



# ILLINOIS HIGHWAY MATERIALS SUSTAINABILITY EFFORTS 2023

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<b>16. Abstract</b> 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 2023, 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.					
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## EXECUTIVE SUMMARY

The Illinois Department of Transportation (IDOT) continues to use various reclaimed and recycled materials in highway construction and maintenance. 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 2023, along with specific reporting on the use of reclaimed asphalt shingles (RAS) and reclaimed asphalt pavement (RAP), 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 into four major groups: aggregate, HMA, concrete, and others. Aggregate includes recycled concrete material (RCM) and reclaimed asphalt pavement (RAP) used as aggregate instead 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 RAS. The concrete group includes fly ash, ground granulated blast furnace slag, and micro silica used to replace 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 2023, reclaimed and recycled materials totaling 1,126,872 tons were used in Illinois highways. This represents a decrease of 213,060 tons or a 15.9% decrease from 2022 quantities of 1,339,932 tons. Funding levels and the portfolio of project types are the major factors influencing recycling levels. According to the “Proposed Highway Improvement Program FY 2023” report, on November 15, 2021, the Infrastructure Investment and Jobs Act (IIJA), also known as the Bipartisan Infrastructure Law, was signed into law. This new five-year funding authorization bill provides an approximately 20% increase in federal formula funds and an estimated 12% increase over existing formula funds. This funding, along with additional funding from the Rebuild Illinois capital program passed in June 2019, will help to make significant progress in addressing our road and bridge needs in Illinois. The IIJA and the Rebuild Illinois capital program have significantly increased the size of IDOT’s highway program.

The FY 2023 Annual Highway Improvement Program remains significantly more extensive than previous years, providing \$3.7 billion of the \$24.6 billion included for highways in the Fiscal Year 2023-2028 Proposed Highway Improvement Program. Also included are projects totaling \$262 million in appropriations from previous fiscal years scheduled to be implemented in 2023. As a result, the FY 2023 Annual Highway Improvement Program totals \$3.962 billion. This allows the department to continue to move assertively towards meeting Transportation Asset Management Plan goals and fixing our state’s crumbling infrastructure.

On a tons-per-mile basis, the number of recycled materials used in 2023 increased from 2022. In 2022, there were 1,137.52 tons/mile, compared to 1,252.22 tons/mile in 2023, a 10.1% increase. The 15.9% decrease in recycled quantities and 23.6% decrease in miles constructed included in the program (1178 miles in 2022 and 900 miles in 2023) compared to 2022 resulted in an increase in tons/mile observed in 2023. The dollar values of the recycled materials reported in 2023 resulted in a total value of recycled materials at \$56,466,182 in 2023, representing a decrease of 34.8% from \$86,668,366 in 2022.

The amount of RAS used in 2023 was 7,569 tons, a significant decrease of 66.8% from the 2022 use of 22,782 tons. The 2023 usage of RAS is down 79.9% from the RAS usage in 2020 of 37,655 tons. Due to the change in reporting and implementation of a new construction and materials management system, the tonnage of HMA constructed in 2023 was finalized and reported at 2,300,700.48 tons. This is a decrease of 54.9% from

5,105,229 tons in 2022. Again, the lower tons of HMA constructed typically result in a lower use of recycled materials. The change in the materials management system allows the user to identify inventories, and once built, they can finalize and approve them in the CMMS system. This new finalization and approval step may decrease the tonnage of HMA, which has been reported significantly in comparison to the previous material management program, MISTIC.

The largest user of RAS, District 1, decreased from 17,026 tons in 2022 to 3,251 tons in 2023. District 1 usage accounted for 46% of the total RAS usage in Illinois. The number of paving projects, lane miles, and types of mixes used heavily influence the amount of RAS used each year. The new reporting system, CMMS, may also be influencing the RAS tonnage reported. The number of IDOT districts for which contractors produced HMA containing RAS dropped to three in 2023, but 483 tons of RAS were reportedly used out-of-state.

The amount of reclaimed asphalt pavement (RAP) used for HMA decreased from 1,051,542 tons in 2022 to 322,825 tons in 2023, or a 69.3% decrease. The significant decrease in RAP tonnage is also likely due to the new reporting system, CMMS, and the lower reported HMA tonnage finalized and approved in 2023.

While reporting tons of materials is straightforward, it does not represent the environmental benefit of recycling them. This report estimates the savings in the equivalent carbon dioxide (CO<sub>2</sub>EQ) emissions of recycled materials used by IDOT. Using fly ash and steel slag resulted in the most significant environmental benefits by replacing energy-intensive cement and virgin aggregate. IDOT's recycling efforts were estimated to reduce CO<sub>2</sub>EQ emissions by 59,794 tons in 2022 and increased to 93,036 in 2023.

