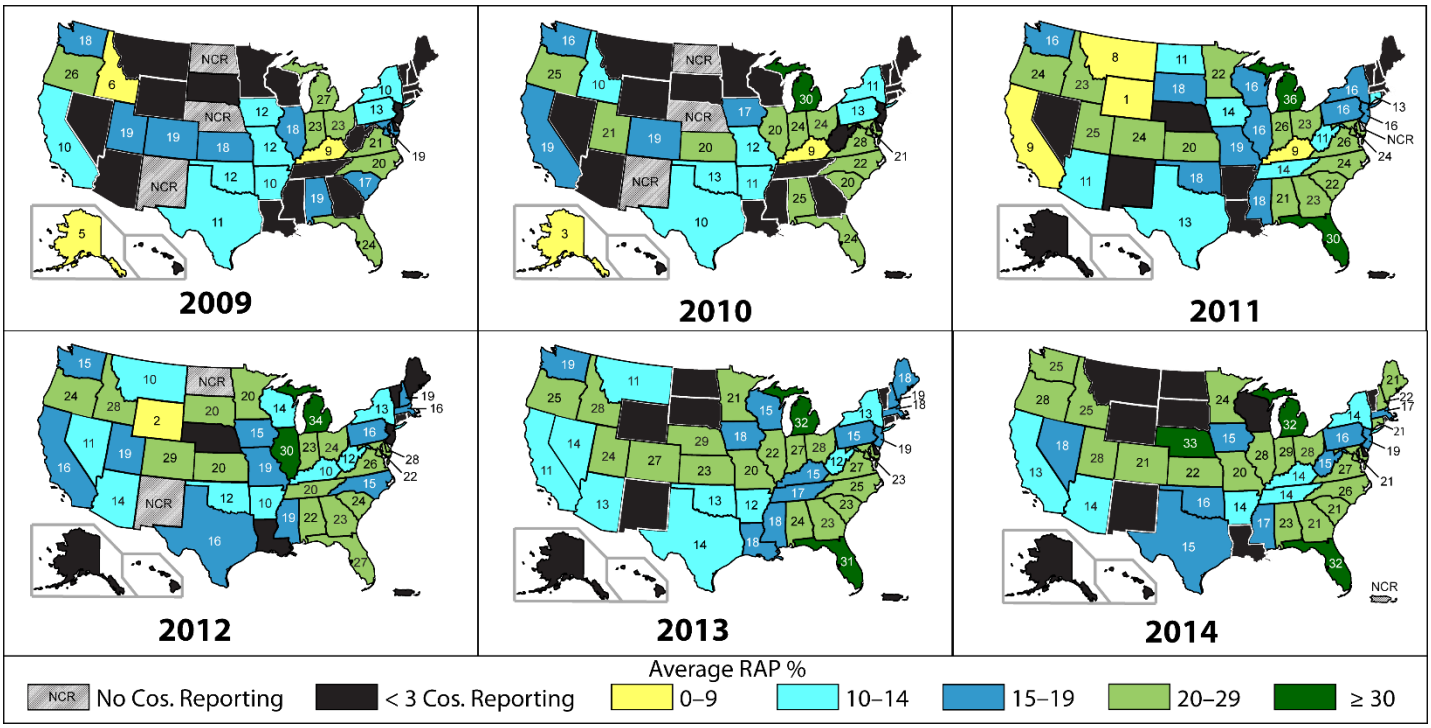


Figure 6: Estimated Average Percent of RAP by State

Table 6: Average Estimated RAP Percent

State	Average RAP Percent						State	Average RAP Percent					
	2009	2010	2011	2012	2013	2014		2009	2010	2011	2012	2013	2014
Alabama	19%	25%	21%	22%	24%	23%	Montana			8%	10%	11%	
Alaska	5%	3%					Nebraska	NCR	NCR			29%	33%
Arizona			11%	14%	13%	14%	Nevada				11%	14%	18%
Arkansas	10%	11%		10%	12%	14%	New Hampshire				19%	19%	22%
California	10%	19%	9%	16%	11%	13%	New Jersey			16%		19%	19%
Colorado	19%	19%	24%	29%	27%	21%	New Mexico	NCR	NCR		NCR		
Connecticut			13%			21%	New York	10%	11%	16%	13%	13%	14%
Delaware			NCR	28%			North Carolina	20%	22%	24%	15%	25%	26%
District of Columbia	NCR	NCR	NCR	NCR		NCR	North Dakota	NCR	NCR	11%	NCR		
Florida	24%	24%	30%	27%	31%	32%	Ohio	23%	24%	23%	24%	28%	28%
Georgia			23%	23%	23%	21%	Oklahoma	12%	13%	18%	12%	13%	16%
Hawaii							Oregon	26%	25%	24%	24%	25%	28%
Idaho	6%	10%	23%	28%	28%	25%	Pennsylvania	13%	13%	16%	16%	15%	16%
Illinois	18%	20%	16%	30%	22%	28%	Puerto Rico						NCR
Indiana	23%	24%	26%	23%	27%	29%	Rhode Island						
Iowa	12%	17%	14%	15%	18%	15%	South Carolina	17%	20%	22%	24%	23%	21%
Kansas	18%	20%	20%	20%	23%	22%	South Dakota			18%	20%		
Kentucky	9%	9%	9%	10%	15%	14%	Tennessee			14%	20%	17%	14%
Louisiana					18%		Texas	11%	10%	13%	16%	14%	15%
Maine					18%	21%	Utah	19%	21%	25%	19%	24%	28%
Maryland	19%	21%	24%	22%	23%	21%	Vermont						
Massachusetts				16%	18%	17%	Virginia	21%	28%	26%	26%	27%	27%
Michigan	27%	30%	36%	34%	32%	32%	Washington	18%	16%	16%	15%	19%	25%
Minnesota			22%	20%	21%	24%	West Virginia			11%	12%	12%	15%
Mississippi			18%	19%	18%	17%	Wisconsin			16%	14%	15%	
Missouri	12%	12%	19%	19%	20%	20%	Wyoming			1%	2%		

No Contractors Reporting	< 3 Contractors Reporting	0–9%	10–14%	15–19%	20–29%	≥ 30%

Figure 7 show the number of states reporting average RAP percentages for various ranges. The number of states reporting average RAP percentages greater than 20 percent has increased significantly, rising from 14 states in 2009 to 27 states in 2014; the number of states reporting RAP percentages less than 15 percent has decreased from 19 states in 2009 to just nine states in 2014.

