CIVIL ENGINEERING STUDIES
Illinois Center for Transportation Series No. 14-016
UILU-ENG-2014-2018
ISSN: 0197-9191

ILLINOIS HIGHWAY MATERIALS SUSTAINABILITY EFFORTS OF 2013

Prepared By
David L. Lippert
Hasan Ozer
Imad L. Al-Qadi
Ahmad K. El-Khatib
Rebekah Yang
Tamin U. Khan
Illinois Center for Transportation
University of Illinois at Urbana-Champaign

Abdul Z. Dahhan
Region 1/District 1
Illinois Department of Transportation

Joseph W. Vespa
James S. Trepanier
Bureau of Materials and Physical Research
Illinois Department of Transportation

Research Report No. FHWA-ICT-14-015

The work described in this report was conducted under the general guidance and funding for R27-160, Sustainability Engineering and Support

Illinois Center for Transportation

August 2014

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FHWA-ICT-14-015		

4. Title and Subtitle Illinois Highway Materials Sustainability Efforts of 2013	**5. Report Date** August 2014
	6. Performing Organization Code
7. Author(s) David L. Lippert, Hasan Ozer, Imad L. Al-Qadi, Ahmad K. El-Khatib, Rebekah Yang, Abdul Z. Dahhan, Joseph W. Vespa, James S. Trepanier	**8. Performing Organization Report No.** ICT-14-016 UILU-ENG-2014-2018
9. Performing Organization Name and Address Illinois Center for Transportation Department of Civil and Environmental Engineering University of Illinois at Urbana-Champaign 205 North Mathews Avenue, MC 250 Urbana, IL 61801	**10. Work Unit (TRAIS)**
	11. Contract or Grant No. R27-160
12. Sponsoring Agency Name and Address Illinois Department of Transportation Bureau of Materials and Physical Research 126 East Ash Street Springfield, IL 26704-4766	**13. Type of Report and Period Covered** Calendar Year 2013
	14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

This report presents the sustainability efforts of the Illinois Department of Transportation (IDOT) in recycling and reclaiming materials for use in highway construction. This report meets the requirements of Illinois Public Act 097-0314 by documenting IDOT's efforts to reduce the carbon footprint and achieve cost savings through the use of recycled materials in asphalt paving projects. This report also covers the development, construction, and initial performance after one winter of demonstration projects that used total recycle asphalt (TRA). TRA may consist of reclaimed asphalt pavement (RAP), recycled concrete material (RCM), steel slag, reclaimed asphalt shingles (RAS), and less than 3% new soft liquid asphalt. No newly mined aggregate is used in the mix. The results of Hamburg wheel tracking and Semi-circular bending (SCB) for fracture energy are presented for durability aspects of both rutting and pavement cracking on three demonstration projects that used TRA mix. Crack surveys were performed to establish early performance history of the TRA mixes. Included in this report is an environmental evaluation of 16 mixes including the TRA mixes used on the three demonstration projects.

17. Key Words	18. Distribution Statement
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	No restrictions. This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161.

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of pages	22. Price
Unclassified	Unclassified	101	

Form DOT F 1700.7 (8-72) **Reproduction of completed page authorized**

ACKNOWLEDGMENTS AND DISCLAIMER

The authors of this report wish to thank the many people involved in developing specifications, conducting laboratory tests, constructing experimental sections, and collecting the data presented in this report:

- We are greatly indebted to the IDOT District Materials Engineers and their staff for timely responses in supplying data.
- Special thanks to Region 1/District 1 staff who developed and constructed the first total recycle asphalt mixes: George Houston, P.E., D-1 Mixtures Control Engineer; Paul Welch, D-1 Senior HMA Lab Supervisor; Velicia Goode-Moore, P.E., Mixtures Control Area Supervisor; Stephen M. Jones, P.E., Mixtures Control Area Supervisor; and Doreen Gonzalez, Mixtures Control Section.
- Jody Meador and Tom Schutzbach of the Materials Integrated System for Test Information and Communication (MISTIC) Unit for assembling recycled material use data.
- Michael Brownlee and David Lass of the Physical Research Section for conducting the detailed crack surveys.
- Jan Yates for coordinating the contractor surveys and responses.
- Steven Gillen of the Illinois Tollway for high recycle mix samples plus information on warm mix asphalt and shingle usage.
- Cynthia Williams of the City of Chicago for information on warm mix asphalt and shingle usage.

EXECUTIVE SUMMARY

The Illinois Department of Transportation (IDOT) has many years of experience using a variety of reclaimed and recycled materials in highway construction. Major material use in highway construction is in the form of aggregates, concrete, and hot-mix asphalt (HMA). It should be no surprise that reclaimed and recycled material use is aligned with usage of these basic construction materials. This report presents the quantity of materials used in 2013, along with specific reporting as required in Illinois Public Act 097-0314. Specific reporting on use of shingles, along with efforts to reduce the carbon footprint and to achieve cost savings through the use of recycled and reclaimed materials, in asphalt paving projects is presented.

In 2013, reclaimed and recycled materials totaling 1,713,296 t were used in Illinois highways. On a tons per mile basis, the amount of recycled materials used 2013 was nearly a fourfold increase over the amount in 2009. These materials were valued at more than $58 million, which is a reduction from the 2012 value because of a revised approach in determining reclaimed material values in this report.

The materials used by IDOT in highway construction can be summarized in four major groups, which are items that relate to uses of aggregate, HMA, concrete, and other. The latter category is made up of by-product lime used for soil modification, glass beads used for pavement-marking retroreflectivity, and steel used for reinforcement. The HMA category includes slags used as aggregate, crumb rubber, reclaimed asphalt pavement (RAP), and reclaimed asphalt shingles (RAS). Concrete-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 recycled concrete material (RCM) and RAP used as an aggregate in lieu of natural aggregates.

The use of RAS has grown to 39,791 t in 2013, which is a 221% increase over 2012 quantities. This increase is the result of a combination of reasons: six additional RAS processing facilities, HMA plant modifications by contractors, specifications that increased asphalt binder replacement (ABR) from both RAP and RAS, marketing efforts of the RAS producers, and under-reporting of usage for 2012. The number of districts to which the contractors supplied RAS in HMA projects increased to seven in 2013 from four in 2012.

Warm-mix asphalt (WMA) technologies can provide environmental benefits through the use of less fuel for heating HMA. After being criticized for having an overly burdensome process for adoption of WMA technologies, IDOT developed a reciprocity procedure with other states and as of April 15, 2013, accepts 15 WMA technologies. Even with this policy change, which removed a main barrier, use of WMA in 2013 was 124,599 t, or approximately 3% of the HMA placed in 2013. When contractors responded to a questionnaire on WMA use, many cited the lack of a clear economic benefit as a reason for not using this technology.

Contractors with HMA projects in 2013 were provided a questionnaire about HMA, RAS, RAP, and recycling in general. The responses indicated that HMA plant upgrades with the addition of bins, tanks, and controls were a major factor in being able to take advantage of high recycling values allowed in current specifications. The contractors were generally pleased with RAS specifications and the RAS material being supplied. Once a plant was set up to use RAS, the contractor expected continued use of mixes containing this material. Local agency projects likely utilize as many or more tons of RAS annually than state projects do, although exact amounts are not known.

A few contractors responded that they disposed of more than 30,000 t in total of RAP, while others indicated that they would use more RAP if it were available. There may be an opportunity to

process and transport excess material rather than dispose of it; however, transportation logistics can be difficult to overcome.

In 2012, IDOT initiated an effort to develop a total recycle asphalt (TRA) mix that could be supplied with approximately 97% recycled material. The TRA does not use any newly mined material and relies on slag and RCM for aggregate, along with RAP and RAS. Approximately 3% new soft paving asphalt binder is added to the mix to obtain the required properties for pavement use.

In 2013, IDOT let and constructed three TRA projects. Construction bid savings from these projects ranged from 4% to 26% over the cost of a nearby conventional HMA project. Pre- and post-construction surveys were conducted in Fall 2013 and Spring 2014 and the performance data recorded. Out of the three TRA projects, one experienced high-severity distress along 82% of the length of the pavement centerline. Other performance differences will require additional monitoring over time. For TRA and other high-recycle mixes, it is essential that the performance be the same as traditional HMA mixes; otherwise, any savings in construction will be spent to repair or replace the pavement sooner than expected.

Current limits on ABR are controlled by specification and have been increased over time. Owing to the lengthy time of adoption of high ABR mixes, construction, and performance feedback, it is not known whether these changes result in performance equivalent to traditional HMA. Fracture energy and modulus testing on various high ABR mixes indicated that it is possible to differentiate among various mixes using those test methods. Research work is underway to establish fracture energy testing protocols and specifications, with the goal of adopting testing procedures to ensure adequate performance properties in high ABR mixes.

An environmental evaluation of these and other mixes was conducted. This evaluation showed that increased ABR was a prime factor in reducing greenhouse gases and reducing overall energy consumption caused by the high-energy content of asphalt binder. The use of steel slag, although a recycled material, caused an increase in greenhouse gases because of the material’s high specific gravity. The increase was primarily from transportation of additional material to produce the volume of mix needed and the extra heating required on the increased mass.

Finally, IDOT has taken steps to increase sustainability efforts by modifying the cooperative research agreement with the Illinois Center for Transportation at the University of Illinois at Urbana-Champaign to focus more on sustainability issues and chartering a sustainability committee.

CONTENTS

CHAPTER 1 INTRODUCTION

Illinois Public Act 097-0314 called on the Illinois Department of Transportation (IDOT) to report annually on efforts to reduce its carbon footprint and achieve cost savings through the use of recycled materials in asphalt paving projects (Illinois General Assembly 2012). The act also required IDOT to allow the use of asphalt shingles as long as such use was without negative impacts to life-cycle cost. While not specifically stated, the underlying premise of the act was for the adoption of more sustainable cost-saving practices through use of recycled materials in hot-mix asphalt (HMA).

Illinois has had many years of experience using various recycled and reclaimed materials in highway construction. These materials tend to be aggregates or materials that extend cement or asphalt. Fly ash and ground granulated blast furnace slag have been added to concrete in Illinois for approximately 50 years. These additions reduce the amount of cement, a carbon-intensive material, while also lending other desirable properties to concrete. Various past reports by IDOT provide excellent background information on reclaimed and recycled materials used in highway construction (Griffiths and Krstulovich 2002; Brownlee and Burgdorfer 2011; Brownlee 2011, 2012; Rowden 2013).

Other materials, such as reclaimed asphalt shingles (RAS), have a much shorter history of use. Until 2011, IDOT was conducting experimental projects using asphalt shingles in HMA. With the passage of Public Act 097-0314, specifications were developed and adopted that would allow RAS to be used on all IDOT projects, if the contractor chose to do so (Lippert and Brownlee 2012; Illinois Department of Transportation 2013). The use of RAS and reclaimed asphalt pavement (RAP) introduces highly aged and brittle asphalts into pavements, which can make cold-season performance a challenge. To counter the hard asphalts of RAP and RAS, much softer asphalts are incorporated into these types of HMA mixes. The goal is for the final mix to have acceptable properties throughout the year for the various environmental conditions in Illinois.

This report provides a summary of the efforts undertaken by IDOT in 2013 related to material sustainability. This report also meets the reporting requirements of Illinois Public Act 097-0314.

This report is structured to first cover the use of all reclaimed and recycled materials. Different in this report compared with past reports on this topic is the presentation of historical trends of recycling in Illinois. A section of the report is specifically dedicated to RAS adoption and shows that IDOT has made substantial progress in meeting the goals outlined in Illinois Public Act 097-0314.

To better understand the contractor’s perspective on the use of a recycled materials and warm-mix asphalt (WMA) technologies, a brief survey was conducted to gather key information that could be used to improve sustainability efforts. The results of that survey are presented.

Also covered in this report is a discussion about the development of total recycle asphalt (TRA), a material that features more than 97% recycled content. The construction and early-life performances of three demonstration sections using specifications for TRA are documented.

Finally, the report presents IDOT’s efforts to focus more on sustainability in the future.

CHAPTER 2 USE OF RECLAIMED AND RECYCLED MATERIALS IN ILLINOIS HIGHWAY CONSTRUCTION IN 2013

2.1 REPORTING HISTORY

In response to legislative inquiries and public questions, the IDOT Bureau of Materials and Physical Research (BMPR) first reported in 2002 on quantities of recycled material used (Griffiths and Krstulovich 2002). Because of requests for updates, BMPR began to report annually on the quantities of reclaimed and recycled materials used starting with calendar year 2009 (Brownlee and Burgdorfer 2011; Brownlee 2011, 2012; Rowden 2013). The 2012 report on reclaimed and recycled materials provided the most in-depth overview of how each material is derived and used in highway construction (Rowden 2013).

This report uses the same methodology for determining quantities as used in past reports from IDOT's Materials Integrated System for Test Information and Communication (MISTIC). Information from that system is summarized to present quantities of each material.

2.2 RECLAIMED OR RECYCLED MATERIALS ADDED OR DELETED IN 2013

During the 2013 reporting year, traditional materials were recycled into Illinois highway construction projects. No materials were added or deleted in 2013.

2.3 MATERIALS RECLAIMED AND RECYCLED IN 2013

2.3.1 Determining Quantities

2.3.1.1 Material Feedstock

For some materials, the final product is made from 100% recycled material. For materials that have sufficient value, the majority of the feedstock is collected and delivered to the producer by the private sector. For steel items, recyclers provide an economic incentive to the public to collect and deliver salvaged metals at a central location. Also, the public sector has contributed to the feedstock through curbside recycling programs. In the case of steel, used cans are collected at curbside for recycling. Contractors doing demolition work often salvage and recycle metals as part of their work. Items collected after consumer use are defined as post-consumer waste.

In the machining and manufacturing of products, scrap materials are often collected and recycled. When collected at the manufacturer, the material is termed post-manufacture waste.

2.3.1.2 Manufactured Products

Ultimately, salvaged items are remade into new products. Salvaged materials from both the post-consumer and post-manufacture waste streams are used for the production of steel items such as rebar, dowel bars, and welded wire fabric. For that reason, steel products listed in this report are considered 100% recycled materials. Salvaged materials are also used to produce large steel shapes for bridge construction; however, information on the recycled content of such items is not typically available in IDOT's MISTIC system and therefore not reported.

2.3.1.3 Contractor-Produced Materials

Contractor-produced materials such as HMA have varying amounts and types of recycled material content from mix to mix. The specifications allow the contractor freedom in selecting mix components and types of recycled materials. The limiting factor on recycling RAP and RAS is in the form of a maximum asphalt binder replacement (ABR) contributed from these components. Limits on ABR are made to ensure that the resulting mix will perform as expected. It is up to the contractor to engineer the final product in such a way that quality-control specifications are met. To determine the quantity of RAP and RAS used, individual contracts are data-mined to determine the quantities of reclaimed materials used on specific jobs. The contracts are then summarized to report annual use. In the case of RAS, contractors were asked to supply quantities of this material by contract. For other materials, quantities presented within this report were supplied by IDOT's BMPR.

2.3.2 Economic Values of Recycled Materials

Economic values for the various materials were updated to provide the most reasonable comparisons from year to year. Suppliers were contacted for 2013 pricing, and a statewide average was determined. For items that have price indexes, such as steel, the monthly IDOT index was averaged for the year (http://www.idot.illinois.gov/doing-business/procurements/construction-services/construction-bulletins/transportation-bulletin/price-indices). For steel, a different approach was used than in past reports and considered more representative of the material being recycled. Using the established index provides a statewide average value of just the steel being recycled, before value-added features such as epoxy coating are added. For RAP, a combination of prorating the asphalt index price and statewide aggregate prices was used to determine the 2013 value. Past reports considered all RAP to have a value as being used in HMA; however, a sizable quantity of RAP is actually used as aggregate. This report separates these two uses of RAP and related values. Past reports have slightly overstated the value of the RAP used, since RAP used in an HMA mix has more potential savings than RAP used as an aggregate.

2.3.3 Recycled and Reclaimed Material Use and Values for 2013

2.3.3.1 Data for 2013

Appendix A presents the 2013 recycled and reclaimed material quantities and values. In total, 1,713,296 t of material were recycled in 2013, with a value of $58,415,692, which is a 43% increase in recycled tonnage from 2012. However, because of the changes in values assigned to various materials as noted previously, the calculated value of the recycled materials decreased 7%.

2.3.3.2 Data Analysis of 2013 Use

To present a more accurate picture of IDOT's recycling efforts, a series of figures provides information about 2013 efforts as well as historical trends. As can be seen in Figure 1, RAP in HMA mixes is the most often used recycled material, followed by recycled concrete material (RCM). The next most used material is RAP as an aggregate.

As noted previously, past reports on this topic reported that all RAP was used in HMA products. In more recent years, use of RAP as an aggregate has increased. In this report, RAP data in tables and charts are separated into HMA and aggregate uses.

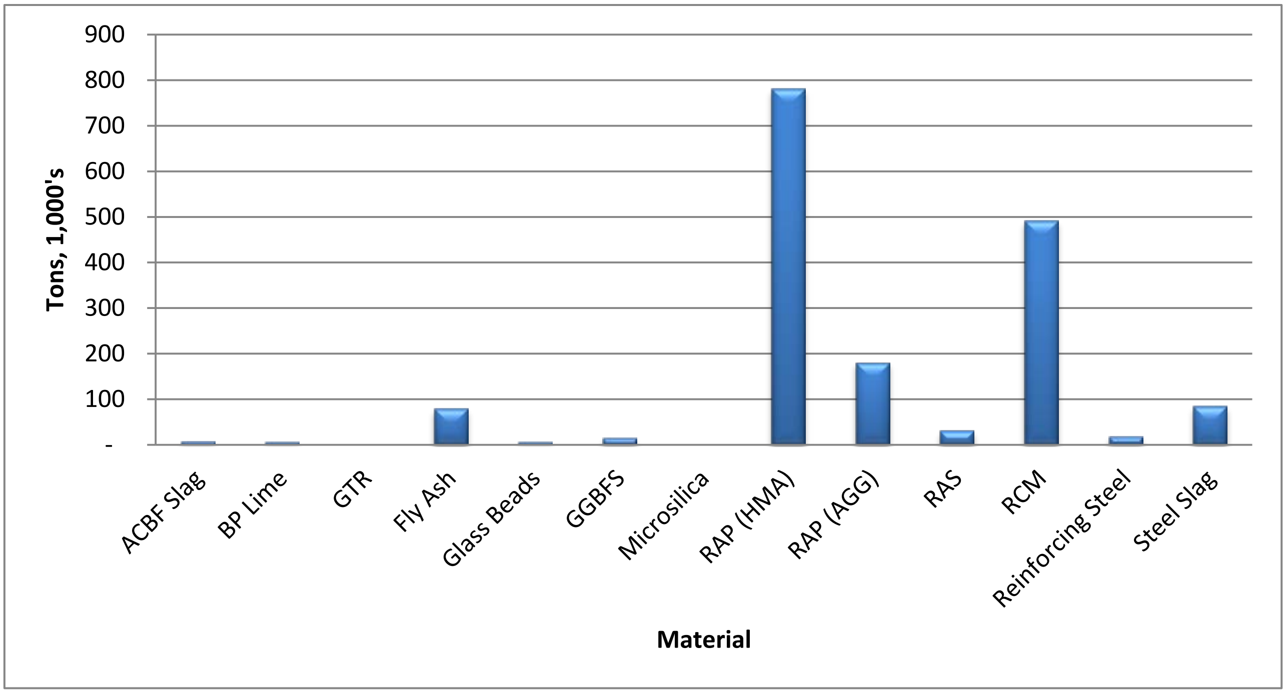


Figure 1. Reclaimed material use, 2013.

Figure 2 breaks out quantities by related uses for HMA, aggregate, concrete, and other. The latter category consists of by-product lime, glass beads, and steel. The HMA category includes slags used as aggregate, crumb rubber, RAP, and RAS. Concrete-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 is composed of RCM and RAP used as an aggregate in lieu of natural aggregates. From this breakout, one can see that the majority of recycled tonnage is related to HMA and aggregate uses.