**TABLE OF CONTENTS**

**CHAPTER 1: INTRODUCTION ..... 5**

**CHAPTER 2: USE OF RECLAIMED AND RECYCLED MATERIALS IN ILLINOIS HIGHWAY CONSTRUCTION IN 2023..... 6**

**2.1 REPORTING HISTORY ..... 6**

**2.2 RECLAIMED AND RECYCLED MATERIALS ADDED OR DELETED IN 2023..... 6**

**2.3 MATERIALS RECLAIMED AND RECYCLED IN 2023 ..... 6**

        2.3.1 Determining Recycle Quantities ..... 6

        2.3.2 Economic Values of Recycled Materials..... 7

        2.3.3 Recycled and Reclaimed Material Use and Values for 2023 ..... 7

**2.4 HISTORICAL RECYCLING TRENDS AND DATA ANALYSIS ..... 9**

        2.4.1. Recycling Relationship to Program Budget ..... 9

        2.4.2 Determination of Recycled Content ..... 9

**2.5 REGIONAL/DISTRICT RECYCLING EFFORTS ..... 11**

**CHAPTER 3: RECLAIMED ASPHALT SHINGLES ..... 12**

**3.1 RAS POLICIES AND SPECIFICATIONS IN EFFECT FOR 2023..... 12**

        3.1.1 RAS Policy for Sources ..... 12

        3.1.2 RAS Specifications ..... 12

**3.2 QUANTITY OF RAS USED IN THE CALENDAR YEAR 2023 ..... 12**

**CHAPTER 4: ENVIRONMENTAL EVALUATION OF RECYCLED MATERIALS USED IN 2023..... 14**

**4.1 LIFE-CYCLE ASSESSMENT..... 14**

**CHAPTER 5: SUSTAINABILITY RESEARCH ACCOMPLISHMENTS AND INITIATIVES.. 17**

**5.1 SUSTAINABILITY RESEARCH ACCOMPLISHMENTS DURING 2023 ..... 17**

        5.1.1 R27-248: Investigation of Dolomite Aggregate Long-Term Cementation and Its Potential Advantage for Building Roads..... 17

        5.1.2 R27-SP56 - Reclaimed Asphalt Pavement (RAP) in Pavement Preservation..... 17

        5.1.3 R27-250 - Using Advanced Binder Rheological Parameters to Predict Cracking Potential of Hot-Mix Asphalt Mixtures with Modified Binders..... 17

**CHAPTER 6: CONCLUSIONS ..... 18**

**REFERENCES ..... 19**

**APPENDIX A: RECYCLED AND RECLAIMED MATERIALS QUANTITIES USED AND EQUIVALENT VALUES, 2023 ..... 22**

**APPENDIX B: RECLAIMED ASPHALT PAVEMENT AND RECLAIMED ASPHALT SHINGLES - STANDARD SPECIFICATIONS FOR ROAD AND BRIDGE CONSTRUCTION, ADOPTED JANUARY 1, 2022, SECTION 1031.....23**



## CHAPTER 1: INTRODUCTION

This report is part of a series of annual reports published since 2010 to document the 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 & Burgdorfer, 2011; Griffiths & Krstulovich, 2002; IDOT, 2013; Lippert & Brownlee, 2012; Lippert et al. 2014, 2015, 2016, 2017; Rowden, 2013; Morse 2018-2023).

In 2012, Illinois Public Act 097-0314 called on IDOT to report annually on efforts to reduce its carbon footprint and achieve cost savings using recycled materials in asphalt paving projects (IDOT, 2013; Lippert & Brownlee, 2012; Rowden, 2013; Morse 2018-2023). The act also required IDOT to allow reclaimed asphalt shingles (RAS) in all hot-mix asphalt (HMA) mixes only if such use does not negatively impact pavement life-cycle cost.

Illinois has many years of experience using various reclaimed materials in highway construction. These 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 lending other desirable properties to concrete. Reclaimed asphalt pavement (RAP) has been widely used since the early 1980's.

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 the use of RAS on all IDOT projects as a contractor option (Lippert & Brownlee, 2012). As with adopting 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 using reclaimed and recycled materials. Chapter 2 presents IDOT's overall use of reclaimed and recycled materials in highway construction projects. Chapter 3 covers IDOT's efforts using RAS in HMA paving. Chapter 4 presents a life-cycle assessment based on available information that portrays the environmental benefits of recycling 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 2023**

### **2.1 REPORTING HISTORY**

The first recycling report was published in 2002 to answer various inquiries on recycling (Griffiths & 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 & 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 the use of recycled materials provided the most in-depth overview of how each material is derived and used in highway construction (Rowden, 2013). The 2013-2021 reports provided benchmark performance measures on recycled material use per mile rather than total quantity (Lippert et al. 2014, 2015, 2016, 2017; Morse 2018-2023).

This report uses the same methodology for determining quantities as past reports from IDOT's Materials Integrated System for Test Information and Communication (MISTIC). Introducing the new construction and materials management system (CMMS) requires the development of new reporting and sorting functions. The CMMS reports are in development and will continue to be refined and improved for future reports. The information from MISTIC and CMMS is summarized to report the quantities of each recycled material. 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) and added CMMS reporting of RAS in 2022.

### **2.2 RECLAIMED AND RECYCLED MATERIALS ADDED OR DELETED IN 2023**

IDOT's list of reclaimed and recycled materials was reviewed while preparing this report. No new materials were added, and no old materials were deleted during the 2023 reporting year.

### **2.3 MATERIALS RECLAIMED AND RECYCLED IN 2023**

#### **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, through how those materials are manufactured, and thus are straightforward to report. Many additional tons of recycled materials are used, but tracking the quantities 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 CMMS and MISTIC reports are the sources 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 in Illinois. Some local agencies that take part in statewide purchase agreements use this quantity.

Previous versions of this report determined RAS quantities via a contractor survey. This data collection method was done because MISTIC reporting of RAS quantities needed to be developed and shown to be reliable.

Improvements in MISTIC and CMMS 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 2023 pricing, a statewide average was determined from supplier- and contractor-provided information. For items with reported price indexes, such as steel, the monthly IDOT index was averaged for the year (IDOT 2023b).

The RAP in the HMA price is a calculated value because it is typically not available through the typical supplier- and contractor-provided information. HMA Producers generally mill and use RAP back in their HMA as opposed to milling and selling it to other HMA Producers. CBM worked with the Illinois Asphalt Pavement Association to develop the following calculation.

