ILLINOIS HIGHWAY MATERIALS SUSTAINABILITY EFFORTS 2022

Prepared by Kelly Morse
Kelly.Morse@illinois.gov

TECHNICAL REPORT DOCUMENTATION PAGE

1. Report No. PRR 177	**2. Government Accession No.** N/A	**3. Recipient's Catalog No.** N/A
4. Title and Subtitle ILLINOIS HIGHWAY MATERIALS SUSTAINABILITY EFFORTS 2022		**5. Report Date** August 29, 2023
		6. Performing Organization Code N/A
7. Author(s) Kelly Morse		**8. Performing Organization Report No.** PRR 177
9. Performing Organization Name and Address Illinois Department of Transportation Bureau of Materials 126 East Ash Street Springfield, IL 62704		**10. Work Unit No.** N/A **11. Contract or Grant No.** NA
12. Sponsoring Agency Name and Address Illinois Department of Transportation (SPR) Bureau of Research 126 East Ash Street Springfield, IL 62704		**13. Type of Report and Period Covered** Calendar Year 2022 **14. Sponsoring Agency Code**

15. Supplementary Notes
Conducted in cooperation with the U.S. Department of Transportation, Federal Highway Administration.

16. Abstract
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 2022, 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.

17. Key Words Reclaimed asphalt shingles (RAS), recycled materials, Illinois Public Act 097-0314, sustainability, reclaimed, recycled, reclaimed asphalt pavement (RAP), recycled concrete material (RCM), fly ash, hot-mix asphalt (HMA), concrete aggregate.	**18. Distribution Statement** No restrictions. This document is available through the National Technical Information Service, Springfield, VA 22161.

19. Security Classif. (of this report) N/A	**20. Security Classif. (of this page)** N/A	**21. No. of Pages** 24	**22. Price** N/A

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 2022, 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 into four major groups: aggregate, HMA, concrete, and others. The aggregate group includes recycled concrete material (RCM) and reclaimed asphalt pavement (RAP) used as an 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 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 2022, reclaimed and recycled materials totaling 1,329,932 tons were used in Illinois highways. This represents an increase of 38,556 tons or a 2.2% increase from 2021 quantities. Funding levels and the portfolio of project types are the major factors influencing recycling levels. The Rebuild Illinois capital program passed in June 2019, significantly increased the size of IDOT’s highway program. The FY 2022 Annual Highway Improvement Program continues to remain significantly higher than previous years. On a tons-per-mile basis, the number of recycled materials used in 2022 decreased from 2021 levels. In 2021 there were 1,500.58 tons/mile, compared to 1,137.52 tons/mile in 2022, a 24% decrease. The slight increase in quantities and significant increases in miles included in the program compared to 2021 resulted in the decrease in tons/mile observed in 2022. The significant increase in the values of the recycled materials reported in 2022, resulted in a total value of recycled materials at $86,668,366 in 2022 representing an increase of 23% from $70,701,760 in 2021. As in most areas of the economy, values in many different areas of highway construction and maintenance increased due to supply chain issues, fuel costs, and the noteworthy increase in the program.

The amount of RAS used in 2022 was 22,782 tons, which is a large increase of 37% from the 2021 use of 16,572 tons. The 2022 usage of RAS is still down from the RAS usage in 2020 of 37,655 tons. Again, the higher tons of HMA constructed typically result in higher use of recycled materials. The largest user of RAS, District 1, had an increase from 12,710 tons in 2021 to 27,026 tons in 2022. District 1 usage accounted for 75% 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 number of IDOT districts for which contractors produced HMA containing RAS dropped to four in 2022.

The amount of reclaimed asphalt pavement (RAP) used for HMA increased from 886,544 tons in 2021 to 1,051,542 tons in 2022, or a 19% increase. The use of RAP was especially high in 2020 at 1,113,695. The use in 2022 is closer to the 2020 quantity with a return of more paving projects using HMA.

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 (CO_2EQ) emissions savings of the recycled materials used by IDOT. The use of reclaimed asphalt pavement (aggregate) and fly ash resulted in the greatest environmental benefits through the replacement of both virgin aggregate and energy-intensive cement. It is estimated that IDOT's recycling efforts reduced CO_2EQ emissions by 59,794 tons in 2022.

TABLE OF CONTENTS

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 and Burgdorfer 2011; Griffiths and Krstulovich 2002; IDOT 2013; Lippert and Brownlee 2012; Lippert et al. 2014, 2015, 2016, 2017; Rowden 2013; Morse 2018-2022).

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 and Brownlee 2012; Rowden 2013; Morse 2018-2022). 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 on 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 the 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 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 2022

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 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 on a per-mile basis rather than total quantity (Lippert et al. 2014, 2015, 2016, 2017; Morse 2018-2022).

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) as well as the newly implemented Construction & Materials Management System (CMMS). Information from MISTIC and CMMS is summarized to report the 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 contactor survey on use to reliance on data contained in MISTIC (Lippert et al. 2017).

2.2 RECLAIMED AND RECYCLED MATERIALS ADDED OR DELETED IN 2022

The list of reclaimed and recycled materials used by IDOT was reviewed while preparing this report. During the 2022 reporting year, no new materials were added, or old materials deleted.

2.3 MATERIALS RECLAIMED AND RECYCLED IN 2022

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 the 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 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 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 CMMS and 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 2022 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 2022b).