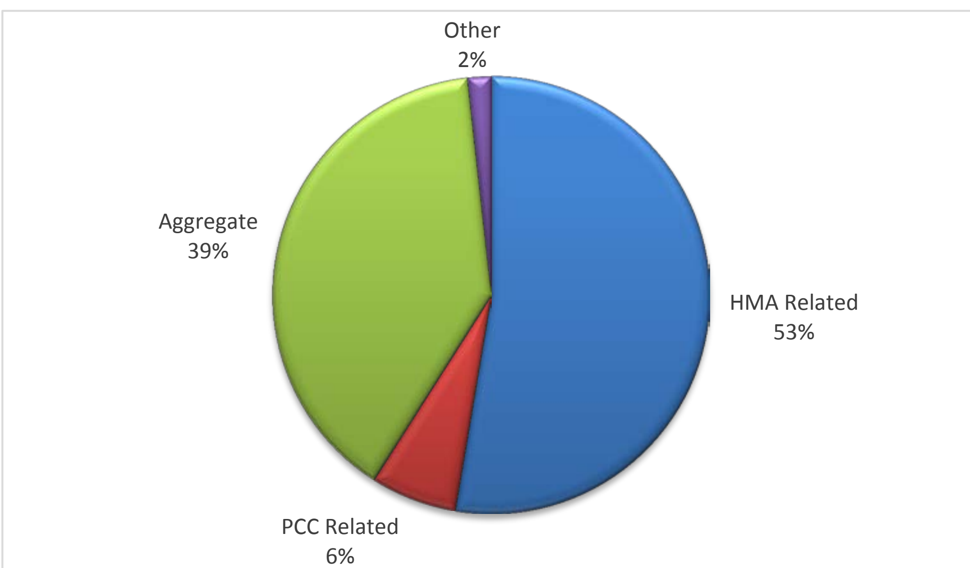


Figure 2. Reclaimed materials by related use, 2013.

2.4 HISTORICAL RECYCLING TRENDS

2.4.1 Data Analysis

2.4.1.1 Recycling Relationship to Program Budget

Recycling quantities are highly correlated to the overall budget and portfolio of project types within that 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. On the other hand, bridge projects tend to use limited amounts of materials because of the short distances involved and size of typical projects. Presented in Figure 3 are the total tons recycled from calendar year 2009 through 2013.

Also presented in the chart by fiscal year (FY; IDOT's FY 2013 is July 1, 2012 to June 30, 2013) are the values of projects awarded, centerline miles paved/improved, and number of bridges built/improved (Illinois Department of Transportation, For the Record 2013). Note that this is not the same time frame as the calendar year (CY) reported for recycled tonnage. However, the values tend to roughly align on a calendar-year basis because there is a delay between the award of contracts (FY) and use of materials in the project (CY). For the purpose of this effort, it was considered reasonable to use all data as if they had been from the same time period by calendar year.

Figure 3 shows that the value of the projects awarded relates to overall recycled tonnage. Other factors are the number of centerline miles and the number of bridges built or improved in the portfolio in a given year.

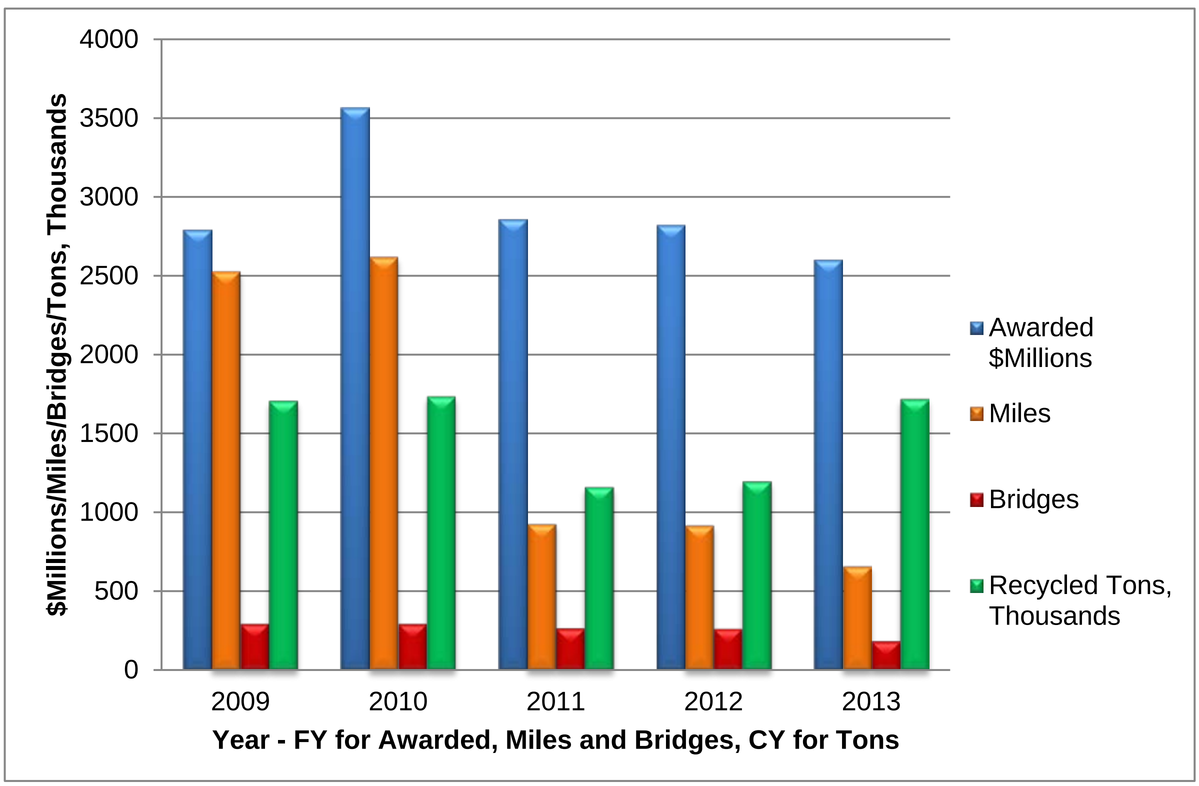


Figure 3. Annual projects awarded (FY), miles improved (FY), bridges built/improved (FY), and recycled tons (CY).

2.4.1.2 Determination of Recycled Content

To provide more representative performance measures of IDOT's recycling efforts, a method was sought to remove the impacts of budget size and portfolio mix between bridges and roadways. The method selected was to calculate the recycled content of the annual program. Figure 4 presents the results of determining tons of recycled material for each centerline mile of improvement. For the purposes of this chart, bridge projects were converted to a mileage distance. Each bridge improvement was considered to be 0.25 mi in length. This approach was considered reasonable because bridge improvements often include some type of approach pavement treatment that can be longer than the bridge itself.

The amount of HMA-related recycling greatly increased after 2010 on an improvement-mile basis. This increase is the result of specification changes and contractor adoption of RAS usage related to PA 097-0314. It should also be noted that in the years 2009 and 2010, a number of miles of improvements were resurfacing projects related to the American Recovery and Reinvestment Act of 2009. Resurfacing projects typically provide the opportunity for using recycled materials only in the HMA mix itself. For urban sections, that would be the thickness of the overlay from curb to curb. Rural sections have similar limits from edge to edge of the HMA overlay, plus an aggregate shoulder wedge that may contain RAP being used as an aggregate.

The tonnage of all materials recycled for a resurfacing project is a fraction of that of new construction or reconstruction. For new construction, recycled materials may be used in each pavement layer, including the subgrade, which is typically modified with reclaimed lime kiln dust or removed and replaced with aggregate that may contain RCM or RAP to provide a stable working platform for the subsequent pavement construction.

On a tons per mile basis, 2013 represents nearly a fourfold increase in the use of recycled materials from 2009.

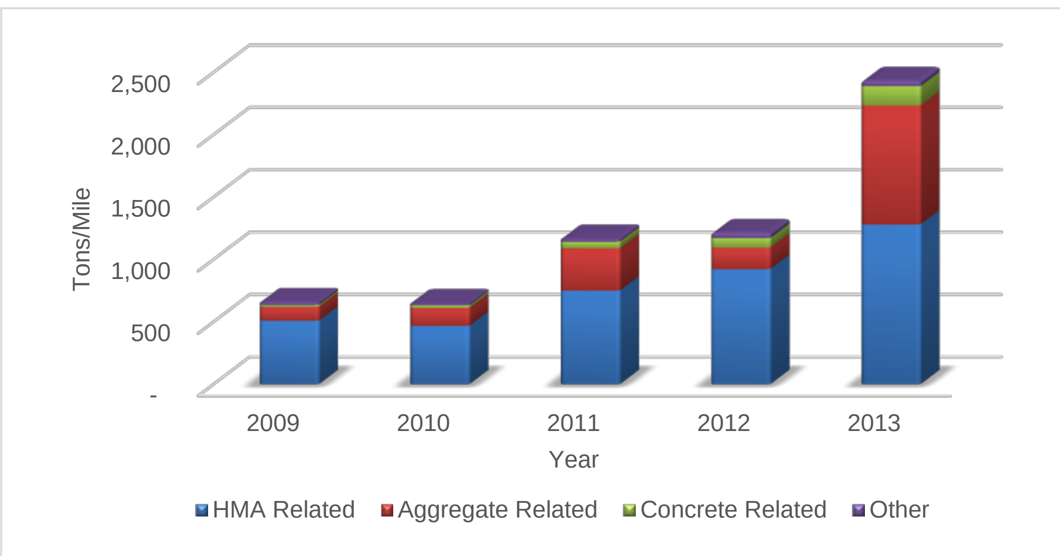


Figure 4. Historical recycled content.

2.5 REGIONAL/DISTRICT RECYCLING EFFORTS

A few of the districts have developed their own special provisions to use resources unique to their area. This is especially true in Region1/District 1, where the scale of materials being used in the public and private sector provides many unique opportunities. The special provisions used in Region 1/District 1 are provided in Appendix B. Comments on each provision follow.

2.5.1 Coarse Aggregate for Backfill, Trench Backfill and Bedding (D-1), and Aggregate Subgrade Improvement (D-1)

Urban sections are primarily “mill and fill” projects where the surface layer is milled off and an equal depth of new HMA material is placed. In those situations, 60% to 70% of the milled material must be used on other projects. Both of these special provisions give the contractor the option of using 100% RAP as an aggregate or blending RAP with other natural aggregates and using the resulting aggregate blend. These special provisions provide additional contractor options when more RAP is being produced than can be used in the contractor’s HMA projects. This report quantifies the RAP used under these special provisions in Appendix A as RAP used for aggregate.

2.5.2 Ground Tire Rubber (GTR) Modified Asphalt Binder (D-1)

This specification gives the contractor the option of using an additional rubber type, ground tire rubber (GTR), for supplying modified asphalt binders. Traditionally, styrene-butadiene copolymer (SBS) is used to produce modified asphalt. During 2008 and 2009, shortages and price escalations of SBS were costly to IDOT. This special provision allows the contractor to switch the rubber modifier to GTR if there are material shortages or pricing issues with SBS. Because SBS polymer-modified asphalt was readily available at reasonable prices during 2013, GTR-modified asphalt was not supplied to IDOT jobs.

2.5.3 Reclaimed Water (D-1)

During production and delivery of ready-mix concrete, trucks often return to the plant with wash water that had been used to clean residual concrete and mortar from the truck mixer. To protect the environment, regulations do not allow disposal of wash water in the roadside ditch area or storm sewer. Consequently, several high-volume concrete production operations have built treatment facilities to reclaim and reuse the wash water in new concrete mixes, if the water meets quality requirements. Although the special provision was issued in December 2013, there will not be major use of recycled water in construction projects until the 2014 construction year.

2.5.4 Pavement Rehabilitation by Hot In-Place Recycling

This type of in-place recycling has been in use in various forms for many years in Region 1/District 1. Key to this technique is the condition of the pavement receiving the treatment. Only pavements with non-structural issues are eligible for this rehabilitation technique. Use details about the technique are not maintained, but a typical construction year in Region 1/District 1 may have one to three projects of this type. Each rehabilitation project is typically a few miles in length.

CHAPTER 3 RECLAIMED ASPHALT SHINGLES

This chapter is a continuation of reporting on the specific status and use of RAS as a result of Illinois Public Act 097-0314 (Illinois General Assembly 2012). Two previous reports provided details of RAS adoption (Lippert and Brownlee 2012; Illinois Department of Transportation 2013). This report uses contractor provided information for the quantities of RAS. This was deemed more accurate due to underreporting of RAS quantities in the MISTIC database. An update of where quantities of RAS are being used, along with specifications and policy changes, are presented to document activities for 2013.

3.1 RAS POLICIES AND SPECIFICATIONS IN EFFECT FOR 2013

3.1.1 RAS Policy for Sources

The BMPR Policy Memorandum, "Reclaimed Asphalt Shingle (RAS) Sources" (28-10.3) was in effect for all 2013 RAS production and represents no change in policy from 2012. The policy can be found in the 2012 report on RAS use (Illinois Department of Transportation 2013). During 2013, IDOT added four new RAS suppliers. Appendix C presents the locations of approved RAS suppliers as of May 1, 2014, and contains two suppliers added in 2014. From the analysis presented in the 2012 report on predicting shingle waste, there are few additional areas where shingle recycling may be viable as an independent business operation (Illinois Department of Transportation 2013).

3.1.2 RAS Specifications

3.1.2.1 Statewide Specifications

The Bureau of Design and Environment (BDE) specification, "Reclaimed Asphalt Shingles (RAS) (BDE)", effective January 1, 2012, was in effect for all newly let HMA projects in 2013. Also, any projects let in 2012 but still under construction in 2013 would have used that specification. The specification can be found in the 2012 report on RAS use (Illinois Department of Transportation 2013).

3.1.2.2 Regional/District Specifications

During 2013, Region 1/District 1 and Region 3/District 4 used their own special provision for RAP and RAS. The district special provisions are provided in Appendix B. While there are differences in the two district specifications, they are similar. The key differences between the statewide BDE and district specifications are as follows:

- The statewide BDE special provision does not distinguish between ABR from RAP or from RAS and treats them equally.
- The district special provisions have ABR tables for RAP alone, Fractionated Reclaimed Asphalt Pavement (FRAP), or RAS alone. For those targeted uses, the district ABR is the same or *lower* by 10 to 20 percentage points than the statewide BDE special provision. An exception is polymer-modified mixes, for which the district ABR is the same as the statewide BDE special provision or is increased 5 percentage points.
- The district ABR for FRAP *plus* RAS requires the materials to be used in equal parts and *increases* the ABR 10 to 20 percentage points from the statewide BDE special provision. Polymer mix ABR is increased 20 percentage points in the district special provisions over the statewide BDE special provision.
- Grade bumping starts at 15% ABR for the district special provisions compared with 20% in the statewide BDE special provision.

3.2 QUANTITY OF RAS USED IN CALENDAR YEAR 2013

As previously reported, the ability to perform a query of RAS tons used on state projects is limited by the MISTIC system (Illinois Department of Transportation 2013), which could lead to under-reporting RAS quantities. For this reason, contractor input was sought to confirm quantities on a project-by-project basis.

In 2013, IDOT experienced a 221% increase in RAS use—to 39,791 t from 12,412 t in 2012. (Illinois Department of Transportation 2013). The increase could be attributed to a number of factors, some of which are as follows:

- Expansion of approved RAS facilities throughout the state
- Contractors making needed plant modifications to use RAS
- Implementation of increased ABR specifications by IDOT
- Marketing efforts of RAS producers
- Under-reporting of quantities used in 2012.

As a comparison, the City of Chicago and Illinois Tollway used approximately 27,000 t and 11,442 t, respectively, during 2013.

In 2012, four districts reported use of RAS. In 2013, the number of districts using RAS increased to seven. Figure 5 presents the percentage of the 2013 statewide total RAS used by each IDOT district.

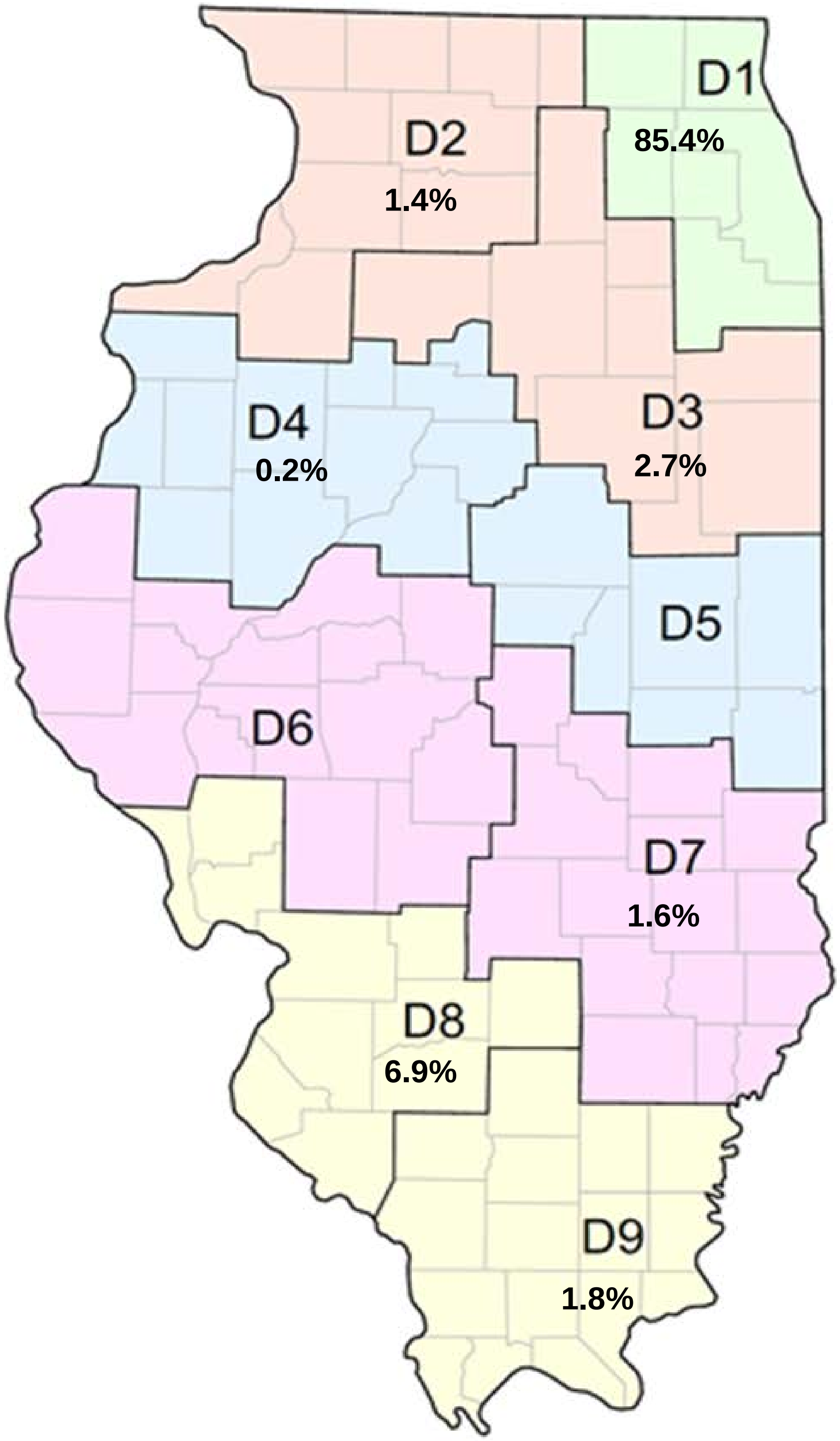


Figure 5. Percentage of RAS used by each district in calendar year 2013.

CHAPTER 4 WARM-MIX ASPHALT

4.1 APPROVED WARM-MIX ASPHALT TECHNOLOGIES

Warm-mix asphalt (WMA) is produced in a typical HMA plant and can bring sustainability benefits by use of less fuel to heat aggregate in the mix. The goal of WMA is to provide the mixing and compaction properties of traditional HMA at lower temperatures. In support of that goal, various WMA technologies are available. A WMA technology can be an additive or a mechanical process. By lowering the mixing/compaction temperatures, emissions at the HMA plant and at the paving site are also reduced.

Prior to 2013, the adoption of WMA in Illinois had been slow, and IDOT was being criticized for having an overly burdensome process for approving WMA technologies. On April 15, 2013, IDOT added a reciprocity process with other states that have successfully used a WMA technology. The change resulted in 15 WMA technologies being approved for use in Illinois (http://www.idot.illinois.gov/Assets/uploads/files/Doing-Business/Specialty-Lists/Highways/Materials/Materials-&-Physical-Research/Hot-Mix-Asphalt/warmmixasphalttechnologies.pdf).

