



ILLINOIS HIGHWAY MATERIALS SUSTAINABILITY EFFORTS 2021

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EXECUTIVE SUMMARY

The Illinois Department of Transportation (IDOT) continues to use a variety of reclaimed and recycled materials in highway construction. Recycled materials are used in highway construction to supplement aggregates, concrete, hot-mix asphalt (HMA), steel, and sealants, as well as for soil modification and pavement markings. This report summarizes the materials used in 2021, along with specific reporting on the use of shingles, efforts to reduce the carbon footprint, and efforts to achieve cost savings by using recycled materials, as required by Illinois Public Act 097-0314.

The recycled materials tracked by IDOT are summarized in four major groups: aggregate, HMA, concrete, and other. The aggregate group includes recycled concrete material (RCM) and reclaimed asphalt pavement (RAP) used as an aggregate in lieu of natural aggregates used as granular fill or as a replacement for natural aggregates in HMA. The HMA group includes slags used as friction aggregate, crumb rubber, RAP, and reclaimed asphalt shingles (RAS). The concrete group includes fly ash, ground granulated blast furnace slag, and microsilica used to replace cement or supplement the cement and provide specific properties to the final concrete product. The “other” category group includes by-product lime used for soil modification, glass beads used for pavement-marking retroreflectivity, and steel used for reinforcement in concrete.

In 2021, reclaimed and recycled materials totaling 1,301,376 tons were used in Illinois highways. This represents a decrease of 137,665-tons or a 10% decrease from 2020 quantities. Funding levels and the portfolio of project types are the major factors influencing recycle levels. On a tons-per-mile basis, the amount of recycled materials used in 2021 increased from 2020 levels. In 2020 there were 1,038.99 tons/mile, compared to 1,500.58 tons/mile in 2021, a 44% increase. The decrease in quantities and significant increases in some of the unit equivalent values compared to 2020, resulted in a total value of \$70,701,760 in 2021 representing an increase of 8% from \$65,356,915 in 2020. As in most areas of the economy, values in many different areas of highway construction and maintenance increased due to supply chain issues and fuel costs.

The amount of RAS used in 2021 was 16,572 tons, which is a decrease of 56% from the 2020 use of 37,655 tons. The largest user of RAS, District 1, had a significant decrease from 22,112 tons in 2020 to 12,710 tons in 2021. District 1 usage accounted for 77% of the total RAS usage in Illinois. The number of paving projects, lane miles, and types of mixes used heavily influences the amount of RAS used each year. The number of IDOT districts for which contractors produced HMA containing RAS dropped to five in 2021.

The amount of reclaimed asphalt pavement (RAP) used for HMA decreased from 1,113,695 tons in 2020 to 886,544 tons in 2021, or a 20% decrease. The use of RAP was especially high in 2020. The use in 2021 is closer to the 2019 quantity of 821,233 tons.

While reporting tons of materials is an easy measure, it does not represent the true environmental benefit of recycling the various materials. This report estimates the equivalent carbon dioxide (CO₂EQ) emissions savings of the recycled materials used by IDOT. The use of fly ash resulted in the greatest environmental benefit by replacement of energy-intensive cement. It is estimated that IDOT's recycling efforts reduced CO₂EQ emissions by 68,931 tons in 2021.

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CHAPTER 1: INTRODUCTION

This report is part of a series of annual reports published since 2010 to document recycling and sustainability efforts of the Illinois Department of Transportation (IDOT). This report also meets the reporting requirements of Illinois Public Act 097-0314 (Illinois General Assembly 2012).

Various past reports by IDOT and the Illinois Center for Transportation (ICT) provide excellent background information on reclaimed and recycled materials used in highway construction (Brownlee 2011, 2012; Brownlee and Burgdorfer 2011; Griffiths and Krstulovich 2002; IDOT 2013; Lippert and Brownlee 2012; Lippert et al. 2014, 2015, 2016, 2017; Rowden 2013; Morse 2018-2021).

In 2012, Illinois Public Act 097-0314 called on IDOT to report annually on efforts to reduce its carbon footprint and achieve cost savings through use of recycled materials in asphalt paving projects (IDOT 2013; Lippert and Brownlee 2012; Rowden 2013; Morse 2018-2021). The act also required IDOT to allow the use of reclaimed asphalt shingles (RAS) in all hot-mix asphalt (HMA) mixes only if such use does not cause negative impacts to pavement life-cycle cost.

Illinois has many years of experience using various reclaimed materials in highway construction. These materials tend to be materials that reduce the use of virgin materials such as aggregate, cement, or asphalt. Fly ash and ground granulated blast furnace slag (GGBFS) have been added to concrete in Illinois for over 50 years. These additions reduce the amount of cement (a carbon-intensive material) required, while also lending other desirable properties to concrete. Reclaimed asphalt pavement (RAP) has been in use since the early 1980s, and its use is widely accepted.

Other materials, such as RAS, have a much shorter history of use. Until 2011, IDOT was conducting experimental projects using RAS in HMA. With the passage of Public Act 097-0314, specifications were developed and adopted to allow use of RAS on all IDOT projects as a contractor option (Lippert and Brownlee 2012). As with the adoption of any new specification or policy, issues and areas of improvement were identified, and changes implemented. Earlier versions of this report documented the resulting changes and improvements.

This report is structured with each chapter covering various aspects of the use of reclaimed and recycled materials. Chapter 2 presents IDOT's overall use of reclaimed and recycled materials in highway construction projects. Chapter 3 provides a specific look at IDOT's efforts in utilizing RAS in HMA paving. Chapter 4 presents a life-cycle assessment based on available information which portrays the environmental benefits of recycling the various materials. Chapter 5 provides an overview of research projects that will provide long-term improvements to the life-cycle of pavements using recycled materials.

CHAPTER 2: USE OF RECLAIMED AND RECYCLED MATERIALS IN ILLINOIS HIGHWAY CONSTRUCTION IN 2021

2.1 REPORTING HISTORY

The first recycling report was published in 2002 to answer various inquiries on recycling (Griffiths and Krstulovich 2002). After that first effort to report on recycled materials, a follow-up report was not produced until construction information was available in 2010 (Brownlee and Burgdorfer 2011). Reporting of recycled material use has since been on an annual basis (Brownlee 2011, 2012; Lippert et al. 2014; Rowden 2013). The 2012 report on use of recycled materials provided the most in-depth overview of how each material is derived and used in highway construction (Rowden 2013). The 2013-2020 reports provided benchmark performance measures on recycled material use on a per-mile basis rather than total quantity (Lippert et al. 2014, 2015, 2016, 2017; Morse 2018-2021).

This report uses the same basic methodology for determining quantities as used in past reports from IDOT's Materials Integrated System for Test Information and Communication (MISTIC). Information from MISTIC is summarized to report quantities of each recycled material. The data reporting followed the same data collection methodology from the 2013 report on use (Lippert et al. 2014). Beginning with the 2016 sustainability report, the RAS data collection methodology was modified from a contractor survey on use to reliance on data contained in MISTIC (Lippert et al. 2017).

2.2 RECLAIMED AND RECYCLED MATERIALS ADDED OR DELETED IN 2021

The list of reclaimed and recycled materials used by IDOT was reviewed while preparing this report. During the 2021 reporting year, no new materials were added, or old materials deleted.

2.3 MATERIALS RECLAIMED AND RECYCLED IN 2021

2.3.1 Determining Recycle Quantities

The quantities presented in this report pertain to the materials for which the amount of recycled material can be soundly documented through existing records. Items such as steel reinforcement and glass beads are composed of 100% recycled materials, by means of how those materials are manufactured, and thus are simple to report. Many additional tons of recycled materials are used, but tracking quantities used is impractical. For example, recycled steel is used in large steel shapes for bridge construction; however, the amount of recycled material varies in each steel heat or batch. Information on the recycled content of such items is not available in the database and therefore not reported.

While MISTIC reports are the source of material quantities for most of the reported materials, there is an exception—namely, glass beads. The reported quantity for glass beads is based on quantities accepted for use in the state of Illinois. This quantity includes use by some local agencies that take part in statewide purchase agreements.

Previous versions of this report determined RAS quantities via a contractor survey. The reason this method of data collection was done was that MISTIC reporting of RAS quantities needed to be developed and shown to be reliable. Improvements in MISTIC documentation and reporting have progressed to the point that there is no longer a need to survey contractors for RAS quantities.

2.3.2 Economic Values of Recycled Materials

Economic values for the various materials were updated to provide a reasonable comparison from year to year. For 2020 pricing, a statewide average was determined from supplier- and contractor-provided information. For items that have price indexes, such as steel, the monthly IDOT index was averaged for the year (IDOT 2020b).