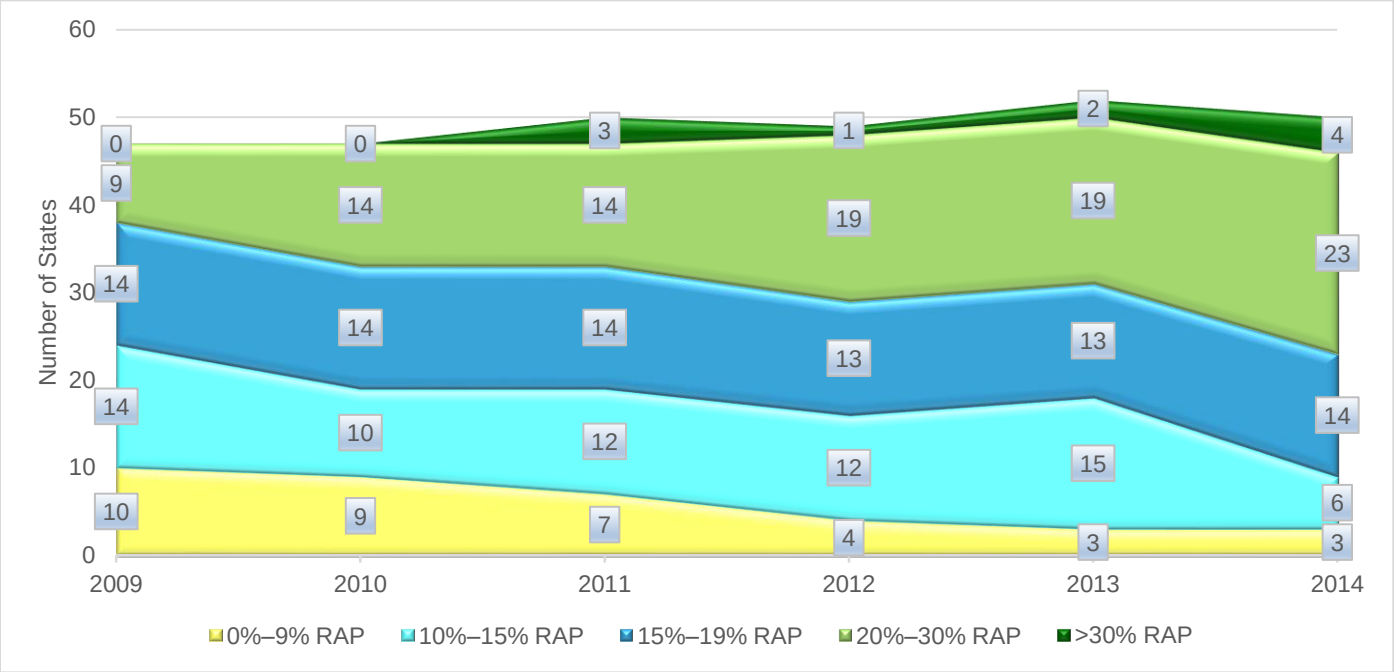


Figure 7: Count of States at Different Average RAP Percentages

Not measured in this survey is the use of in-place asphalt pavement recycling techniques, such as full-depth reclamation (FDR), cold in-place recycling (CIR), and hot in-place recycling (HIR). Some cold central plant recycling (CCPR) may be included in the tons reported as used in other or used in cold mix.

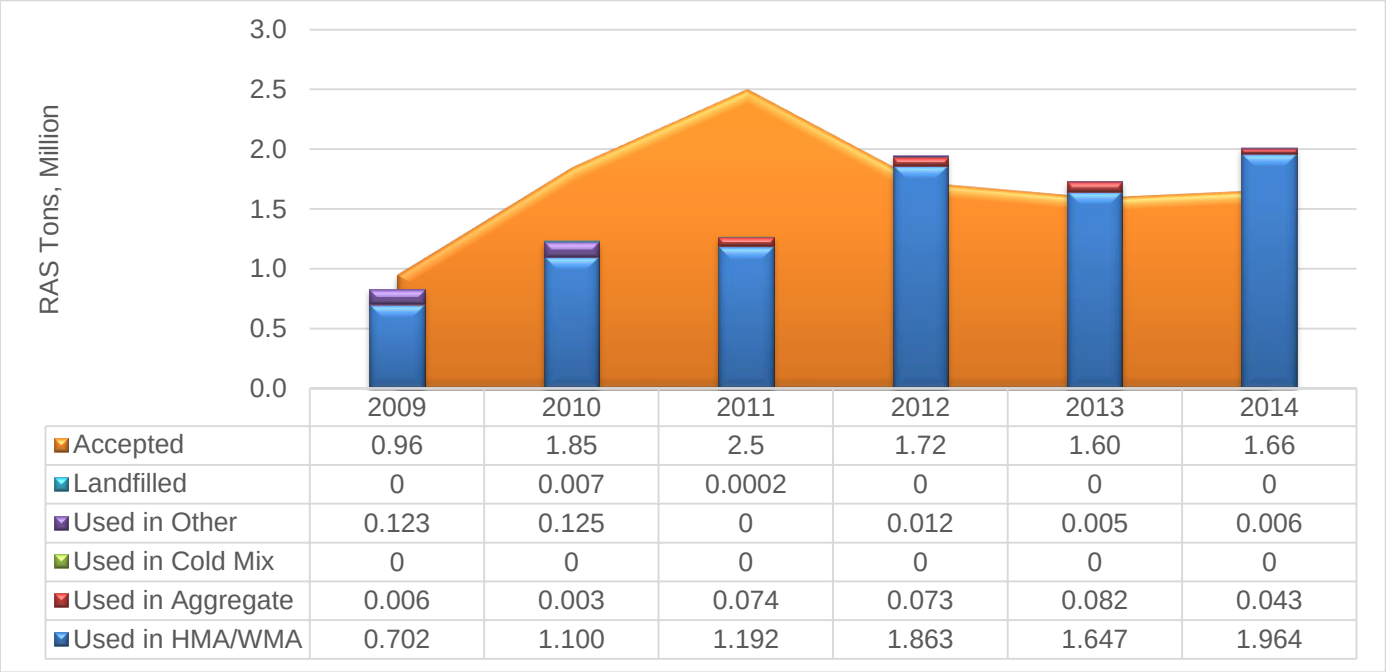
Reclaimed Asphalt Shingles

Table 5 includes the summary of RAS data from the 2014 survey. The information requested in the survey is detailed in Appendix A and summarized in Table 1. Producers were not asked about allowable RAS or binder replacement requirements for their states. For the 2009–2011 surveys, more unprocessed shingles were received than were used for all purposes, including landfilling. Beginning in 2012 this changed with a total of 224,000, 135,000, and 349,000 more tons of RAS being used than was received in 2012, 2013, and 2014 respectively. When it was first noticed that contractors were reporting using RAS in greater quantities than they received, they were contacted to confirm these values. All contractors contacted indicated that they either had RAS stockpiled or were purchasing it from shingle processors. It is assumed that other contractors reporting similar values also had shingles stockpile or were purchasing them from shingle processors. From 2013 to 2014, the amount of RAS accepted by producers increased by 4.1 percent, following declines of 31 and 7 percent from 2011 to 2012 and 2012 to 2013, respectively. Most RAS is used in asphalt pavement mixtures with the second highest use being with aggregate. RAS use in aggregates increased from 6,000 tons in 2009 to 82,000 tons in 2013, but declined to 43,000 tons in 2014. No RAS was reported as being landfilled in 2009 or 2012–2014; in 2010 and 2011, the amount landfilled was about 7,000 and 200 tons, respectively.