2.3.3 Recycled and Reclaimed Material Use and Values for 2022

2.3.3.1 Data for 2022

Appendix A presents the 2022 recycled and reclaimed material quantities and values. In total, 1,339,932 tons of recycled materials were used in 2022, which is a 2.2% increase in recycled tonnage from the 1,309,376 tons in 2021. The value of 2022 recycled materials was $86,668,366, a significant, 49% increase from $58,087,762 in 2021. In 2022, the miles of roadway improvement increased to 1,178 miles from 867 miles in 2021. The number of bridges constructed or rehabilitated increased from 70 in 2021 to 170 in 2022. The overall value of projects awarded in 2022 was higher at $3.605 Billion, as compared with 2021 figures of $3.460 Billion. The increase in miles of roadway improvements resulted in an increase in recycled tonnage in 2022. This is greatly influenced by the type and scope of projects constructed.

2.3.3.2 Data Analysis of 2022 Use

To present a more accurate picture of IDOT's recycling effort, a series of figures is presented which provides information on 2022 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.

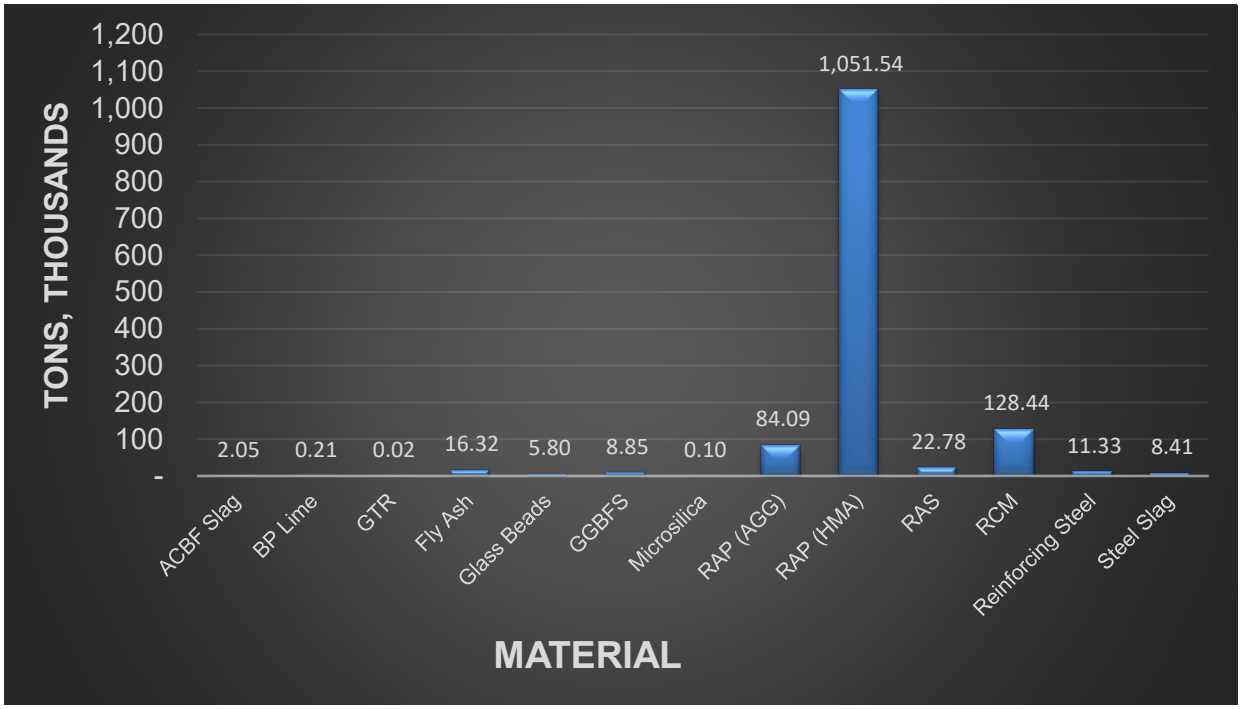

Figure 1. Reclaimed material used in 2022.

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 microsilica used to 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 the majority of IDOT recycled tonnage.

