Association of Modified Asphalt Producers

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Recycling Mod-Bit Roofing or Polymer Modified Asphalt Roofing Products

White Paper

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The AMAP Roofing White Paper Sub-Committee is a new and collaborative cohort of industrial partners who provide technical perspectives and insights from residential roofing, commercial roofing, and asphalt modification. The mission of this subcommittee is to publish technical perspectives for AMAP members that review critical industrial topics in asphalt modification and roofing. This white paper addresses key industrial sustainability challenges and technical opportunities for recycling modified roofing products. Herein, this document provides technical insights to support the roofing industry's goal toward reducing landfill disposal.

Keywords

Recycled Shingles
Shingle Diversion
Shingle Landfill
Modified Asphalt Shingles
Mod-Bit Roofing RAS
Recycled Asphalt Shingles
Modified Aspahlt Membrane

Executive Summary

The AMAP Roofing White Paper Sub-Committee was established in 2024 and consists of a collaborative cohort of industrial partners who provide technical perspectives and insights from residential roofing, commercial roofing, and asphalt modification. The mission of this subcommittee is to publish technical perspectives for AMAP members that review critical industrial topics in asphalt modification and roofing. This review article sets the tone for that intention with a comprehensive topic overview of technical challenges and opportunities for recycling mod-bit roofing and polymer-modified asphalt (PMA) roofing products. There are minimal sustainable recycling solutions for reuse applications for these materials in North America, and managing their end-of-life cycles may significantly help the industry reach its waste diversion goal to 50% by 2035 and 0% by 2050.[3]

Critical challenges range from environmental impact and limited recycling applications to complexities in waste streams, quality, and regulatory compliance. Lack of effective recycling practices for modified asphalt roofing materials and the difficulty in distinguishing them from conventional oxidized blown roofing products has led to high rates of waste disposal to landfill. Precedence for aging and cracking effects in paving when using recycled asphalt shingles (RAS) in volumetric measurements has also led to a decline in transportation use while applications in shingle production remains in early development.[7] Differentiating mod-bit roofing and PMA roofing products without specialized testing methods remains a challenge in waste streams and roofing waste collection. Local, state, and federal agencies define regulatory compliance guidelines that specify acceptable limits for extraneous materials in RAS and are dependent by region.[11,12]

Adopting cutting-edge technologies and optimizing recycling processes will enable the asphalt roofing industry to make meaningful strides towards minimizing waste and maximizing material reuse to achieve higher waste reduction goals. Equipment innovation involving advancements in milling apparatuses, integrated sieving systems, and use of artificial intelligence enhances separation and sorting of fine asphalt particles and increases recovered binder purity and homogeneity. Equally important to equipment innovation are the advancements made in chemical treatments and additives that enhance the properties of recycled asphalt, including bio-based oils, waste plasticizers, or newly engineered chemical formulations.[20]

Understanding the importance and feasibility of recycling diverse roofing products among industry stakeholders is crucial for industry-wide awareness, participation, and support. This review serves as a comprehensive resource that describes technical challenges in roofing waste recycling, and serves as a call to action for further technical advancements and opportunities for modified asphalt roofing products. Industry stakeholders are also reminded to monitor legislation and regulation regarding construction and demolition waste recycling, and also asphalt recycling. Further resources and connections are available through AMAP and other industrial associations.

Introduction[1]

Diverting roofing material waste from landfill remains a key initiative for the asphalt roofing industry. More than 15 million tons of waste is generated annually and over 90% of that is sent to landfill.[2] Landfills are at the risk of saturation and shutdown, as well as growing regulatory influence. The asphalt roofing industry recognizes the critical risks in roofing material waste generation and proactively aspires to "reduce landfill disposal of asphalt-based roofing materials to 50% by 2035 and to approach 0% by 2050."[3] The industry has also seen continuous growth in the use of modified bitumen or polymer-modified asphalt (PMA) roofing materials due to their durability, cold weather resistance, and impact resistance. However, there are little to no known sustainable recycling solutions or outlets for reuse applications for these materials in North America, posing challenges to their end-of-life management and to reaching the roofing industry's waste diversion goals.