#### *Assumptions*

- a. 5.5% asphalt binder per ton of HMA mixture (denoted as  $P_{AB}$  in the equation below)
- b. 94.5% aggregate per ton of HMA mixture (denoted as  $P_A$  in the equation below)
- c. PG 64-22 asphalt binder price of \$ 607.61 (denoted as  $C_{AB}$  in the equation below)
- d. Aggregate cost of \$ 27.00 (denoted as  $C_A$  in the equation below)

#### *Example Calculation*

$$RAP \text{ in HMA Price} = (P_{AB} \times C_{AB}) + (P_A \times C_A)$$

$$RAP \text{ in HMA Price} = (5.5\% \times \$607.61) + (94.5\% \times \$27.00) = \$58.93$$

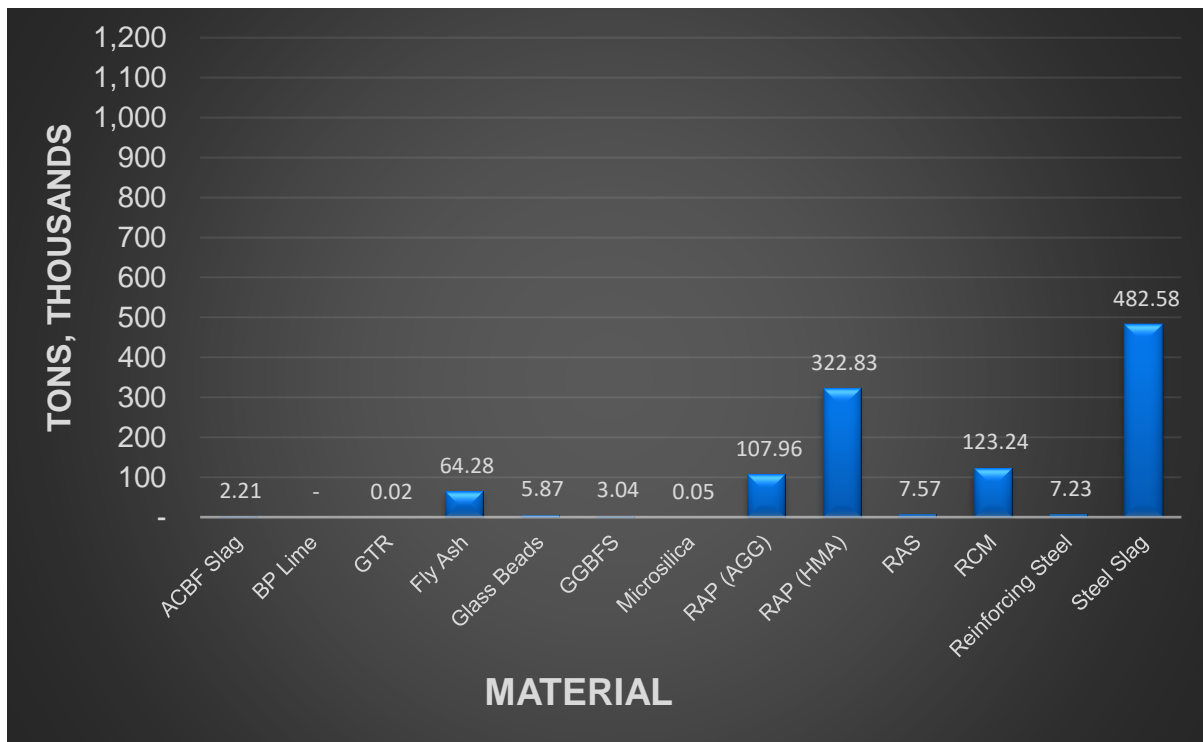
### 2.3.3 Recycled and Reclaimed Material Use and Values for 2023

#### *2.3.3.1 Data for 2023*

Appendix A presents the quantities and values of 2023 recycled and reclaimed materials. In total, 1,126,872 tons of recycled materials were used in 2023, a 15.9% decrease in recycled tonnage from the 1,339,932 tons in 2022. The value of 2023 recycled materials was \$56,466,182, a significant 34.8% decrease from \$86,668,366 in 2022. In 2023, the miles of roadway improvement decreased to 900 miles from 1,178 miles in 2022. The number of bridges constructed or rehabilitated decreased from 170 in 2022 to 162 in 2023. The overall value of projects awarded in 2023 was higher at \$3.962 Billion, compared with 2022 figures of \$3.605 Billion. The decrease in miles of roadway improvements resulted in decreased recycled tonnage in 2023. The type and scope of projects significantly influenced this. In addition, the new CMMS reporting process drastically reduced the HMA-related material tonnages.

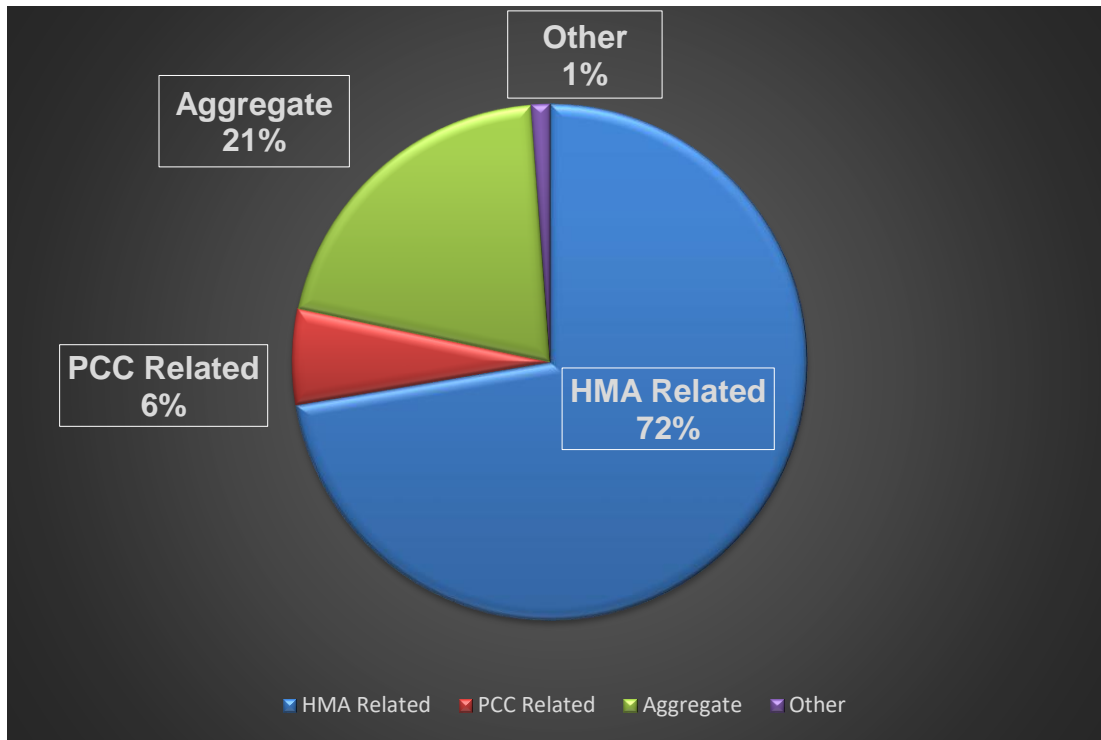
#### *2.3.3.2 Data Analysis of 2023 Use*