2.3.3 Recycled and Reclaimed Material Use and Values for 2021

2.3.3.1 Data for 2021

Appendix A presents the 2021 recycled and reclaimed material quantities and values. In total, 1,301,376 tons of recycled materials were used in 2021, which is a 10% decrease in recycled tonnage from the 1,439,041 tons in 2020. The value of 2021 recycled materials were \$70,701,760, an 8% increase from \$65,356,915 in 2020. In 2021, the miles of roadway improvement decreased to 867 miles from 1,385 miles in 2020. The number of bridges constructed or rehabilitated increased from 61 in 2020 to 70 in 2021. The overall value of projects awarded in 2021 was significantly higher at \$3.460 Billion, as compared with 2020 figures of \$2.149 Billion. The decrease in miles of roadway improvements resulted in a decrease in recycled tonnage in 2021. This is greatly influenced by the type and scope of projects constructed.

2.3.3.2 Data Analysis of 2021 Use

To present a more accurate picture of IDOT's recycling effort, a series of figures is presented which provides information on 2021 results, as well as historical trends. As shown in Figure 1, the bulk of the recycled tonnage was made up of three materials: RAP in HMA, recycled concrete material (RCM), and RAP as an aggregate.

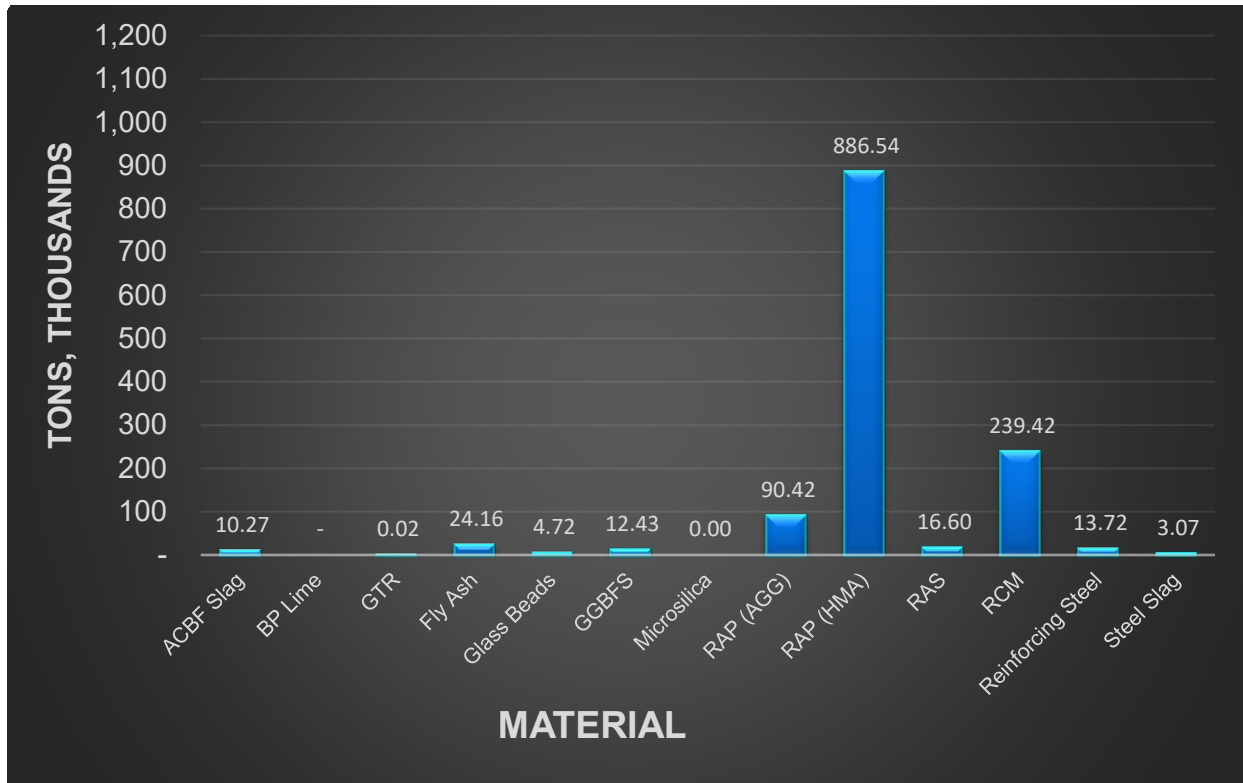


Figure 1. Reclaimed material used in 2021.

Figure 2 breaks out quantities by related uses for HMA, aggregate, Portland Cement Concrete (PCC), and other. The other category consists of by-product lime, glass beads, and steel. The HMA category includes slags used as friction aggregate (in HMA), crumb rubber, RAP, and RAS. PCC-related materials include fly ash, ground granulated blast furnace slag (GGBFS), and microsilica used to replace cement or provide specific properties to the final concrete product. Aggregate use consists of RCM and RAP used in lieu of natural aggregates. From this summary, recycled materials related to HMA and aggregate use represents the majority of IDOT recycled tonnage.

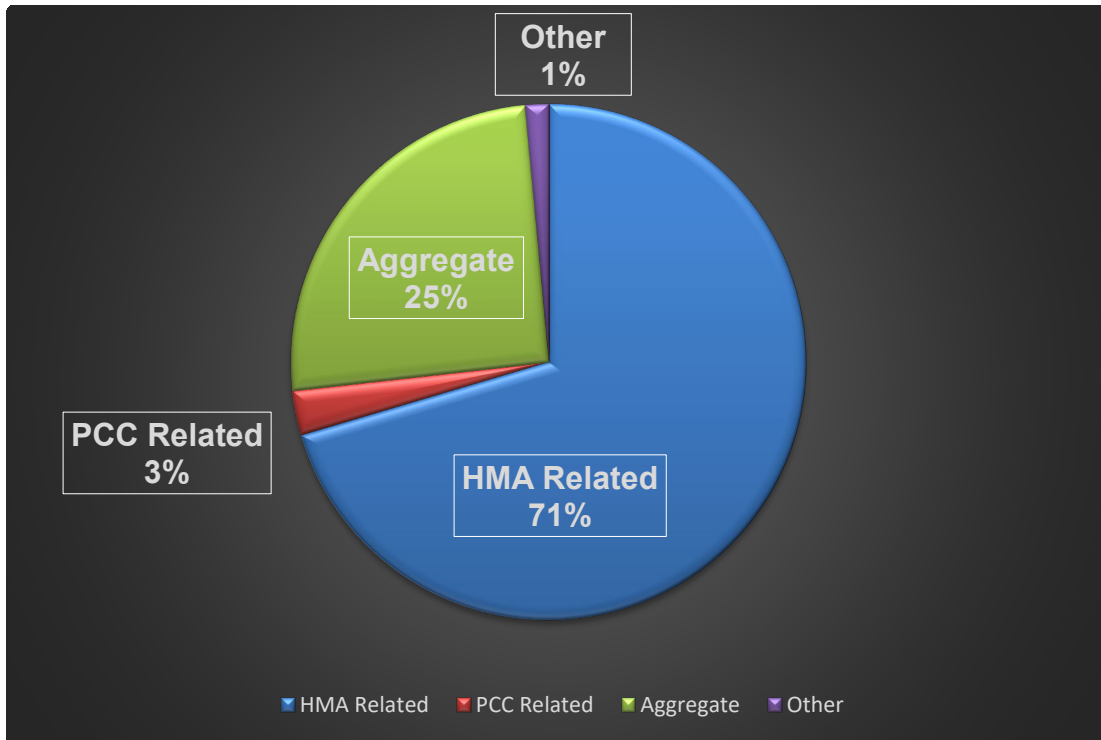


Figure 2. Reclaimed materials by related tons of use in 2021.

2.4 HISTORICAL RECYCLING TRENDS AND DATA ANALYSIS

2.4.1. Recycling Relationship to Program Budget

Recycling quantities are highly correlated to the overall budget and portfolio of project types (bridge vs. pavement resurfacing vs. reconstruction) within a budget year. In general, resurfacing projects result in RAP being both produced and used. Major reconstruction or new alignment (Greenfield) projects can use substantial amounts of recycled material. By contrast, bridge projects tend to use limited amounts of recycled material because of the short lengths involved with these types of projects.

Presented in Figure 3 are the total tons recycled from calendar years 2013 through 2021.

Also presented in the chart by fiscal year (FY; IDOT's FY is July 1 through June 30) are the values of projects awarded, centerline miles paved/improved, and number of bridges built/improved (IDOT 2020a). Note that this timeframe is not the same as the calendar year (CY) reported for recycled tonnage. However, the values tend to align themselves roughly on a CY basis because of the delay between the award of contracts and the use of materials in the project. For this report, it was considered reasonable to use all data as if they had been from the same time-period by CY.