4.2 WARM-MIX ASPHALT SPECIFICATIONS

The approach taken by IDOT is that WMA is allowed, but not required. This approach is taken because many HMA plants in rural areas do not routinely operate or supply mix to IDOT projects. Thus, the cost of making plant upgrades to allow use of WMA can be substantial when amortized over only a few thousand tons of mix a year. There is a small cost savings from reduced fuel use, but the cost of using WMA additives or equipment typically is not completely offset. This is especially true with the adoption of lower cost natural gas as the prime fuel for firing HMA plants. In 2013, all HMA contracts contained provisions that allowed use of WMA if the contractor wished to do so (http://www.idot.illinois.gov/Assets/uploads/files/Doing-Business/Standards/District-Specific-Standards/4/Special-Provisions/bde-specials/z40600.pdf).

4.3 WARM-MIX ASPHALT USE IN 2013

The changes that moved 15 WMA technologies to an approved status were expected to greatly increase the use of WMA in the 2013 construction season. However, the use of WMA has been limited at best. Reportedly, some contractors that once had supplied WMA have since stopped the practice. From information collected from the districts, use of WMA for IDOT contracts was 124,599 t, which represents 3% of the 4,566,943 t of HMA produced in 2013.

The City of Chicago in-house asphalt crews utilized 66,000 t of WMA in 2013 as part of their supply contract requirements. For city projects constructed through lettings, WMA was a contractor option allowed by specification. No contractor selected the WMA option on these projects.

The Illinois Tollway specifications require the use of WMA; however, the contractor may seek permissive use of HMA in needed situations. The result has been the usage of WMA in almost all cases. This approach resulted in 347,445 t of WMA being used in 2013 on Illinois Tollway projects.

4.4 BARRIERS TO USE OF WARM-MIX ASPHALT

As a result of feedback from industry that the former approval process was burdensome and created a significant barrier to WMA use for producers, IDOT added a reciprocity process. However, once the barrier was removed, there was limited adoption of WMA. To encourage use of WMA, IDOT specifications allow an extra 5% ABR before requiring an asphalt grade change to softer liquid asphalts (http://www.idot.illinois.gov/Assets/uploads/files/Doing-Business/Specialty-Lists/Highways/Design-&-Enviroment/BDE-Special-Provisions/11alspcs.pdf) that are more costly. This approach may not be a substantial incentive in the contractor's decision-making process to adopt WMA; however, this feature was used for part of the tonnage of WMA in 2013. Without this incentive, WMA use would likely be less. The main barrier to use is the lack of a clearly visible economic benefit to adopting WMA.

CHAPTER 5 HOT-MIX ASPHALT QUESTIONNAIRE ABOUT 2013 PRODUCTION

5.1 NEED FOR QUESTIONNAIRE

Although use of RAS is rapidly being adopted into HMA production and RAP recycling content has increased, contractors are using the specification changes to various degrees. Changes approving several WMA technologies for use were expected to greatly increase WMA usage, which did not happen. To obtain more information on contractors' business decisions about the use of RAP, RAS, and WMA, a questionnaire was sent to the contractors who supplied HMA for IDOT's projects in 2013.

5.2 QUESTIONNAIRE AND RESULTS

5.2.1 Questionnaire

One questionnaire was sent to each company that had a HMA project in 2013. The questionnaire focused on RAS, RAP, WMA, and HMA production and a summary of results is presented in Appendix D.

5.2.2 Results

There were 42 questionnaires returned from a mailing to 56 contractors. Various types of questions were posed, with follow-ups to obtain responses from subgroups that were or were not using a process. When rating-type questions were posed, the scale was always 0 to 5, with 0 being the most negative response and 5 being the most favorable. Of the questionnaires returned, there were a few that were not completely filled out. The number of respondents taking part in a question was noted for each question. A complete summary of the responses can be found in Appendix D.

5.2.2.1 Analysis of RAS-Related Questions

Of the 42 respondents, 45% have used RAS in a mix. Those using RAS seem to be pleased with the gradation consistency of the material being supplied; the average score on that question was 3.76 on a scale of 0 to 5. Once using RAS, contractors are highly likely to continue to use to the greatest extent possible, as indicated by an average score of 4.39. Although precise data are not available, local agencies using their own funding seem to be a major recipient of RAS mixes, which may rival the amount used on state highways. Private companies are also using RAS to a large extent, but to a lesser extent than local agencies.

Respondents not using RAS offered a variety of reasons for that choice, but the most prevalent responses were that their HMA plant was not set up to use RAS and that the economics of RAS use were not appropriate for their logistical case. Setting up an HMA plant to use RAS can entail extra feeder bins for RAS, the ability to fractionate RAP with related RAP feeder bins, additional liquid storage tank(s), and related electronic control upgrades. Depending on the production quantities of HMA that could utilize RAS, the upgrade cost may not be recoverable. Only a few respondents indicated that RAS hauling and local availability was a controlling issue.

5.2.2.2 Analysis of RAP/RAS/ABR -Related Questions

On the question about how straightforward the RAP/RAS/ABR specifications used by IDOT were, the average score was 2.84. Of the eight respondents who gave the specifications low ratings of 0 or 1, only one contractor had actually used RAS, while 11 of 15 contractors who had used RAS gave higher ratings of 4 or 5. These results perhaps indicate that specifications could be confusing to first-time users. However, they are better understood by contractors who have already been using

RAP/RAS in production. Accordingly, the needs of first-time users should be kept in mind when these specifications are revised.

Out of 39 companies responding to the question on grade bumping, 56% used grade bumping to enable use of higher ABR mixes. Those that did not use RAS indicated that the number of tanks available at their plant limited their ability to grade bump and thus the amount of ABR that could be used in a mix.

On disposal of RAP, only four out of 40 respondents, or 10%, indicated that they had disposed of RAP in 2013. Of the four that did dispose of RAP, one indicated disposal of a small quantity of RAP that had been contaminated with soil or other material and thus was not allowed to be used. The other three disposed of more than 10,000 t of RAP each. As to the different reasons for RAP disposal, there was no single reason that clearly stood out.

The inability to fractionate RAP and the required additional feeder bins were the main reasons cited for limiting RAP use. The most cited specification limitations were the table limits of ABR from RAP/RAS/FRAP and the dust/AC ratio. The restriction of 10% maximum ABR in polymer mixes was the leading response. Of special note were the two contractors who indicated that they had a limited supply of RAP that could be used in HMA. Depending on logistics and transportation cost, it is possible that the contractors who dispose of RAP could process and transport it to those in short supply.

5.2.5.3 Analysis of WMA-Related Questions

For private and state projects alike, there was a low WMA participation rate of 20% and 15%, respectively, by contractors responding to this question. Reasons for lack of use were cost of additives and/or equipment with no clearly visible cost savings or other benefits. The limited use of WMA for private projects is telling in that WMA use is not being overly restricted by IDOT’s specifications and policies.

When rating IDOT’s specifications and approved technologies, respondents had an average score of 2.97. This response seems to indicate that, while, improvement could be made, there is no significant lack of understanding of these documents.

5.2.2.4 Analysis of Aggregate Specific Gravity Question

Of 36 responses received to this question, 72% indicated that they would favor high gravity aggregates. Only 6% would favor a low gravity aggregate. Other comments received were that accurate gravity is more important. From a sustainability viewpoint, the pursuit of higher-gravity aggregates and the resulting higher-gravity mixes means that more hauling is required to construct HMA sections. The reasons for the desire for high-gravity mixes should be explored to determine whether various policies and specifications tend to favor the calculation of various specification parameters such as voids in the mineral aggregate (VMA), asphalt content, and density. Specifications that increase the quantity of material delivered to a project for higher-gravity mixes should also be reviewed because these additions result in increased project cost.

CHAPTER 6 TOTAL RECYCLE ASPHALT

6.1 HISTORY OF HIGH-RECYCLE PAVEMENT EFFORTS IN ILLINOIS

In the mid-1980s, many pavements were in need of major rehabilitation. For some sections, it was evident that conventional patch and overlay was not necessarily the best and most economical choice for the life-cycle of pavement going forward. For this reason, total reconstruction was being considered as a viable alternative. IDOT decided to explore the possibility of recycling the existing pavement into the reconstructed pavement section.

6.1.1 Recycling Demonstration Projects

Between 1986 and 1987, two demonstration projects were constructed by IDOT in which concrete pavements were recycled back into concrete and HMA pavement. In 1992, construction and performance data were summarized on these sections (Schutzbach 1993). The report showed that for the HMA sections of I-57 in Pulaski County (mileposts 8.96 to 13.10), there were some differences in production that correctly predicted performance differences later in each section. Moisture susceptibility testing according to AASHTO T283 was relatively new to Illinois at the time, and specification limits were not yet in place. As constructed, the southbound segment used all virgin aggregates and the northbound segment used RCM and a virgin aggregate/RCM blend as the paving aggregates. The virgin HMA binder mix used in the southbound lanes had a tensile strength ratio (TSR) of 0.60 based on an Illinois Modified AASHTO T283 test method that uses a single hot-water bath as conditioning. The HMA binder mix in the northbound lanes using RCM as aggregate or a blend of virgin aggregate/RCM had TSRs of 0.82 and 0.84, respectively (4-in. specimens). Later, IDOT would establish a TSR limit of 0.75 for 4-in. specimens and 0.85 for 6-in. specimens (Illinois Department of Transportation 2007).

From 1988 through 1992, rut depth measurements were collected manually and using automated road profiler methods (Schutzbach 1993). The first 3 years of manually collected rut-gauge measurements did not show any significant difference between the southbound virgin mix and northbound recycled concrete mixes. However, tests in later years showed that the virgin aggregate and RCM sections had increasingly divergent average rutting values. By 1992, the southbound virgin aggregate lanes and northbound RCM lanes had road profiler rut depths of 0.33 and 0.26 in., respectively.

A review of rutting data in 2000 continued to show significant performance differences between the southbound sections that used virgin aggregate and the northbound lanes that used recycled concrete as aggregate. The data show that 2.3 of the 4.14 mi of the southbound driving lane exceeded 0.35 in. in rut depth, while the northbound driving lane did not have any mileage exceeding 0.35 in. in rut depth (Illinois Department of Transportation 2001). At the heart of the performance difference is that RCM provides an anti-stripping feature that can be measured in AASHTO T283 and observed in rutting performance. Use of RCM as aggregate can produce desirable benefits in HMA mixes.

The demonstration projects in the mid-1980s were unique recycling projects in which the condition of the original pavement warranted removal and replacement. Such projects are not the norm in Illinois. More common are relatively thin, two-lift resurfacings in the 2.25-in. range on non-interstate and in the 3.75-in. range on interstate highways. As a result of these thin sections, the majority of HMA tonnage placed annually is surface mix. To develop a high-recycle mix that would have the greatest potential use, IDOT determined that development should focus on surface mixes.

6.2 CONCEPT DEVELOPMENT

The past several years, recycling has gained a great deal of interest nationally as well as in Illinois. To demonstrate IDOT's "green" efforts, BMPR began assimilating data and publishing reports on the use of recycled materials in Illinois highways (Griffiths and Krstulovich 2002; Brownlee and Burgdorfer 2011; Brownlee 2011, 2012; Rowden 2013).

In assembling the annual update on the use of recycled and reclaimed materials report, it was evident that crushed concrete was a large part of the recycled material stream. The Standard Specifications have long allowed the use of crushed concrete as an aggregate in HMA, concrete, and aggregate applications. However, the use of crushed concrete has been primarily for non-quality aggregate applications such as aggregate subgrade to construct a working platform or porous granular embankment (PGE) with a top size of 6 or 9 in. Using crushed concrete in these non-quality applications is an economical recycling model; however, crushed concrete is of sufficient quality that value-added applications in HMA are possible.

State DOTs have always been concerned that unlimited use of RAP would result in poorly performing pavements. For this reason, many states established limits on the amount of RAP or the amount of ABR from recycled materials allowed in HMA. Many limitations on RAP content by state highway agencies have roots back to the mid-1990s when a new national mix design procedure called Superpave was implemented. One main goal of this design process was to select the liquid asphalt binder based on the environmental and traffic demands of the pavement section being designed. In the mid-1990s in Illinois, RAP was not a well-managed material and was highly variable. With the implementation of Superpave and the related use of polymer asphalt grades, limitations on RAP use were adopted. As more experience was gained in RAP processing with the fractionation of RAP into different sizes, allowable RAP percentages were increased. With the addition of RAS into HMA, specification limits were converted to ABR so that the contribution from both RAP and RAS could be considered together. Experience with high ABR allowances by the City of Chicago and the Illinois State Toll Highway Authority led to additional increases in IDOT's ABR allowances.

As specifications allowed higher ABR quantities, questions of how high one can go were being raised. In 2012, IDOT proposed to develop an HMA surface mix that consisted of all recycled aggregates. The aggregates would consist of slag aggregate, RCM, and much larger quantities of RAP than traditionally allowed. The use of RAS and high values of ABR would be allowed in this new mix. The mix was dubbed TRA because all the aggregates were reclaimed materials. Soft paving-grade asphalt was added to the mix to counter the aged reclaimed asphalt materials. Development of the concept was meant to be a paradigm shift in recycled material use and moving ABR limits ahead as much as possible rather than on a slow, incremental basis.

Specifications were drafted by BMPR that would allow use of TRA for the surface course on low-volume resurfacing projects and presented to Region 1/District 1, which covers the Chicago metro area and surrounding counties.

6.2.1 Laboratory Mix Design Development

Region 1/District 1 worked on specification refinements and gathered RCM, RAP, RAS, and slag aggregates for a lab mix design development program. Lab mix design and testing indicated the TRA mix was a viable mix, but the feasibility of moving the mix to full-scale HMA production in a typical HMA plant was still a question.

6.2.2 Plant Mix Trial

In December 2012, the weather cooperated with some unusually warm days, and TRA mix was produced in an HMA plant and laid in a contractor's yard. Samples were obtained and tested for TSR, Hamburg wheel tracking, and disk-shaped compact tension testing. The results are presented in Table 1.

Table 1. Initial Plant Trial Production of TRA

Test	Result
TSR	0.91
Hamburg	5.3 mm at 20,000 passes
ASTM D 7413-07 disk-shaped compact tension test at –12°C	494 J/m^2

From this experience, the special provision was finalized as shown in Appendix E for use in three 2013 demonstration projects. Table 2 presents the key HMA specification parameters used for the 2013 demonstration projects compared with standard HMA mix (Illinois Department of Transportation 2012a).

Table 2. Key Specification Parameters of N50 Mix Designs for Standard HMA and Total Recycle Asphalt

Specification Item	Standard HMA	Total Recycle Asphalt
Air voids, percent	4.0	3.0
VMA, percent	15	15
ABR maximum percentage, surface	30	60

6.3 DEMONSTRATION PROJECT CONSTRUCTION

With the finalization of the specification, the next phase was to use the TRA mix in a limited number of 2013 construction projects to provide constructability and long-term performance data. Three demonstration projects were on the April 26, 2013, IDOT letting. The projects are detailed in the following sections.

6.3.1 26th Street in Chicago Heights, Illinois

This project was let as Item 4 on the April 26, 2013, letting as Contract 60L62. The electronic plans and specifications are located at http://eplan.dot.il.gov/desenv/042613/60L62-004/.

6.3.1.1 Project Location

This project is located on 26th Street (FAU 1633) and begins approximately 230 ft east of the centerline of Western Avenue and extends easterly to a point approximately 80 ft west of the centerline of East End Avenue for a total distance of 10,640 ft (2.02 mi). The project is located in the Village of Park Forest and the City of Chicago Heights in Cook County. Figure 6 presents a picture of the section prior to construction.

Figure 6. Condition of 26th Street in Chicago Heights, Summer 2013.

6.3.1.2 Existing and Proposed Cross-Sections

The cross-section at the time of rehabilitation consisted of an original 9-in. concrete pavement that had HMA overlays totaling 5-3/4 in. As part of the rehabilitation, 2-1/4 in. of HMA was milled, and then a level binder consisting of a 3/4-in.-thick polymer-modified 4.75-mm N50 HMA was laid. Finally, the section was topped off with 1-1/2 in. of TRA.

6.3.1.3 Construction

"D" Construction, Inc. of Coal City, Illinois, was the contractor for the section. The section was paved on September 30, 2013. The contractor designed the mix for the section similar to what the district had previously developed. The mixture details are provided in Table 3.

Table 3. Mixture Details of 26th Street in Chicago Heights

Material	Percent
Minus 3/8-in. FRAP	51.5
Crushed Concrete	30.0
Steel Slag	15.0
Reclaimed Asphalt Shingles (RAS)	3.5
Added Asphalt Content (PG 52-28)	2.7
Total AC Content	6.7
Total ABR	60

Production of the mix and laydown were very similar to those for standard HMA. Figure 7 shows the section during construction.

Figure 7. Construction of 26th Street in Chicago Heights, Fall 2013.

6.3.2 Harrison Street in Hillside, Illinois

This project was let as Item 28 on the April 26, 2013, letting as Contract 60N67. The electronic plans and specifications are located at http://eplan.dot.il.gov/desenv/042613/60N67-028/.

6.3.2.1 Project Location

This project is located within the Village of Hillside in Cook County, and begins at a point on the centerline of Harrison Street (FAU 1427) approximately 77 ft north of IL 38 (Roosevelt Road) and extends north and then east to approximately 59 ft west of Wolf Road. This project has a gross and net length of 5,927.6 ft (1.12 mi). Figure 8 presents a photo of the section prior to construction.

Figure 8. Condition of Harrison Street in Hillside, Summer 2013.

6.3.2.2 Existing and Proposed Cross-Sections

The existing cross-section consists of the original concrete pavement of unknown thickness, which was overlaid with 3 in. of HMA. The work under this contract started with milling off the HMA overlay down to the original bare concrete pavement. Next, a level binder was laid that consisted of a 1-in.-thick polymer-modified 4.75-mm N50 HMA. The section was topped with 2 in. of TRA.

6.3.2.3 Construction

K-Five Construction Corporation of Lemont, Illinois, was the contractor for the section. The paving on this project was completed August 15, 2013. The mixture design parameters are provided in Table 4.

Table 4. Mixture Details of Harrison Street in Hillside

Material	Percent
Coarse FRAP	27.0
Fine FRAP	26.0
Crushed Concrete	27.0
Steel Slag	15.0
Reclaimed Asphalt Shingles (RAS)	5.0
Added Asphalt Content (PG 52-28)	2.7
Total AC Content	6.5
Total ABR	56

Production of the mix and laydown were very similar to those for standard HMA. A photo taken during construction is shown in Figure 9.

Figure 9. Harrison Street construction, August 2013.

6.3.3 Richards Street in Joliet, Illinois

This project was let as Item 31 on the April 26, 2013, letting as Contract 60P70. The electronic plans and specifications are located at http://eplan.dot.il.gov/desenv/042613/60P70-031/.

6.3.3.1 Project Location

The resurfacing improvement of Richards Street begins at 5th Avenue and extends in a southerly direction approximately 5,364 ft (1.015 mi) to Manhattan Road. The improvement is located in the City of Joliet and Lockport Township, Will County. Figure 10 presents a photo of the section prior to work starting on the section.

Figure 10. Condition of Richards Street in Joliet, Summer 2013.

6.3.3.2 Existing and Proposed Cross-Sections

This section consisted of a four-lane divided highway, with a bare, 10-in. concrete pavement, part of which had been overlaid with 3 in. of HMA. As part of the rehabilitation, all the HMA was removed by milling down to bare concrete pavement. Next, a level binder was laid over the entire section that consisted of a 1-in.-thick polymer-modified 4.75-mm N50 HMA. The section was topped with 2 in. of TRA.

6.3.3.3 Construction

Austin Tyler Construction, LLC of Elwood, Illinois, was the contractor. The contractor did not adopt the mix developed by the district that used recycled concrete as part of the aggregate and RAS. Instead the contractor decided to develop their own mix using steel slag for the entire recycled aggregate portion. The mix did not contain RAS. The initial test strip had problems meeting performance criteria. As a result, the test strip was removed, a revised mix design was adopted, and the TRA surface was paved on October 30 and 31, 2013. The mixture design parameters are provided in Table 5.