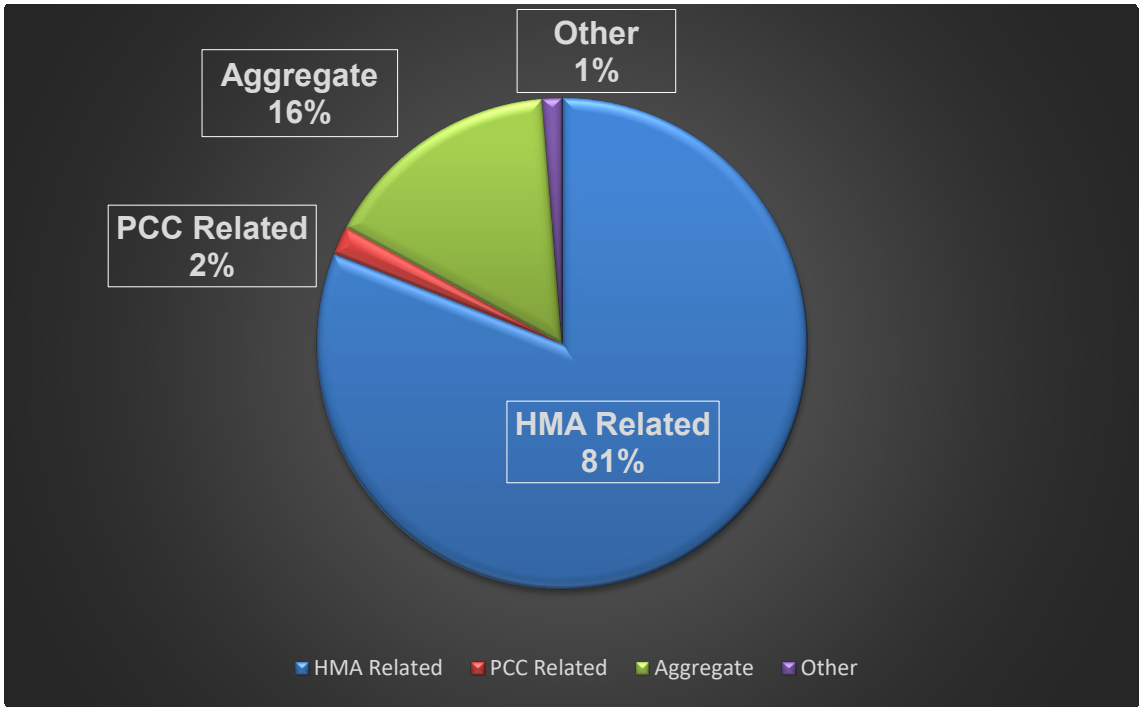

Figure 2. Reclaimed materials by related tons of use in 2022.

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 2012 through 2022.

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 2022a). 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 by CY.

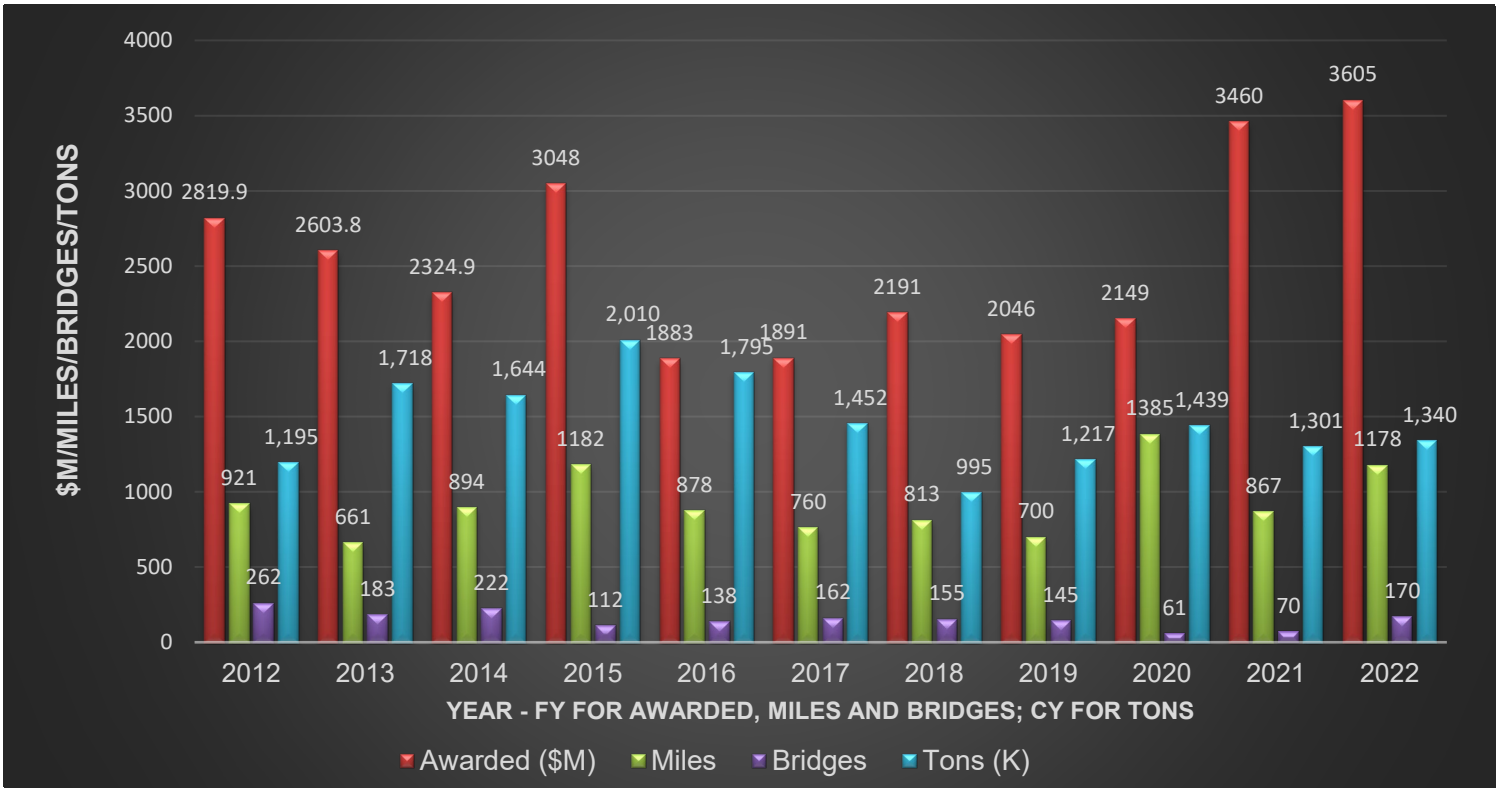

Figure 3. Annual projects awarded (FY), miles improved (FY), bridges built/improved (FY), and recycled tons (CY).

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 2012. On a tons-per-mile basis, 2022 represents a 24% decrease in recycle quantity from 2021, or 1,500.58 tons/mile in 2021 to 1,137.52 tons/mile in 2022. This is due to the large increase in bridges from 70 in 2021 to 170 in the 2022 program. As mentioned previously, bridges utilize less recycled materials.