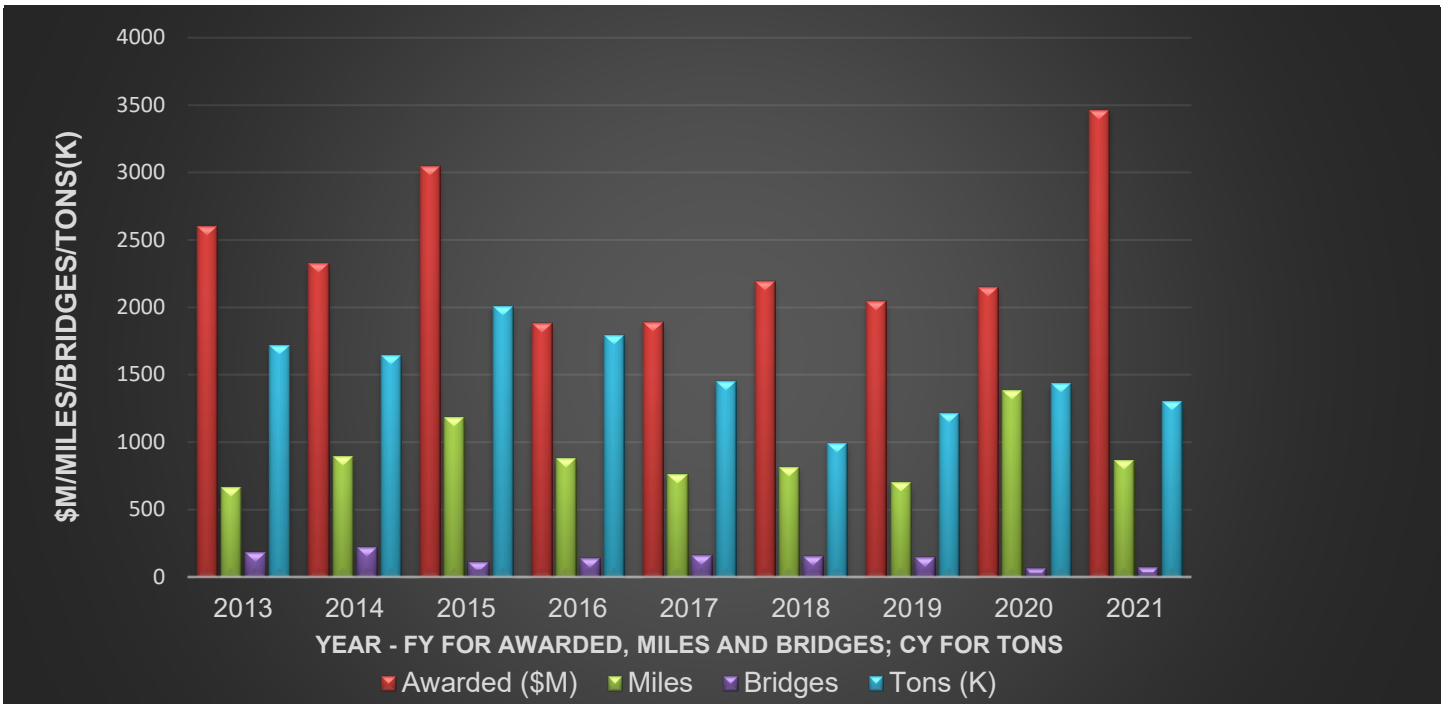


Figure 3. Annual projects awarded (FY), miles improved (FY), bridges built/improved (FY), and recycled tons (CY).

2.4.2 Determination of Recycled Content

To provide a more representative performance measurement of IDOT’s recycling efforts, previous reports presented the general recycle content by calendar year (Lippert et al. 2014, 2015, 2016, 2017). That approach is continued in this report. Figure 4 represents the results of determining the average tons of recycled material for each centerline mile of improvement since 2013. On a tons-per-mile basis, 2021 represents a 44% increase in recycle quantity from 2020, or 1,038.99 tons/mile in 2020 to 1,500.58 tons/mile in 2021.

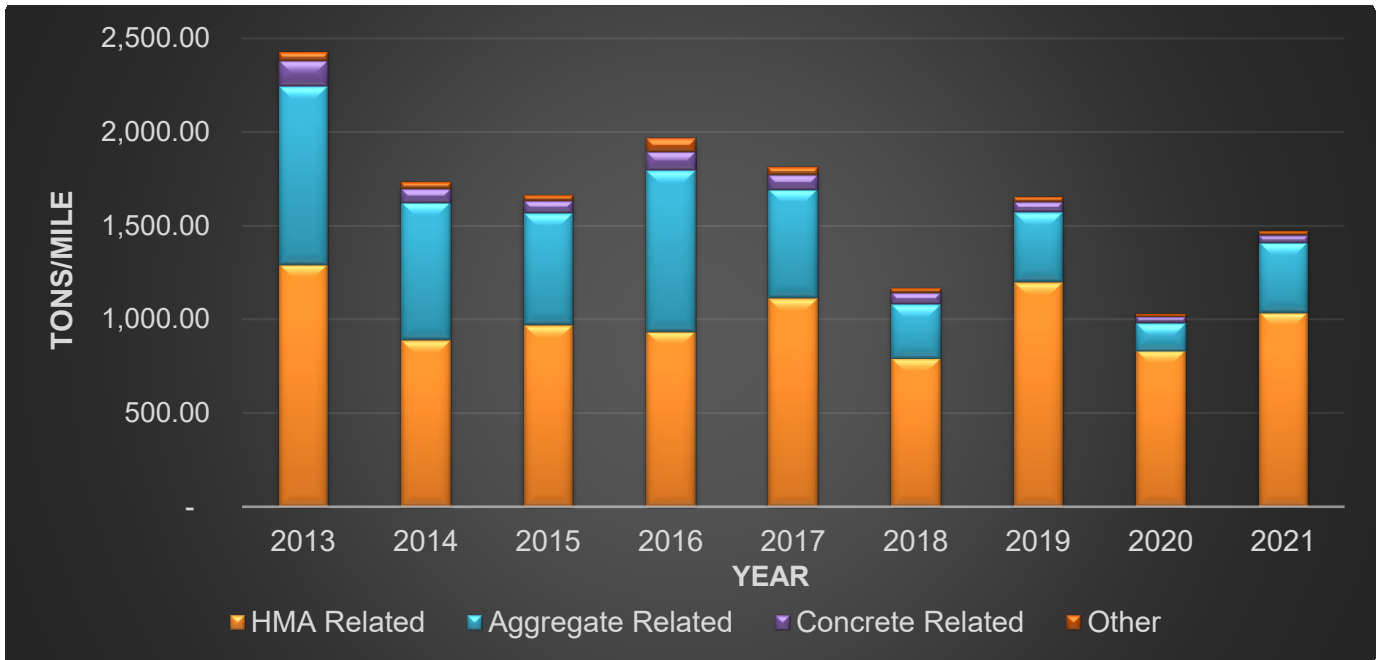


Figure 4. Historical recycle content.

2.5 REGIONAL/DISTRICT RECYCLING EFFORTS

Due to the use of RAP/RAS throughout the State and the desire for a consistent specification, a Statewide Special Provision was drafted in 2020 and was used in projects effective in 2021. This Special Provision will help unify the requirements across the State for these recycled materials.

CHAPTER 3: RECLAIMED ASPHALT SHINGLES

This chapter is a continuation of reporting on the specific status and use of RAS as required by Illinois Public Act 097-0314 (Illinois General Assembly 2012). Several reports provided details of RAS adoption (IDOT 2013; Lippert and Brownlee 2012; Lippert et al. 2014, 2015, 2016, 2017). MISTIC data were used to report 2021 RAS usage.

3.1 RAS POLICIES AND SPECIFICATIONS IN EFFECT FOR 2021

3.1.1 RAS Policy for Sources

The Central Bureau of Materials (CBM) Policy Memorandum, “Reclaimed Asphalt Shingle (RAS) Sources” (28-10.3), continued to be in effect for all RAS suppliers and represents no change in policy since 2012. The policy can be found in the report on RAS use in 2012 (IDOT 2013). The current, 2022 version of the Certified Sources for Reclaimed Asphalt Shingles list contains a total of 22 suppliers.

3.1.2 RAS Specifications

3.1.2.1 Statewide Specifications

The Bureau of Design and Environment (BDE) specification, “Reclaimed Asphalt Pavement and Reclaimed Asphalt Shingles (BDE),” was drafted in 2020 with an effective date of January 8, 2021. A copy of that special provision is included in Appendix B.

3.1.2.2 Regional/District Specifications

The District 1 Special Provisions did not change in 2020. The November 1, 2019 “Reclaimed Asphalt Pavement and Reclaimed Asphalt Shingles (D-1)” special provision is included in Appendix C. With the combination of the two separate special provisions, the Statewide Special Provision should be included in future projects.

3.2 QUANTITY OF RAS USED IN CALENDAR YEAR 2021

In 2021, IDOT experienced a significant decrease in RAS use. The total used in 2021 was 16,572 tons compared to 37,655 tons in 2020. This change represents a decrease of 56%. The largest user of RAS, District 1, had a decrease from 22,112 tons in 2020 to 12,710 tons in 2021.

In 2021, five of the nine districts reported use of RAS, which is one less than the previous year. The map in Figure 5 provides the percentage of the 2021 statewide total RAS used by each IDOT district.