Figure 8 shows the total estimated amount of RAS used and for which purpose. Total RAS use increased rapidly from 2009 to 2010 and from 2011 to 2012 at rates of about 48 and 54 percent. From 2012 to 2013 there was a moderate decrease of 11 percent, in total RAS used, but this rebounded by 16 percent from 2013 to 2014. This increase is due to an increase in the average percent of RAS being used in Commercial & Residential sector mixes, as well as an increase in

the total tons of asphalt mix produced for that sector. From the first survey in 2009 to 2014, RAS use in asphalt mixtures has increased nearly 180 percent.

As with RAP, RAS is primarily used in asphalt mixtures. Figure 9 summarizes how RAS was used in the different sectors of the paving market. These values were calculated using the average percentages of RAS reported for the different sectors and were adjusted to account for differences between reported RAS tons and tons calculated from the percentage by sector. There was a moderate decrease in the tons of RAS used by DOTs from 2013 to 2014, due to the decline in total DOT mix tonnage. During this same period, RAS use by Other Agencies increased slightly while the Commercial & Residential sector saw significant increases in RAS use. Figure 10 shows the average RAS percent used in asphalt mixes for the three sectors. These values were calculated using the average percentages of RAS reported for the different sectors and adjusted to account for differences between reported RAS tonnage and tons calculated from the percentage by sector. Overall, RAS use has seen relatively steady growth in all sectors from 2009 to 2014 amid some year-to-year variation. Growth has been greatest in the Commercial and Residential (0.1 percent per year) and Other Agency (0.08 percent per year) sectors with slower growth in the DOT sector (0.05 percent per year). The number of companies/branches using RAS increased steadily from 44 in 2009 to 97 from 2012 to 2013, but decreased to 87 in 2014. Part of this decrease is likely due to the decrease in the number of companies responding to the survey. The percentage of companies reporting using RAS has declined steadily from 41 percent in 2012 to 38 percent in 2014.



	2009	2010	2011	2012	2013	2014
Accepted	0.96	1.85	2.5	1.72	1.60	1.66
Landfilled	0	0.007	0.0002	0	0	0
Used in Other	0.123	0.125	0	0.012	0.005	0.006
Used in Cold Mix	0	0	0	0	0	0
Used in Aggregate	0.006	0.003	0.074	0.073	0.082	0.043
Used in HMA/WMA	0.702	1.100	1.192	1.863	1.647	1.964

Figure 8: Summary of RAS Use (Million Tons)

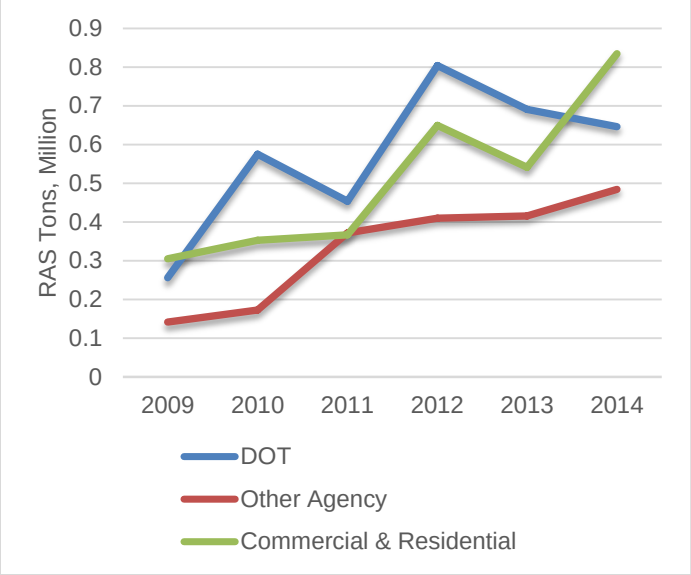


Figure 9: Estimated RAS Use by Sector (Million Tons)

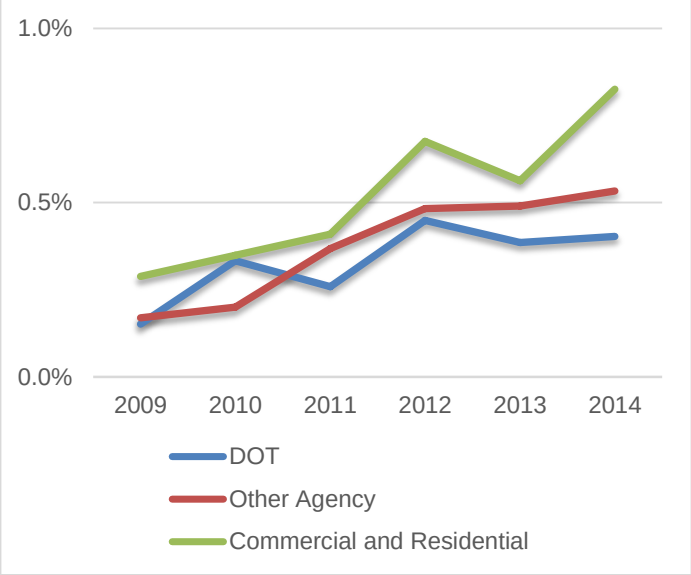


Figure 10: Average Percent RAS Used by Sector

Figure 11 shows states where plant-mix producers reported using RAS in 2009 through 2014. Red indicates states where RAS use was not reported for that year. The number of states where plant-mix producers reported using RAS increased each year from 22 in 2009 to 38 in 2013, but decreased to 36 in 2014. Four states — Georgia, Louisiana, New Jersey and Wyoming — reported RAS use in 2013 but did not report using RAS in 2014. North Dakota reported using RAS in for the first time in 2014. Colorado reported RAS use from 2009 to 2012, but not in 2013; for 2014 the state, again reported using RAS. Table 6 shows the states where producers reported using RAS for 2009–2014.