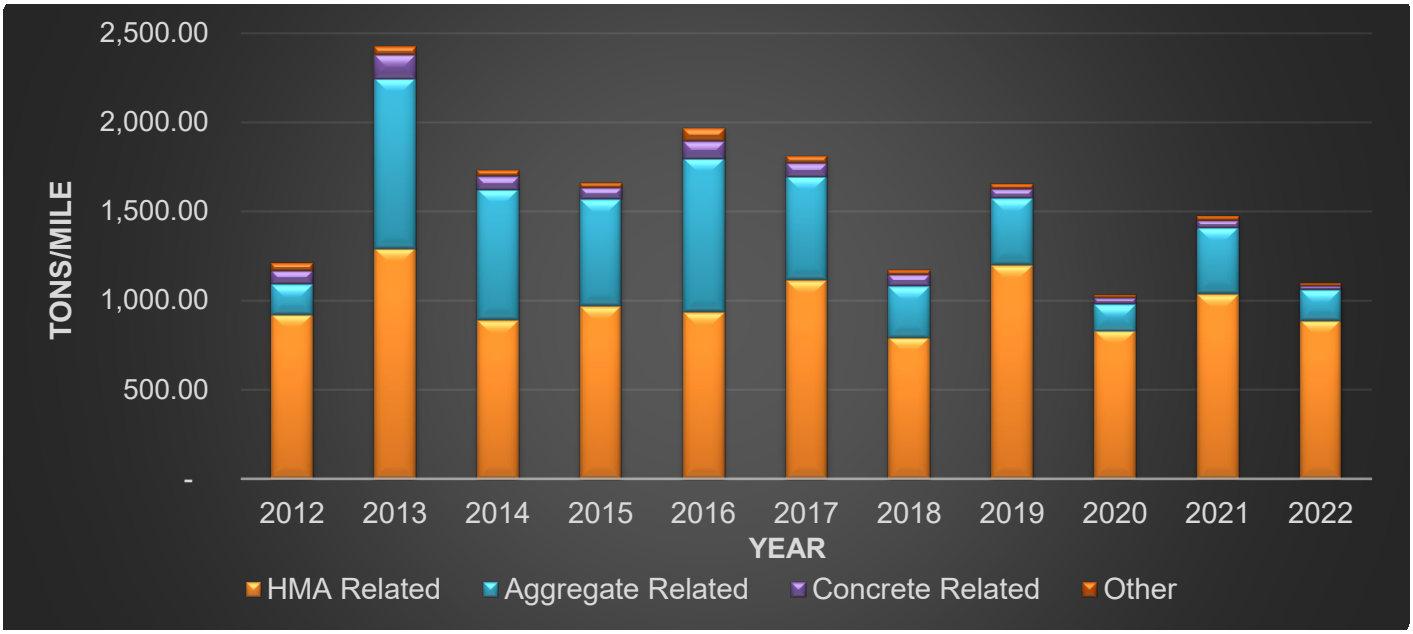

Figure 4. Historical recycle content.

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 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). CMMS and MISTIC data were used to report 2022 RAS usage.

3.1 RAS POLICIES AND SPECIFICATIONS IN EFFECT FOR 2022

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 23 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

The implementation of the Standard Specification mentioned above has minimized the need for regional or district specifications.

3.2 QUANTITY OF RAS USED IN THE CALENDAR YEAR 2022

In 2022, IDOT experienced an increase in RAS use. The total used in 2022 was 22,782 tons compared to 16,572 tons in 2021. This change represents an increase of 38%. The largest user of RAS, District 1, had an increase from 12,710 tons in 2021 to 17,026 tons in 2022. This likely represents RAS use to correspond with the increase in HMA placed in District 1. District 1 constructed 22% more tons of HMA in 2022 compared to 2021.

In 2022, four 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 2022 statewide total RAS used by each IDOT district.