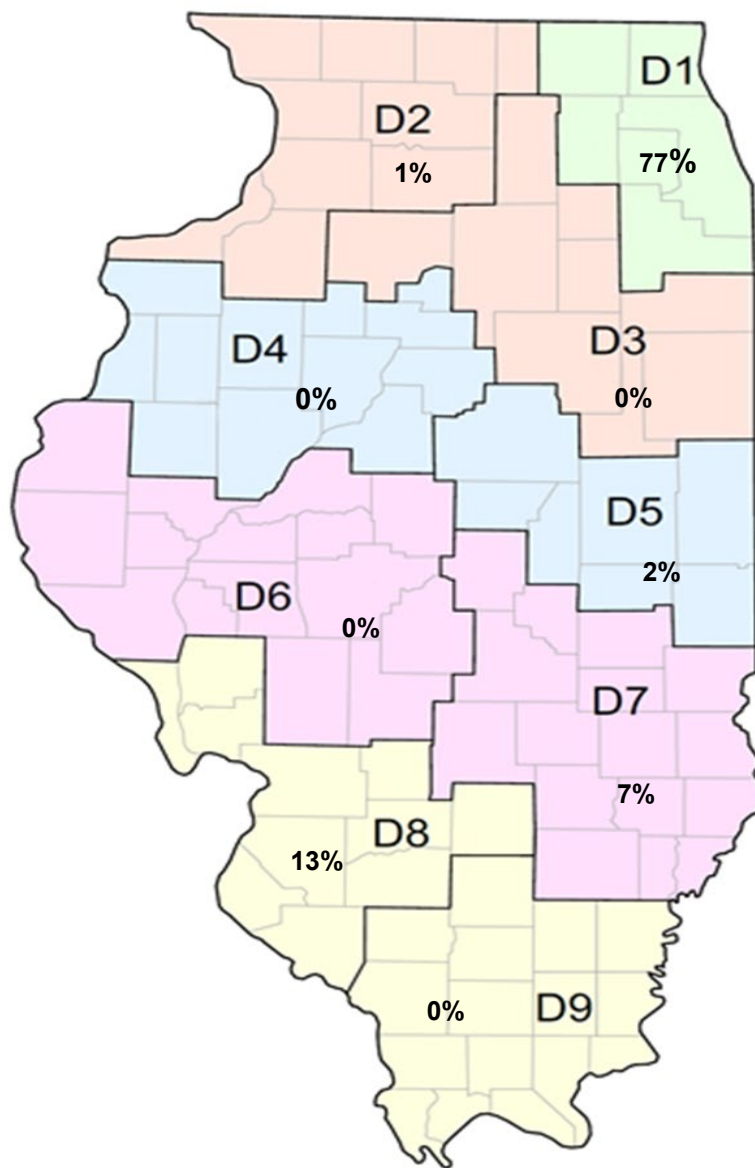


Figure 5. Percentage of RAS used by each district in calendar year 2021.

CHAPTER 4: ENVIRONMENTAL EVALUATION OF RECYCLED MATERIALS USED IN 2021

Over the years, the prime driver for use of recycled materials has been the initial cost savings of using reclaimed materials. Often these materials have a low economical value due to the need to remove or dispose of them from the site of generation. Often these materials can be used to replace more costly virgin materials, provided they are produced to a consistent quality standard. The ability to fully or partially replace virgin and/or manufactured materials with a product that otherwise would be landfilled or stockpiled as a waste can also greatly reduce the environmental burden of highway materials. As such, this chapter provides a summary of quantitative analysis for using recycled materials in terms of carbon emissions.

4.1 LIFE-CYCLE ASSESSMENT

An approach used for evaluation of the environmental burden of processes in life-cycle assessment (LCA) can also be applied to pavements and paving materials. This approach estimates, based upon documented processes, all aspects of a material used for a given application from cradle to grave. As part of the LCA process, each step of material production is analyzed in detail to determine a common and simple environmental-burden measure. Typically, the measure used is carbon dioxide equivalents per ton of the material used, or CO₂EQ/ton.

For a simple example of aggregate production, fuel and electricity use can be assigned to each step. For virgin aggregate, the material must be mined, crushed, sized, transported to the site, placed, compacted, and used for the duration of the facility, then salvaged or wasted at the end of the facility's life. Recycled aggregates have an advantage in that they do not have the economic or environmental burden of mining, which is a major part of the environmental savings in recycled aggregate.

This report used LCA values from the literature for both virgin materials and recycled materials used in Illinois to estimate a CO₂EQ/ton for each material recycled and the virgin material being replaced. The difference in CO₂EQ/ton between virgin and recycled material is the "savings" noted in Table 1 for each material, in kilograms equivalent of CO₂ for each ton of material recycled, for which information was available (Chen et al. 2010; EarthShift 2013; Prusinski 2003; Sunthonpagasit and Duffey 2004; World Steel Association 2011). For 2021, the total CO₂EQ savings in tons is also presented. This estimate includes typical transportation distances for Illinois. A main assumption is that the performance of the highway infrastructure item is equivalent for both virgin and recycled options.

Materials that have low CO₂EQ, such as aggregates, have very low values of savings when recycled materials are used. By contrast, when energy-intensive materials such as lime and cement are replaced with by-products such as fly ash, by-product lime, or GGBFS, very high savings of CO₂EQ can be realized.

From this simple analysis, it is estimated that a total of 67,369 tons of CO₂EQ was saved in 2021. Appendix A presents an accounting of CO₂EQ saved in 2021 for each of the materials used. As noted previously, using total tons of recycled material alone is limited as a performance measure for recycling. The environmental burden saved by material for 2021 is presented in Figure 6. This picture is very different from the tons of material as presented in Figure 1. Likewise, Figure 7 shows the distribution of CO₂EQ savings by related use, which differs greatly from the tonnage distribution presented previously in Figure 2.

Table 1. Estimated Environmental-Burden Savings by Use of Recycled Material

Material	Savings per Ton of Use, CO ₂ EQ (kg)	2020 CO ₂ EQ Savings (Tons)
Air-Cooled Blast Furnace Slag	13	147
By-Product Lime	920	NA
Crumb Rubber	1,704	40
Fly Ash	894	23,807
Glass Beads	929	6,398
Ground Granulated Blast Furnace Slag	763	10,455
Microsilica	NA	NA
Reclaimed Asphalt Pavement Used for Aggregate	0.8	80
Reclaimed Asphalt Pavement Used For HMA	17	16,613
Reclaimed Asphalt Shingles	79	1,445
Recycled Concrete Material	0.8	211
Steel Reinforcement	640	9,677
Steel Slag	17	58
Wet Bottom Boiler Slag	NA	NA