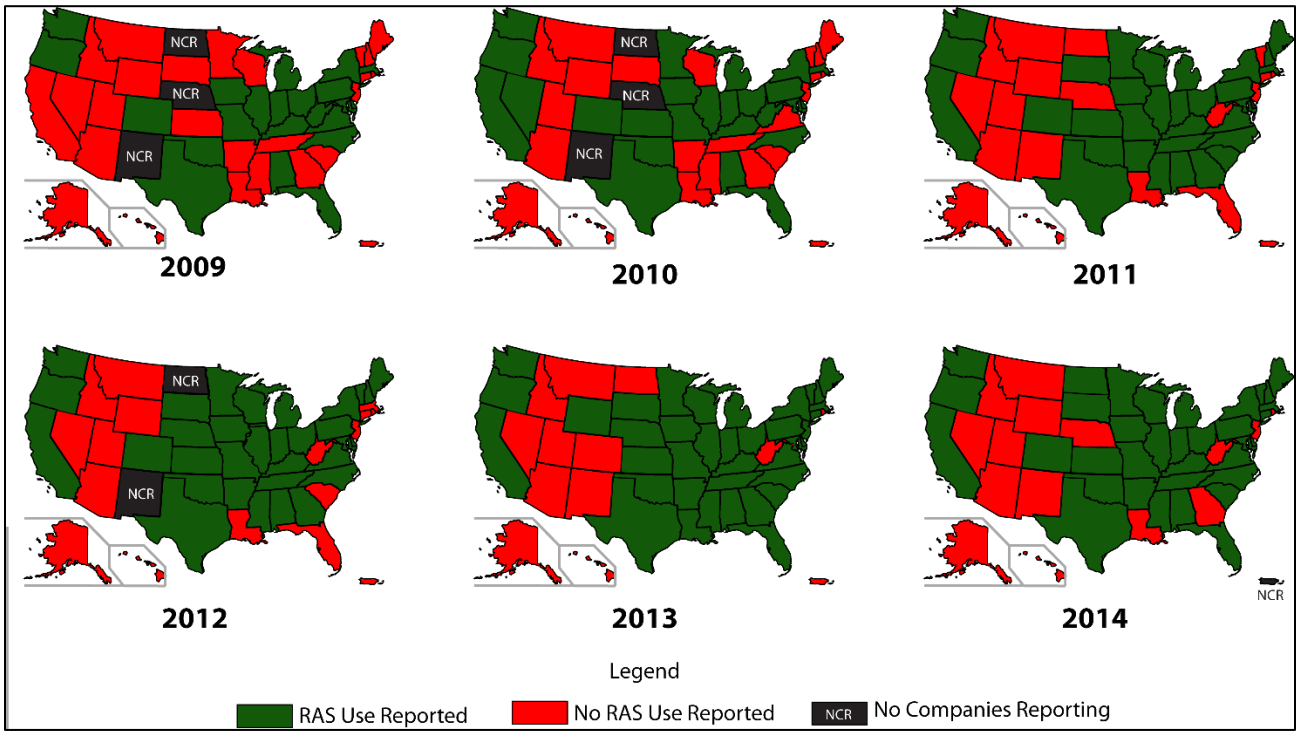


Figure 11: States with Companies/Branches Reporting Using RAS

Table 7: States Reporting RAS Use

State	RAS Used?						State	RAS Used?					
	2009	2010	2011	2012	2013	2014		2009	2010	2011	2012	2013	2014
Alabama	Yes	Yes	Yes	Yes	Yes	Yes	Montana	No	No	No	No	No	No
Alaska	No	No	No	No	No	No	Nebraska	NCR	NCR	No	Yes	Yes	No
Arizona	No	No	No	No	No	No	Nevada	No	Yes	No	No	No	No
Arkansas	No	No	Yes	Yes	Yes	Yes	New Hampshire	No	No	Yes	Yes	Yes	Yes
California	No	Yes	Yes	Yes	Yes	Yes	New Jersey	No	No	No	No	Yes	No
Colorado	Yes	Yes	Yes	Yes	No	Yes	New Mexico	NCR	NCR	No	NCR	No	No
Connecticut	No	No	No	No	Yes	Yes	New York	Yes	Yes	Yes	Yes	Yes	Yes
Delaware	Yes	Yes	NCR	Yes	Yes	Yes	North Carolina	Yes	Yes	Yes	Yes	Yes	Yes
District of Columbia	NCR	NCR	NCR	NCR	No	NCR	North Dakota	NCR	NCR	No	NCR	No	Yes
Florida	Yes	Yes	No	No	Yes	Yes	Ohio	Yes	Yes	Yes	Yes	Yes	Yes
Georgia	No	No	Yes	Yes	Yes	No	Oklahoma	Yes	Yes	Yes	Yes	Yes	Yes
Hawaii	No	No	No	No	No	No	Oregon	Yes	Yes	Yes	Yes	Yes	Yes
Idaho	No	No	No	No	No	No	Pennsylvania	Yes	Yes	Yes	Yes	Yes	Yes
Illinois	Yes	Yes	Yes	Yes	Yes	Yes	Puerto Rico	No	No	No	No	No	NCR
Indiana	Yes	Yes	Yes	Yes	Yes	Yes	Rhode Island	No	No	No	No	No	No
Iowa	Yes	Yes	Yes	Yes	Yes	Yes	South Carolina	No	No	Yes	No	Yes	Yes
Kansas	No	Yes	Yes	Yes	Yes	Yes	South Dakota	No	No	Yes	Yes	Yes	Yes
Kentucky	Yes	Yes	Yes	Yes	Yes	Yes	Tennessee	No	No	Yes	Yes	Yes	Yes
Louisiana	No	No	No	No	Yes	No	Texas	Yes	Yes	Yes	Yes	Yes	Yes
Maine	No	No	Yes	Yes	Yes	Yes	Utah	No	No	No	No	No	No
Maryland	Yes	Yes	Yes	Yes	Yes	Yes	Vermont	No	No	No	Yes	Yes	Yes
Massachusetts	Yes	Yes	Yes	No	Yes	Yes	Virginia	Yes	No	Yes	Yes	Yes	Yes
Michigan	Yes	Yes	Yes	Yes	Yes	Yes	Washington	Yes	Yes	Yes	Yes	Yes	Yes
Minnesota	No	Yes	Yes	Yes	Yes	Yes	West Virginia	Yes	Yes	No	No	No	No
Mississippi	No	No	Yes	Yes	Yes	Yes	Wisconsin	No	No	Yes	Yes	Yes	Yes
Missouri	Yes	Yes	Yes	Yes	Yes	Yes	Wyoming	No	No	No	No	Yes	No

NCR	= No Contractors Reporting
Yes	= RAS Use Reported
No	= No RAS Use Reported

Warm-Mix Asphalt

Table 5 includes the summary WMA data from the survey. The survey asked producers their estimated percentages of tons produced for the different sectors and the percent of which technologies were used.

The percent of companies/branches using WMA saw rapid increases from 2009 to 2011 but only modest increases from 2011 to 2013, with a slight decrease in 2014, as shown in Figure 12. Figure 13 shows a steady increase in the number of tons of WMA produced from 2011 to 2013, with a modest increase in 2014. WMA use reached almost 114 million tons in 2014, which is a little less than one-third of the total asphalt mix production for the year, as is shown in Figure 14. This is probably attributable to increased acceptance of WMA by all industry sectors as illustrated in Figure 13.