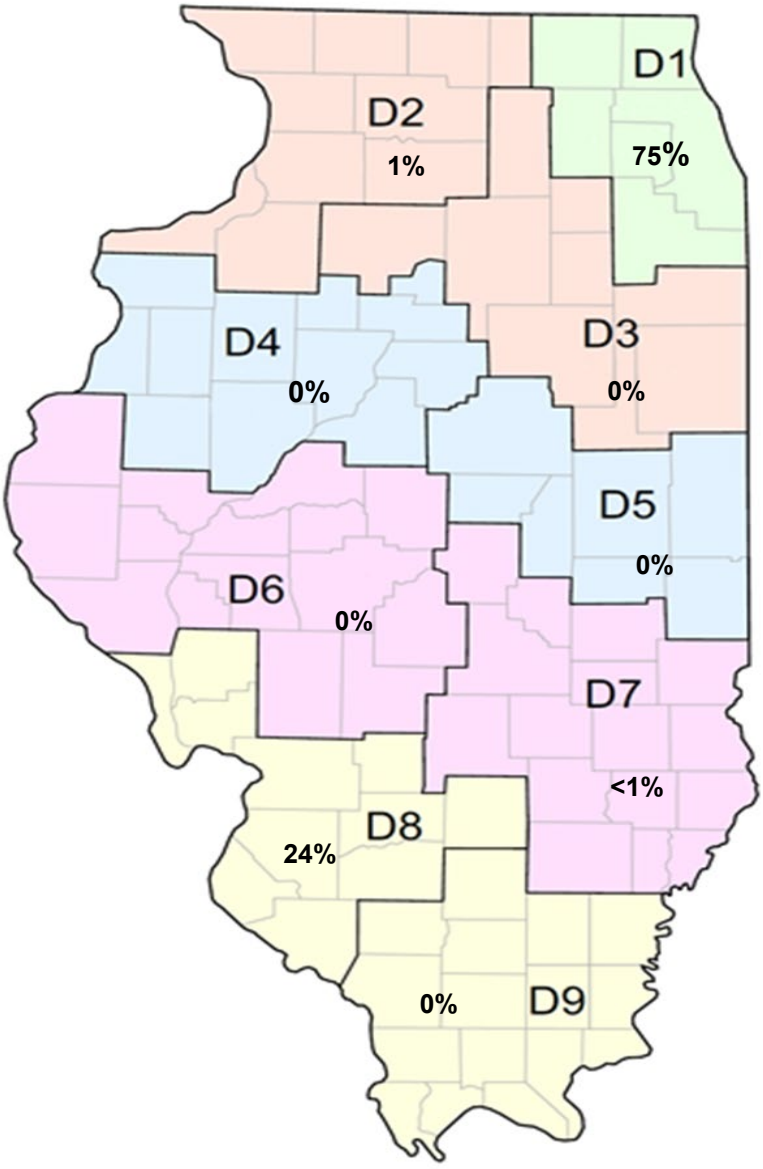

Figure 5. Percentage of RAS used by each district in the calendar year 2022.

CHAPTER 4: ENVIRONMENTAL EVALUATION OF RECYCLED MATERIALS USED IN 2022

Over the years, the prime driver for the 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 replace virgin and/or manufactured materials with a product that otherwise would be landfilled or stockpiled as 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 the evaluation of 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 common and simple environmental-burden measure. Typically, the measure used is carbon dioxide equivalents per ton of the material used, or CO_2EQ/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 CO_2EQ/ton for each material recycled and the virgin material being replaced. The difference in CO_2EQ/ton between virgin and recycled material is the "savings" noted in Table 1 for each material, in kilograms equivalent of CO_2 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 2022, the total CO_2EQ 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 CO_2EQ, 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 CO_2EQ can be realized.

From this simple analysis, it is estimated that a total of 59,764 tons of CO_2EQ was saved in 2022. Appendix A presents an accounting of CO_2EQ saved in 2022 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 2022 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_2EQ 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_2EQ (kg)	2022 CO_2EQ Savings (Tons)
Air-Cooled Blast Furnace Slag	13	29
By-Product Lime	920	213
Crumb Rubber	1,704	28
Fly Ash	894	16,081
Glass Beads	929	5,938
Ground Granulated Blast Furnace Slag	763	7,446
Microsilica	NA	NA
Reclaimed Asphalt Pavement Used for Aggregate	0.8	74
Reclaimed Asphalt Pavement Used For HMA	17	19,705
Reclaimed Asphalt Shingles	79	1,984
Recycled Concrete Material	0.8	113
Steel Reinforcement	640	7,995
Steel Slag	17	158
Wet Bottom Boiler Slag	NA	NA