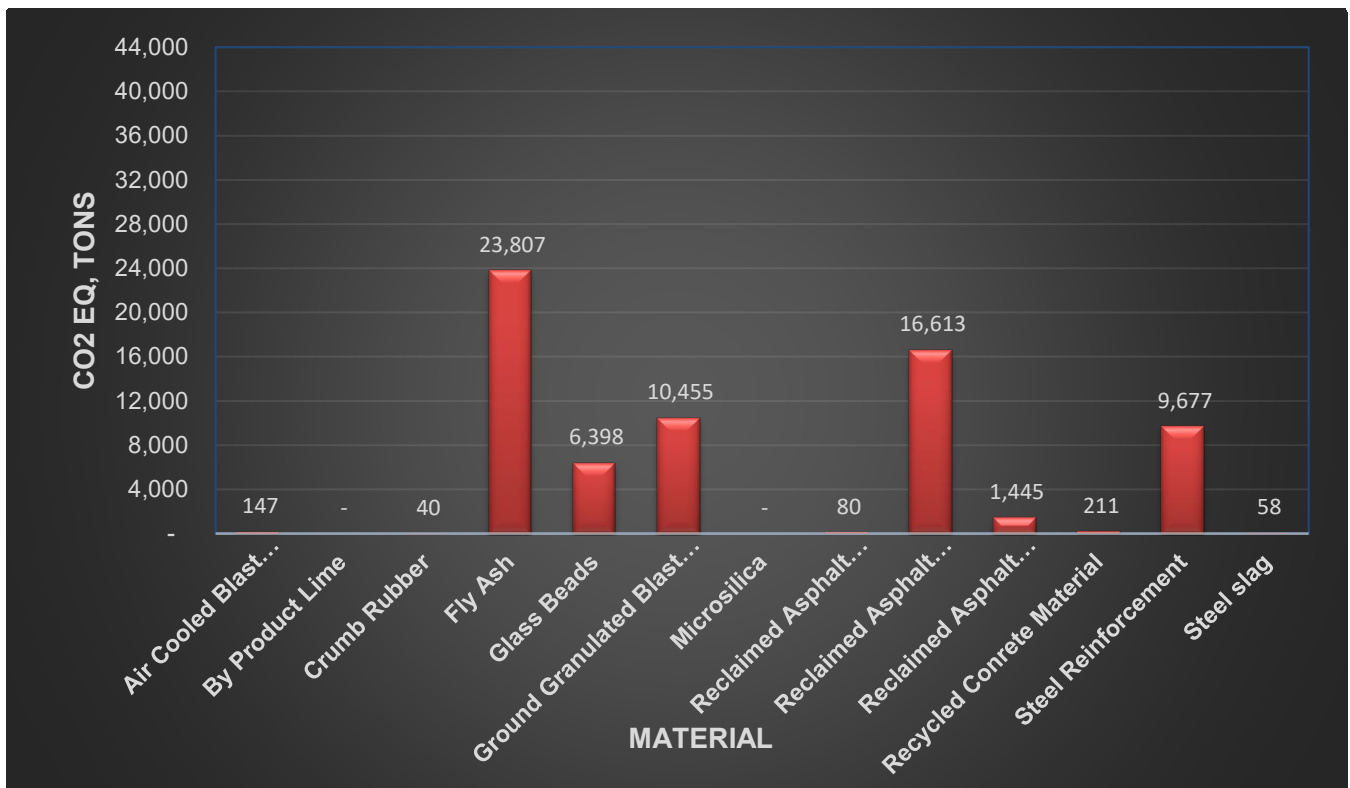


Figure 6. CO₂EQ saved, by material, in 2021

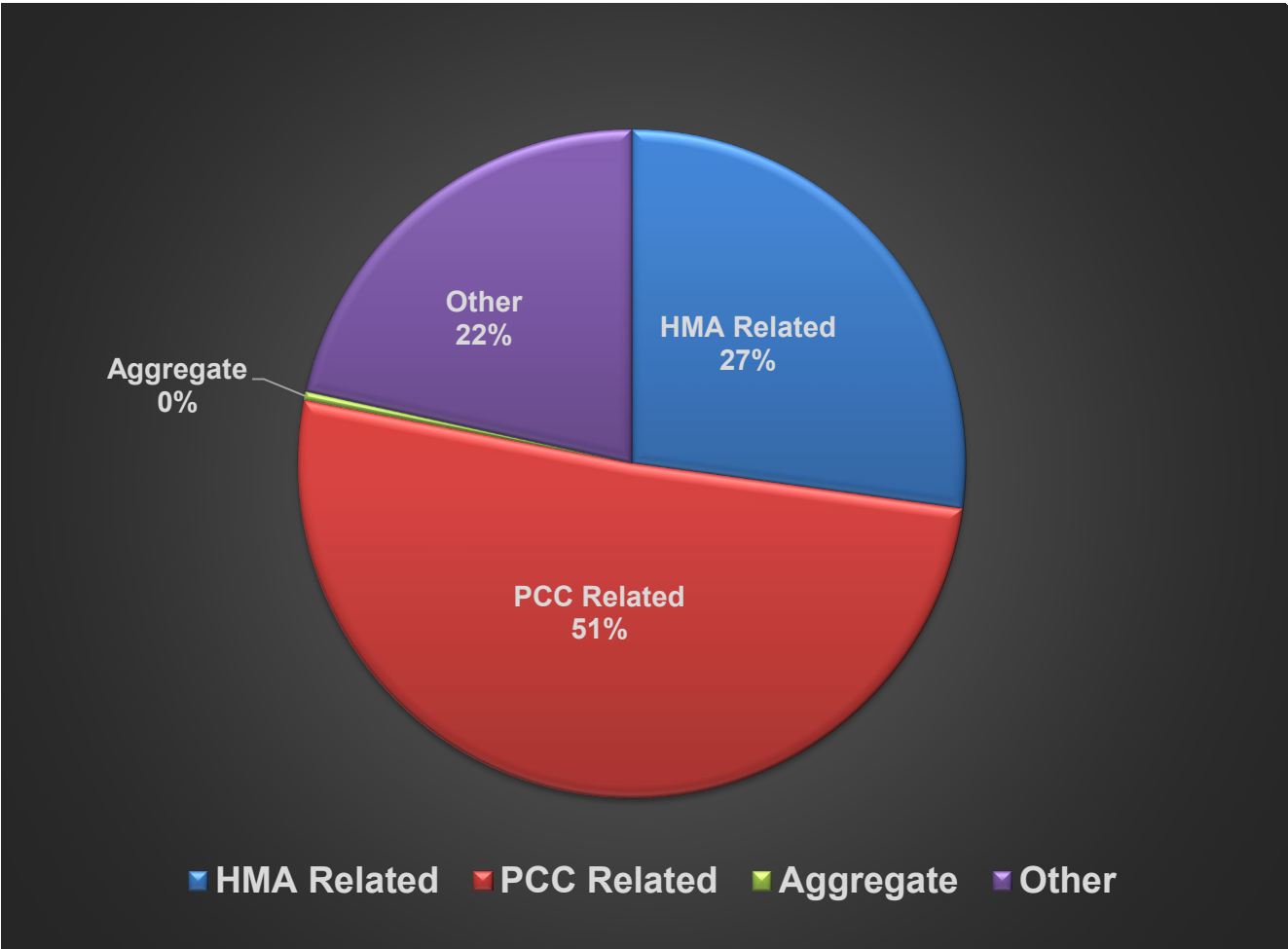


Figure 7. CO₂EQ saved, by related use, in 2021.

CHAPTER 5: SUSTAINABILITY-RESEARCH ACCOMPLISHMENTS AND INITIATIVES

During 2021, IDOT had several sustainability-related studies underway with ICT. These efforts focused on the use of recycled materials. Each of these studies resulted in an interim or final report. A brief description of each effort is provided.

5.1 SUSTAINABILITY RESEARCH ACCOMPLISHMENTS DURING 2021

5.1.1 R27-180 Concrete Pavement Mixtures with High Supplementary Cementitious Materials (SCM) Content

This project was completed in June 2021. The goal of the project was to develop tools and guidance to allow for higher volumes of cement-replacing materials, like fly ash, in concrete pavements while balancing the properties that affect concrete's early strength gain or setting time. The research team not only provided tools for better quality control of fly ash, but also developed guidelines for mix design and testing protocols. The project yielded three volumes of reports, which can be found [here](#).

5.1.2 R27-196HS Rheology-Chemical Based Procedure to Evaluate Additives/Modifiers used in Asphalt Binders for Performance Enhancements (Phase 2)

This project started in July 2018 and concluded in June 2021. To meet increasing needs for more sustainable pavement practices while continuing to improve its long-term performance, the research team investigated ways to soften asphalt binder to reduce cracking. After examining the mechanical and chemical properties of the modified binders, the research team proposed testing protocols and thresholds for different performance indicators to ensure desired pavement performance and validated them with field samples. The project report can be found [here](#).

5.1.3 R27-193-1 Flexible Pavement Recycling Techniques

This project began in July 2018 and concluded in July 2021. The project reviewed cold in-place recycling and full-depth reclamation projects identified by the Illinois Department of Transportation (IDOT) from the Transportation Bulletin. The project's activities confirmed that cold in-place recycling, full depth reclamation techniques, and cold central plant recycling projects are successfully utilized in Illinois. Recommendations for improving the above-discussed techniques were provided. The project report can be found [here](#).

5.1.4 R27-193-2 Flexible Pavement Design (Full-Depth and Rubblization)

This project began in July 2018 and concluded in July 2021. This study helped IDOT to identify and utilize the best available technology for design and construction of full-depth hot-mix asphalt as well as pavement design for HMA pavement over Rubblized Portland cement concrete. The project report and a summary of activities can be found [here](#).

5.1.5 R27-SP43 Aggregate Subgrade Improvements Using Quarry By-Products(QB): A Field Investigation

This project began in May 2020 and concluded in June 2021. This project used real traffic loads and environmental conditions to investigate the performance of aggregate subgrade improvements with quarry by-products. The designs with these quarry byproducts were deemed sustainable and adequate for the purpose of this project and are expected to show good performance. The project report can be found [here](#).

5.1.6 R27-212 Beneficial Use of Dredged Material from the Illinois Marine Transportation System

Approximately 270 to 285 million cubic yards of material dredged annually by the U.S. Army Corps of Engineers (USACE) is re-usable because it is not contaminated. The objective of this research is to identify possible applications for use of non-hazardous dredge material from IDOT projects, and to find the most economical and environmentally friendly applications for use of non-hazardous dredge material in Illinois. The project will also investigate the origin, distribution, and frequency of dredged material production across Illinois, find existing limitations for use of materials, and propose potential modifications to remove these limitations to increase use. This project is scheduled to end in October 2022.

5.1.7 R27-227 Moisture Content and In-Place Density of Cold Recycle Treatments

This project began in May 2020 and concluded in May 2022. This study investigated the feasibility of monitoring moisture content and density of an emulsified asphalt mixture during curing. The findings determined that the reflected waves in ground penetrating radar can be used to calculate dielectric properties related to material composition and determine the amount of moisture in the pavement. The project report can be found [here](#).