Table 5. Mixture Details of Richards Street, Joliet

Material	Percent
Coarse FRAP Plus 3/8-in.	6.0
Fine FRAP Minus 3/8-in.	24.0
Fine Steel Slag (FM 20)	24.0
Coarse Steel Slag (CM 13)	45.5
Mineral Filler	0.5
Added Asphalt Content (PG 52-28)	3.4
Total AC Content	5.4
Total ABR	37

Once adjusted, the revised mix production and laydown were very similar to those for standard HMA. A photo taken during construction is shown in Figure 11.

Figure 11. Construction of Richards Street in Joliet, October 2013.

6.3.4 Wolf Road in Hillside, Illinois (Comparison Section)

This project was let as Item 9 on the April 26, 2013, letting as Contract 60M30. The electronic plans and specifications are located at http://eplan.dot.il.gov/desenv/042613/60M30-009/.

This project was selected as a comparison section because it is near one of the TRA projects and represents rehabilitation typically performed in District 1 in terms of both pavement design and mix use. This section was not considered a true control section since it was an N70 mix, while the TRA mixes were all N50 designs.

6.3.4.1 Project Location

The resurfacing improvement of this project begins at a point on the centerline of Wolf Road at IL 38 (Roosevelt Road) and extends in a northerly direction to 135 ft north of Harrison Street within the Village of Hillside in Cook County. This project has a gross and net length of 2,638 ft (0.5 mi).

Unfortunately, due to the timing of selecting this section as a comparison section, pre- and post-overlay surveys were not able to be completed in 2013. Also, for that reason, no photos are available for the pre-overlay conditions other than on Google Street View for October 2012, as shown in Figure 12.

Figure 12. Condition of Wolf Road, October 2012 (Google Street View).

6.3.4.2 Existing and Proposed Cross-Sections

The section at the time of the work consisted of a bare, 10-in. concrete pavement. As part of the rehabilitation, a wedge of the concrete was removed by milling at the curbline, which tapered to 0 at a point 6 ft away from the curb edge. Next, a level binder was laid over the passing lane and continued into the driving lane up to the milled area. The level binder consisted of a 1-in. polymer-modified 4.75-mm, N50 HMA mix. The section was topped with a 1-1/2-in. HMA, N70 mix, which used a PG 64-22 grade asphalt. The mix was designed at 4% air voids.

6.3.4.3 Construction

K-Five Construction Corporation of Lemont, Illinois, was the contractor for the section. The paving on this project was completed in 2013. The mix design parameters are provided in Table 6.

Table 6. Mix Details of Wolf Road

Material	Percent
Crushed Stone (CM 16)	51.3
Stone Sand (FM 20)	8.0
Natural Sand (FM 02)	10.0
Minus 200 (collected dust)	0.7
Coarse FRAP	25.0
Fine FRAP	5.0
Added Asphalt Content (PG 64-22)	4.7
Total AC Content	5.9
Total ABR	20
Air Voids	4.0

6.4 BID COST COMPARISON

All projects were on the April 26, 2013, IDOT letting. The Wolf Road section was also used for bidding comparisons. The Wolf Road project featured 1,382 t of N70 HMA surface course mix, which was bid at $68/t of mix compared with an average of $59.16/t for TRA, or a 13% reduction over the conventional mix. Individual projects varied from 4% to 26% below the bid price of Wolf Road. Table 7 presents details of the bids on the projects.

Table 7. Bidding Information

Project	Mix Type*	Tons	Bidders	High Bid	Low Bid
26th Street	TRA SC N50	3,060	3	$142.00	$50.50
Harrison Street	TRA SC N50	2,131	6	$83.00	$65.00
Richards Street	TRA SC N50	2,223	4	$146.50	$62.00
Wolf Road (Comparison)	HMA SC N70	1,382	8	$85.00	$68.00

*HMA = conventional hot-mix asphalt; TRA = total recycle asphalt.

The TRA mixes used between 2.7% and 3.4% new asphalt binder, which is a decrease in the amount of new liquid asphalt typically added to a mix. The ABR and aggregate from RAP are the main sources of the savings that are passed along in the bid cost.

6.5 FIELD MATERIAL TESTING

Region 1/District 1 performed acceptance testing per contract requirements for the various sections. Because of the experimental nature of the sections, additional mix was sampled for testing at the Illinois Center for Transportation (ICT Project R27-128: *Testing Protocols to Insure Performance of High Asphalt Binder Replacement Mixes Using RAP and RAS*).

6.5.1 District Acceptance Testing

Routine quality assurance tests for were averaged and summarized as shown in Table 8.

Table 8. Quality Assurance Test Results

Project	Average Binder Content, %	Average Density, %	Average Dust/AC Ratio	Average Air Voids, %
Harrison Street, Hillside	6.5	96.1	1.0	1.4
26th Street, Chicago Heights	6.3	95.3	1.1	2.0
Richards Street, Joliet	5.2	95.0	1.1	2.6
Wolf Road, Hillside	5.7	94.1	1.1	4.3

6.6 DISTRESS SURVEY AND PERFORMANCE MONITORING

6.6.1 Long-Term Monitoring Using Condition Rating Survey

For long-term performance monitoring, Illinois uses the Condition Rating Survey (CRS) rating on a scale of 1.0 to 9.0. A rating of 1.0 indicates that a pavement section is impassable, while a 9.0 is assigned to newly constructed roads the year of improvement. Biennial surveys establish ratings, with a model being used to predict condition in a year when a survey is not conducted. Other than the assigned values of 9.0 for 2013, CRS data were not available on these sections. It will take 4 to 5 years of data to establish CRS performance trends. To provide performance trends in a more timely fashion, detailed distress surveys were conducted.

6.6.2 Short-Term Monitoring Using Distress Surveys

All projects were completed in 2013, and pavement distress surveys (pre- and post-construction) were completed by BMPR. This information will be the basis for determining early-performance trends of these sections. All three TRA sections and Wolf Road (comparison section) were surveyed.

Distress surveys consisted of walking the sections with field sheets representing the pavement and related survey stations. Data are recorded by mapping and coding the distress as outlined in the Bureau of Materials and Physical Research Pavement Distress Manual (Illinois Department of Transportation 2012b). This type of record provides an early-life distress history that can be compared with that of similar pavements.

Summaries of the distress surveys for each section for pre-construction (except for Wolf Road comparison section), post-construction, and in Spring 2014 can be found in Appendix F.

6.6.2.1 Chicago Heights: 26th Street Performance

Survey data showed that approximately 33% of the pre-existing transverse cracking length has reflected through the new overlay over the winter at some severity level. Of the cracks reflecting through the overlay, approximately 1% are at medium severity, with no high-severity transverse cracking. Reflective cracks over underlying pavement joints and cracks are expected when concrete pavement is overlaid with HMA.

While centerline cracking distress is not uncommon after a severe winter as was experienced in 2013/2014, the distress severity of the centerline on this section is not typical. The entire section length is experiencing centerline cracking distress, with approximately 82% of the section length at a high-distress severity.

Material immediately adjacent to the centerline joint has raveled away, leaving a gap in the range of +/– 1 in. at the surface. Other areas have this gap plus a longitudinal crack that is parallel to the joint 1 to 3 in. away from the actual joint. It would appear that the material between the joint and crack will be lost in the near future, as has already occurred in some areas of the section. The contract special provisions included longitudinal joint testing; however, the very narrow nature of the distress is such that testing may not have detected the quality problem as presented in Figures 13 and 14 due to a small offset from the edge of the pavement allowed under this special provision.

Figure 13. Cracking parallel to centerline joint of 26th Street, April 2014.

Figure 14. Raveled centerline joint of 26th Street, April 2014.

6.6.2.2 Hillside: Harrison Street Performance

Distress surveys found that approximately 88% of the pre-existing transverse cracking length has reflected through the new overlay over the winter at some severity level. Of the cracks reflecting through the overlay, approximately 6% are at a medium severity, with no high-severity transverse cracking.

Centerline cracking after the first winter was low severity for a distance of 47 ft, which is less than 1% of the joint length. However, there is 497 linear ft of longitudinal cracking at a low severity level. A majority of the cracking is located near the pavement edge. It is not certain, but the distress may be the result of problems with the underlying condition of the pavement and not related to the mix itself.

A typical view of the Harrison Street section is shown in Figure 15.

Figure 15. Typical view of Harrison Street, April 2014.

6.6.2.3 Joliet: Richards Street Performance

Of note on this section compared with 26th Street and Harrison Street is that neither RAS nor RCM was used in the mix. To increase the ABR, fine-graded RAP was used.

The survey data showed that approximately 7% of the pre-existing transverse cracking length has reflected through the new overlay over the winter at a low level.

Because of the location of the distress, some of the longitudinal cracking could have been classified as centerline distress. However, the cracking was located approximately 1 ft off the centerline joint, so the data were kept separate and recorded as being a longitudinal crack. Both distresses were low severity, with 81 linear ft of centerline cracking and 300 ft of longitudinal cracking, or approximately 5% of the section length.

In the April 2014 survey, there was 172 lane-ft of alligator or fatigue cracking at a low severity. A small quantity of alligator cracking was identified during the pre-existing condition survey. These areas of distress indicate that there are underlying pavement support or structural problems that are probably unrelated to the mix used.

A typical view of Richards Street is shown in Figure 16.

Figure 16. Typical view of Richards Street, April 2014.

6.6.2.4 Hillside: Wolf Road Performance

The pavement distresses found during the April 2014 surveys were 52 linear ft of low-severity centerline cracking and a total of 3,188 linear ft of transverse cracking, of which 108 linear ft was at a medium severity. The remaining transverse cracking was at a low severity.

A typical view of Wolf Road is shown in Figure 17.

Figure 17. Typical view of Wolf Road, April 2014.

6.7 LABORATORY PERFORMANCE CHARACTERIZATION

This section presents performance test results of eight plant-produced asphalt mixtures designed with recycled materials including RAP, RAS, slag, and RCM, including the TRA discussed in the previous section. Semi-circular bending (SCB) fracture tests were conducted at various loading rates and temperature conditions.

6.7.1 Materials and Specimen Preparation

Eight mixes were selected for mixture characterization. Six of these mixes are from an ongoing ICT project, "Testing Protocols to Ensure Performance of High Asphalt Binder Replacement Mixes Using RAP and RAS" (R27-128). Two of the TRAs produced in 2013 were also included in the testing program. A summary of the mixes and their design and volumetric characteristics are shown in Table 9.

Table 9. Summary of Mix Designs Including Total Recycle Mixes (Richards Street and 26th Street) and ICT R27-128 Project Mixes

Mix ID	PG Grade	NMAS (mm)	% Total Binder	% ABR	% Recycled Content				% Voids	G_{mb}, Design	% VMA
					RAP	RAS	RCM	Slag			
N50-34-TRA-R*	58-28	9.5	5.39	34	30	—	—	70	4.0	2.788	15.3
N50-50	58-28	9.5	5.5	49	42	4	—	—	3.0	2.424	13.0
N50-60	46-34	9.5	5.6	59	42	6	—	—	3.0	2.424	13.0
N50-60-TRA-26*	52-28	12.5	6.72	60	52	4	30	15	3.0	2.452	15.1
N70-25	58-28	9.5	6.0	25	29	—	—	—	4.0	2.389	14.5
N70-50	58-28	19	6.0	48	30	5	—	—	4.0	2.383	14.5
N80-25	70-28	9.5	6.1	26	8	5	—	—	3.5	2.405	16.1
N80-50	70-28	9.5	6.0	50	10	8	—	—	3.5	2.405	15.8

* These mixes are total recycle asphalt (TRA) mixes produced by IDOT District 1 for two of the three pilot projects in 2013 (R = Richards Street, 26 = 26th Street).
"—" indicates item does not apply to this mix.

6.7.2 Fracture Characterization with Semi-Circular Bending Test

The SCB test is used to determine cracking resistance of asphalt mixtures. The primary outcome of this test is the fracture energy, often expressed as joules per square meter (J/m^2). The fracture energy (G_f) is defined as the energy required to propagate a crack for a unit area. The SCB fixture is illustrated in Figure 18 along with a typical outcome of an SCB test and fracture energy calculation method. The fracture energy is calculated by dividing the area under the load-displacement curve, also known as the work of fracture, by the area through which the crack propagates.

SCB fracture tests were conducted on the aforementioned mixes using various testing procedures, including different temperatures and loading rates. This section presents the results of the tests conducted at 10°F (–12°C) and 77°F (25°C). Testing at 10°F (–12°C) was displacement controlled through use of a crack mouth opening displacement (CMOD) gauge. The displacement rate specified was 0.00046 in./sec (0.7 mm/min). Testing at 77°F (25°C) was displacement controlled through using a linear variable displacement transducer (LVDT) as shown in Figure 18. Three displacement rates, 0.5 in./min, 1 in./min, and 2 in./min (12.5 mm/min, 25 mm/min, and 50 mm/min) were used.

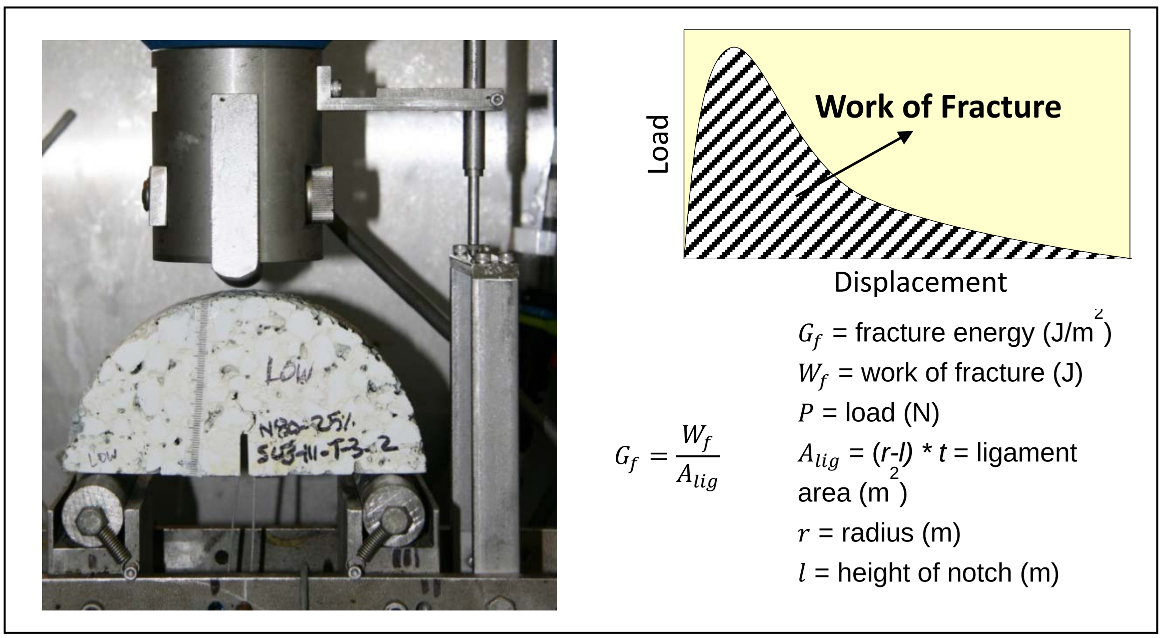


Figure 18. Semi-circular bending test fixture and typical outcome from this test to calculate fracture energy.

6.7.2.1 Specimen Preparation

SCB specimens were prepared from gyratory specimens 7 in. (180 mm) tall with a 5.9-in. (150-mm) diameter. An air void content of 7% ± 0.5% was targeted for all slices obtained from the compacted specimens. Two slices 2 in. (50 mm) thick were extracted from each gyratory specimen; each slice was halved, making two test specimens. Hence, four specimens can be made from one gyratory sample. Notches of 0.6 in. (15 mm) were machined into the center of each specimen. It should be noted that the change in the air void content throughout the gyratory specimens can result in some variations in the SCB testing results.

6.7.2.2 Discussion of Semi-Circular Bending Fracture Test Results

Figure 19 presents the results from the SCB fracture tests at 10°F (–12°C) and a 0.00046 in./sec (0.7 mm/min) crack mouth opening rate. This is considered to be the conventional low-temperature test method. The following observations can be made based on the low-temperature fracture results:

- The fracture energy of the mixes varies from 450 to 650 J/m^2.
- The fracture energy of N50 mixes appears to be lower than the rest of the groups (lower end of 450 to 650 J/m^2 range), whereas N80 mixes (all of which are stone matrix asphalt) and TRA are at the higher end of that range.
- In general, fracture energy is higher for lower ABR levels. However, this test method could not show the effect of ABR level very clearly within each mix group (N50, N70, N80, and TRA).

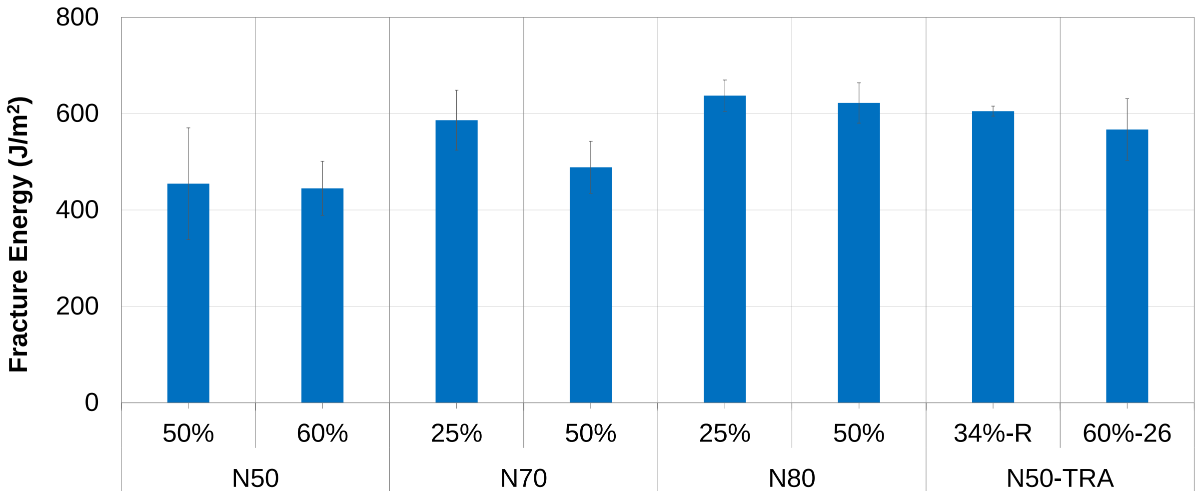


Figure 19. Fracture energy results from the SCB test conducted at10°F(–12°C) using CMOD control and 00.00046 in./sec. (7 mm/min) opening rate.

Figure 20 presents the fracture energy results from the SCB tests conducted at 25°C (77°F) at various LVDT displacement rates. The following observations can be made based on the results presented in the figure:

- Fracture energy range for all mixes is 700 to 1,600 J/m^2, 650 to 1,300 J/m^2, and 850 to 2,200 J/m^2 for 0.5 in./min, 1 in./min, and 2 in./min (12.5 mm/min, 25 mm/min, and 50 mm/min), respectively.
- Generally, it appears that increasing the ABR level could result in fracture energy reduction regardless of the displacement rate.
- In general, fracture energy increases with increasing displacement rate. Hence, proper loading rates should be selected for testing.

The two TRA mixes behave significantly different under these testing conditions. The fracture energy of the mix N50-34-TRA-R is significantly higher than that of the mix N50-60-TRA-26 at all displacement rates. Considering all mixes, the fracture energy of the mix N50-34-TRA-R is at the higher end of the fracture energy range, whereas the mix N50-60-TRA-26 is near the average of all mixes tested.