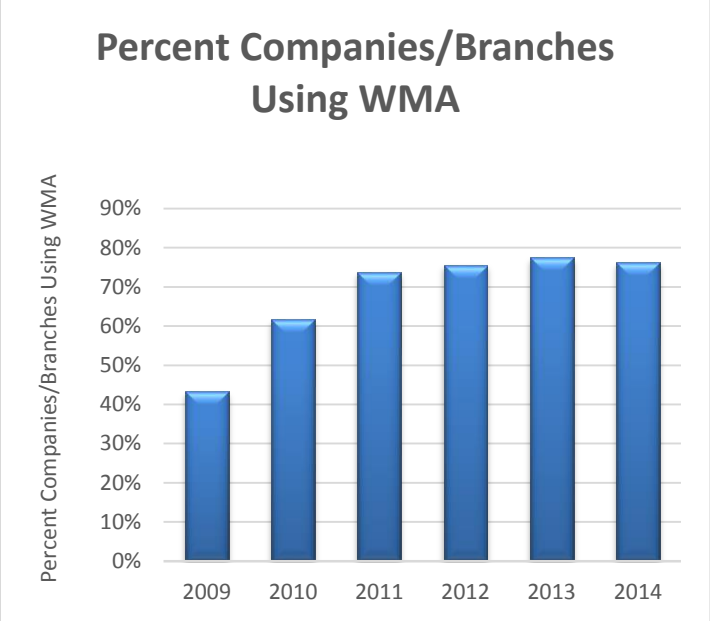


Figure 12: Number of Companies/Branches Using WMA

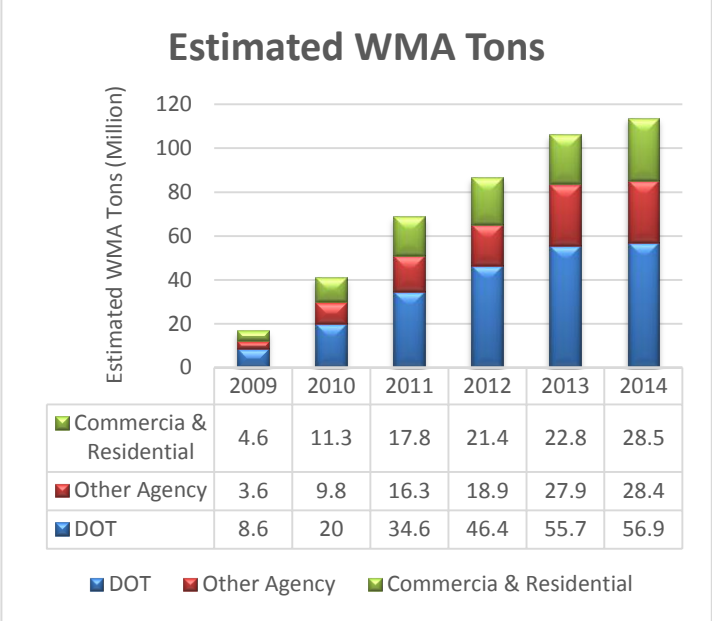


Figure 13: Estimated Tons (in Millions) WMA by Industry Sector

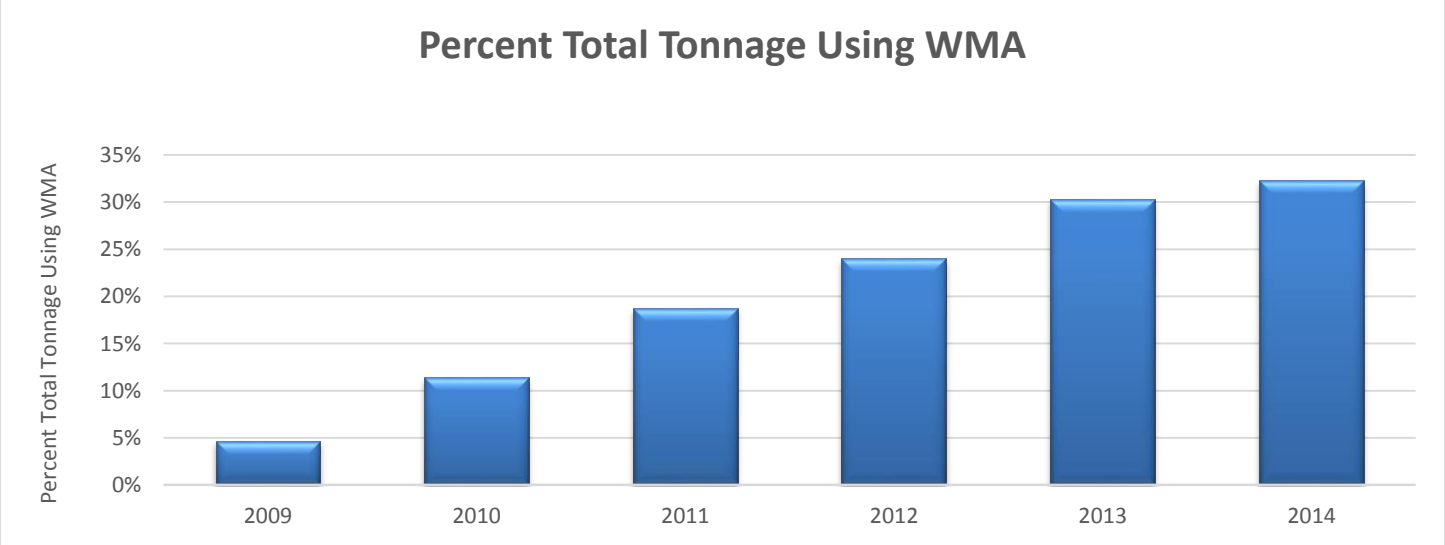


Figure 14: Percent of Total Tonnage Using WMA

Figure 15 shows the estimated total tons of WMA produced in each state. It should be noted that the accuracy of data for individual states will vary depending on the number of responses received from each state and the total number of tons represented by the responses.

From 2013 to 2014, 20 states saw an increase of 5 percent or greater in WMA production, while 13 states had a decrease of 5 percent or greater in WMA production. Three states — Colorado, Minnesota, and South Dakota — had an increase of 25 percent or greater in WMA production. Wyoming had a dramatic 53 percent increase. Idaho made a 28 percent increase from 2012 to 2013 and a 24 percent increase from 2013 to 2014. One state — New Jersey — had a decrease of 25 percent in WMA production. The reasons for these fluctuations are uncertain. WMA makes up over half of total asphalt mix production in 15 states, up from eight states in 2013, and six of them — Delaware, Kansas, Louisiana, Mississippi, Ohio, and Virginia — reported WMA as 75 percent or more of total production in 2014. Nevada and Rhode Island did not report the use of WMA in 2014.

Nationally, the total tons of WMA increased from 106.4 million tons in 2013 to 113.8 million tons in 2014, a 7 percent increase.

Plant foaming is most commonly used technology in the production of WMA. Use of WMA additives increased from 13.1 percent in 2013 to 15.5 percent in 2014. This is still below the 17 percent market share noted in 2009, but given that WMA tonnage has increased by more than 577 percent since 2009, the volume of additives used, along with plant foaming, has increased significantly. WMA additives can have compaction, antistrip, and other benefits that may encourage use even when a reduction in production temperature is not sought or achieved by the producer.