5.1.8 R27-248: Investigation of Dolomite Aggregate Long-Term Cementation and Its Potential Advantage for Building Roads

The objective of the proposed research is to systematically study the effects of chemical, mineralogical and physical properties of dolomitic aggregate fines on the long-term performances of both unbound and chemically stabilized aggregate base/subbase materials. After different periods of conditioning, the characterization tests will be conducted to identify changes in the phase compositions and mineralogy that may be contributing to cementation and strength gain. This project is scheduled to end in December 2024.

CHAPTER 6: CONCLUSIONS

The goal of this report is to provide a single-source document for 2021 sustainability efforts in highway materials that serves to meet the reporting requirement of Illinois Public Act 097-0314. In summary, the 2021 efforts in recycling resulted in the following:

- In 2021, recycled materials used in highway projects totaled 1,301,376 tons, with a value of \$70,701,760. The tonnage decreased from 2020 values while prices in 2021 increased.
- Usage of reclaimed asphalt shingles (RAS) in 2021 was 16,572 tons compared to 37,655 tons in 2020. This change represents a decrease of 56%. Districts 1 and 8 had significant decreases in RAS use in 2021.
- It is estimated, using the life-cycle assessment (LCA), that carbon dioxide–equivalent emissions were reduced by 68,931 tons in 2021. The use of Fly Ash and RAP accounted for the greatest contribution by reducing over 40,000 tons combined.
- With respect to material sustainability research projects in 2021, the department had eight projects active or ongoing. These research projects will result in a total of at least eight publications in the form of interim/final reports and white papers.

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APPENDIX A: RECYCLED AND RECLAIMED MATERIALS: QUANTITIES USED AND EQUIVALENT VALUES, 2021

Material	Unit Equivalent Value	Quantity ¹ Tons	Total Equivalent Value to Department	CO ₂ Equivalent Savings Tons ⁶
Air-cooled blast furnace slag	\$85.00	10,271	\$873,035	147
By-product lime	\$13.00	NA	\$1,599	NA
Crumb rubber ²	\$400.00	21	\$12,369	40
Fly ash	\$77.00	24,158	\$1,524,480	23,807
Glass beads ³	\$776.000	6,248	\$4,588,003	6,398
Ground granulated blast furnace slag	\$85.00	12,431	\$1,872,890	10,455
Microsilica	\$500.00	NA	\$24,500	-
Reclaimed asphalt pavement used for Aggregate	\$18.00	90,423	\$478,057	80
Reclaimed asphalt pavement used for HMA	\$42.72	886,544	\$41,563,097	16,613
Reclaimed asphalt shingles	\$23.97	16,598	\$1,307,787	1,445
Recycled concrete material	18.00	239,418	\$1,421,581	211
Steel reinforcement ⁴	\$1,293.30	13,716	\$12,215,141	9,677
Steel slag	\$35.00	3,073	\$341,519	58
Wet-bottom boiler slag ⁵	NA	NA	NA	NA
Totals	—	1,302,902	\$70,701,760	68,931

¹ Quantities were calculated from amounts assigned to projects in calendar year 2020. Prior to summation of values, metric values were converted to English values using factors located in Appendix B of the *Standard Specifications for Road and Bridge Construction*.

² Crumb rubber: This material quantity was calculated as 5% of the quantity of hot-poured joint sealant used in 2020.

³ Glass beads use is based on tested and approved quantities and not projects assigned through MISTIC.

⁴ Steel reinforcement: For this report, the IDOT monthly steel index was averaged for 2020 and used to represent the value of just the steel contained in these products. This approach does not include the epoxy coating value in the calculation of the material being recycled, which is a more accurate representation.

⁵ Wet-bottom boiler slag: No records were found in MISTIC that indicated WBBS was used for any IDOT projects in 2020.

⁶ Based on typical haul distances for Illinois and industrial averages between virgin material and recycled/reclaimed material found in the literature.

APPENDIX B: RECLAIMED ASPHALT PAVEMENT AND RECLAIMED ASPHALT SHINGLES (BDE), JANUARY 8, 2021

<https://idot.illinois.gov/Assets/uploads/files/Doing-Business/Specialty-Lists/Highways/Design-&-Environment/BDE-Special-Provisions/80306.pdf>

APPENDIX C: RECLAIMED ASPHALT PAVEMENT AND RECLAIMED ASPHALT SHINGLES (D-1), NOVEMBER 1, 2019

Revise Section 1031 of the Standard Specifications to read:

“SECTION 1031. RECLAIMED ASPHALT PAVEMENT AND RECLAIMED ASPHALT SHINGLES

1031.01 Description. Reclaimed asphalt pavement and reclaimed asphalt shingles shall be according to the following.

- (a) Reclaimed Asphalt Pavement (RAP). RAP is the material resulting from cold milling or crushing an existing hot-mix asphalt (HMA) pavement. RAP will be considered processed FRAP after completion of both crushing and screening to size. The Contractor shall supply written documentation that the RAP originated from routes or airfields under federal, state, or local agency jurisdiction.
- (b) Reclaimed Asphalt Shingles (RAS). Reclaimed asphalt shingles (RAS). RAS is from the processing and grinding of preconsumer or post-consumer shingles. RAS shall be a clean and uniform material with a maximum of 0.5 percent unacceptable material, as defined in Central Bureau of Materials Policy Memorandum, “Reclaimed Asphalt Shingle (RAS) Sources”, by weight of RAS. All RAS used shall come from a Central Bureau of Materials approved processing facility where it shall be ground and processed to 100 percent passing the 3/8 in. (9.5 mm) sieve and 90 percent passing the #4 (4.75 mm) sieve. RAS shall meet the testing requirements specified herein. In addition, RAS shall meet the following Type 1 or Type 2 requirements.
 - (1) Type 1. Type 1 RAS shall be processed, preconsumer asphalt shingles salvaged from the manufacture of residential asphalt roofing shingles.
 - (2) Type 2. Type 2 RAS shall be processed post-consumer shingles only, salvaged from residential, or four unit or less dwellings not subject to the National Emission Standards for Hazardous Air Pollutants (NESHAP).

1031.02 Stockpiles. RAP and RAS stockpiles shall be according to the following.

- (a) RAP Stockpiles. The Contractor shall construct individual, sealed RAP stockpiles meeting one of the following definitions. Additional processed RAP (FRAP) shall be stockpiled in a separate working pile, as designated in the QC Plan, and only added to the sealed stockpile when test results for the working pile are complete and are found to meet tolerances specified herein for the original sealed FRAP stockpile. Stockpiles shall be sufficiently separated to prevent intermingling at the base. All stockpiles (including unprocessed RAP and FRAP) shall be identified by signs indicating the type as listed below (i.e. “Non- Quality, FRAP -#4 or Type 2 RAS”, etc...).
- (1) Fractionated RAP (FRAP). FRAP shall consist of RAP from Class I, HMA (High and Low ESAL) or equivalent mixtures. The coarse aggregate in FRAP shall be crushed aggregate and may represent more than one aggregate type and/or quality but shall be at least C quality. All FRAP shall be processed prior to testing and sized into fractions with the separation occurring on or between the #4 (4.75 mm) and 1/2 in. (12.5 mm) sieves. Agglomerations shall be minimized such that 100 percent of the RAP in the coarse fraction shall pass the maximum sieve size specified for the mixture composition of the mix design.
- (2) Restricted FRAP (B quality) stockpiles shall consist of RAP from Class I, HMA (High ESAL), or HMA (High ESAL). If approved by the Engineer, the aggregate from a maximum 3.0 in. (75 mm) single combined pass of surface/binder milling will be classified as B quality. All millings from this application will be processed into FRAP as described previously.

- (3) Conglomerate. Conglomerate RAP stockpiles shall consist of RAP from Class I, HMA (High and Low ESAL) or equivalent mixtures. The coarse aggregate in this RAP shall be crushed aggregate and may represent more than one aggregate type and/or quality but shall be at least C quality. This RAP may have an inconsistent gradation and/or asphalt binder content prior to processing. All conglomerate RAP shall be processed (FRAP) prior to testing. Conglomerate RAP stockpiles shall not contain steel slag or other expansive material as determined by the Department.
- (4) Conglomerate "D" Quality (DQ). Conglomerate DQ RAP stockpiles shall consist of RAP from HMA shoulders, bituminous stabilized subbases or HMA (Low ESAL)/HMA (Low ESAL) IL-19.0L binder mixture. The coarse aggregate in this RAP may be crushed or round but shall be at least D quality. This RAP may have an inconsistent gradation and/or asphalt binder content. Conglomerate DQ RAP stockpiles shall not contain steel slag or other expansive material as determined by the Department.
- (5) Non-Quality. RAP stockpiles that do not meet the requirements of the stockpile categories listed above shall be classified as "Non-Quality".