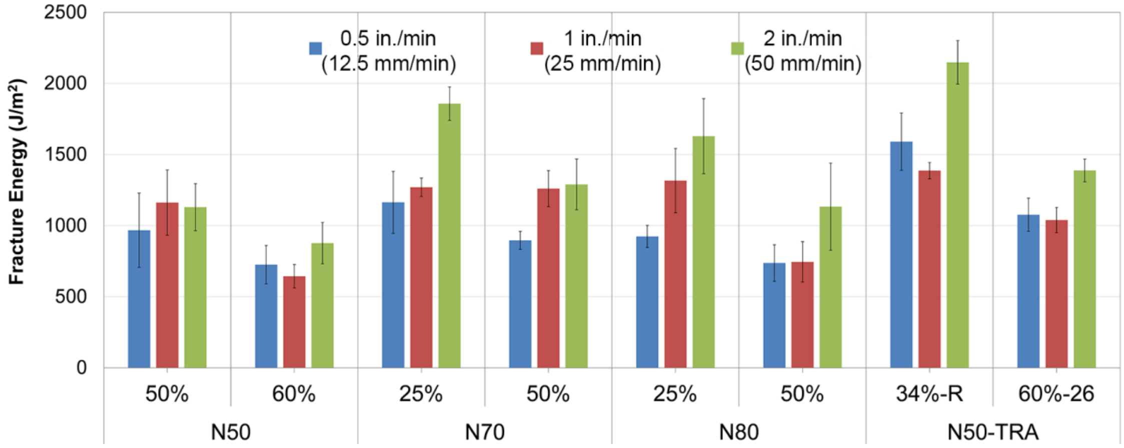


Figure 20. Fracture energy results from the SCB test conducted at 77°F (25°C) using LVDT control and varying rates 0.5 in./min, 1 in./min, and 2 in./min (12.5, 25, and 50 mm/min).

6.7.3 Mix Characterization Using the Complex Modulus Test

The complex modulus (E*) is one of the material characterization inputs that can be used in the AASHTOWare Mechanistic Empirical Pavement Design procedure to predict pavement performances. Complex modulus defines the relationship between stress and strain for a linear viscoelastic material under sinusoidal loading. Recent research recommends this test for comparative study of mixes (Bonaquist et al. 2003; Carpenter 2007; Vavrik et al. 2008; Braham et al. 2011; Ozer et al. 2012).

The tests are performed in a temperature-controlled chamber at 14°F (–10°C), 39°F (4°C), 70°F (21°C), 99°F (37°C), and 131°F (55°C) under a frequency sweep mode of 25 Hz, 10 Hz, 5 Hz, 1 Hz, 0.5 Hz, and 0.1 Hz in accordance with AASHTO T342-11 *Standard Method of Test for Determining Dynamic Modulus of Hot-Mix Asphalt Concrete Mixtures*. The tests are conducted using a controlled-stress mode with a specified strain limit of 50-150 microstrain to ensure that the material stays within the linear viscoelastic limit. Master curves can be developed from the modulus values obtained at the range of temperatures and frequencies. Figure 21 shows the complex modulus test setup used in the experiments.

Figure 21. Complex modulus test specimen and fixture with axial extensometers mounted to measure deformations.

Test specimens were fabricated using the Superpave gyratory compactor and compacted to a height of 7 in. (180 mm) and a diameter of 5.9 in. (150 mm) to achieve a target air void of 7% ± 0.5% on the test specimens. These specimens were then cut and cored to a height of 6 in. (150 mm) and diameter of 4 in. (100 mm). The axial strain measurements were obtained with three strain transducers placed at 120-degree offsets around the sample.

6.7.3.1 Complex Modulus Test Results

The results of the complex modulus tests are presented for the mixes grouped with respect to their specific N-design but varying ABR. Viscoelastic characteristics of the mixes were investigated using the following plots:

- *Complex modulus vs. frequency (Master curve)*—Master curve provides linear viscoelastic characterization of asphalt mixes over a wide range of temperatures and frequencies. Complex modulus values contain elastic and viscous phases of asphalt mixes.
- *Phase angle vs. frequency (Phase curve)*—Phase angle curve indicates how the viscous phase of asphalt mixes is evolving with temperature and loading frequency (i.e., 0 degrees: very stiff or rigid; 90 degrees very fluid or water-like).
- *Complex modulus vs. Phase angle (Black curve)*—Black curves indicate how Complex modulus and Phase angle are correlated to each other. These curves are often used to seek fingerprints of modification of asphalt binders, such as polymer modification.

- *Storage modulus (elastic part) vs. loss modulus (viscous part) (Cole-Cole curve)*—Cole-Cole plots are also commonly used in the literature to study the interaction of complex modulus components (elastic and viscous parts) of the viscoelastic materials.

6.7.3.2 N50 Mixtures with Varying ABR

There are four N50 mixes with varying percentages of ABR. Two of the N50 mixes are total recycled mixes (N50-34-TRA-R and N50-60-TRA-26). The ABR level of the N50 mixes varied from 34% to 60%. Plots of the viscoelastic characterization of N50 mixes are shown in Figure 22.

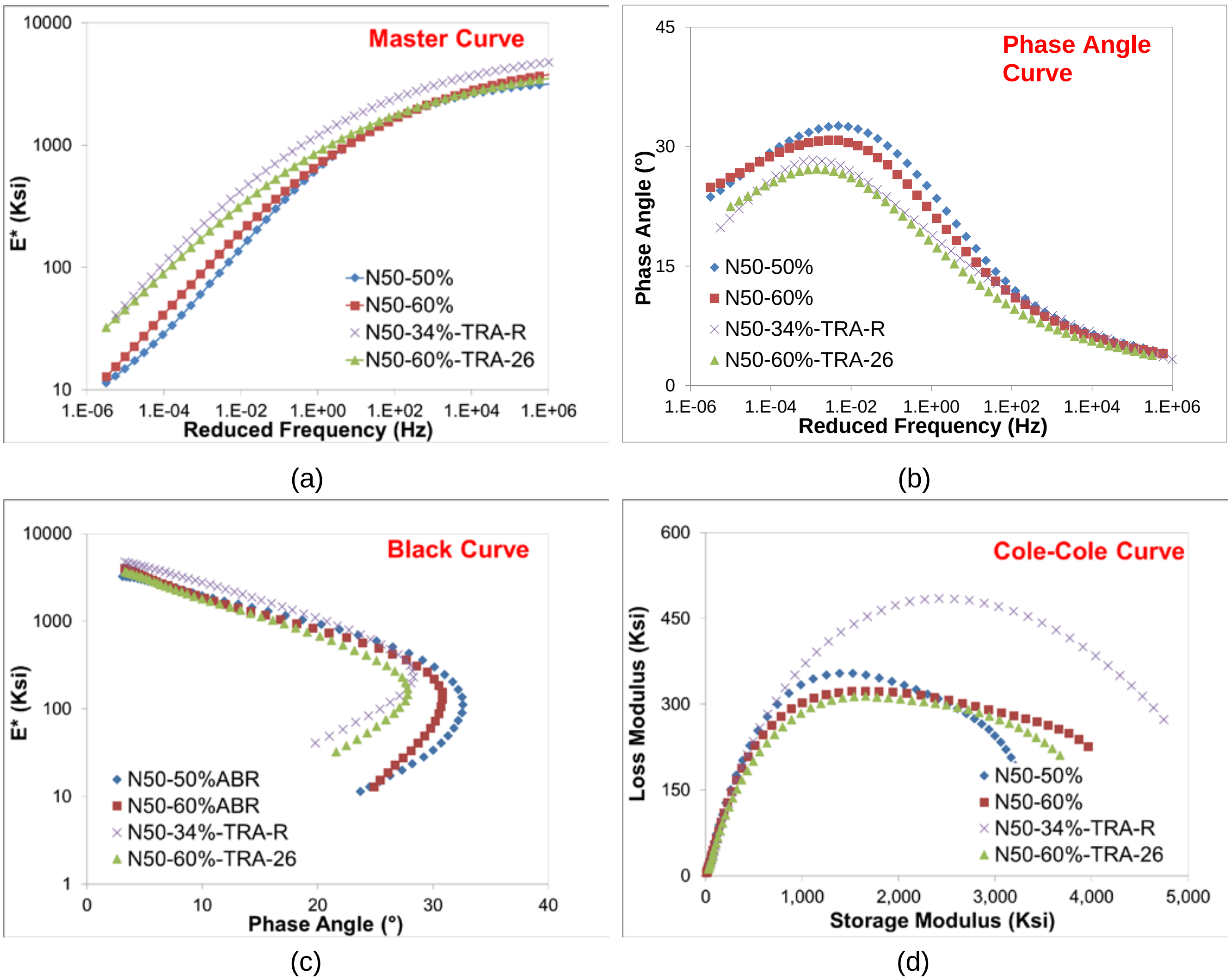


Figure 22. Viscoelastic characterization of the N50 mixes: (a) Master curve, (b) Phase angle, (c) Black curve, (d) Cole-Cole plots.

The following summarizes the viscoelastic characteristics of the N50 mixes:

- The differences in the mixes are more evident in the Cole-Cole and Black curves compared with the Master curve.

- Total recycle mixes (N50-34-TRA-R and N50-60-TRA-26) behave different than the other two N50 mixes.
- The complex modulus of total recycle mixes are stiffer than those of the other two N50 mixes, especially at higher temperatures and lower loading frequencies.
- The total recycle mix (N50-34-TRA-R) has a significantly higher storage and loss modulus (clearly observed in the Cole-Cole plot), which can be attributed to 70% slag content. Contribution of aggregates to the overall stiffness of asphalt mixes will be higher with slags as compared to that of natural and crushed aggregates.
- Loss modulus is the property that can distinguish the mixes from each other. This is an important characteristic of a mix because it can affect the cracking resistance of mixes. As loss modulus of an asphalt mix is decreasing, stress relaxation property can also be reduced.

6.7.3.3 N70 Mixtures with Varying ABR

Viscoelastic characteristics of the two N70 mixes with 25% and 50% are discussed. Figure 23 presents results of viscoelastic characterization with the four plots introduced in the previous section.

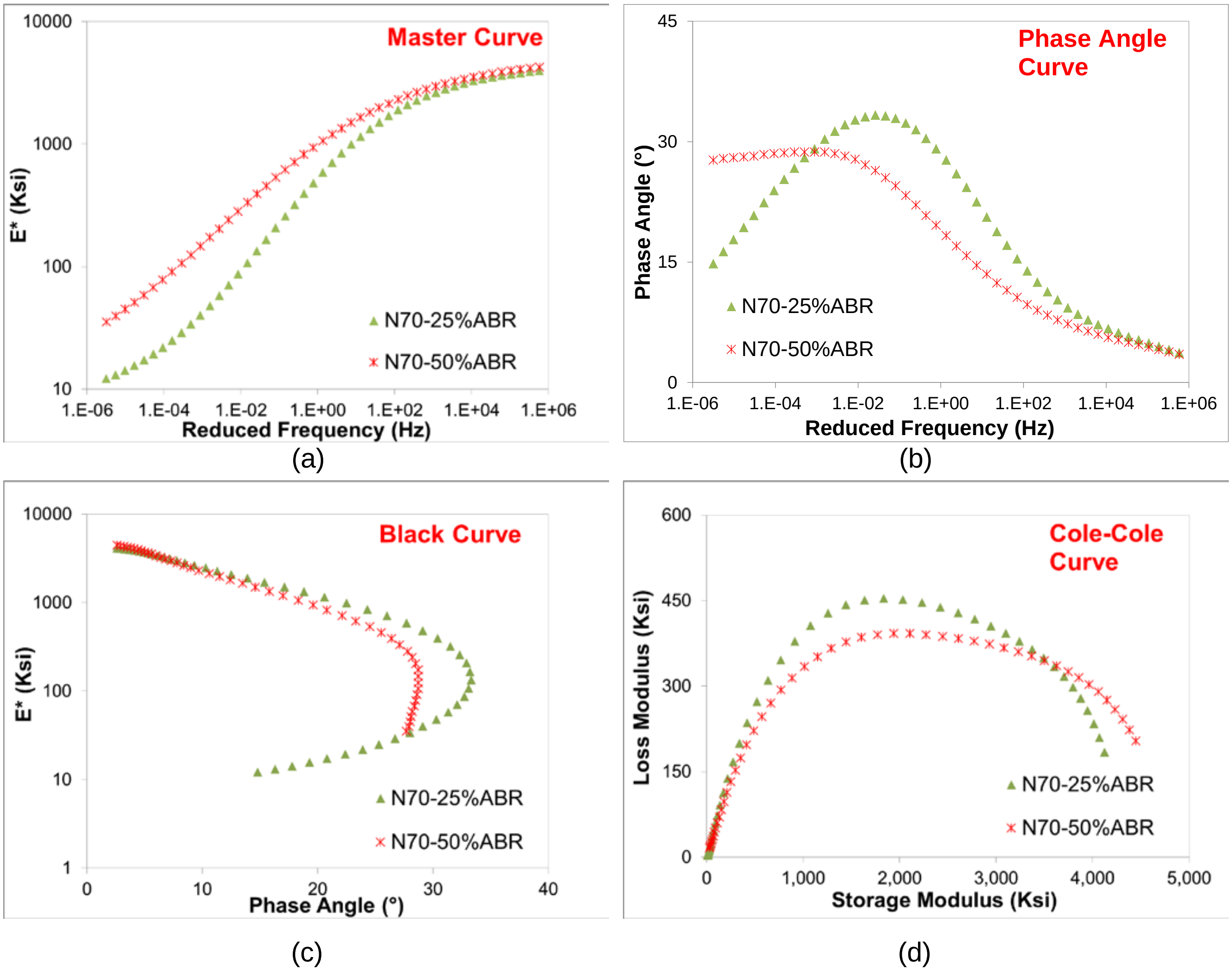


Figure 23. Viscoelastic characterization of the N70 mixes: (a) Master curve, (b) Phase angle, (c) Black curve, (d) Cole-Cole plots.

The following summarizes the viscoelastic characteristics of the N70 mixes:

- A clear increase in the modulus is evident in the Master curve with the increase in ABR level.
- Phase angle is also clearly reduced (or shifted to the left) with the increase of ABR (smaller loss component with increasing ABR at the same frequency).
- Storage and loss modulus curves shrink with the increase in ABR, as evidenced by the Cole-Cole plot. This indicates, in general, a reduction in loss modulus of the mixes for the same storage modulus, which may indicate changes in the stress relaxation potential of the mixes tested.

6.7.3.4 N80 Mixtures with Varying ABR

Finally, viscoelastic characteristics of the two N80 mixes with 25% and 50% ABR are discussed. These are stone mastic mixtures (SMA) prepared with PG70-28 binder grade. Figure 24 presents the four viscoelastic curves for N80 mixes.

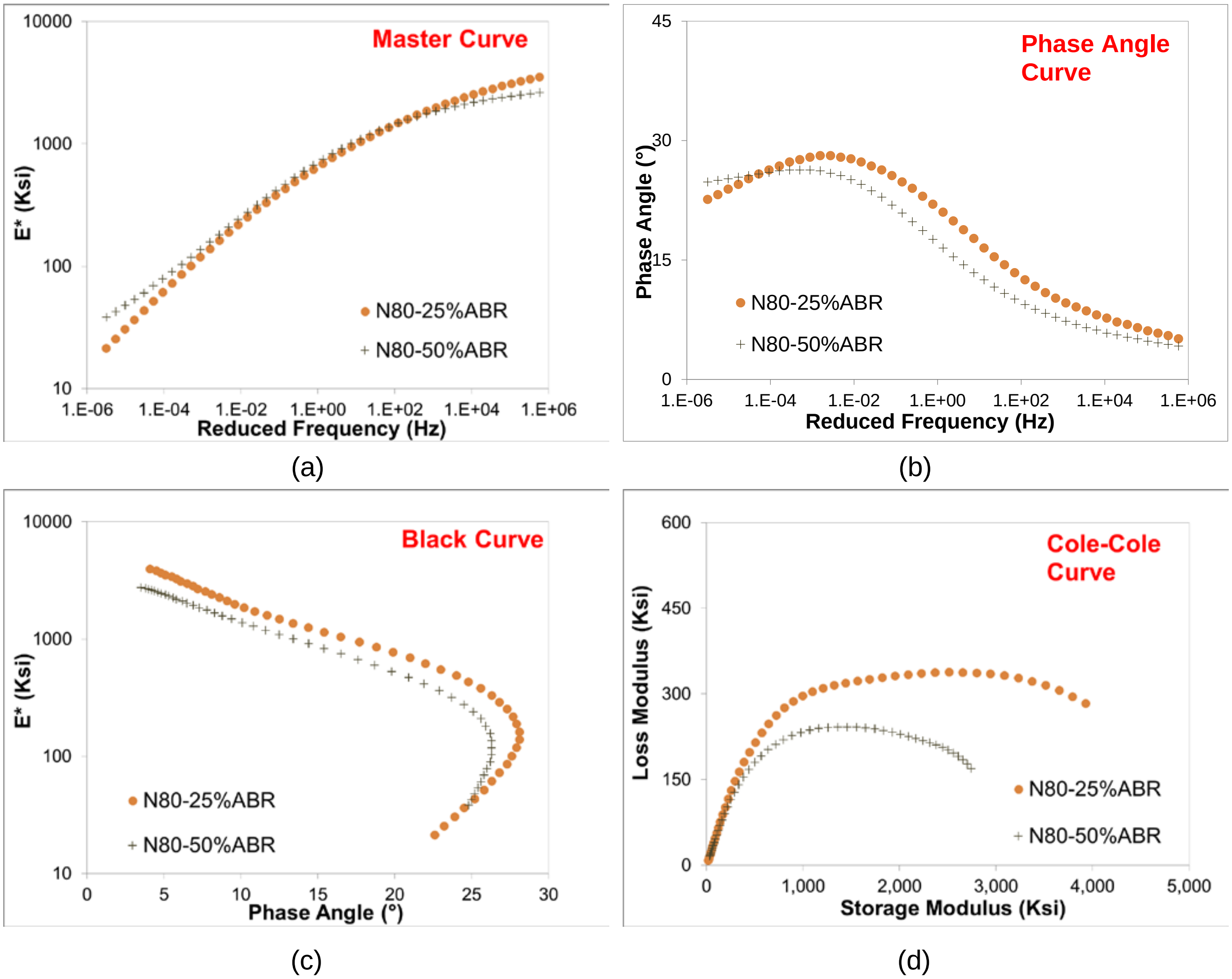


Figure 24. Viscoelastic characterization of the N80 mixes: (a) Master curve, (b) Phase angle, (c) Black curve, (d) Cole-Cole plots.

The following summarizes the viscoelastic characteristics of the N80 mixes:

- According to the Master curve plot, the two N80 mixtures do not appear to be different from each other.
- A slight reduction (or shift to the left) was observed in the Phase angle curve at the higher ABR content, similar to the behavior of N70 mixes.

- Similar to the previous cases, the Cole-Cole plot illustrates significant differences in the response of the mixes when the ABR level is increased. The Cole-Cole curve shrinks with the increasing ABR level.

6.8 ENVIRONMENTAL EVALUATION OF MIXES

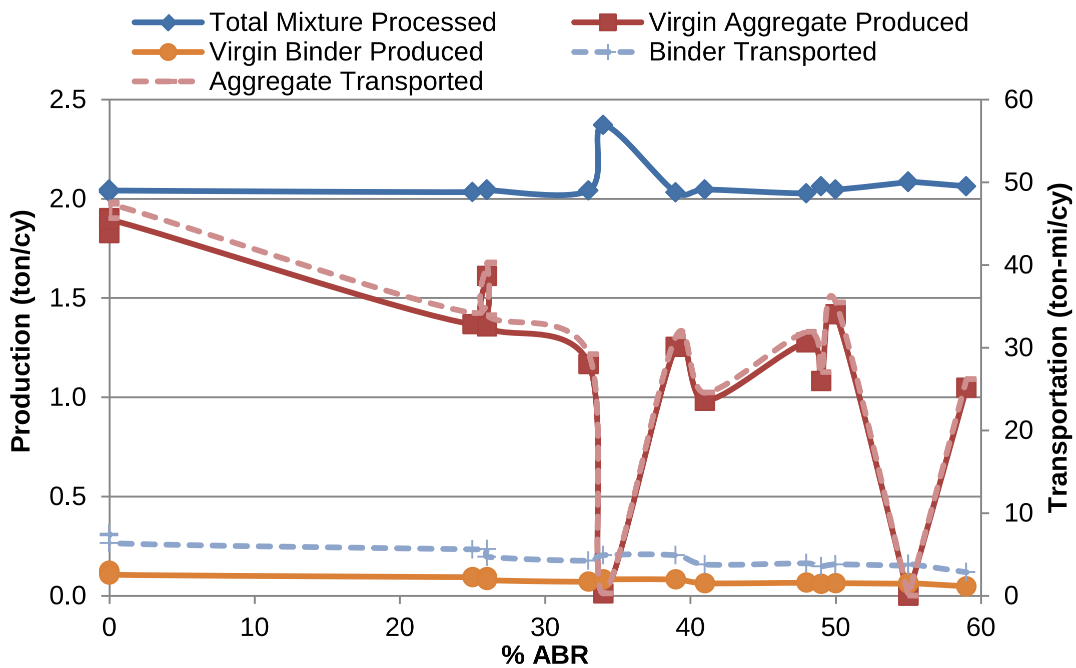
Use of recycled materials, industrial by-products, or WMA technologies in pavement construction is one of the most common potentially sustainable practices. The ABR and TRA mixes examined in this report are considered to be environmentally sustainable designs because of their ability to reduce the amounts of virgin binder and virgin aggregates needed. To estimate the potential reduction in environmental burdens that ABR and TRA mixes may have, the quantities of major energy-intensive processes required for 16 mixes were calculated. A summary of the mixes analyzed in this study is provided in Table 10. Three mixes in this sample, N70-0, N80-0, and N90-0, have been included with 0% ABR as control mixes.