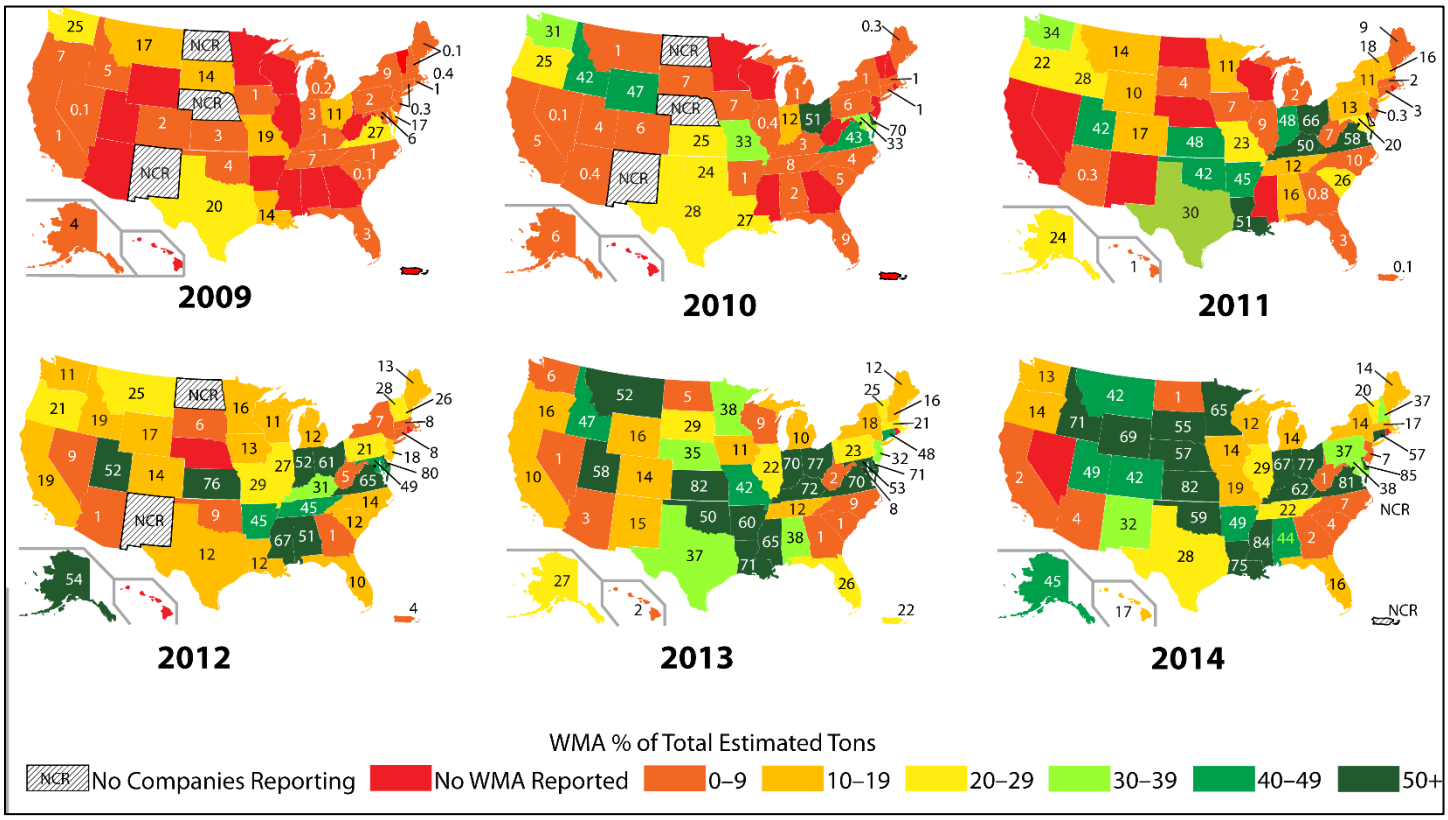


Figure 15: Estimated Percent of Total Production Using WMA

Other Recycled Materials

Starting with the 2012 survey, a series of questions was asked about the use of other recycled materials used in asphalt mixtures. Table 1 summarizes the questions in this section. The full questionnaire is included as Appendix A.

Producers were asked how many tons of mix were produced that incorporated other recycled materials, as well as how many tons of specific materials were used in mix production during 2014. Three recycled materials — ground tire rubber (GTR), steel slag, and blast furnace slag — were specifically listed in the survey. Respondents were able to specify up to two additional recycled materials that were used in mixes. Because the response rate to these questions about other recycled materials was expected to be low and because producers may not track the use of these materials, state and national estimates of total quantities used for these materials were not calculated. **All values in this section are reported values and do not represent estimates of the total quantity of these materials by state or nationally.** A total of 51 contractors from 24 states reported using other recycled materials in asphalt mixtures for 2014.

Ground Tire Rubber

Table 8 summarizes information on the use of ground tire rubber. 19 producers from nine states reported using GTR in some mixes. It must be noted that Arizona, which is known to use large quantities of GTR in mixes, had a relatively low participation rate in the survey, while Georgia had a very high participation rate. This likely explains why Georgia's reported quantity of GTR is higher than Arizona. The total reported tons of asphalt pavement mix using GTR stayed relatively flat from 2013 to 2014, rising from 1,195,594 tons in 2013 to 1,200,181 tons in 2014.

While reporting of tons produced that incorporate GTR is relatively straightforward to track and report, the tons of GTR used is harder to document due to different methods of producing mixes that incorporate GTR — the wet process, which uses GTR as an asphalt cement (AC) modifier, and the dry process, which incorporates GTR as a fine aggregate (Bahia, 2011) — and the likelihood that the GTR is either preblended at with AC at the terminal or it is blended onsite by a third party. Given these factors, producer reports of tons of GTR used versus tons of mix produced using GTR were given a heightened level of scrutiny to determine if the reported data was in a reasonable range. When reported tons of GTR were outside of the expected range producers were contacted to obtain correct values.

To give a picture of the total market size for GTR, the Rubber Manufacturers Association reports that 24.4 percent of U.S. scrap tires were processed into GTR in 2013. After removing wire, fluff, and agglomerated rubber, some 7 percent by weight of GTR produced (about 45,000 tons) was used in asphalt pavements in 2013 (RMA, 2014), including asphalt pavement mixtures, chip seals, and seal coats. Based on the RMA (2014) estimate, the GTR use reported in this survey represents about 28 percent of total GTR used in asphalt mixtures in the United States.

Table 8: Reported Tons Ground Tire Rubber

State	Reported Tons of Mix Using GTR			Reported Tons of GTR Used		
	2012	2013	2014	2012	2013	2014
Arizona	33,590	26,300	12,000	532	380	142
California	101,000	523,213	623,953	—	3,748	9,173
Florida	86,441	250,779	198,046	195	531	419
Georgia	281,958	65,000	162,000	—	260	750
Illinois	—	4,500	—	—	20	—
Indiana	—	13,000	—	—	30	—
Louisiana	25,000	104,395	—	—	550	—
Maine	—	14,000	—	—	219	—
Massachusetts	—	24,897	81,882	—	324	1,146
Michigan	2,400	12,000	9,300	20	71	51
Missouri	100,000	50,000	—	300	180	—
New Hampshire	—	28,000	50,000	—	358	780
New York	—	10	—	—	—	—
Ohio	36,200	1,500	23,000	—	8	150
Pennsylvania	—	18,000	—	—	140	—
Puerto Rico	—	10,000	NCR	—	170	—
Texas	25,000	50,000	40,000	—	—	200
Total	691,589	1,195,594	1,200,181	1,047	6,989	12,811
No. of Contractors	15	29	19			

Steel & Blast Furnace Slag

Tables 9 and 10 summarize the reported use of steel slag and blast furnace slag in asphalt mixes, respectively. Ten states reported using steel slag and seven states reported using blast slag in 2014. It is interesting to note that while the total tons of mix and materials for each slag type vary from year to year, there has been a consistent increase in the combined use of both slags as illustrated in Figure 16. Since slag aggregates are often used to improve skid resistance, this increase may be due to an increased emphasis on safety by pavement owners.