RAP or FRAP containing contaminants, such as earth, brick, sand, concrete, sheet asphalt, bituminous surface treatment (i.e. chip seal), pavement fabric, joint sealants, plant cleanout etc., will be unacceptable unless the contaminants are removed to the satisfaction of the Engineer. Sheet asphalt shall be stockpiled separately.

- (b) RAS Stockpiles. Type 1 and Type 2 RAS shall be stockpiled separately and shall be sufficiently separated to prevent intermingling at the base. Each stockpile shall be signed indicating what type of RAS is present.

However, a RAS source may submit a written request to the Department for approval to blend mechanically a specified ratio of Type 1 RAS with Type 2 RAS. The source will not be permitted to change the ratio of the blend without the Department prior written approval. The Engineer's written approval will be required, to mechanically blend RAS with any fine aggregate produced under the AGCS, up to an equal weight of RAS, to improve workability. The fine aggregate shall be "B Quality" or better from an approved Aggregate Gradation Control System source. The fine aggregate shall be one that is approved for use in the HMA mixture and accounted for in the mix design and during HMA production.

Records identifying the shingle processing facility supplying the RAS, RAS type, and lot number shall be maintained by project contract number and kept for a minimum of three years.

1031.03 Testing. FRAP and RAS testing shall be according to the following.

- (a) FRAP Testing. When used in HMA, the FRAP shall be sampled and tested either during processing or after stockpiling. It shall also be sampled during HMA production.
 - (1) During Stockpiling. For testing during stockpiling, washed extraction samples shall be run at the minimum frequency of one sample per 500 tons (450 metric tons) for the first 2000 tons (1800 metric tons) and one sample per 2000 tons (1800 metric tons) thereafter. A minimum of five tests shall be required for stockpiles less than 4000 tons (3600 metric tons).

- (2) Incoming Material. For testing as incoming material, washed extraction samples shall be run at a minimum frequency of one sample per 2000 tons (1800 metric tons) or once per week, whichever comes first.
- (3) After Stockpiling. For testing after stockpiling, the Contractor shall submit a plan for approval to the District proposing a satisfactory method of sampling and testing the RAP/FRAP pile either in-situ or by restockpiling. The sampling plan shall meet the minimum frequency required above and detail the procedure used to obtain representative samples throughout the pile for testing.

Before extraction, each field sample of FRAP, shall be split to obtain two samples of test sample size. One of the two test samples from the final split shall be labeled and stored for Department use. The Contractor shall extract the other test sample according to Department procedure. The Engineer reserves the right to test any sample (split or Department-taken) to verify Contractor test results.

- (b) RAS Testing. RAS shall be sampled and tested during stockpiling according to Central Bureau of Materials Policy Memorandum, "Reclaimed Asphalt Shingle (RAS) Sources". The Contractor shall also sample as incoming material at the HMA plant.

- (1) During Stockpiling. Washed extraction and testing for unacceptable materials shall be run at the minimum frequency of one sample per 200 tons (180 metric tons) for the first 1000 tons (900 metric tons) and one sample per 1000 tons (900 metric tons) thereafter. A minimum of five samples are required for stockpiles less than 1000 tons (900 metric tons). Once a ≤ 1000 ton (900 metric ton), five-sample/test stockpile has been established it shall be sealed. Additional incoming RAS shall be in a separate working pile as designated in the Quality Control plan and only added to the sealed stockpile when the test results of the working pile are complete and are found to meet the tolerances specified herein for the original sealed RAS stockpile.

- (2) Incoming Material. For testing as incoming material at the HMA plant, washed extraction shall be run at the minimum frequency of one sample per 250 tons (227 metric tons). A minimum of five samples are required for stockpiles less than 1000 tons (900 metric tons). The incoming material test results shall meet the tolerances specified herein.

The Contractor shall obtain and make available all test results from start of the initial stockpile sampled and tested at the shingle processing facility in accordance with the facility's QC Plan.

Before extraction, each field sample shall be split to obtain two samples of test sample size. One of the two test samples from the final split shall be labeled and stored for Department use. The Contractor shall extract the other test sample according to Department procedures. The Engineer reserves the right to test any sample (split or Department-taken) to verify Contractor test results.

1031.04 Evaluation of Tests. Evaluation of test results shall be according to the following.

- (a) Evaluation of FRAP Test Results. All test results shall be compiled to include asphalt binder content, gradation and, when applicable (for slag), G_{mm} . A five-test average of results from the original pile will be used in the mix designs. Individual extraction test results run thereafter, shall be compared to the average used for the mix design, and will be accepted if within the tolerances listed below.

Parameter	FRAP
No. 4 (4.75 mm)	± 6 %
No. 8 (2.36 mm)	± 5 %
No. 30 (600 μm)	± 5 %
No. 200 (75 μm)	± 2.0 %
Asphalt Binder	± 0.3 %
G _{mm}	± 0.03 ^{1/}

- 1/ For stockpile with slag or steel slag present as determined in the current Manual of Test Procedures Appendix B 21, "Determination of Reclaimed Asphalt Pavement Aggregate Bulk Specific Gravity".

If any individual sieve and/or asphalt binder content tests are out of the above tolerances when compared to the average used for the mix design, the FRAP stockpile shall not be used in Hot-Mix Asphalt unless the FRAP representing those tests is removed from the stockpile. All test data and acceptance ranges shall be sent to the District for evaluation.

The Contractor shall maintain a representative moving average of five tests to be used for Hot-Mix Asphalt production.

With the approval of the Engineer, the ignition oven may be substituted for extractions according to the ITP, "Calibration of the Ignition Oven for the Purpose of Characterizing Reclaimed Asphalt Pavement (RAP)" or Illinois Modified AASHTO T-164-11, Test Method A.

- (b) Evaluation of RAS Test Results. All of the test results, with the exception of percent unacceptable materials, shall be compiled and averaged for asphalt binder content and gradation. A five-test average of results from the original pile will be used in the mix designs. Individual test results run thereafter, when compared to the average used for the mix design, will be accepted if within the tolerances listed below.

Parameter	RAS
No. 8 (2.36 mm)	± 5 %
No. 16 (1.18 mm)	± 5 %
No. 30 (600 μm)	± 4 %
No. 200 (75 μm)	± 2.5 %
Asphalt Binder Content	± 2.0 %

If any individual sieve and/or asphalt binder content tests are out of the above tolerances when compared to the average used for the mix design, the RAS shall not be used in Hot-Mix Asphalt unless the RAS representing those tests is removed from the stockpile. All test data and acceptance ranges shall be sent to the District for evaluation.

- (c) Quality Assurance by the Engineer. The Engineer may witness the sampling and splitting conduct assurance tests on split samples taken by the Contractor for quality control testing a minimum of once a month.

The overall testing frequency will be performed over the entire range of Contractor samples for asphalt binder content and gradation. The Engineer may select any or all split samples for assurance testing. The test results will be made available to the Contractor as soon as they become available.

The Engineer will notify the Contractor of observed deficiencies.

Differences between the Contractor's and the Engineer's split sample test results will be considered acceptable if within the following limits.

Test Parameter	Acceptable Limits of Precision	
	FRAP	RAS
% Passing: ^{1/}		
1/2 in.	5.0%	
No. 4	5.0%	
No. 8	3.0%	4.0%
No. 30	2.0%	4.0%
No. 200	2.2%	4.0%
Asphalt Binder Content	0.3%	3.0%
G _{mm}	0.030	

1/ Based on washed extraction.

In the event comparisons are outside the above acceptable limits of precision, the Engineer will immediately investigate.

- (d) Acceptance by the Engineer. Acceptable of the material will be based on the validation of the Contractor's quality control by the assurance process.

1031.05 Quality Designation of Aggregate in RAP and FRAP.

- (a) RAP. The aggregate quality of the RAP for homogeneous, conglomerate, and conglomerate "D" quality stockpiles shall be set by the lowest quality of coarse aggregate in the RAP stockpile and are designated as follows.
- (1) RAP from Class I, HMA (High ESAL), or (Low ESAL) IL-9.5L surface mixtures are designated as containing Class B quality coarse aggregate.
 - (2) RAP from HMA (Low ESAL) IL-19.0L binder mixture is designated as Class D quality coarse aggregate.
 - (3) RAP from Class I, HMA (High ESAL) binder mixtures, bituminous base course mixtures, and bituminous base course widening mixtures are designated as containing Class C quality coarse aggregate.
 - (4) RAP from bituminous stabilized subbase and BAM shoulders are designated as containing Class D quality coarse aggregate.

- (b) FRAP. If the Engineer has documentation of the quality of the FRAP aggregate, the Contractor shall use the assigned quality provided by the Engineer.