Challenges:

- Environmental impact: The lack of effective recycling practices for modified bitumen and PMA roofing materials contributes to the overall disposal of roofing materials to landfill.
- Limited recycling applications: Few recycling technologies and applications for end-of-life PMA roofing materials exist. Finding efficient ways to recycle and reuse these potentially valuable asphalt products will reduce dependence on virgin resources.
- Complexity in waste streams: Additional complexity arises in the ability or lack of ability to segregate asphalt roofing waste streams (e.g. modified asphalt roofing materials from unmodified asphalt roofing materials).
- Regulatory compliance: Evolving environmental regulations and sustainability standards necessitate proactive measures within the roofing industry to comply with waste management and recycling mandates.

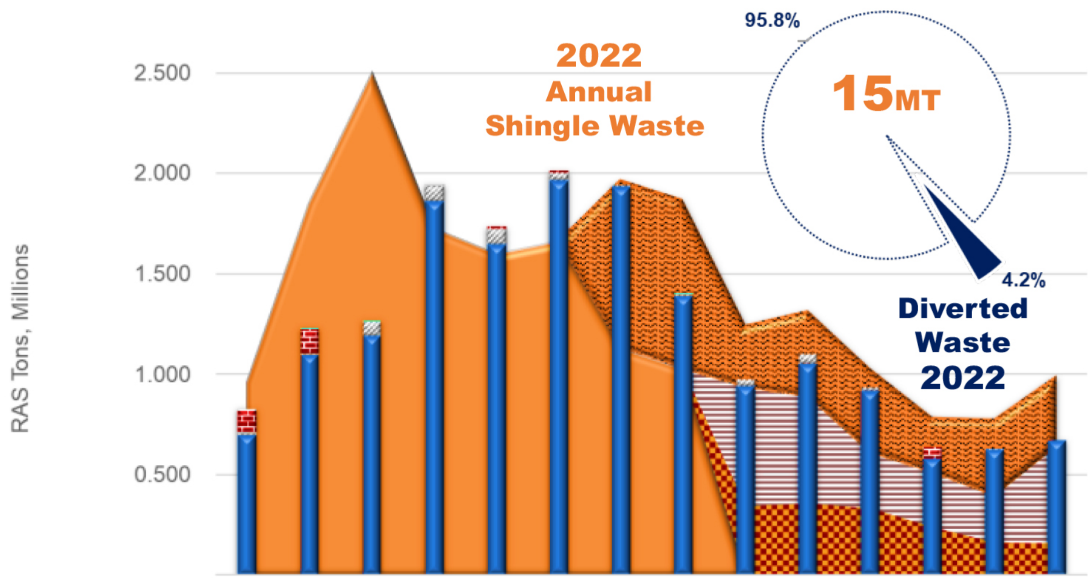
Industry Needs:

- Research and development: There is a critical need for robust research to explore innovative recycling methods tailored to these specialized roofing materials, covering a range of modified asphalt roofing product and application types (commercial/residential, low slope/steep slope, membrane/shingle products).
- Technological advancements: Development of cost-effective and scalable technologies for recycling modified bitumen and PMA roofing materials is imperative for widespread adoption.
- Applications development: Identification and development of new applications for the re-used or recycled roofing materials or end-of-life products.

Herein, this review describes methods and applications for recycling or reusing modified asphalt roofing materials. It covers key technical challenges, assembles past research and development, identifies potential technical solutions, and describes current or developing applications to support the roofing industry's advancement toward their goals for roofing material diversion from landfill. The dissemination of this information among industry stakeholders regarding the importance and feasibility of recycling these materials is crucial for industry-wide participation and support.

Challenges for Environmental Impact

Recycling of asphalt roofing products is minimal, and most product waste goes to landfills, contributing to negative environmental impacts. As per the EPA's 2020 report, 15.1 million tons of asphalt roofing waste are produced annually out of which 13.9 million tons are composed of post-consumer roofing waste, while the remaining 1.2 million tons are from pre-consumer scrap and/or waste produced during manufacturing.[2]