The National Slag Association estimates that 20 million tons of slag is produced and marketed annually (NSA, 2015). With 1.2 million tons of slag reported as used in asphalt mixes for 2014, this survey captures the use of more than 6 percent of total available slag. Because reported total tons of asphalt mixes from states using slag is about 55 percent of their total estimated tons, it is likely that asphalt pavements incorporate about 10 percent of total available slag.

Table 9: Reported Tons for Steel Slag, 2012–2014

State	Reported Tons of Mix Using Steel Slag			Reported Tons of Steel Slag Used		
	2012	2013	2014	2012	2013	2014
Alabama	625,000	750,000	837,083	133,441	165,000	112,480
Arkansas	120,000	25,000	84,900	12,000	2,500	12,735
Illinois	23,000	43,700	56,407	8,000	16,300	21,991
Indiana	70,000	161,115	111,800	44,000	61,985	41,500
Iowa	20,000	97,500	57,689	—	10,200	9,432
Kentucky	5,714	508,000	125,000	800	173,265	15,000
Michigan	—	750,000	754,131	—	95,000	136,382
Minnesota	145,500	200,000	238,000	21,800	30,000	34,000
Ohio	150,000	185,319	185,125	42,030	79,085	60,133
Tennessee	30,000	—	—	6,000	—	—
Washington	450,000	586,000	416,000	80,000	82,954	60,000
Total	1,639,214	3,306,634	2,866,135	348,071	716,289	503,653

Table 10: Reported Tons for Blast Furnace Slag, 2012–2014

State	Reported Tons of Mix Using Blast Furnace Slag			Reported Tons of Blast Furnace Slag Use		
	2012	2013	2014	2012	2013	2014
Alabama	100,000	110,000	100,000	10,100	12,500	10,000
Illinois	—	—	40,000	—	—	10,000
Indiana	1,487,000	116,500	375,000	304,000	57,000	150,000
Iowa	—	5,000	15,000	—	500	1,500
Kentucky	—	16,000	828,243	—	7,500	191,067
Michigan	500,000	700,000	329,000	50,000	107,000	43,750
Ohio	208,028	416,250	794,6000	72,400	110,613	145,105
Virginia	54,520	—		16,356	—	—
West Virginia	588,120	504,704	1,065,382	180,308	155,032	190,000
Total	2,937,668	1,868,454	3,547,225	633,164	450,145	741,422

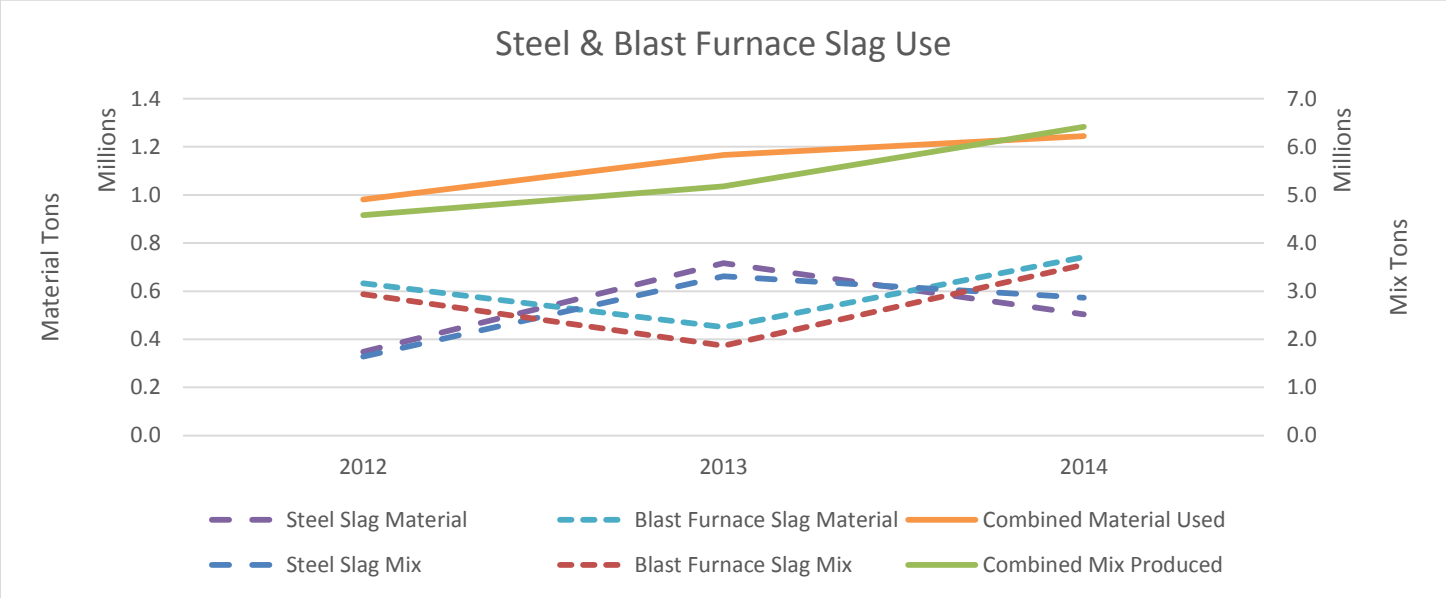


Figure 16: Steel and Blast Furnace Slag Use, 2012–2014

Other Recycled Materials

Table 11 summarizes other recycled materials used in asphalt mixtures. Other reported recycled materials include fly ash, cellulose fiber, foundry sand, and recycled glass. Recycled glass was only reported by Virginia in 2012 and has not been reported since. Fly ash use has been reported in Mississippi and Texas each year of the survey; Wisconsin reported using fly ash for the first time in 2014. Six states — Florida, Louisiana, Maryland, New York, Texas, and Virginia — reported using cellulose fibers in 2014. Georgia, which is known to use SMA and OGFC mixes that typically require fibers, reported using cellulose fibers in 2013, but did not report their use in 2014.