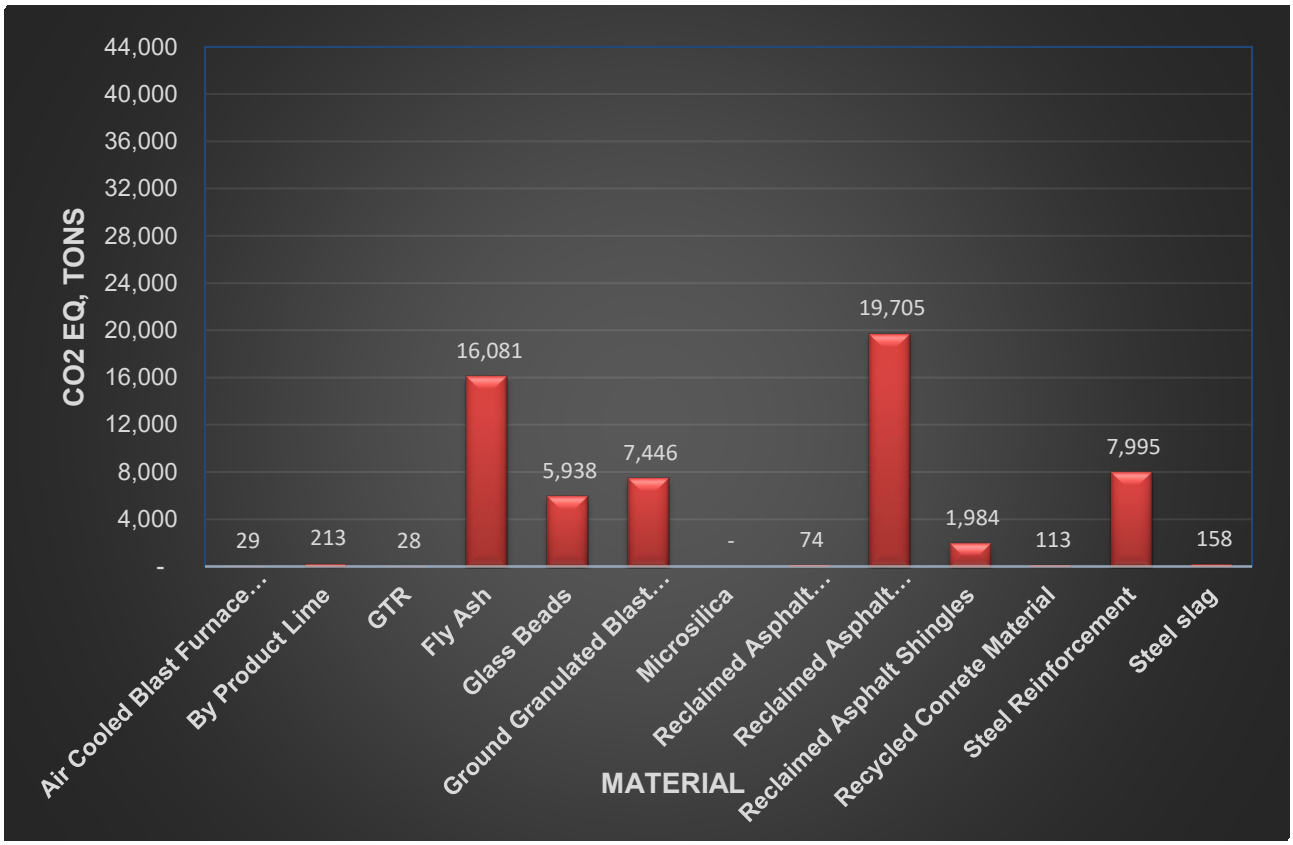

Figure 6. CO_2EQ saved, by material, in 2022.

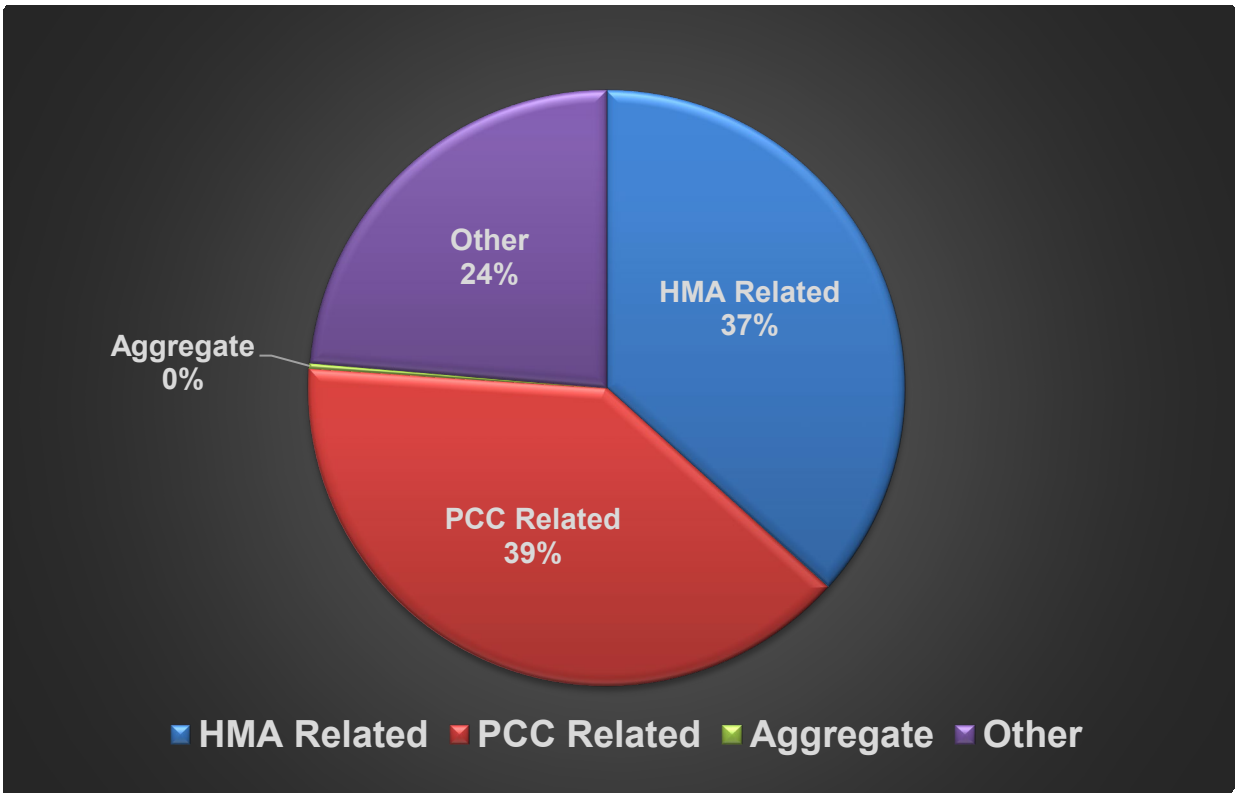

Figure 7. CO_2EQ saved, by related use, in 2022.

CHAPTER 5: SUSTAINABILITY-RESEARCH ACCOMPLISHMENTS AND INITIATIVES

During 2022, 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 2022

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 the increased need for more sustainable pavement practices while continuing to improve its long-term performance, the research team investigated ways to soften asphalt binders 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 the 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 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 reusable because it is not contaminated. The objective of this research is to identify possible applications for the use of non-hazardous dredge material from IDOT projects and to find the most economical and environmentally friendly applications for the use of non-hazardous dredge material in Illinois. The project also investigated the origin, distribution, and frequency of dredged material production across Illinois, found existing limitations for the use of materials, and proposed potential modifications to remove these limitations to increase use. The report can be found here.

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 the 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.