A series of figures present a more accurate picture of IDOT's recycling effort, providing information on 2023 results and historical trends. As shown in Figure 1, the bulk of the recycled tonnage comprised four materials: Steel Slag, RAP in HMA, recycled concrete material (RCM), and RAP as an aggregate.



**Figure 1. Reclaimed material used in 2023.**

Figure 2 breaks out quantities by related uses for HMA, aggregate, Portland Cement Concrete (PCC), and others. 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 micro silica, which replace cement or provide specific properties to the final concrete product. Aggregate use consists of RCM and RAP used in place of natural aggregates. From this summary, recycled materials related to HMA and aggregate use represent most of IDOT's recycled tonnage.



**Figure 2. Reclaimed materials by related tons of use in 2023.**

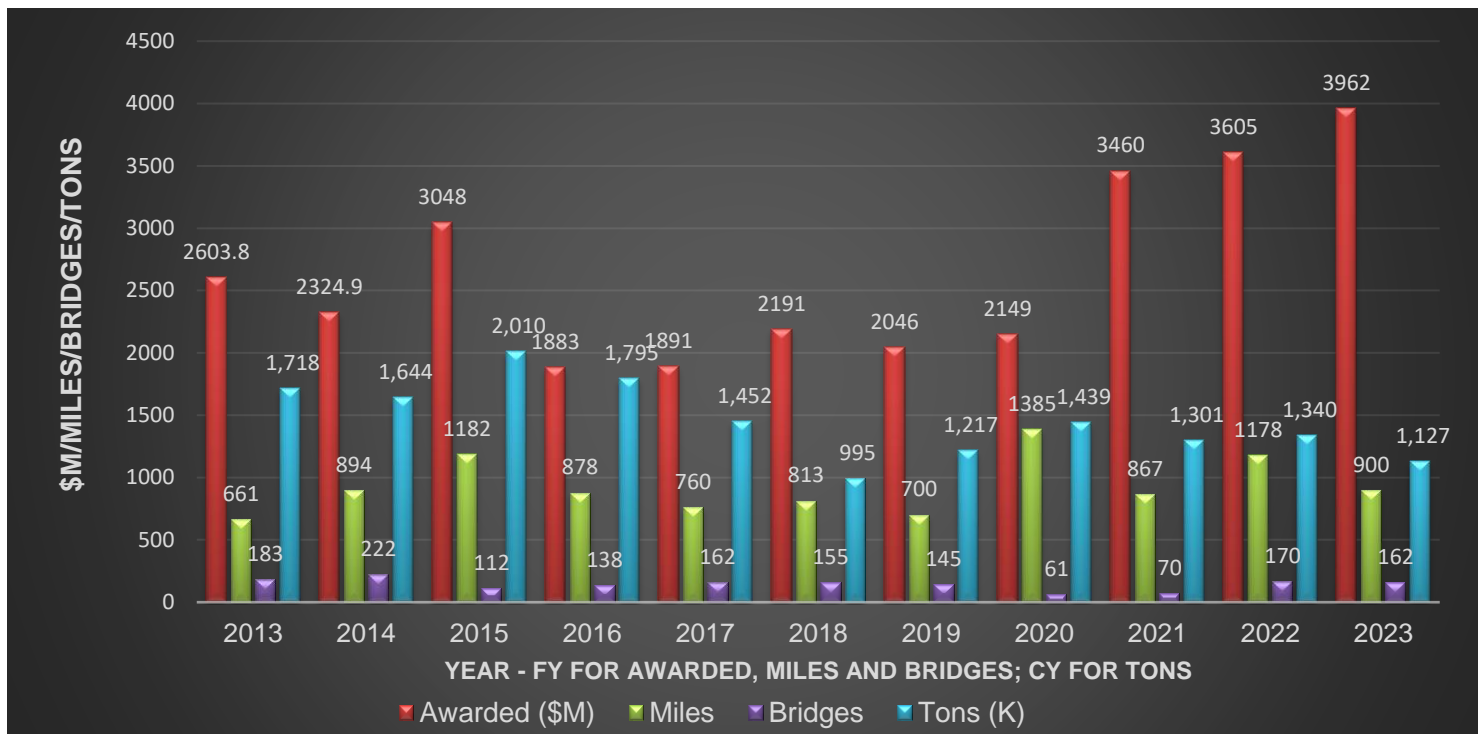
## **2.4 HISTORICAL RECYCLING TRENDS AND DATA ANALYSIS**

### **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. Exceptions are large structures over rivers.

Presented in Figure 3 are the total tons recycled from calendar years 2013 through 2023.