Table 10. Summary of Major Design Characteristics of the Mixes Used for Sustainability Assessment

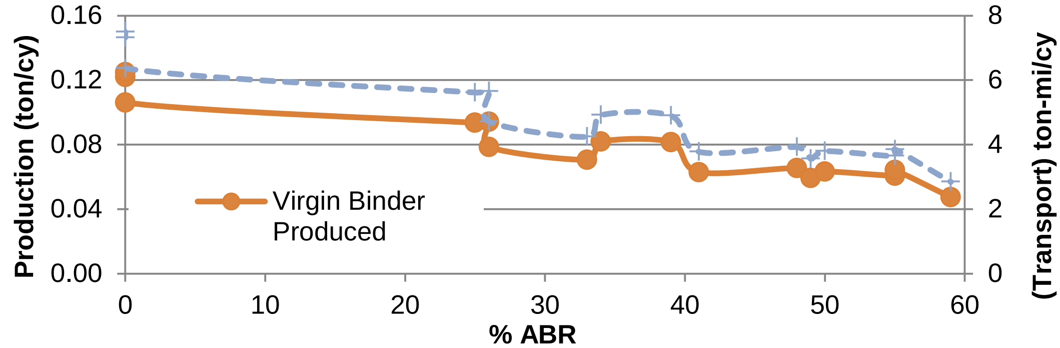
Mix ID	PG Grade	NMAS (mm)	% Total Binder	% ABR	% Recycled Content				% Voids	G_{mb}, Design
					RAP	RAS	RCA	Slag		
N50-34-TRA-R[1]	58-28	9.5	5.39	34	30	—	—	70	4.0	2.788
N50-50	58-28	9.5	5.5	49	42	4	—	—	3.0	2.424
N50-56-TRA-H[1]	52-28	12.5	6.5	57	53	5	27	15	3.0	2.450
N50-60	46-34	9.5	5.6	59	42	6	—	—	3.0	2.424
N50-60-TRA-26[1]	52-28	12.5	6.72	60	52	4	30	15	3.0	2.452
N70-0	58-28	9.5	6.0	—	—	—	—	—	4.0	2.389
N70-25	58-28	9.5	6.0	25	29	—	—	—	4.0	2.389
N70-38	58-28	19	6.4	39	30	5	—	—	4.0	2.387
N70-50	58-28	19	6.0	48	30	5	—	—	4.0	2.383
N80-0	70-28	9.5	6.1	—	—	—	—	—	3.5	2.405
N80-25[2]	70-28	9.5	6.1	26	8	5	—	—	3.5	2.405
N80-50[2]	70-28	9.5	6.0	50	10	8	—	—	3.5	2.405
N90-0	58-28	19	5.2	—	—	—	—	—	4.0	2.398
N90-26	58-28	19	5.2	26	30	—	—	—	4.0	2.397
N90-33	58-28	19	5.2	33	40	—	—	—	4.0	2.401
N90-41	58-28	19	5.2	41	50	—	—	—	4.0	2.405

[1] These mixes are total recycle asphalt (TRA) mixes produced by IDOT District 1 for the three pilot projects in 2013 (R = Richards Street, 26 = 26th Street, H = Harrison Street).
[2] N80 mixes are stone matrix asphalt.
"—" indicates item does not apply to this mix.

Using the volumetrics and mix designs given in Table 10, the tonnages of virgin aggregate, virgin binder, and total mixture material were calculated for each mix. These quantities were chosen because the production of aggregate, production of binder, and mixing and drying of raw materials at the plant are the most energy-intensive processes in HMA production (Kang et al. 2014). Figure 25 shows the tons needed per cubic yard (cy) of HMA for each of these processes. In addition, the hauling distances (ton-mile) for raw materials are included. The transportation distances of raw materials to plant were assumed to be 25 mi for aggregate, 60 mi for binder, and 0 mi for recycled materials (in-plant processing).



(*a*)



(*b*)

Figure 25. Quantities produced and transported per cy asphalt mixture for (*a*) all energy-intensive items and (*b*) only virgin binder, detailed.

As ABR increases, a clear reduction in virgin binder required is seen in Figure 25(b) with slight aberrations that are the result of differences in mix designs. The environmental burdens attributed to the production of this binder have been reported to be in the range of approximately 350 to 860 lb (160 to 390kg) CO_2EQ/t for greenhouse gases and 3.3 to 5.3 mm Btu/t for energy consumption (Stripple; Franklin Associates 2001). In comparison, reported values for virgin aggregate production are 2.9 to 3.5 lb (1.3 to 1.5kg) CO_2EQ/t and 0.030 to 0.069 mm Btu/t (Stripple; Mareeau et al. 2007), and for mixing and drying at the plant they are 33 to 45 lb (15 to 20kg) CO_2EQ/t and 0.31 to 0.35 mm Btu/t (Stripple; Zapata et al 2005; U.S.E.P.A. 2004). Thus, even though binder is only 5% to 7% of the mix design by weight, its production can easily contribute 30% to 50% of the total environmental burden of producing an HMA mixture. The exact environmental impacts for binder can depend on the region where it is produced and whether the binder has been modified. For example, the N80 mixes in this study contain polymer-modified binder, which is more environmentally intensive to produce because of the extra additives and energy required for blending and storage. Thus, using ABR with these mixes is expected to provide even greater environmental savings with respect to the amount of virgin binder needed. Such savings need to be balanced with performance the selected polymer-modified binder was intended to provide.

The TRA mixes shown in Figure 25(a) can be distinguished by the lack of virgin aggregates required. However, these mixes also correspond to higher total mixture processed. The TRAs differ from the other mixes because they include steel slag and RCM. Steel slag is a heavy aggregate that results in a denser mix. The higher G_{mb} of the TRA mixes (especially N50-TRA-R at 2.788, from Table 10) means that more material mass is required per volume of project. This increases the environmental impacts related to mixture production and transportation of raw materials to the plant and the final mix to the jobsite. The savings from using only recycled materials as aggregate must compete against the increases attributable to transportation and plant processes. Thus, the added environmental impacts from transportation and plant operations may lessen the environmental savings of TRAs. Furthermore, the contractor producing the N50-TRA-H mix needed to slow the plant to provide additional heating of the steel slag and RCM to obtain a suitable final mix temperature. It is expected that this behavior would increase energy use and hence the environmental impacts estimated for HMA plant operations.

As discussed, sustainability performance cannot always be easily predicted, and the benefits or trade-offs of using recycled materials or other sustainable technologies must be considered. A more comprehensive method of quantifying environmental burdens can be performed by using life-cycle assessment (LCA). This approach evaluates the inputs and outputs of a product system, such as an individual mix or pavement structure, by the use of environmental inventory data collected for relevant processes. If desired, there is an opportunity to perform a LCA study of ABR and TRA mixes to detail the environmental impacts of these mixes. For the current study, the potential impacts of using various recycled materials on major processes in HMA production are summarized in Table 11.

Table 11. Potential Changes in the Environmental Impacts of Major Processes Attributable to Use of Recycled Products (RAP, RAS, RCM, and Steel Slag)

Processes		Impact of Recycled Product			
		RAS	RAP	Steel Slag	RCM
Transportation to the plant and from the plant		↔	↔	↑[1]	↔
Plant production		↗[2]	↗[2]	↑[1]	↔
Raw material acquisition	Aggregates	↘[3]	↘[3]	↘[3]	↘[3]
	Binder	↓[4]	↓[4]	↔	↔

↑ : significant increase; ↗: some increase; ↔: no change; ↘: some decrease; ↓ : significant reduction.
[1]Environmental impact will increase as a result of transportation of steel slag and production of asphalt mixture with steel slag due to increasing masses transported and produced.
[2]Environmental impact due to plant production can slightly increase when RAP and RAS are used due to overheating of virgin aggregates.
[3]When recycled materials replace natural aggregates (sand/gravel or manufactured), some reduction in the environmental impact is expected.
[4]When recycled materials replace petroleum-based asphalt binder, significant reduction is expected due to the binder's higher environmental impact.

6.9 PERFORMANCE OF TRA SECTIONS

It can be difficult to directly compare survey data unless on a percentage basis or distress per standard unit of measure. For this reason, Table 12 presents select data normalized to 1,000 lane ft or 1,000 ft of joint that may be related to mix properties.

Table 12. Distress per Standard Unit, Spring 2014

	Project			
Recycle Content/Distress	**26th Street, Chicago Heights**	**Harrison Street, Hillside**	**Richards Street, Joliet**	**Wolf Road, Hillside**
ABR%/RAS%	60/3.5	56/5.0	37/0.0	20/0.0
Percent Transverse Crack Reflection	33%	88%	7%	NA%
Transverse Cracking, Ft/1,000 Lane Ft Low Severity	180	460	50	149
Transverse Cracking, Ft/1,000 Lane Ft Medium Severity	2	28	—	5
Centerline Cracking Ft/1,000 Ft of Joint Low Severity	182	8	1	5
Centerline Cracking Ft/1,000 Ft of Joint Medium Severity	1	—	—	
Centerline Cracking Ft/1,000 Ft of Joint High Severity	817	—	—	

These sections will be monitored over time to determine performance differences between different ABR levels and recycled materials. Construction cost savings and any environmental benefits from recycling must be accompanied by pavement performance similar to traditional mixes. Any differences will quickly erode any construction savings with time due to repairs and/or early pavement replacement.

CHAPTER 7 ADDITIONAL SUSTAINABILITY EFFORTS

In September 2013, IDOT chartered the Sustainability Committee to provide guidance to the Department on sustainability efforts. In 2013, the committee primarily focused on establishing their mission and direction.

In December 2013, IDOT expanded its cooperative agreement with the University of Illinois at Urbana-Champaign to include an effort on sustainability research.

CHAPTER 8 SUMMARY

The goal of this report was to provide a single source document for 2013 sustainability efforts in highway materials that serves to meet the reporting requirement of Illinois Public Act 097-0314.

- The Illinois Department of Transportation (IDOT) has made significant shifts in specifications, policies, and procedures that have greatly increased the recycled content of Illinois highways. This is evidenced by a fourfold increase in recycled content from 2009 to 2013 in the average mile of highway improved annually.
- Districts continue to identify unique ways in which more sustainable practices can be implemented, such as using wash water returned to concrete ready-mix plants in new mixes.
- Specific to reclaimed asphalt shingles (RAS), contractors made great strides in plant modifications to add bins, tanks, and other necessary modifications to use high asphalt binder replacement (ABR) mixes that may include RAS. The result was a 221% increase in RAS use in 2013.
- Warm-mix asphalt (WMA) is available to be used by contractors if they desire. IDOT has removed a significant barrier to the use of WMA technologies by means of a reciprocity process with other states. However, because of the direct cost of using WMA and the lack of a visible economic benefit, contractors have limited their use of WMA on IDOT projects as well as private work.
- More than 90% of the Hot Mix Asphalt (HMA) contractors reported that they are able to use the reclaimed asphalt pavement (RAP) they generate on their projects. Of the few contractors disposing of excess RAP, their excess totaled more than 30,000 t. Other contractors reported that the amount of RAP available for use was limited. Accordingly, there may be an opportunity to transport excess RAP to deficit areas rather than disposing of the material.
- A majority of contractors actively seek out higher specific gravity materials for use in HMA.
- Using RCM as an HMA aggregate source may have potential in large metropolitan areas where there is a supply of such material.
- IDOT has developed and deployed total recycle asphalt (TRA) through demonstration projects. TRA is a mixture which uses RAP, recycled concrete materials (RCM), slag, and RAS, but no newly mined aggregate. The mix allows up to 60% ABR, which is beyond the current limits for HMA specifications.
- For HMA plants that had been modified to produce high ABR mixes (typical modifications incorporate the ability to use fractionated reclaimed asphalt pavement (FRAP), RAS tanks for additional liquid asphalt grades, and/or related controls), no additional equipment or plant modifications were required for the construction of the TRA projects.
- Of the three TRA projects constructed, one project showed high severity distress at the centerline joint after one winter for 82% of the joint length. The other two TRA sections currently show only limited, low-severity distress at the centerline.
- Data showed that of the pre-existing transverse cracks and joints, 7 to 88% of these reflected through the TRA overlays on a per project basis after one winter.

- The amount of transverse cracking in the TRA overlays after one winter ranged from 50 to 460 linear feet per 1,000 lane feet, while the comparison section that utilized a traditional surface mix showed 149 linear feet per 1,000 lane feet. More study is needed to determine if rates are related to mix properties or the underlying pavement.
- The inclusion of a fracture energy test may improve the performance of mixes using high ABR. Research is currently underway looking at this approach.
- From the environmental analysis, it can be concluded that ABR mixes can indeed reduce energy consumption and related emissions compared with traditional mixes. In general, as ABR increases in the mixes, corresponding energy and emissions are reduced. The TRA mixes used in this study tend to be heavier because they include steel slag, and they may produce lower energy savings because they require more materials and processing. However, when even the lowest ABR is incorporated and multiplied over a road network, the environmental benefits when using ABR and TRA mixes can be significant as long as performance of the road in which these mixes are used does not deteriorate any faster than the mixes without recycled material. Therefore, to capture the true savings over the life cycle of a pavement, pavement life should also be considered in the environmental calculations.
- Further environmental studies could consider the effect of various raw material hauling distances. As hauling distances for virgin materials are decreased and hauling distances for recycled materials are increased, it is anticipated that there will be an optimal percentage of ABR which, if exceeded, may actually increase the environmental impacts of the mixes using recycled contents.
- In the past few years, a number of unique mixes have been introduced into the pavement inventory in an effort to improve sustainability; however, a truly sustainable pavement is one that provides long-term, low-maintenance performance. There exist a number of pavements constructed with and without RAS and with low and high ABR, as well as those that used WMA. It would be possible to develop datasets to determine the performance of these various pavement groups with time.
- IDOT continues to strive to increase sustainable practices through internal committees and cooperative research efforts with the University of Illinois at Urbana-Champaign.

REFERENCES

Bonaquist, R., Christensen, D., and Stump, W., 2003. "Simple performance tester for Superpave mix design." First-article development and evaluation. NCHRP Report No. 513, Transportation Research Board, Washington, DC.

Braham, A., Zofka, A., Li, X., and Ni, F., 2011. "Exploring the reduction of laboratory testing for the cohesive zone model for asphalt concrete." International Journal of Pavement Engineering 13(4):350–359.

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

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

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

Carpenter, S.H., 2007. "Dynamic modulus performance of IDOT mixtures." Report No. FHWA-ICT-07-007. Illinois Center for Transportation, University of Illinois at Urbana-Champaign, Rantoul, IL.

Franklin Associates, 2001. "A Life cycle Inventory for Road and Roofing Asphalt." Athena Institute, Ottawa, Ontario, Canada.

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

Illinois Department of Transportation, 2013. For the Record 2013, Fiscal Year 2013, Highway Improvement Awards, Springfield, Illinois, Illinois Department of Transportation.

Illinois Department of Transportation, August 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, Illinois, Illinois Department of Transportation, Bureau of Materials and Physical Research.

Illinois Department of Transportation, January 1, 2007. Article 1030.04 (c), Standard Specifications for Road and Bridge Construction.

Illinois Department of Transportation, January 1, 2012. Standard Specifications for Road and Bridge Construction.

Illinois Department of Transportation, March 2001. 2000 Interstate Surface Quality – An Analysis of International Roughness Index and Rut Depths on Illinois Interstate Pavements. Illinois Department of Transportation, Bureau of Materials and Physical Research.

Illinois Department of Transportation, May 2012, Bureau of Materials and Physical Research, Pavement Distress Manual.

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

Kang, S., Yang, R., Ozer, H., & Al-Qadi, I. L., 2014. Life-cycle greenhouse gases and energy consumption for material and construction phases of pavement with traffic delay. The Journal of Transportation Research Record, Transportation Research Board of the National Academies, In Press (217).

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

Marceau, M. L., Nisbet, M. A., and Vangeem, M. G., 2007. "Life cycle Inventory of Portland Cement Concrete." No. SN2011, Portland Cement Association, Skokie, Illinois.

Ozer, H., Al-Qadi, I.L., and Kanaan, A. 2012. "Laboratory evaluation of high asphalt binder replacement with recycled asphalt shingles (RAS) for a low N-design asphalt mixture." Report No. FHWA-ICT-12-018. Illinois Center for Transportation, University of Illinois at Urbana-Champaign, Rantoul, IL.

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

Schutzbach, A. M., February 1993. Recycling Old PCC Pavement – Performance Evaluation of FAI 57 Inlays. Physical Research Report No. 113, Springfield, Illinois, Illinois Department of Transportation, Bureau of Materials and Physical Research.

Stripple, H. , 2001. Life Cycle Assessment of Road: A Pilot Study for Inventory Analysis (No. B 1210 E) (Second.). Gothenburg, Sweden.

U. S. Environmental Protection Agency (2004). "AP-42 Compilation of Air Pollutant Emission Factors." Retrieved from http://epa.gov/ttn/chief/ap42/ch11/final/c11s01.pdf .

Vavrik, W.R., Carpenter, S.H., Gillen, S., Behnke, J., and Garrott, F. 2008. "Evaluation of field-produced hot mix asphalt (HMA) mixtures with fractionated recycled asphalt pavement (RAP): 2007 Illinois Tollway field mix trials." Report ICT-08-030. Illinois Center for Transportation, University of Illinois at Urbana-Champaign, Rantoul, IL.

Zapata, P., and J. Gambatese (2005). "Energy Consumption of Asphalt and Reinforced Concrete Pavement Materials and Construction." Journal of Infrastructure Systems, Vol. 11, pp. 9-20.

APPENDIX A 2013 UTILIZED RECYCLED AND RECLAIMED MATERIALS QUANTITIES AND EQUIVALENT VALUES

MATERIAL	UNIT EQUIVALENT VALUE	QUANTITY[1]	TOTAL EQUIVALENT VALUE TO DEPARTMENT
AIR-COOLED BLAST FURNACE SLAG	$9.90	7,091	$70,201
BY-PRODUCT LIME	$40/TON	5,670	$226,800
CRUMB RUBBER[2]	$0.21/LB	94,049	$19,750
FLY ASH	$20/TON	80,440	$1,608,800
GLASS BEADS[3]	$0.248/LB	12,256,200	$3,039,538
GROUND GRANULATED BLAST FURNACE SLAG	$65/TON	15,045	$977,925
MICROSILICA	$480/TON	7	$3,360
RECLAIMED ASPHALT PAVEMENT USED FOR HMA	$33.10/TON	782,171	$25,889,860
RECLAIMED ASPHALT PAVEMENT USED FOR AGGREGATE	$7.50/TON	181,825	$1,363,688
RECLAIMED ASPHALT SHINGLES[4]	$42.50/TON	39,791	$1,691,118
RECYCLED CONCRETE MATERIAL	$7.50/TON	491,835	$3,688,763
STEEL REINFORCEMENT[5]	$996/TON	18,295	$18,221,820
STEEL SLAG	$19.00/TON	84,951	$1,614,069
WET-BOTTOM BOILER SLAG[6]	N/A	-	
GRAND TOTALS (TONS)		1,713,296	$58,415,692

[1] Quantities were calculated as the total amount assigned to projects in Calendar Year 2013. Prior to summation of values, metric values were converted to English values using the conversion factors located in Appendix B of the *Standard Specifications for Road and Bridge Construction.*

[2] CRUMB RUBBER: This material quantity was calculated as 5 percent of the quantity of hot-poured joint sealant used in 2013.