5.1.9 R27-SP56 - Reclaimed Asphalt Pavement (RAP) in Pavement Preservation

Pavement preservation, an economically and environmentally friendly technique, allows pavements to last longer as well as 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 as well as potentially decrease construction costs. This project is scheduled to end in October 2023.

CHAPTER 6: CONCLUSIONS

The goal of this report is to provide a single-source document for 2022 sustainability efforts in highway materials that serve to meet the reporting requirement of Illinois Public Act 097-0314. In summary, the 2022 efforts in recycling resulted in the following:

- In 2022, recycled materials used in highway projects totaled 1,339,932 tons, with a value of $86,668,366. The tonnage increased from 2021 as did the monetary values.

- Usage of reclaimed asphalt shingles (RAS) in 2022 was 22,782 tons compared to 16,572 tons in 2021. This change represents an increase of 38%. Districts 1 and 8 had significant increases in RAS use in 2022.

- It is estimated, using the life-cycle assessment (LCA), that carbon dioxide–equivalent emissions were reduced by 59,764 tons in 2022. The use of Fly Ash and RAP accounted for the greatest contribution by reducing over 35,000 tons combined.

- Concerning material sustainability research projects in 2022, the department had nine projects active or ongoing. These research projects will result in a total of at least nine publications in the form of interim/final reports and white papers.

REFERENCES

Bhatterai, R., Kalita, P., Azeem, A., and Jha, R. 2016a. *Evaluation of Curb and Gutter Inlet Protection Products for Sediment Retention.* Report FHWA-ICT-16-001. Rantoul, IL: Illinois Center for Transportation, University of Illinois at Urbana-Champaign.

Bhatterai, R., Kalita, P., Garcia, C. B., Monical, J., and Schumacher, P. 2016b. *Evaluation of Ditch Checks for Sediment Retention.* Report FHWA-ICT-16-002. Rantoul, IL: Illinois Center for Transportation, University of Illinois at Urbana-Champaign.

Bhatterai, R., Kalita, P., Garcia, C. B., Monical, J., Stoklosa, M., and Azeem, A. 2016c. *Evaluation of Ditch Inlet Protection Products for Sediment Retention.* Report FHWA-ICT-16-003. Rantoul, IL: Illinois Center for Transportation, University of Illinois at Urbana-Champaign.

Bhatterai, R., Kalita, P., Azeem, A., and Jha, R. 2016d. *Evaluation of Flared-End Inlet Protection Products for Sediment Retention.* Report FHWA-ICT-16-004. Rantoul, IL: Illinois Center for Transportation, University of Illinois at Urbana-Champaign.

Brownlee, M. 2011. *Utilization of Recycled Materials in Illinois Highway Construction in 2010.* Physical Research Report No. 160. Springfield, IL: Illinois Department of Transportation, Bureau of Materials and Physical Research.

Brownlee, M. 2012. *Utilization of Recycled Materials in Illinois Highway Construction in 2011.* Physical Research Report No. 161. Springfield, IL: Illinois Department of Transportation, Bureau of Materials and Physical Research.

Brownlee, M., and Burgdorfer, R. 2011. *Utilization of Recycled Materials in Illinois Highway Construction in 2009*. Physical Research Report No. 158. Springfield, IL: Illinois Department of Transportation, Bureau of Materials and Physical Research.

Chen, C., Habert, G., Bouzidi, Y., Jullien, A., and Ventura, A. 2010. LCA Allocation Procedure Used as an Incitative Method for Waste Recycling: An Application to Mineral Additions in Concrete. *Resources Conservation and Recycling* 54(12):1231–1240.

EarthShift. US-Ecoinvent Database. 2013. Version 2.2. Zurich: Swiss Center for Life-Cycle Inventories.

Griffiths, C.T., and Krstulovich, J.M. Jr. 2002. *Utilization of Recycled Materials in Illinois Highway Construction*. Physical Research Report No. 142. Springfield, IL: Illinois Department of Transportation, Bureau of Materials and Physical Research.

Illinois Department of Transportation (IDOT). 2013. *Use of Reclaimed Asphalt Shingles in Illinois: Second Edition: A Report in Accordance with Public Act 097-0314*. Physical Research Report No. 163. Springfield, IL: Illinois Department of Transportation, Bureau of Materials and Physical Research.

Illinois Department of Transportation (IDOT). 2022. *Qualified Producer List of Certified Sources for Reclaimed Asphalt Shingles.* Springfield, IL: Illinois Department of Transportation, Bureau of Materials and Physical Research. http://idot.illinois.gov/Assets/uploads/files/Doing-Business/Specialty-

Lists/Highways/Materials/Materials-&-Physical-Research/Hot-Mix-Asphalt/reclaimedasphaltshingles.pdf

Illinois Department of Transportation (IDOT). 2022a. *For the Record, Fiscal Year 2022*. Springfield, IL: Illinois Department of Transportation.

Illinois Department of Transportation (IDOT). 2022b. "Price Indices." http://www.idot.illinois.gov/doing-business/procurements/construction-services/construction-bulletins/transportation-bulletin/price-indices). Springfield, IL: Illinois Department of Transportation.

Illinois General Assembly (2012). *Public Act 097-0314.* http://www.ilga.gov/legislation/publicacts/fulltext.asp?Name=097-0314.

Lippert, D. L., and Brownlee, M. 2012 (August). *Use of Reclaimed Asphalt Shingles in Illinois: A Report in Accordance with Public Act 097-0314*. Physical Research Report No. 162. Springfield, IL: Illinois Department of Transportation, Bureau of Materials and Physical Research.