Table 11: Other Recycled Materials

State & Type of Other Recycled Material	Reported Tons of Mix Produced Using Other Recycled Material			Reported Tons of Other Recycled Material Used		
	2012	2013	2014	2012	2013	2014
Cellulose Fiber						
Florida	—	20,204	73,600	—	71	311
Georgia	—	43,000	—	—	129	—
Indiana	—	6,000	—	—	60	—
Louisiana	—	31,651	1,500	—	63	30
Maryland	—	145,000	120,000	—	440	360
Minnesota	—	5,000	—	—	15	—
Mississippi	76,000	—	—	250	—	—
New York	—	—	700	—	—	1
Texas	—	30,600	36,000	—	90	44
Virginia	—	—	74,000	—	—	120
Total	76,000	281,455	305,800	250	868	866
Fly Ash						
Mississippi	50,000	50,000	15,000	2,400	2,500	600
Texas	18,000	25,000	20,000	1,200	1,700	1,000
Wisconsin	—	—	26,000	—	—	1,500
Total	68,000	75,000	61,000	3,600	4,200	3,100
Bottom Ash						
South Dakota	52,000	—	—	4,280	—	—
Foundry Sand						
Missouri	5,000	15,130	22,310	500	1,514	2,231
Recycled Glass						
Virginia	173	—	—	34	—	—

Summary and Conclusions

The objective of this survey was to quantify the use of recycled materials and WMA produced by the asphalt pavement industry during the 2014 construction season. Asphalt mix producers from all 50 states completed the 2014 survey, and data was collected from a total of 228 companies/branches with 1,185 plants.

The estimated total asphalt mix production saw a slight increase from 350.7 million to 352.0 million tons from 2013 to 2014. The estimated DOT tonnage remained constant at 160 million tons for 2013 and 2014, while Other Agency tonnage decreased from 96.5 million to 90.7 million tons from 2013 to 2014. There was an increase in Commercial & Residential tonnage from 94.1 million ton 101.1 million tons.

The use of recycled material continues to increase slightly. The survey shows:

- The percent of producers reporting using RAP increased from 96 percent in 2009 and 2010 to 98 percent in 2011 and 2012 to 100 percent in 2013 and 2014.

- The average percent RAP used by all sectors has seen variable growth from 2009 to 2014. However, the change in the total percentage of RAP use by all sectors has increased steadily since 2009 at a rate of about 1 percent per year. The average estimated percent RAP used in all mixes has increased from 15.6 percent in 2009 to 20.4 percent in 2014.
- The estimated tons of RAP used in asphalt mixes reached 71.9 million tons in 2014. This represents greater than a 28 percent increase in the amount of tons used from 2009 to 2014.
- Contractors/branches reported having excess RAP increased from 87 to 91 percent from 2013 to 2014. For the second time in the survey's history, the estimated amount of RAP used for all purposes in 2014, including landfilling, exceeded the amount accepted. RAP use exceeded RAP received by 1.2 million tons in 2012 and 5.6 million tons in 2014.
- Use of both recycled manufacturing waste and post-consumer asphalt shingles in asphalt mixes increased from 1.65 million tons in 2013 to 1.96 million tons in 2014, which is the highest amount used since the survey began in 2009. This represents an 18.8 percent increase from 2013 to 2014, and a nearly 180 percent increase since 2009.
- The amount of RAS accepted by asphalt mix producers increased from 1.6 million tons in 2013 to 1.7 million tons in 2014, but remains below the high of 2.5 million tons in 2010. Since 2012, more RAS accepted been used for all purposes each year than is accepted. In 2014, 349,000 more tons of RAS was used for all purposes than was accepted. This is attributed to contractors having stockpiles of RAS and purchasing RAS from shingle processors. Eighty-two percent of contractors/branches using RAS reported having excess RAS for 2014.
- Of the RAS used in 2014, about 98 percent was used in asphalt mixtures. The remainder was primarily combined with aggregates. No RAS was landfilled.
- The number of states with reported RAS use decreased from 38 states in 2013 to 36 states in 2014.
- The combined saving of asphalt binder ($550/ton) and aggregate ($9.50/ton) by using RAP and RAS in asphalt mixes is more than $2.8 billion. This keeps asphalt pavement mixture costs competitive and allows owners to achieve more roadway maintenance and construction activities within limited budgets.
- The number of states reporting use of ground tire rubber (GTR) in asphalt mixtures decreased from 17 in 2013 to nine in 2014, although the reported tonnage of mix produced using GTR remained essentially flat.
- The number of states reporting use of steel or blast furnace slags remained constant at 11 states in 2013 and 2014, although a slight but steady increase in the use of these materials is being reported.
- Three states, Mississippi, Texas and Wisconsin, reported using fly ash in asphalt mixtures in 2014. Mississippi and Texas reported using fly ash in both 2012 and 2013.
- The number of states reporting use of cellulose fibers decreased from seven states in 2013 to six states in 2014.
- Less commonly reported recycled materials in 2014 included foundry sand.

The use of WMA continues to increase, but at a slower rate. The survey shows:

- The estimated total production of WMA for 2014 was about 114 million tons. This was about a 7 percent increase over 2013 WMA (106 million tons) and more than 577 percent increase over 2009.
- WMA was about one-third of the total estimated asphalt mixture market in 2014.
- Plant foaming, representing over 84 percent of the market, is the most commonly used warm-mix technology; additives accounted for about 16 percent of the market.

The 2014 survey results show that the asphalt pavement industry continues to improve its outstanding record of sustainable practices by further increasing the use of recycled materials and WMA. RAP use has seen a steady increase of about 1 percent per year since 2009. In 2012 and 2014, more RAP was used than accepted. This was primarily due to a decrease in the amount of RAP collected compared to previous years. The reason for this decrease is uncertain, but it may be partially due to reduced construction activity, as indicated by lower total production volumes since 2011. While slightly more RAP was used than received in 2014, 91 percent of producers indicated they have excess RAP on hand, revealing that opportunities remain to increase the amount of RAP used in asphalt mixes through permissive specifications and through improved RAP processing, production equipment and procedures, and education.

RAS use saw a strong increase in 2014 to an all-time high of more than 1.96 million tons used in asphalt mixes. This represents nearly 15 percent of the estimated 13.2 million ton waste shingle market (1.2 million tons of MWAS and 12 million tons of PCAS).[1] As with RAP, permissive specifications, improved processing, production equipment and procedures, and education will help improve the amount and percentages used in asphalt mixes.

The asphalt pavement industry repurposes many products from other industries. The survey shows that steel and blast furnace slag use was reported in 11 states in 2013 and 2014, GTR use was reported in 16 jurisdictions in 2013 and nine states in 2014; cellulose fiber use was reported in one state in 2012, seven states in 2013, and six states in 2014; and fly ash in two states for 2012 and 2013, and three states in 2014. One state has reported using foundry sand each year since 2012.

WMA use again increased, but at a lower rate, in 2014 with a total production of a little less than 114 million tons, which represents nearly one-third of the total estimated asphalt mix production. All states, with the exceptions of Nevada and Rhode Island, reported using WMA in 2014. WMA use is expected to continue to grow as contractors and agencies gain experience and more states implement permissive specifications.

[1] According to the Asphalt Roofing Manufacturers Association (ARMA, 2015), about 13.2 million waste shingles are generated annually — about 12 million tons of post-consumer asphalt shingles (PCAS) and 1.2 million tons of manufacturing waste (MWAS). This is an increase from the traditionally cited figure of 11 million tons (NAHB, 1998), reflecting changes in housing stock and the housing market since 1998.

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