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 2023a). This timeframe differs from the calendar year (CY) reported for recycled tonnage. However, the values tend to align 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 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)(Morse, 2018, 2019, 2020, 2021, 2022). 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, 2023 represents a 10.1% increase in recycle quantity per mile from 2022, or 1,137.52 tons/mile in 2022, to 1,252.22 tons/mile in 2023.

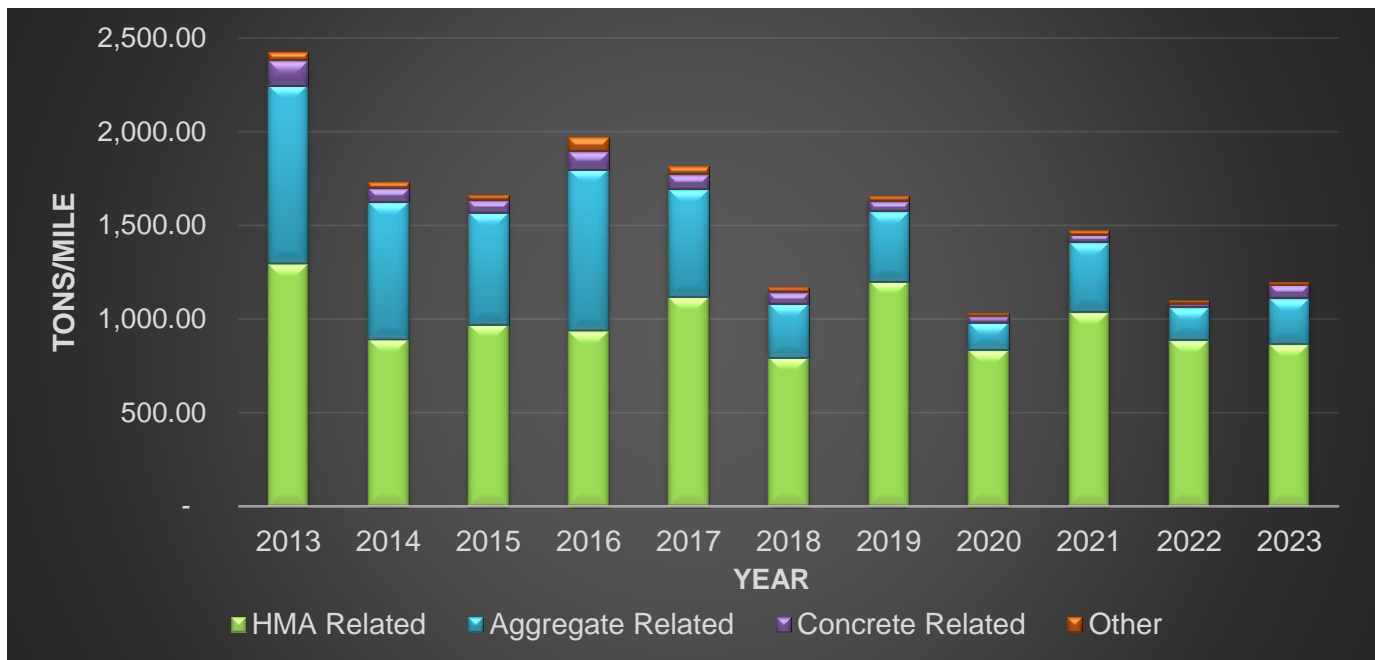


Figure 4. Historical recycle content.

## 2.5 REGIONAL/DISTRICT RECYCLING EFFORTS

Due to the use of RAP/RAS throughout the State and the desire for a consistent specification, a Standard Specification for Road and Bridge Construction was implemented effective January 1, 2022. The link is attached in Appendix B.

## **CHAPTER 3: RECLAIMED ASPHALT SHINGLES**

This chapter continues 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 & Brownlee, 2012; Lippert et al., 2014, 2015, 2016, 2017). MISTIC data and CMMS reports were used to report 2023 RAS usage.

### **3.1 RAS POLICIES AND SPECIFICATIONS IN EFFECT FOR 2023**

#### **3.1.1 RAS Policy for Sources**

The Central Bureau of Materials (CBM) Policy Memorandum, “Reclaimed Asphalt Shingle (RAS) Sources” (28-10.3), has 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 2023 version of the Certified Sources for Reclaimed Asphalt Shingles list contains 17 suppliers.

#### **3.1.2 RAS Specifications**

##### *3.1.2.1 Statewide Specifications*

Reclaimed Asphalt Pavement and Reclaimed Asphalt Shingles – Standard Specifications for Road and Bridge Construction, Adopted January 1, 2022, Section 1031.

##### *3.1.2.2 Regional/District Specifications*

Implementing the Standard Specification mentioned above has minimized the need for regional or district specifications.

### **3.2 QUANTITY OF RAS USED IN THE CALENDAR YEAR 2023**

In 2023, IDOT experienced a decrease in RAS use. The total used in 2023 was 7,568.6 tons compared to 22,782 tons in 2022. This change represents a decrease of 66.8%. The largest user of RAS in 2023, District 8, decreased from 5,496 tons in 2022 to 3,769.3 tons in 2023. This likely represents a decrease in RAS use corresponding with the significant decrease in the CMMS finalized and reported HMA tons placed throughout the state.

In 2023, three of the nine districts reported using RAS, one less than the previous year. The map in Figure 5 provides the percentage of the 2023 statewide total RAS used by the three IDOT districts.