RAS	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Processed Shingles Accepted	-	-	-	-	-	-	0.842	0.846	0.311	0.430	0.423	0.278	0.385	0.356
PCAS	-	-	-	-	-	-	-	-	0.591	0.534	0.277	0.277	0.230	0.483
MWAS	-	-	-	-	-	-	-	-	0.344	0.356	0.334	0.237	0.165	0.158
Unprocessed Shingles Accepted	0.957	1.851	2.500	1.724	1.599	1.684	1.129	1.027	-	-	-	-	-	-
Landfilled	-	0.007	0.000	-	-	-	-	0.005	-	-	-	-	-	-
Used in Other	0.123	0.125	-	0.012	0.005	0.006	-	-	-	-	-	0.055	-	-
Used in Cold Mix	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Used in Aggregate	0.006	0.003	0.074	0.073	0.082	0.043	0.009	0.009	0.036	0.050	0.018	-	0.003	-
Used in HMA/WMA	0.702	1.100	1.192	1.863	1.647	1.964	1.931	1.390	0.944	1.053	0.921	0.586	0.630	0.673

Figure 1 | RAS usage in asphalt pavement construction over time.[5]

The most common use of recycled asphalt shingles (RAS) is in asphalt pavement construction because of its high asphalt content (18-30%).[4] This makes RAS a sustainable and economic choice in the paving industry. From 2010 to 2015, the annual use of RAS kept increasing and reached almost 2.0 million tons by 2015. However, the use of RAS in paving construction took a declining trend starting 2016 and only around 0.67 million tons were recycled in 2022 as per NAPA's latest report (Figure 1).[5] This is attributed to the aging of asphalt in recycled shingles which makes the asphalt brittle and results in premature cracking when used extensively.[6] This led to a decline in RAS usage by different state transportation departments.[7] It should be noted that the NAPA 2022 report does not specify if RAS content was derived from air blown asphalt or PMA roofing products and does not account for RAS usage in lower percentages or balanced mixed designs.

It is often challenging to differentiate recycled roofing products coming to waste streams made from conventional air blown and PMAs. Furthermore, if it's separated, PMAs are softer and require lower processing temperatures and smaller batch sizes to avoid gumming, impacting production efficiency.[8] In addition, only limited studies have shown the potential of using recycled roofing waste from modified bitumen/PMAs.[9,10] Singhvi et al. (2024) evaluated the cracking potential of asphalt mixtures designed with laboratory aged asphalt from air-blown and polymer-modified coating asphalt to simulate field RAS.[9] The findings from mixture cracking indices, namely, flexibility index, CT index, and Texas overlay showed that asphalt mixtures with polymer-modified RAS have better flexibility over RAS from air blown coating. Furthermore, the laboratory simulated RAS from air-blown coating was compared to actual field RAS, which showed similar cracking indices from the mixture evaluation.[9] AIF recently published a report which evaluated the binder properties extracted from field aged shingles exposed in Bloomington, IL. There were two polymer-modified and two air-blown coatings used in this study. The shingles were field aged for 5.5 years and were extracted for binder characterization. The binder rheology of extracted binders showed that the polymer modified coating asphalt possess increased flexibility over air blown coatings. This further indicates the potential of RAS obtained from shingles made from polymer modified coatings may show more flexibility than air blown coatings at the end-of-life.[10]

Challenges in Waste Stream and Quality

The complexity of waste streams from mod-bit roofing and PMA roofing products presents significant challenges for recycling efforts, primarily due to the difficulty in distinguishing these modified materials from the comprehensive landfill of roofing products and other construction materials. Bulk waste content is often convoluted with a variety of foreign materials such as nails, metal, glass, rubber, paper, wood, brick, plastic, and other contaminants. Local, state, and federal agencies set compliance regulations that specify acceptable limits for these extraneous materials in RAS and vary by region.[11,12] Separating and processing heterogeneous materials such as granules, fiberglass or organic felt, and asphalt binder remains a critical challenge in managing the end-of-life cycle for roofing products and poses a unique challenge in distinguishing modified asphalt from conventional oxidized asphalt within the final recycled content. Specialized testing methods, including new rheological methods referenced by Rowe et al., offer potential new techniques for analyzing unknown asphalt binders and providing guidance in their use in asphalt formulations.[10,13]

Currently, there are no policies that mandate the separation or segregation of PMA roofing materials from unmodified asphalt roofing materials. The process of sorting, testing, and separating these products would require significant investment in both technology and labor. Therefore, for recycling efforts to succeed, any proposed solution must be both practical and cost-effective, incorporating reliable identification and separation methods that can be implemented on a large scale. Only by developing such processes can the recycling of PMA roofing materials become more feasible and efficient, reducing their environmental impact, and contributing to the overall sustainability of the roofing industry.