If the quality is not known, the quality shall be determined as follows. Fractionated RAP stockpiles containing plus #4 (4.75 mm) sieve coarse aggregate shall have a maximum tonnage of 5,000 tons (4,500 metric tons). The Contractor shall obtain a representative sample witnessed by the Engineer. The sample shall be a minimum of 50 lb. (25 kg). The sample shall be extracted according to Illinois Modified AASHTO T 164 by a consultant laboratory prequalified by the Department for the specified testing. The consultant laboratory shall submit the test results along with the recovered aggregate to the District Office. The cost for this testing shall be paid by the Contractor. The District will forward the sample to the Central Bureau of Materials Aggregate Lab for MicroDeval Testing, according to ITP 327. A maximum loss of 15.0 percent will be applied for all HMA applications. The fine aggregate portion of the fractionated RAP shall not be used in any HMA mixtures that require a minimum of "B" quality aggregate or better, until the coarse aggregate fraction has been determined to be acceptable thru a MicroDeval Testing.

1031.06 Use of FRAP and/or RAS in HMA. The use of FRAP and/or RAS shall be the Contractor's option when constructing HMA in all contracts.

- (a) FRAP. The use of FRAP in HMA shall be as follows.

- (1) Coarse Aggregate Size (after extraction). The coarse aggregate in all FRAP shall be equal to or less than the nominal maximum size requirement for the HMA mixture to be produced.
- (2) Steel Slag Stockpiles. FRAP stockpiles containing steel slag or other expansive material, as determined by the Department, shall be homogeneous and will be approved for use in HMA (High ESAL and Low ESAL) mixtures regardless of lift or mix type.
- (3) Use in HMA Surface Mixtures (High and Low ESAL). FRAP stockpiles for use in HMA surface mixtures (High and Low ESAL) shall have coarse aggregate that is Class B quality or better. FRAP shall be considered equivalent to limestone for frictional considerations unless produced/screened to minus 3/8 inch.
- (4) Use in HMA Binder Mixtures (High and Low ESAL), HMA Base Course, and HMA Base Course Widening. FRAP stockpiles for use in HMA binder mixtures (High and Low ESAL), HMA base course, and HMA base course widening shall be FRAP in which the coarse aggregate is Class C quality or better.
- (5) Use in Shoulders and Subbase. FRAP stockpiles for use in HMA shoulders and stabilized subbase (HMA) shall be FRAP, Restricted FRAP, conglomerate, or conglomerate DQ.

- (b) RAS. RAS meeting Type 1 or Type 2 requirements will be permitted in all HMA applications as specified herein.

- (c) FRAP and/or RAS Usage Limits. Type 1 or Type 2 RAS may be used alone or in conjunction with FRAP in HMA mixtures up to a maximum of 5.0 percent by weight of the total mix.

When FRAP is used alone or FRAP is used in conjunction with RAS, the percent of virgin asphalt binder replacement (ABR) shall not exceed the amounts listed below for a given N Design.

Maximum Asphalt Binder Replacement (ABR) for FRAP with RAS Combination

HMA Mixtures <i>1/ 2/ 4/</i>	Maximum % ABR			
	Ndesign	Binder ^{5/}	Surface ^{5/}	Polymer Modified ^{3/}
30L		50	40	30
50		40	35	30
70		40	30	30
90		40	30	30
SMA				30
IL-4.75				40

1/ For Low ESAL HMA shoulder and stabilized subbase, the percent asphalt binder replacement shall not exceed 50 % of the total asphalt binder in the mixture.

2/ When the binder replacement exceeds 15 % for all mixes, except for SMA and IL-4.75, the high and low virgin asphalt binder grades shall each be reduced by one grade (i.e. 25 % binder replacement using a virgin asphalt binder grade of PG64-22 will be reduced to a PG58-28). When constructing full depth HMA and the ABR is less than 15 %, the required virgin asphalt binder grade shall be PG64-28.

3/ When the ABR for SMA or IL-4.75 is 15 % or less, the required virgin asphalt binder shall be SBS PG76-22 and the elastic recovery shall be a minimum of 80. When the ABR for SMA or IL-4.75 exceeds 15%, the virgin asphalt binder grade shall be SBS PG70-28 and the elastic recovery shall be a minimum of 80.

4/ When FRAP or RAS is used alone, the maximum percent asphalt binder replacement designated on the table shall be reduced by 10 %.

5/ When the mix has Illinois Flexibility Index Test (I-FIT) requirements, the maximum percent asphalt binder replacement designated on the table may be increased by 5%.

1031.07 HMA Mix Designs. At the Contractor's option, HMA mixtures may be constructed utilizing FRAP and/or RAS material meeting the detailed requirements specified herein.

(a) FRAP and/or RAS. FRAP and /or RAS mix designs shall be submitted for verification. If additional FRAP or RAS stockpiles are tested and found to be within tolerance, as defined under "Evaluation of Tests" herein, and meet all requirements herein, the additional FRAP or RAS stockpiles may be used in the original design at the percent previously verified.

(b) RAS. Type 1 and Type 2 RAS are not interchangeable in a mix design.

The RAP, FRAP and RAS stone specific gravities (G_{sb}) shall be according to the "Determination of Aggregate Bulk (Dry) Specific Gravity (G_{sb}) of Reclaimed Asphalt Pavement (RAP) and Reclaimed Asphalt Shingles (RAS)" procedure in the Department's Manual of Test Procedures for Materials.

1031.08 HMA Production. HMA production utilizing FRAP and/or RAS shall be as follows.

A scalping screen, gator, crushing unit, or comparable sizing device approved by the Engineer shall be used in the RAS and FRAP feed system to remove or reduce oversized and agglomerated material.

If during mix production, corrective actions fail to maintain FRAP, RAS or QC/QA test results within control tolerances or the requirements listed herein, the Contractor shall cease production of the mixture containing FRAP or RAS and conduct an investigation that may require a new mix design.

- (a) FRAP. The coarse aggregate in all FRAP used shall be equal to or less than the nominal maximum size requirement for the HMA mixture being produced.
- (b) RAS. RAS shall be incorporated into the HMA mixture either by a separate weight depletion system or by using the RAP weigh belt. Either feed system shall be interlocked with the aggregate feed or weigh system to maintain correct proportions for all rates of production and batch sizes. The portion of RAS shall be controlled accurately to within ± 0.5 percent of the amount of RAS utilized. When using the weight depletion system, flow indicators or sensing devices shall be provided and interlocked with the plant controls such that the mixture production is halted when RAS flow is interrupted.
- (c) HMA Plant Requirements. HMA plants utilizing FRAP and/or RAS shall be capable of automatically recording and printing the following information.

(1) Dryer Drum Plants.

- a. Date, month, year, and time to the nearest minute for each print.
- b. HMA mix number assigned by the Department.
- c. Accumulated weight of dry aggregate (combined or individual) in tons (metric tons) to the nearest 0.1 ton (0.1 metric ton).
- d. Accumulated dry weight of RAS and FRAP in tons (metric tons) to the nearest 0.1 ton (0.1 metric ton).
- e. Accumulated mineral filler in revolutions, tons (metric tons), etc. to the nearest 0.1 unit.
- f. Accumulated asphalt binder in gallons (liters), tons (metric tons), etc. to the nearest 0.1 unit.
- g. Residual asphalt binder in the RAS and FRAP material as a percent of the total mix to the nearest 0.1 percent.
- h. Aggregate RAS and FRAP moisture compensators in percent as set on the control panel. (Required when accumulated or individual aggregate and RAS and FRAP are printed in wet condition.)

- i. When producing mixtures with FRAP and/or RAS, a positive dust control system shall be utilized.
- j. Accumulated mixture tonnage.
- k. Dust Removed (accumulated to the nearest 0.1 ton (0.1 metric ton))

(2) Batch Plants.

- a. Date, month, year, and time to the nearest minute for each print.
- b. HMA mix number assigned by the Department.
- c. Individual virgin aggregate hot bin batch weights to the nearest pound (kilogram).
- d. Mineral filler weight to the nearest pound (kilogram).
- e. RAS and FRAP weight to the nearest pound (kilogram).
- f. Virgin asphalt binder weight to the nearest pound (kilogram).
- g. Residual asphalt binder in the RAS and FRAP material as a percent of the total mix to the nearest 0.1 percent.

The printouts shall be maintained in a file at the plant for a minimum of one year or as directed by the Engineer and shall be made available upon request. The printing system will be inspected by the Engineer prior to production and verified at the beginning of each construction season thereafter.

1031.09 RAP in Aggregate Surface Course and Aggregate Wedge Shoulders, Type B. The use of RAP in aggregate surface course and aggregate shoulders shall be as follows.

- (a) Stockpiles and Testing. RAP stockpiles may be any of those listed in Article 1031.02, except “Non-Quality” and “FRAP”. The testing requirements of Article 1031.03 shall not apply. RAP used shall be according to the current Central Bureau of Materials Policy Memorandum, “Reclaimed Asphalt Pavement (RAP) for Aggregate Applications”.
- (b) Gradation. The RAP material shall meet the gradation requirements for CA 6 according to Article 1004.01(c), except the requirements for the minus No. 200 (75 µm) sieve shall not apply. The sample for the RAP material shall be air dried to constant weight prior to being tested for gradation.”