Lippert, D. L., Kang, S., and Ozer, H., 2015. *Illinois Highway Materials Sustainability Efforts of 2014*. Report FHWA-ICT-15-014. Rantoul, IL: Illinois Center for Transportation, University of Illinois at Urbana-Champaign.

Lippert, D. L., Ozer, H., Al-Qadi, I.L., El-Khatib, A.K., Yang, R., Khan, T.U., Dahhan, A.Z., Vespa, J.W., and Trepanier, J.S. 2014. *Illinois Highway Materials Sustainability Efforts of 2013*. Report FHWA-ICT-14-015. Rantoul, IL: Illinois Center for Transportation, University of Illinois at Urbana-Champaign.

Lippert, D. L., Wu, S., and Ozer, H., 2016. *Illinois Highway Materials Sustainability Efforts of 2015*. Report FHWA-ICT-16-017. Rantoul, IL: Illinois Center for Transportation, University of Illinois at Urbana-Champaign.

Lippert, D. L., Wu, S., and Ozer, H., 2017. *Illinois Highway Materials Sustainability Efforts of 2016*. Report FHWA-ICT-17-014. Rantoul, IL: Illinois Center for Transportation, University of Illinois at Urbana-Champaign.

Lippert, D. L., Wu., S., Ozer, H., Al-Qadi, I. L., Meister, J. M., Renshaw, G., Barry, M. K., Said, I. M., Luque, A., Safi, F., Murphy, T. R., Trepanier, J. S., and Vespa, J. W. 2017. *Construction and Performance Monitoring of Various Asphalt Mixes in Illinois: 2016 Interim Report*. Report FHWA-ICT-17-003. Rantoul, IL: Illinois Center for Transportation, University of Illinois at Urbana-Champaign.

Morse, K., 2021. *2021 IDOT Recycle Report*. Physical Research Report No. 175. Springfield, IL: Illinois Department of Transportation, Central Bureau of Materials.

Ozer, H., Renshaw, G., Hasiba, K., and Al-Qadi, I. L., 2016. *Evaluation of the Impacts of Re-Refined Engine Oil Bottoms (ReOb) on Performance Graded Asphalt Binders and Asphalt Mixtures.* Report FHWA-ICT-16-006. Rantoul, IL: Illinois Center for Transportation, University of Illinois at Urbana-Champaign.

Prusinski, J. 2003. *Life-cycle Inventory of Slag Cement Manufacturing Process*. CTL Project No. 312012. Skokie, IL: Construction Technology Laboratories, Inc.

Rowden, L. 2013. *Utilization of Recycled Materials in Illinois Highway Construction in 2012.* Physical Research Report No. 164. Springfield, IL: Illinois Department of Transportation, Bureau of Materials and Physical

Research.

Sharma, B. K., Ma, J., Kunwar, B., Singhvi, P., Ozer, H., and Rajagopalan, N. 2017. *Modeling the Performance Properties of RAS and RAP Blended Asphalt Mixes Using Chemical Compositional Information.* Report FHWA-ICT-17-001. Rantoul, IL: Illinois Center for Transportation, University of Illinois at Urbana-Champaign.

Sunthonpagasit, N., and Duffey M.R. 2004. "Scrap Tires to Crumb Rubber: Feasibility Analysis for Processing Facilities." *Resources Conservation and Recycling* 40(4):281–299.

World Steel Association. 2011. *Life-cycle Assessment Methodology Report*. Brussels: World Steel Association.

APPENDIX A: RECYCLED AND RECLAIMED MATERIALS: QUANTITIES USED AND EQUIVALENT VALUES, 2022

Material	Unit Equivalent Value	Quantity[1] Tons	Total Equivalent Value to Department	CO_2 Equivalent Savings Tons[6]
Air-cooled blast furnace slag	$8.23	2,049	$16,863	29
By-product lime	$13.00	210	$2,730	213
Crumb rubber[2]	$400.00	15	$6,013	28
Fly ash	$60.00	16,318	$979,080	16,081
Glass beads[3]	$736.000	5,798	$4,267,402	5,938
Ground granulated blast furnace slag	$85.00	8,853	$752,505	7,446
Microsilica	$500.00	99	$49,500	-
Reclaimed asphalt pavement used for Aggregate	$8.60	84,086	$723,140	74
Reclaimed asphalt pavement used for HMA	$55.16	1,051,542	$58,003,057	19,705
Reclaimed asphalt shingles	$23.05	22,782	$525,125	1,984
Recycled concrete material	$12.30	128,441	$1,579,824	113
Steel reinforcement[4]	$1,727.50	11,333	$19,578,196	7,995
Steel slag	$22.00	8,406	$184,932	158
Wet-bottom boiler slag[5]	NA	NA	NA	NA
Totals	**—**	**1,339,932**	**$86,668,366**	**59,764**

[1] Quantities were calculated from amounts assigned to projects in the calendar year 2022. Before the 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 2022.
[3] Glass beads use is based on tested and approved quantities and not projects assigned through CMMS and MISTIC.
[4] Steel reinforcement: For this report, the IDOT monthly steel index was averaged for 2022 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 CMMS or MISTIC that indicated WBBS was used for any IDOT projects in 2022.
[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 - STANDARD SPECIFICATIONS FOR ROAD AND BRIDGE CONSTRUCTION, ADOPTED JANUARY 1, 2022, SECTION 1031

chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://public.powerdms.com/IDOT/documents/1945348/Standard%20Specifications%20for%20Road%20and%20Bridge%20Construction%202022