Challenges in Recycling Applications

The latest report published by National Asphalt Pavement Association (NAPA) provides details about use of RAS across the United States and tracks the changes over the last few years.[5] Figures 3 and 4 show the decline is RAS tons and percentage use based on industrial sectors.[5] Total estimated amount of unprocessed and processed shingles received by producers increased by 28% from 2021 through 2022. In 2022, the estimate amount was 997,000 tons which was more than the combined amount of RAS used in asphalt mixtures (673,000 tons) for that year. The number of companies using RAS decreased from 65 in 2021 to 50 in the 2022 construction season. In 2022, out of 50 state Departments of Transportation (DOT), 27 DOTs allowed RAS in some asphalt mixtures and 5 DOTs allowed RAS in all mixtures. Alaska, Hawaii, Louisiana, North Dakota, and Wyoming did not allow use of RAS in asphalt mixtures in any sector. These statistics and survey data go on to show the decrease in amount of RAS usage in the construction industry.

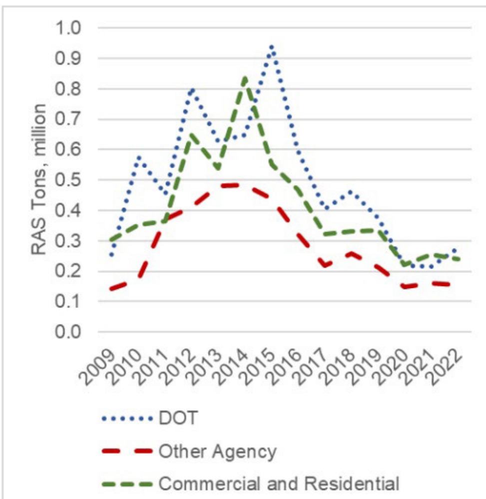


Figure 3 | Estimated RAS Use by Sector[5]

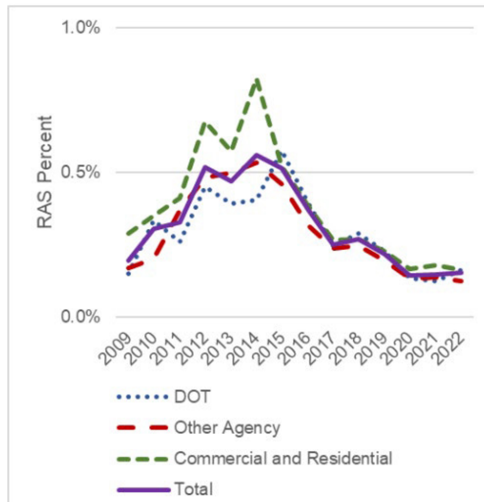


Figure 4 | Average Percent RAS Used by Sector[5]

There are a few challenges with respect to recycling applications and are listed below:

- Incompatibility: Challenges in waste streams and quality can lead to variation in RAS compatibility with fresh asphalt. Lower dosage quantities, raw material characterization, performance-guided formulations, and balanced mix design strategies can offer potential methods for achieving RAS mix compatibility and performance improvements.[10,13,14]
- Excessive and improper use in the past and negative perception: Paving embrittlement and premature cracking when using extensive RAS levels has led to a decline in RAS usage by different state transportation departments.[7] A negative perception of RAS-based mixture performance continues to be a barrier for its usage in the industry.
- Lack of research: New research studies are on-going to fundamentally improve RAS properties and its chemical compatibility with fresh asphalt binder for improved blending and performance.[15] These efforts aspire to enable increased quantities of RAS consumption without road agencies needing to ban RAS usage altogether. It should be noted that historically, RAS was applied without sufficient research with respect to

resultant cracking performance and the RAS waste stream consisted of air-blown asphalt and not the PMA that is being increasingly used in shingle manufacturing today. There are significant improvements on these fronts, and they are expected to improve the adaptation of RAS in the industry.

- Lack of education and outreach: RAS has unique chemistry and material behavior properties and given that the paving industry in general is not aware of research and improvements in the roofing industry and materials. It is important to educate the paving industry and road agencies regarding all the latest developments to reduce (and possibly remove) the barriers and perceived notion regarding usage of RAS in asphalt pavements.