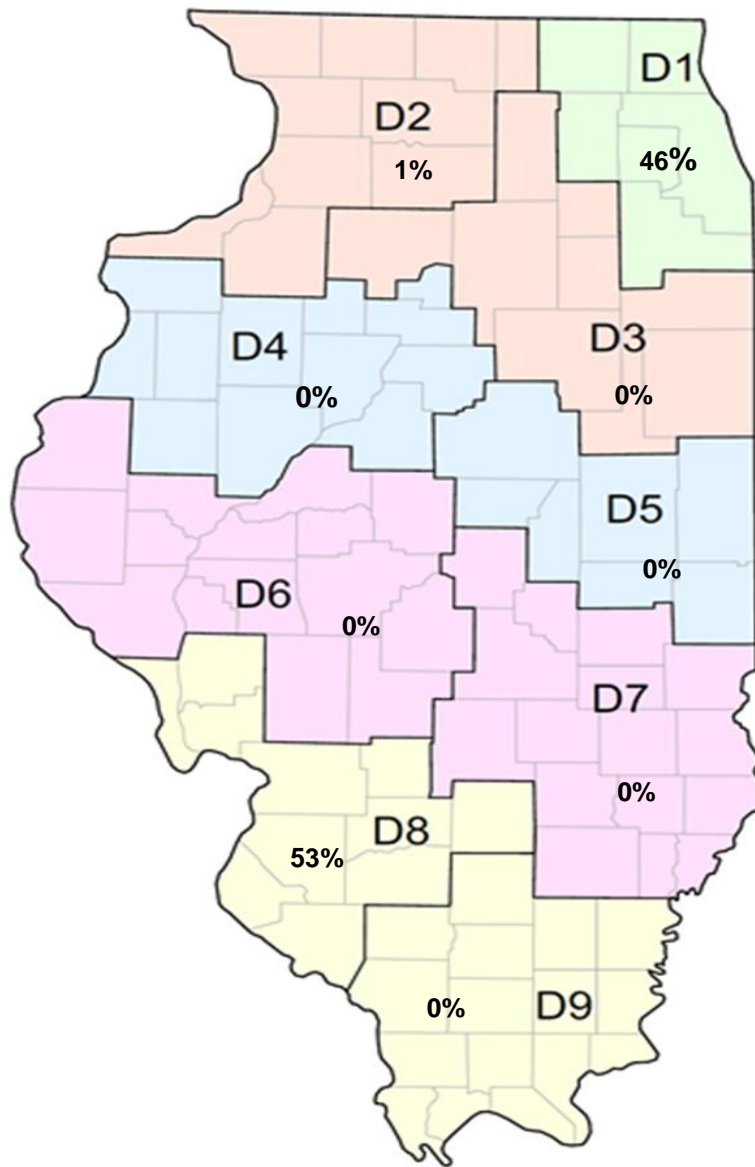


Figure 5. Percentage of RAS used by each district in the calendar year 2023.

# CHAPTER 4: ENVIRONMENTAL EVALUATION OF RECYCLED MATERIALS USED IN 2023

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

## 4.1 LIFE-CYCLE ASSESSMENT

An approach to evaluate the environmental burden of processes in life-cycle assessment (LCA) can also be applied to pavements and paving materials. Based on documented processes, this approach estimates 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 standard and simple environmental burden measure. Typically, the measure used is carbon dioxide equivalents per ton of the material used, or CO<sub>2</sub>EQ/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 significant 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 CO<sub>2</sub>EQ/ton for each material recycled and the virgin material being replaced. The difference in CO<sub>2</sub>EQ/ton between virgin and recycled material is the “savings” noted in Table 1 for each material, in kilograms equivalent of CO<sub>2</sub> for each ton of material recycled, for which information was available (Chen et al., 2010; EarthShift, 2013; Prusinski, 2003; Sunthonpagasit & Duffey, 2004; World et al., 2011). For 2023, the total CO<sub>2</sub>EQ savings in tons is also presented. This estimate includes typical transportation distances for Illinois. A primary assumption is that the performance of the highway infrastructure item is equivalent for both virgin and recycled options.

Materials with low CO<sub>2</sub>EQ, such as aggregates, have minimal savings values 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 CO<sub>2</sub>EQ savings can be realized.

From this simple analysis, it is estimated that a total of 93,036 tons of CO<sub>2</sub>EQ was saved in 2023. Appendix A presents an accounting of CO<sub>2</sub>EQ saved in 2023 for each material 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 2023 is presented in Figure 6. This picture is very different from the tons of material presented in Figure 1. Likewise, Figure 7 shows the distribution of CO<sub>2</sub>EQ savings by related use, which differs significantly from the previous tonnage distribution in Figure 2.

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

Material	Savings per Ton of Use, CO <sub>2</sub> EQ (kg)	2023 CO <sub>2</sub> EQ Savings (Tons)
Air-Cooled Blast Furnace Slag	13	32
By-Product Lime	920	-
Crumb Rubber	1,704	30
Fly Ash	894	63,347
Glass Beads	929	6,014
Ground Granulated Blast Furnace Slag	763	2,556
Microsilica	NA	NA
Reclaimed Asphalt Pavement Used for Aggregate	0.8	95
Reclaimed Asphalt Pavement Used For HMA	17	6,050
Reclaimed Asphalt Shingles	79	659
Recycled Concrete Material	0.8	109
Steel Reinforcement	640	5,102
Steel Slag	17	9,043
Wet Bottom Boiler Slag	NA	NA