[3] GLASS BEADS usage is based on tested and approved quantities and not projects assigned through MISTIC.

[4] RECLAIMED ASPHALT SHINGLE quantities are from survey of contractor records and not projects assigned through MISTIC.

[5] STEEL REINFORCEMENT: Past reports separated dowel bars, rebar, and welded wire reinforcement. Dowel bars and rebar are epoxy coated the majority of the time and the related cost with epoxy coating was used to calculate values in the 2012 report. For this report, the IDOT monthly steel index was averaged for the year 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.

[6] WET-BOTTOM BOILER SLAG: No records were found in MISTIC that indicated WBBS was used for any IDOT projects in 2013.

APPENDIX B DISTRICT RECYCLING SPECIAL PROVISIONS

APPENDIX B1

COARSE AGGREGATE FOR BACKFILL, TRENCH BACKFILL AND BEDDING (D-1)

Effective: November 1, 2011

Revised: November 1, 2013

This work shall be according to Section 1004.05 of the Standard Specifications except for the following:

Reclaimed Asphalt Pavement (RAP) maybe blended with gravel, crushed gravel, crushed stone crushed concrete, crushed slag, chats, crushed sand stone or wet bottom boiler slag. The RAP used shall be according to the current Bureau of Materials and Physical Research Policy Memorandum, “Reclaimed Asphalt Pavement (RAP) for Aggregate Applications”. The RAP shall be uniformly graded and shall pass the 1.0 in. (25 mm) screen. When RAP is blended with any of the coarse aggregate listed above, the blending shall be done mechanically with calibrated feeders. The feeders shall have an accuracy of $\pm$ 2.0 percent of the actual quantity of material delivered. The final blended product shall not contain more than 40 percent by weight RAP.

The coarse aggregate listed above shall meet CA 6 and CA 10 gradations prior to being blended with the processed and uniformly graded RAP. Gradation deleterious count shall not exceed 10% of total RAP and 5% of other by total weight.

APPENDIX B2

GROUND TIRE RUBBER (GTR) MODIFIED ASPHALT BINDER (D-1)

Effective: June 26, 2006

Revised: January 1, 2013

Add the following to the end of article 1032.05 of the Standard Specifications:

> “(c) Ground Tire Rubber (GTR) Modified Asphalt Binder. A quantity of 10.0 to 14.0 percent GTR (Note 1) shall be blended by dry unit weight with a PG 64-28 to make a GTR 70-28 or a PG 58-28 to make a GTR 64-28. The base PG 64-28 and PG 58-28 asphalt binders shall meet the requirements of Article 1032.05(a). Compatible polymers may be added during production. The GTR modified asphalt binder shall meet the requirements of the following table.

Test	Asphalt Grade GTR 70-28	Asphalt Grade GTR 64-28
Flash Point (C.O.C.), AASHTO T 48, °F (°C), min.	450 (232)	450 (232)
Rotational Viscosity, AASHTO T 316 @ 275 °F (135 °C), Poises, Pa·s, max.	30 (3)	30 (3)
Softening Point, AASHTO T 53, °F (°C), min.	135 (57)	130 (54)
Elastic Recovery, ASTM D 6084, Procedure A (sieve waived) @ 77 °F, (25 °C), aged, ss, 100 mm elongation, 5 cm/min., cut immediately, %, min.	65	65

Note 1. GTR shall be produced from processing automobile and/or light truck tires by the ambient grinding method. GTR shall not exceed 1/16 in. (2 mm) in any dimension and shall contain no free metal particles or other materials. A mineral powder (such as talc) meeting the requirements of AASHTO M 17 may be added, up to a maximum of four percent by weight of GTR to reduce sticking and caking of the GTR particles. When tested in accordance with Illinois modified AASHTO T 27, *a* 50 g sample of the GTR shall conform to the following gradation requirements:

Sieve Size	Percent Passing
No. 16 (1.18 mm)	100
No. 30 (600 μm)	95 ± 5
No. 50 (300 μm)	> 20

Add the following to the end of Note 1. of article 1030.03 of the Standard Specifications:

“A dedicated storage tank for the Ground Tire Rubber (GTR) modified asphalt binder shall be provided. This tank must be capable of providing continuous mechanical mixing throughout by continuous agitation and recirculation of the asphalt binder to provide a uniform mixture. The tank shall be heated and capable of maintaining the temperature of the asphalt binder at 300 °F to 350 °F (149 °C to 177 °C). The asphalt binder metering systems of dryer drum plants shall be calibrated with the actual GTR modified asphalt binder material with an accuracy of ± 0.40 percent.”

Revise 1030.02(c) of the Standard Specifications to read:

“(c) RAP Materials (Note 3) ……………………………………..…..1031”

Add the following note to 1030.02 of the Standard Specifications:

Note 3. When using reclaimed asphalt pavement and/or reclaimed asphalt shingles, the maximum asphalt binder replacement percentage shall be according to the most recent special provision for recycled materials.

APPENDIX B3

RECLAIMED WATER (D-1)

Effective: December 1, 2013

General. This specification covers the blending, testing, storing, use of and requirements for reclaimed water in Portland cement concrete.

Material. Reclaimed water shall consist of wash out, runoff, and/or storm water that has been combined with water conforming to Article 1002.01. Reclaimed water meeting the quality requirements of this specification shall be evaluated for acceptance by the Department.

Use. Reclaimed water will only be allowed in Class PV and SI concrete mix designs at a maximum of 20.0% total by weight. Reclaimed water is prohibited in all other concrete class mix designs. This material will only be allowed in work without reinforcing steel only. Dowel bars and tie bars are not considered reinforcing steel.

Reclaimed water shall be weighed or metered separately from water conforming to Article 1002.01 and shall be detailed separately on batch sheets used to document concrete batch weights.

Quality. The reclaimed water shall be clean, clear, and free from sugar. Reclaimed water shall be combined at a 1:4 ratio with water conforming to Article 1002.01 and the combination shall be according to Article 1002.02 except for the following:

> “(2) Alkalinity -- 0.1 Normal HCl.. 60 ml max.*
>
> *To neutralize 200 ml sample.”

Water Intake. Reclaimed water shall enter a settling pond before being filtered to remove the necessary amount of solids to meet specifications in Article 1002.02. The intake of the pipeline shall be at a minimum height of 2 ft (600 m) above the bottom of the reclaimed water settling pond. A properly labeled tank shall be provided for storage of the reclaimed water. The tank is to be separate from water which has been approved by the Illinois Department of Public Health for drinking or household use. The tank may be heated, however the maximum water temperature of the reclaimed water shall not exceed 150 ˚F (65 ˚C).

Quality Control and Quality Assurance (QC/QA).

(a) Quality Control by Contractor. The Contractor shall provide evidence to assure conformance to the standards stated in Article 1002.02 (a) and (b). The Engineer shall be immediately notified of any failing tests and subsequent remedial action. Inability to maintain the reclaimed water within specifications is cause for the Engineer to suspend the use of reclaimed water in concrete until adjustments have been made and the water is within the specifications.

    Water samples will be taken on the same date and sampled as follows: three liters from the tank containing water that conforms to Art. 1002.01 and three liters from the filtered tank. Both samples must be submitted to the Department for testing every 4 months and when requested by the Engineer. A state representative must witness the sampling. The results from these samples shall serve as a check to the data provided by the contractor.

One Trial Batch per proposed mix design is required to verify minimum strengths can be achieved as defined in Article 1020.04 of the Standard Provision.

(b) Quality Assurance by the Engineer. The Engineer will conduct independent assurance tests on split samples taken by the Contractor for quality control testing.

(c) Documentation. The Contractor shall be responsible for documenting all test results. Records of testing shall be kept for a minimum of three years. The Contractor shall provide the Engineer full access to all documents.

APPENDIX B4

PAVEMENT REHABILITATION BY HOT IN-PLACE RECYCLING

Effective: July 11, 2003

Revised: ~~January 1, 2012~~ May 5, 2014

Description: This work shall consist of rehabilitating an HMA pavement surface by heating, scarifying using flexible tines for a specified depth, rejuvenating, remixing, reshaping, screeding, and recompacting the existing surface. The completed, recycled mat is to serve as the leveling surface.

CONSTRUCTION REQUIREMENTS

General: The Department may conduct some advanced testing, to determine the asphalt cement content (AC) in the existing pavement. The Engineer may make available to the Contractor the results of advanced testing.

The entire surface to be rehabilitated shall be free of water, earth, and foreign material. All base failures shall be repaired prior to the hot in-place recycling according to Section 358. All raised reflective pavement markers and thermoplastic pavement markings shall be removed, prior to the recycling operation. Recycling work shall be performed only when the temperature in the shade is at least 45 ºF (7 ºC) and the forecast are for rising temperatures.

Equipment and Construction Requirements: The surface of the existing pavement shall be heated with continuously moving radiant type heater(s) to allow the pavement to be scarified, without fracturing of aggregate. The pavement shall be scarified to a minimum depth of 3/4 inch (20 mm). This will yield ~~an~~ approximately a weight of 9 lb/sq ft (48 kg/sq m) of loose material. Heat shall be applied under an enclosed or shielded hood and shall extend at least 6 inches (150 mm) beyond the width of recycling on both sides. After heating, the scarification shall dislodge but not fracture aggregate to the specified depth. The heating and scarification operation shall not exceed a forward speed of 25 ft (8 m) per minute. When a recycling pass is being made adjacent to a previously recycled mat, the longitudinal recycling seam shall extend at least 4 inches (100 mm) into the previously recycled mat.

A rejuvenating agent, approved by the Department, shall be applied at the rate of 0.10 gal/sq yd (0.5 L/sq m) either before the scarification or into the mixing device. The rate of application shall be automated to maintain the specified application rate in relation to the operating speed of the recycling machine. The machine shall include equipment and instrumentation to monitor and report the rate of application of the rejuvenating agent. The Engineer will verify the application rate of the rejuvenating agent and shall verify the amount of gallons (liters) used. The Engineer may adjust the rate of the rejuvenating agent if the existing pavement condition warrants.

Immediately after scarifying and mixing, the mixture shall be leveled. The spreading and finishing section of the recycling machine shall be capable of spreading and finishing the surface in lane widths. The screed shall effectively produce a uniform finished surface without tearing, shoving, or gouging of the mix.

The process, either with individual machines or with a self-contained recycling machine shall protect or supplement the heat of the mixture to provide mixture behind the screed with a minimum temperature range of 220 to 320 ºF (105 to 160 ºC). The mixture shall be compacted by a pneumatic roller for breakdown meeting requirements of Article 1101.01(c) and finish roller meeting requirement of Article 1101.01(e). The density of the finished surface shall be to the satisfaction of The Engineer.

Determination of the actual depth and weight of milled surface shall be as follows:

At locations determined by The Engineer, a ring test shall be performed, by the contractor and witnessed by The Engineer, directly behind the recycling paving train, and before the breakdown roller has passed the specified location.

A metal ring of known internal area (1 sq ft (0.1 sq m) suggested), and with sufficient rigidity to penetrate the loosened material shall then be pushed into the loosened mat.

The loosened material within the ring shall be removed with a small scoop and a brush.

The removed material shall be weighed, and the pounds per square foot (kilograms per square meter) of recycled material shall be calculated.

This process shall be performed on site for each 1/4 mile (0.4 km) of each lane.

Once a ring test is determined, the material shall be replaced and the test area shall be struck level before any roller passes.

Should a ring test yield less than 9 lb/sq ft (44 kg/sq m) the contractor shall take cores at locations determined by The Engineer, to determine the recycled mat thickness.

The Engineer may, and the Contractor shall monitor the recycling thickness on an ongoing basis by probing or by other means. If at any time the required recycling ~~thickens~~ thickness is not being met, the contractor shall take corrective actions. If the variation from the target recycling thickness and/or mixture properties is excessive or goes uncorrected, the Engineer reserves the right to suspend operations until the probable cause(s) of the deficiencies are corrected.

Method of Measurement. The recycling process will be measured for payment in place and the area computed in square yards (square meters). The rejuvenating agent will be measured for payment in gallons (liters) in accordance with the applicable portions of Section 1032.

All thermoplastic pavement marking removal and raised reflective pavement marker removal will be measured and paid for according to Section 703 or Section 783.

Basis of Payment. This work will be paid for at the contract unit price per square yard (square meter) for HOT IN-PLACE RECYCLING and per gallon (liter) for ASPHALT REJUVENATING AGENT.

APPENDIX B5

AGGREGATE SUBGRADE IMPROVEMENT (D-1)

Effective: February 22, 2012

Revised: November 1, 2013 ~~January 1, 2013~~

Add the following Section to the Standard Specifications:

“**SECTION 303. AGGREGATE SUBGRADE IMPROVEMENT**

303.01 Description. This work shall consist of constructing an aggregate subgrade improvement.

303.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Coarse Aggregate	1004~~.06~~
(b) Reclaimed Asphalt Pavement (RAP) (Notes 1, 2 and 3)	1031

Note 1. Crushed RAP, from either full depth or single lift removal, may be mechanically blended with aggregate gradations CS 01 or CS 02 but shall not exceed 40 percent of the total product. The top size of the Coarse RAP shall be less than 4 in. (100 mm) and well graded.

Note 2. RAP having 100 percent passing the 1 1/2 in. (37.5 mm) sieve and being well graded, may be used as capping aggregate in the top 3 in. (75 mm) when aggregate gradations CS 01 or CS 02 are used in lower lifts. When RAP is blended with any of the coarse aggregates, the blending shall be done with mechanically calibrated feeders.

Note 3. The RAP used for aggregate subgrade improvement shall be according to the current Bureau of Materials and Physical Research Policy Memorandum, “Reclaimed Asphalt Pavement (RAP) for Aggregate Applications”.

303.03 Equipment. The vibratory machine shall be according to Article 1101.01, or as approved by the Engineer.

303.04 Soil Preparation. The stability of the soil shall be according to the Department’s Subgrade Stability Manual for the aggregate thickness specified.

303.05 Placing Aggregate. The maximum nominal lift thickness of aggregate gradations CS 01 or CS 02 shall be 24 in. (600 mm).

303.06 Capping Aggregate. The top surface of the aggregate subgrade shall consist of a minimum 3 in. (75 mm) of aggregate gradations CA 06 or CA 10. When Reclaimed Asphalt Pavement (RAP) is used, it shall be crushed and screened where 100 percent is passing the 1 1/2 in. (37.5 mm) sieve and being well graded. RAP that has been fractionated to size will not be permitted for use in capping. Capping aggregate will not be required when the aggregate subgrade improvement is used as a cubic yard pay item for undercut applications. When RAP is blended with any of the coarse aggregates, the blending shall be done with mechanically calibrated feeders.

303.07 Compaction. All aggregate lifts shall be compacted to the satisfaction of the Engineer. If the moisture content of the material is such that compaction cannot be obtained, sufficient water shall be added so that satisfactory compaction can be obtained.

303.08 Finishing and Maintenance of Aggregate Subgrade Improvement. The aggregate **subgrade** improvement shall be finished to the lines, grades, and cross sections shown on the plans, or as directed by the Engineer. The aggregate subgrade improvement shall be maintained in a smooth and compacted condition.

303.09 Method of Measurement. This work will be measured for payment according to Article 311.08.

303.10 Basis of Payment. This work will be paid for at the contract unit price per cubic yard (cubic **meter**) for AGGREGATE SUBGRADE IMPROVEMENT or at the contract unit price per square yard (square meter) for AGGREGATE SUBGRADE IMPROVEMENT, of the thickness specified.

Add the following to Section 1004 of the Standard Specifications:

"**1004.06 Coarse Aggregate for Aggregate Subgrade Improvement.** The aggregate shall be according to Article 1004.01 and the following.

(a) Description. The coarse aggregate shall be crushed gravel, crushed stone, or crushed concrete.

(b) Quality. The coarse aggregate shall consist of sound durable particles reasonably free of deleterious materials.

(c) Gradation.

(1) ~~The coarse aggregate gradation for total subgrade thickness less than or equal to 12 in. (300 mm) shall be CS 02.~~ The coarse aggregate gradation for total subgrade thicknesses of ~~more than~~ 12 in. (300 mm) or greater shall be CS 01 or CS 02.

(2)

	COARSE AGGREGATE SUBGRADE GRADATIONS Sieve Size and Percent Passing				
Grad No.	8”	6”	4”	2”	#4
CS 01	100	97 ± 3	90 ± 10	45 ± 25	20 ± 20
CS 02		100	80 ± 10	25 ± 15	

	COARSE AGGREGATE SUBGRADE GRADATIONS (Metric)				
	Sieve Size and Percent Passing				
Grad No.	200 mm	150 mm	100 mm	50 mm	4.75 mm
CS 01	100	97 ± 3	90 ± 10	45 ± 25	20 ± 20
CS 02		100	80 ± 10	25 ± 15	

(3) The 3 in. (75 mm) capping aggregate shall be gradation CA 6 or CA 10.

(4) Gradation deleterious count shall not exceed 10% of total RAP and 5% of other by total weight.”

APPENDIX B6

RECLAIMED ASPHALT PAVEMENT AND RECLAIMED ASPHALT SHINGLES (D-1)

Effective: November 1, 2012

Revise: January 1, 2013

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 by 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 Bureau of Materials and Physical Research Policy Memorandum "Reclaimed Asphalt Shingle (RAS) Sources", by weight of RAS. All RAS used shall come from a Bureau of Materials and Physical Research 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. No additional RAP shall be added to the pile after the pile has been sealed. Stockpiles shall be sufficiently separated to prevent intermingling at the base. All stockpiles (including unprocessed RAP and Processed 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, Superpave 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 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 mix the RAP will be used in.

(2) Restricted FRAP (B quality) stockpiles shall consist of RAP from Class I, Superpave (High ESAL), or HMA (High ESAL). If approved by the Engineer, the aggregate from a maximum 3.0 inch 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, Superpave 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 Superpave (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/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. The Contractor shall construct individual, sealed RAS stockpiles meeting one of the following definitions. No additional RAS shall be added to the pile after the pile has been sealed. 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. RAP/FRAP and RAS testing shall be according to the following.

(a) RAP/FRAP Testing. When used in HMA, the RAP/FRAP shall be sampled and tested either during processing or after stockpiling.

(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) 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 whether RAP or 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 either during or after stockpiling.

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 s 1000 ton (900 metric ton), five-sample/test stockpile has been established it shall be sealed. Additional incoming RAS shall be stockpiled 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.

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.

1031.03 Evaluation of Tests. Evaluation of tests results shall be according to the following.

(a) Evaluation of RAP/FRAP Test Results. All of the extraction results shall be compiled and averaged for asphalt binder content and gradation and, when applicable (for slag) Gmm. Individual extraction test results, when compared to the averages, will be accepted if within the tolerances listed below.

Parameter	RAP or FRAP	Conglomerate "D" Quality RAP
1 in. (25 mm)		± 5 %
1/2 in. (12.5 mm)	± 8 %	± 15 %
No. 4 (4.75 mm)	± 6 %	± 13 %
No. 8 (2.36 mm)	± 5 %	
No. 16 (1.18 mm)		± 15 %
No. 30 (600 um)	± 5 %	
No. 200 (75 um)	± 2.0 %	± 4.0 %
Asphalt Binder	± 0.4 % [1/]	± 0.5 %
Gmm	± 0.03 [2/]	

1/ The tolerance for FRAP shall be ± 0.3 %.
2/ For slag and steel slag

If more than 20 percent of the individual sieves and/or asphalt binder content tests are out of the above tolerances, the RAP/FRAP shall not be used in HMA unless the RAP/FRAP representing the failing tests is removed from the stockpile. All test data and acceptance ranges shall be sent to the District for evaluation.

With the approval of the Engineer, the ignition oven may be substituted for extractions according to the Illinois Test Procedure, "Calibration of the Ignition Oven for the Purpose of Characterizing Reclaimed Asphalt Pavement (RAP)".