Potential for Technical Solutions

Reducing landfill disposal of roofing material waste requires on-going innovation in equipment, chemical treatments, and product design. Recent advancements highlight the industry's dedication to sustainable and circular economic principles. By adopting cutting-edge technologies and optimizing recycling processes, the asphalt roofing sector will continue to make meaningful strides toward minimizing waste and maximizing material reuse to achieve higher waste reduction goals.

A key challenge in asphalt roofing recycling is the effective processing and separation of heterogeneous materials—including granules, fiberglass or organic felt, and PMA. Recent developments in advanced recycling equipment have significantly improved both efficiency and material recovery.[16-19] For example, specialized milling apparatuses have been engineered to break down the complex composition of roofing products while preserving reusable components and, in some cases, homogenizing asphaltic waste streams-containing PMA.[16,17] Integrated sieving system improvements enhance separation of fine asphalt particles from non-asphaltic materials, thereby increasing the purity of the recovered binder.[17] In parallel, innovative heat-based processing systems have been introduced that use infrared heating combined with controlled oxygen levels to soften asphalt without excessive energy consumption. This method prevents oxidation while preserving the performance characteristics of the binder, allowing for the efficient extraction and reuse of high-quality asphalt material.[18] Artificial intelligence (AI) is also starting to make an entrance into these technologies to improve these processes such as AI-driven sorting systems. By employing hyperspectral imaging and machine learning algorithms, AI has helped improve the differentiation between modified and unmodified roofing products, reducing contamination and bolstering the viability of recycled materials for new roofing or paving applications.[19]

Equally important to equipment innovation are the advancements made in chemical treatments and additives that enhance the properties of recycled asphalt. Rejuvenating agents derived from bio-based oils, waste plasticizers, or newly engineered chemical formulations have been developed to restore the elasticity and adhesion of aged asphalt binders. These agents penetrate the oxidized material to enhance ductility, rendering the binder suitable for reuse in hot-mix asphalt and new shingle production.[20] In addition, compatibilizers—such as maleic anhydride-functionalized polymers and reactive elastomers—improve the integration of the recycled polymer-modified asphalt with virgin materials, reducing brittleness and extending durability.[20] These approaches complement the benefits of advanced sorting technologies already in use.[19] There are other chemical innovations such as a solvent-dissolution that selectively dissolves and recovers asphalt binder while leaving impurities behind. This environmentally friendly process targets aged bitumen while preserving essential polymer modifiers, ensuring an efficient recovery process.[21]

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Emerging new product trends also point to the design of roofing products with recyclability as a core feature. These new functional designs, such as modular shingle configurations, facilitate the separation of layers at the end of a shingle's lifecycle. By simplifying the segregation of asphalt, granules, and reinforcements through techniques like heat-sealable edge technology, these designs reduce labor-intensive processing and lower contamination risks.[22] Other approaches include formulations that incorporate higher percentages of recycled content—such as pre-treated recycled asphalt mixes—to improve adhesion and impact resistance without compromising durability, ensuring the product remains recyclable after its service life.

Thermally reactive coatings that incorporate phase-change materials have been engineered to become pliable under controlled heating, allowing for efficient separation of asphalt binder, granules, and reinforcing layers. This innovation not only minimizes mechanical wear on recycling equipment but also enhances overall recovery efficiency, further supporting sustainable recycling practices.[18]

Conclusions and Recommendations for Next Steps

Supporting end-of-life cycles of PMA and mod-bit roofing products remains a critical challenge in enabling their sustainable recycling solutions for reuse. Many of the challenges are directly linked to historical stigma and trending declines in RAS usage in paving and transportation, lack of compositional differentiation and contaminations in waste streams, and lack of awareness toward RAS chemical usage with fresh asphalt binder. Technical advancements in waste stream sorting and binder recovery are now emerging to enable purer and more homogenous RAS supplies. Progress in roofing product and formulation now permit new ways to achieve functional designs with RAS, including modular shingle configurations and chemically compatibilized RAS-modified asphalt formulations. Many of these advanced technologies have been achieved within roofing asphalt applications, and it is important to share these new best practices within the paving and transportation industries to overcome historic stigma. Exploring innovative recycling methods tailored to meet these specialized roofing materials and continuing to create robust research and development efforts will drive recycling capabilities and support the industry's sustainability goals in roofing waste diversion.

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