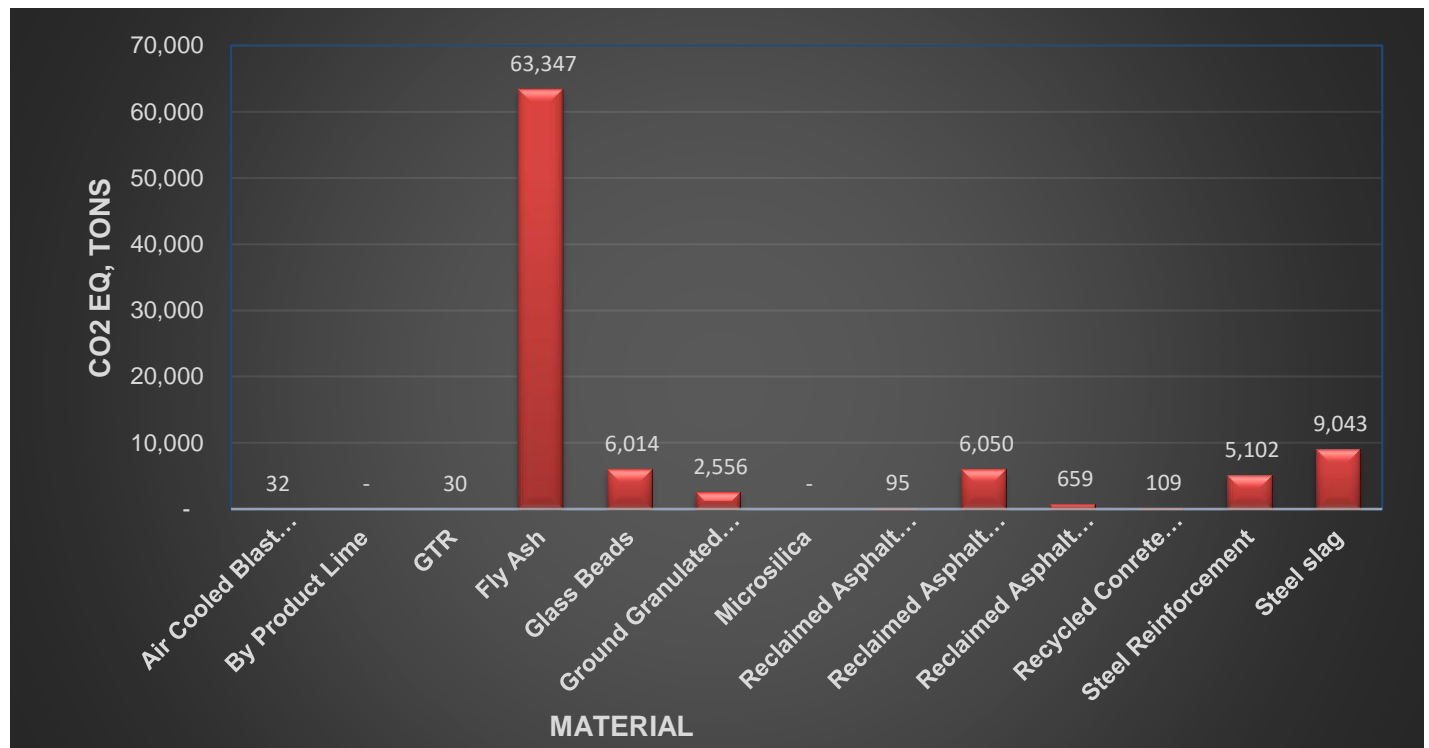
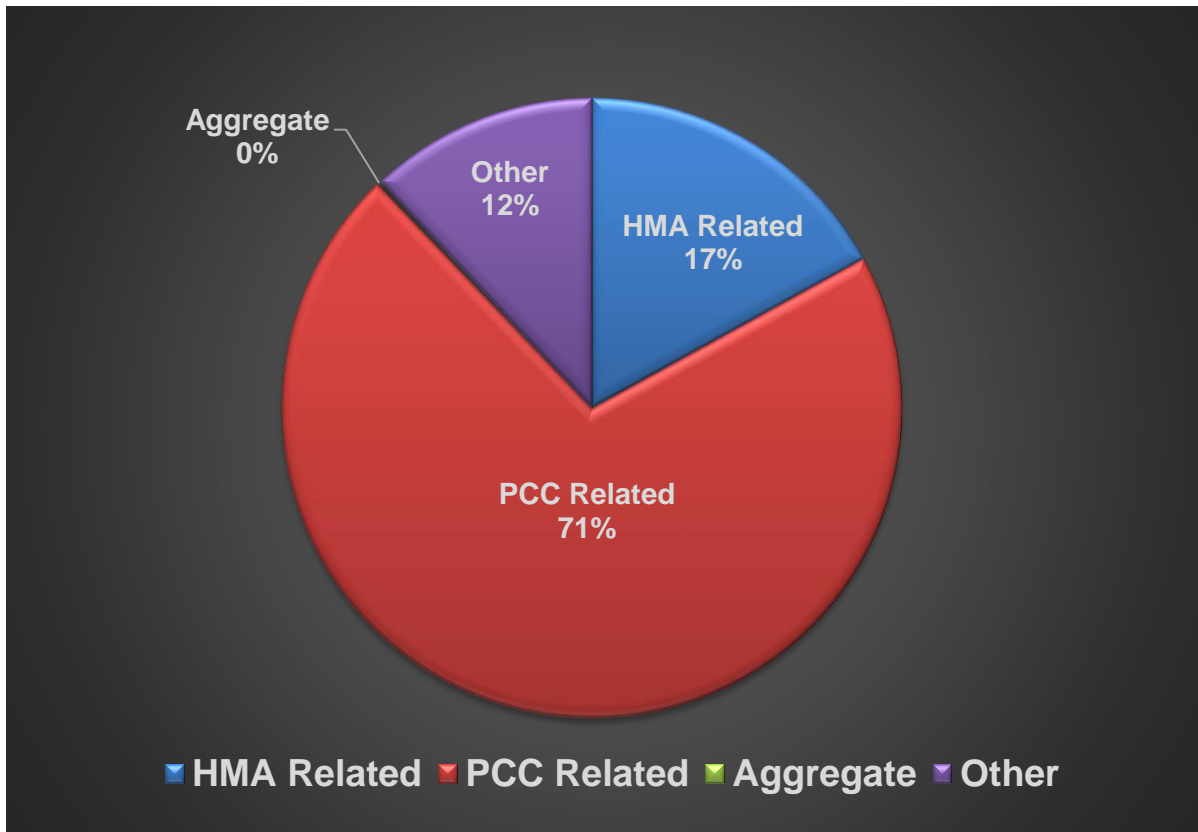


Figure 6. CO<sub>2</sub>EQ saved by material in 2023.



**Figure 7. CO<sub>2</sub>EQ saved by related use in 2023.**

## **CHAPTER 5: SUSTAINABILITY-RESEARCH ACCOMPLISHMENTS AND INITIATIVES**

During 2023, IDOT had three 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 2023**

#### **5.1.1 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 conditioning periods, the characterization tests will be conducted to identify changes in the phase compositions and mineralogy contributing to cementation and strength gain. This project is scheduled to end in December 2024.

#### **5.1.2 R27-SP56 - Reclaimed Asphalt Pavement (RAP) in Pavement Preservation**

Pavement preservation, an economically and environmentally friendly technique, allows pavements to last longer and improves ride quality. The goal of this project is to explore the use of reclaimed asphalt pavement (RAP) in IDOT's pavement preservation treatments. Researchers will survey agencies' use of RAP in pavement preservation practices, evaluate its performance and cost-benefit, and determine its availability in Illinois. Effectively using RAP in pavement preservation treatments will provide environmental benefits and potentially decrease construction costs. This project ended in October 2023.

#### **5.1.3 R27-250 - Using Advanced Binder Rheological Parameters to Predict Cracking Potential of Hot-Mix Asphalt Mixtures with Modified Binders**

This project has two objectives. First, it evaluates the potential of advanced binder rheological parameters to predict HMA cracking potential. Second, it evaluates the potential to blend softener-modified binders with a Styrene-butadiene-styrene (SB) polymer. The project began in August 2022 and is scheduled to end in February 2025.

## CHAPTER 6: CONCLUSIONS

The goal of this report is to provide a single-source document for 2023 sustainability efforts in highway materials that serve to meet the reporting requirement of Illinois Public Act 097-0314. In summary, the 2023 efforts in recycling resulted in the following:

- In 2023, recycled materials used in highway projects totaled 1,126,872 tons, with a value of \$56,466,182. The tonnage decreased from 2022, and so did the monetary value.
- The usage of reclaimed asphalt shingles (RAS) in 2023 was 7,568.6 tons compared to 22,782 tons in 2022. This change represents a decrease of 66.8%. Districts 1 and 8 combined for 99% of the RAS use in 2023.
- It is estimated, using the life-cycle assessment (LCA), that carbon dioxide—equivalent emissions were reduced by 93,036 tons in 2023. Fly Ash and Steel Slag accounted for the most significant contribution by reducing over 72,390 tons combined. The carbon dioxide—equivalent emissions reductions in 2023 were improved by 55.7% more than in 2022 at 59,764 tons.
- In 2023, the department had three active or ongoing material sustainability research projects. These research projects will result in at least three publications in interim/final reports and white papers.

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## APPENDIX A: RECYCLED AND RECLAIMED MATERIALS: QUANTITIES USED AND EQUIVALENT VALUES, 2023

Material	Unit Equivalent Value	Quantity <sup>1</sup> Tons	Total Equivalent Value to Department	CO <sub>2</sub> Equivalent Savings Tons <sup>6</sup>
Air-cooled blast furnace slag	\$8.23	2,212	\$18,205	32
By-product lime	\$13.00	-	-	-
Crumb rubber <sup>2</sup>	\$400.00	16	\$6,349	30
Fly ash	\$65.00	64,281	\$4,178,265	63,347
Glass beads <sup>3</sup>	\$996.00	5,873	\$5,849,408	6,014
Ground granulated blast furnace slag	\$158.00	3,039	\$480,162	2,556
Microsilica	\$540.00	48	\$25,920	NA
Reclaimed asphalt pavement used for Aggregate	\$8.60	107,962	\$928,473	95
Reclaimed asphalt pavement used for HMA	\$58.93	322,825	\$19,024,077	6,050
Reclaimed asphalt shingles	\$23.63	7,569	\$178,855	659
Recycled concrete material	\$10.00	123,236	\$1,232,360	109
Steel reinforcement <sup>4</sup>	\$1,925.93	7,231	\$13,927,346	5,102
Steel slag	\$22.00	482,580	\$10,616,760	9,043
Wet-bottom boiler slag <sup>5</sup>	NA	NA	NA	NA
<b>Totals</b>	<b>—</b>	<b>1,126,872</b>	<b>\$56,466,182</b>	<b>93,036</b>

<sup>1</sup> Quantities were calculated from amounts assigned to projects in the calendar year 2023. Before the summation of values, metric values were converted to English values using factors in Appendix B of the *Standard Specifications for Road and Bridge Construction*.

<sup>2</sup> Crumb rubber: This material quantity was calculated as 5% of the hot-poured joint sealant used in 2023.

<sup>3</sup> Glass bead units are based on tested and approved quantities and not projects assigned through CMMS and MISTIC.

<sup>4</sup> Steel reinforcement: For this report, the IDOT monthly steel index was averaged for 2023 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.

<sup>5</sup> Wet-bottom boiler slag: No records were found in CMMS or MISTIC that indicated WBBS was used for any IDOT projects in 2023.

<sup>6</sup> 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 - STANDARD SPECIFICATIONS FOR ROAD AND BRIDGE CONSTRUCTION, ADOPTED JANUARY 1, 2022, SECTION 1031**

<https://public.powerdms.com/IDOT/documents/1945348/Standard%20Specifications%20for%20Road%20and%20Bridge%20Construction%202022>