(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. Individual test results, when compared to the averages, 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)	± 2.0 %
Asphalt Binder Content	± 1.5 %

If more than 20 percent of the individual sieves and/or asphalt binder content tests are out of the above tolerances, the RAS shall not be used in Department projects unless the RAS, RAP or FRAP representing the failing tests is removed from the stockpile. All test data and acceptance ranges shall be sent to the District for evaluation.

1031.05 Quality Designation of Aggregate in RAP/FRAP.

(a) RAP. The aggregate quality of the RAP for homogenous, 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, Superpave (High ESAL)/HMA (High ESAL), or (Low ESAL) IL- 9.5L surface mixtures are designated as containing Class B quality coarse aggregate.

(2) RAP from Superpave (High ESAL)/HMA (Low ESAL) IL-19.0L binder mixture is designated as Class D quality coarse aggregate.

(3) RAP from Class I, Superpave (High ESAL)/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 prequalified by the Department for the specified testing. The consultant 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 BMPR Aggregate Lab for MicroDeval Testing, according to Illinois Modified AASHTO T 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 RAS, RAP or FRAP in HMA. The use of RAS, RAP or FRAP shall be a Contractor's option when constructing HMA in all contracts.

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

(1) Coarse Aggregate Size (after extraction). The coarse aggregate in all RAP shall be equal to or less than the nominal maximum size requirement for the HMA mixture to be produced.

(2) Steel Slag Stockpiles. RAP/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). RAP/FRAP stockpiles for use in HMA surface mixtures (High and Low ESAL) shall have coarse aggregate that is Class B quality or better. RAP/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. RAP/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. RAP/FRAP stockpiles for use in HMA shoulders and stabilized subbase (HMA) shall be RAP, 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) RAP/FRAP and/or RAS Usage Limits. Type 1 or Type 2 RAS may be used alone or in conjunction with RAP or FRAP in HMA mixtures up to a maximum of 5.0% by weight of the total mix.

When the Contractor chooses the RAP option, the percentage of the percentage of virgin asphalt binder replaced by the asphalt binder from the RAP shall not exceed the percentages indicated in the table below for a given N Design:

Max Asphalt Binder Replacement RAP Only
Table 1

HMA Mixtures 1/, 2/•	Maximum % Asphalt Binder replacement (ABR)		
Ndesign	Binder/Leveling Binder	Surface	Polymer Modified
30L	25	15	10
50	25	15	10
70	15	10	10
90	10	10	10
105	10	10	10
4.75 mm N-50			15
SMA N-80			10

1/ For HMA "All Other" (shoulder and stabilized subbase) N-30, the percent asphalt binder replacement shall not exceed 50% of the total asphalt binder in the mixture.

2/ When the asphalt binder replacement exceeds 15 percent, the high and low virgin asphalt binder grades shall each be reduced by one grade (i.e. 25 percent binder replacement would require a virgin asphalt binder grade of PG64-22 to be reduced to a PG58-28). When constructing full depth HMA and the ABR is less than 15 percent, the required virgin asphalt binder grade shall be PG64-28.

When the Contractor chooses either the RAS or FRAP option, the percent binder replacement shall not exceed the amounts indicated in the tables below for a given N Design.

Max Asphalt Binder Replacement RAS or FRAP
Table 2

HMA Mixtures [1/, 2/]	Level 1 - Maximum % ABR		
Ndesign	Binder/Leveling Binder	Surface	Polymer Modified [3/, 4/]
30L	35	30	15
50	30	25	15
70	30	20	15
90	20	15	15
105	20	15	15
4.75 mm N-50			25
SMA N-80			15

1/ For HMA "All Other" (shoulder and stabilized subbase) N-30, the percent asphalt binder replacement shall not exceed 50% of the total asphalt binder in the mixture.

2/ When the asphalt binder replacement exceeds 15 percent 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 percent binder replacement will require a virgin asphalt binder grade of PG64-22 to be reduced to a PG58- 28). When constructing full depth HMA and the ABR is less than 15 percent, the required virgin asphalt binder grade shall be PG64-28.

3/ When the ABR for SMA is 15 percent or less, the required virgin asphalt binder grade shall be SBS PG76-22.

4/ When the ABR for IL-4.75 mix is 15 percent or less, the required virgin asphalt binder grade shall be SBS PG76-22. When the ABR for the IL-4.75 mix exceeds 15 percent, the virgin asphalt binder grade shall be SBS PG70- 28.

When the Contractor chooses the RAS with FRAP combination, the percent asphalt binder replacement shall split equally between the RAS and the FRAP, and the total replacement shall not exceed the amounts indicated in the tables below for a given N Design.

Max Asphalt Binder Replacement RAS and FRAP Combination
Table 3

HMA Mixtures [1/, 2/]	Level 2 - Maximum % ABR		
Ndesign	Binder/Leveling Binder	Surface	Polymer Modified [3/, 4/]
30L	•		
50	50	40	30
70	40	35	30
90	40	30	30
105	40	30	30
4.75 mm N-50			40
SMA N-80			30

1/ For HMA "All Other" (shoulder and stabilized subbase) N-30, the percent asphalt binder replacement shall not exceed 50% of the total asphalt binder in the mixture.

2/ When the binder replacement exceeds 15 percent 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 percent binder replacement will require a virgin asphalt binder grade of PG64-22 to be reduced to a PG58-28).

3/ When the ABR for SMA is 15 percent or less, the required virgin asphalt binder shall be SBS PG76-22. When the ABR for SMA exceeds 15%, the virgin asphalt binder grade shall be SBS PG70-28.

4/ When the ABR for IL-4.75 mix is 15 percent or less, the required virgin asphalt binder grade shall be SBS PG76-22. When the ABR for the IL-4.75 mix exceeds 15 percent, the virgin asphalt binder grade shall be SBS PG70-28.

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

All HMA mixtures will be required to be tested, prior to submittal for Department verification, according to Illinois Modified AASHTO T324 (Hamburg Wheel) and shall meet the following requirements:

Asphalt Binder Grade	# Repetitions	Max Rut Depth (mm)
PG76-XX	20,000	12.5
PG70-XX	20,000	12.5
PG64-XX	10,000	12.5
PG58-XX	10,000	12.5
PG52-XX	10,000	12.5
PG46-XX	10,000	12.5

Note: For SMA Designs (N-80) the maximum rut depth is 6.0 mm at 20,000 repetitions. For IL 4.75 mm Designs (N-50) the maximum rut depth is 9.0 mm at 15,000 repetitions.

1031.08 HMA Production. All HMA mixtures shall be sampled within the first 500 tons (450 metric tons) on the first day of production or during start up with a split reserved for the, , Department. The mix sample shall be tested according to the Illinois Modified AASHTO T 324 and shall meet the requirements specified herein. Mix production shall not exceed 1500 tons (1350 metric tons) or one day's production, whichever comes first, until the testing is completed and the mixture is found to be in conformance. The requirement to cease mix production may be waived if the plant produced mixture demonstrates conformance prior to start of mix production for a contract.

To remove or reduce agglomerated material, a scalping screen, gator, crushing unit, or comparable sizing device approved by the Engineer shall be used in the RAS, RAP and FRAP feed system to remove or reduce oversized material. If material passing the sizing device adversely affects the mix production or quality of the mix, the sizing device shall be set at a size specified by the Engineer.

If the RAS, RAP and FRAP control tolerances or QC/QA test results require corrective action, the Contractor shall cease production of the mixture containing RAs, RAP or FRAP and either switch to the virgin aggregate design or submit a new RAS, RAP or FRAP design.

(a) RAP/FRAP. The coarse aggregate in all RAP/FRAP used shall be equal to or less than the 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. RAS, RAP and FRAP.HMA plants utilizing RAS, RAP and FRAP 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, RAP 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, RAP and FRAP material as a percent of the total mix to the nearest 0.1 percent.

h. Aggregate RAS, RAP and FRAP moisture compensators in percent as set on the control panel. (Required when accumulated or individual aggregate and RAS, RAP 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)

(2) Batch Plants.

b. Date, month, year, and time to the nearest minute for each print.

c. HMA mix number assigned by the Department.

d. Individual virgin aggregate hot bin batch weights to the nearest pound (kilogram).

e. Mineral filler weight to the nearest pound (kilogram).

f. RAS, RAP and FRAP weight to the nearest pound (kilogram).

g. Virgin asphalt binder weight to the nearest pound (kilogram).

h. Residual asphalt binder in the RAS, RAP 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 Shoulders. The use of RAP or FRAP 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 Article1031.03 shall not apply.

(b) Gradation. One hundred percent of the RAP material shall pass the 1 1/2 in. (37.Smm) sieve. The RAP material shall be reasonably well graded from coarse to fine. RAP material that is gap-graded, FRAP, or single sized will not be accepted for use as Aggregate Surface Course and Aggregate Shoulders."

APPENDIX B7

RECLAIMED ASPHALT PAVEMENT AND SHINGLES (D-4)

Effective: January 1, 2013

Revise Section 1031 of the Standard Specifications to read:

"**SECTION 1031. RECLAIMED ASPHALT PAVEMENT AND SHINGLES**

1031.01 Description. RAP is reclaimed asphalt pavement resulting from cold milling and crushing of 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.

RAS is reclaimed asphalt shingles resulting from the processing and grinding of either preconsumer or post consumer shingles.

RAS shall be a clean and uniform material with a maximum of 0.5 percent unacceptable materials, as defined in Bureau of Materials and Physical Research Policy (BMPR) Memorandum *Reclaimed Asphalt Shingle (RAS) Sources*, by weight of RAS. All RAS used shall come from a BMPR approved processing facility. All RAS shall be processed to 100 percent passing the 3/8" and a minimum of 90 percent passing the # 4 sieve.

RAS shall meet either Type 1 or Type 2 requirements as specified herein.

(a) Type 1. Type 1 RAS shall be processed, preconsumer asphalt shingles salvaged from the manufacture of residential asphalt roofing shingles.

(b) 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. The Contractor shall construct individual, sealed RAP or RAS stockpiles meeting one of the following definitions. No additional RAP or RAS shall be added to the pile after the pile has been sealed. Stockpiles shall be sufficiently separated to prevent intermingling at the base. All stockpiles (including unprocessed RAP and Processed FRAP) shall be identified by signs indicating the type as listed below (i.e. "crushed natural aggregate, ACBF and steel slag, crystalline structure or Type 2 RAS", etc…).

(a) Fractionated RAP (FRAP). FRAP shall consist of RAP from Class I, Superpave (High ESAL), HMA (High 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 (4.75mm) and ½ in. (12.5mm) 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 mix the RAP will be used in.

(b) Restricted FRAP (B quality) stockpiles shall consist of RAP from Class I, Superpave (High ESAL), or HMA (High ESAL). If approved by the Engineer, the aggregate from a maximum

3.0 inch 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.

(c) Conglomerate. Conglomerate RAP stockpiles shall consist of RAP from Class I, Superpave (High ESAL), HMA (High 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.

(d) Conglomerate “D” Quality (DQ). Conglomerate DQ RAP stockpiles shall consist of RAP from HMA shoulders, bituminous stabilized subbases or Superpave (Low ESAL)/HMA (Low ESAL) IL-19.0L binder mixture. The coarse aggregate in this RAP may be crushed or processed (FRAP DQ) 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.

(e) Non-Quality. RAP stockpiles that do not meet the requirements of the stockpile categories listed above shall be classified as “Non-Quality”.

RAP/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.

Type 1 and Type 2 RAS shall be stockpiled separately and shall not be intermingled. 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 shall be 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 3 years.

1031.03 Testing. When used in HMA, the RAS/RAP/FRAP shall be sampled and tested either during processing or after stockpiling.

(a) RAS shall be sampled and tested as follows:

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 ton (900 metric ton) thereafter. A minimum of five tests are required for stockpiles less than 1000 ton (900 metric ton). Once a ≤ 1000 ton, five-test stockpile has been established it shall be sealed. Additional incoming RAS shall be stockpiled 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.

All of the test results, with the exception of percent unacceptable materials, shall be compiled and averaged for asphalt binder content, and gradation. Individual test results, when compared to the averages, 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)	± 2.0 %
Asphalt Binder Content	± 1.5 %

(b) RAP/FRAP shall be sampled and tested as follows:

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).

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.

All of the RAP/FRAP extraction results shall be compiled and averaged for asphalt binder content and gradation and, when applicable (for slag) G_{mm}. Individual extraction test results, when compared to the averages, will be accepted if within the tolerances listed below.

Parameter	RAP or FRAP	Conglomerate “D” Quality RAP
1 in. (25 mm)		± 5 %
1/2 in. (12.5 mm)	± 8 %	± 15 %
No. 4 (4.75 mm)	± 6 %	± 13 %
No. 8 (2.36 mm)	± 5 %	
No. 16 (1.18 mm)		± 15 %
No. 30 (600 µm)	± 5 %	
No. 200 (75 µm)	± 2.0 %	± 4.0 %
Asphalt Binder	± 0.4 % 1/	± 0.5 %
G_{mm}	± 0.03 2/	

1/ The tolerance for FRAP shall be ± 0.3 %
2/ for slag and steel slag

Before extraction, each field sample whether, RAS, RAP or 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.

If more than 20 percent of the individual sieves are out of the gradation tolerances, or if more than 20 percent of the asphalt binder content test results fall outside the appropriate tolerances, the RAS, RAP or FRAP shall not be used in HMA unless the RAS, RAP or FRAP representing the failing tests is removed from the stockpile. All test data and acceptance ranges shall be sent to the District for evaluation.

With the approval of the Engineer, when testing for RAP or FRAP, the ignition oven may be substituted for extractions according to the Illinois Test Procedure, "Calibration of the Ignition Oven for the Purpose of Characterizing Reclaimed Asphalt Pavement (RAP)".

1031.04 Quality Designation of Aggregate in RAP/FRAP.

(a) The aggregate quality of the RAP, Fractionated RAP, Restricted FRAP, Conglomerate, and conglomerate "D" quality stockpiles shall be set by the lowest quality of coarse aggregate in the stockpile and are designated as follows:

   (1) RAP from Class I, Superpave (High ESAL)/HMA (High ESAL), or HMA (Low ESAL) IL-9.5L surface mixtures are designated as containing Class B quality coarse aggregate.

   (2) RAP from Superpave (Low ESAL)/HMA (Low ESAL) IL-19.0L binder mixture is designated as Class D quality coarse aggregate.

   (3) RAP from Class I, Superpave (High ESAL), or 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) The aggregate quality of FRAP shall be determined as follows.

   (1) 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 according to note (2) herein:

   (2) Fractionated RAP stockpiles containing plus #4 (4.75 mm) sieve coarse aggregate shall have a maximum tonnage of 5000 tons (4500 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 prequalified by the Department for the specified testing. The consultant 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 BMPR Aggregate Lab for MicroDeval Testing, according to Illinois Modified AASHTO T 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.

031.05 Use of RAS, RAP or FRAP in HMA. The use of RAS, RAP or FRAP shall be a Contractor’s option when constructing HMA in all contracts.

The use of RAS shall be as follows:

Type 1 or Type 2 RAS may be used alone or in conjunction with, Fractionated Reclaimed Asphalt Pavement (FRAP) or Reclaimed Asphalt Pavement (RAP), in all HMA mixtures up to a maximum of 5.0 percent by weight of total mix.

The use of RAP/FRAP shall be as follows:

(a) Coarse Aggregate Size (after extraction), the coarse aggregate in all RAP or FRAP shall be equal to or less than the maximum size requirement for the HMA mixture to be produced.

(b) Steel Slag Stockpiles. RAP/FRAP stockpiles containing steel slag or other expansive material, as determined by the Department, shall be homogeneous and will be approved for use in all HMA (High ESAL and Low ESAL) mixtures regardless of lift or mix type.

(c) Use in HMA Surface Mixtures (High and Low ESAL). RAP/FRAP and Restricted FRAP stockpiles for use in HMA surface mixtures (High and Low ESAL) shall in which the coarse aggregate is Class B quality or better. RAP/FRAP shall be considered equivalent to Limestone for frictional considerations unless produced/screened to minus 3/8 inch.

(d) Use in HMA Binder Mixtures (High and Low ESAL), HMA Base Course, and HMA Base Course Widening. RAP/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.

(e) Use in Shoulders and Subbase. RAP/FRAP stockpiles for use in HMA shoulders and stabilized sub base (HMA) shall RAP, Restricted FRAP, Conglomerate, or Conglomerate DQ.

When the Contractor chooses the RAP option, the percentage of virgin asphalt binder replaced by the asphalt binder from the RAP shall not exceed the percentages indicated in the table below for a given N Design:

Max Asphalt Binder Replacement RAP Only
Table 1

HMA Mixtures [1/, 2/]	Maximum % Asphalt Binder replacement (ABR)		
Ndesign	Binder/Leveling Binder	Surface	Polymer Modified
30L	25	15	10
50	25	15	10
70	15	10	10
90	10	10	10
105	10	10	10
4.75 MM N-50			15
SMA N-80			10

1/ For HMA “All Other” (shoulder and stabilized subbase) N-30, the percent asphalt binder replacement shall be up to 50% of the total asphalt binder in the mixture.

2/ When the asphalt binder replacement exceeds 15 percent, the high and low virgin asphalt binder grades shall each be reduced by one grade (i.e. 25 percent binder replacement would require a virgin asphalt binder grade of PG64-22 to be reduced to a PG58-28).

When the Contractor chooses either the RAS or FRAP option, the percent binder replacement shall not exceed the amounts indicated in the tables below for a given N Design.

Max Asphalt Binder Replacement RAS or FRAP
Table 2

HMA Mixtures [1/, 2/]	Level 1 - Maximum % ABR		
Ndesign	Binder/Leveling Binder	Surface	Polymer [3/, 4/] Modified
30L	35	30	15
50	30	25	15
70	30	20	15
90	20	15	15
105	20	15	15
4.75 MM N-50			25
SMA N-80			15

1/ For HMA “All Other” (shoulder and stabilized subbase) N-30, the percent asphalt binder replacement shall not exceed 50% of the total asphalt binder in the mixture.

2/ When the asphalt binder replacement exceeds 15 percent 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 percent binder replacement will require a virgin asphalt binder grade of PG64-22 to be reduced to a PG58-28).

3/ When the ABR for SMA is 15 percent or less the required virgin asphalt binder shall be SBS PG76-22.

4/ When the ABR for IL 4.75 mix is 15% or less the required virgin asphalt binder shall be SBS PG 76-22. When the ABR for the IL 4.75 is more than 15%, the virgin asphalt binder shall be SBS PG 70-28.

When the Contractor chooses the RAS with FRAP combination, the percent asphalt binder replacement shall split equally between the RAS and the FRAP, and the total replacement shall not exceed the amounts indicated in the tables below for a given N Design.

Max Asphalt Binder Replacement RAS and FRAP Combination
Table 3

HMA Mixtures [1/, 2/]	Level 2 - Maximum % ABR		
Ndesign	Binder/Leveling Binder	Surface	Polymer Modified [3/, 4/]
30L	50	40	30
50	40	35	30
70	40	30	30
90	40	30	30
105	40	30	30
4.75 MM N-50			40
SMA N-80			30

1/ For HMA "All Other" (shoulder and stabilized sub base) N-30, the percent asphalt binder replacement shall be up to 50% of the total asphalt binder in the mixture.

2/ When the binder replacement exceeds 15 percent 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 percent binder replacement will require a virgin asphalt binder grade of PG64-22 to be reduced to a PG58-28).

3/ When the ABR for SMA is 15 percent or less the required virgin asphalt binder shall be SBS PG76-22. When the ABR for SMA exceeds 15%, the virgin asphalt binder grade shall be SBS PG70-28.

4/ When the ABR for IL 4.75 mix is 15% or less the required virgin asphalt binder shall be SBS PG 76-22. When the ABR for the IL 4.75 is more than 15%, the virgin asphalt binder shall be SBS PG 70-28.

1031.06 HMA Mix Designs. All HMA mixtures will be required to be tested, prior to submittal for Department verification, According to Illinois Modified AASHTO T324 (Hamburg Wheel) and shall meet the following requirements:

Asphalt Binder Grade	# Repetitions	Max Rut Depth (mm)
PG76-XX	20,000	12.5
PG70-XX	15,000	12.5
PG64-XX	10,000	12.5
PG58-XX	10,000	12.5

Note: For SMA Designs (N-80) the maximum rut depth is 6.0 mm at 20,000 repetitions.
For IL 4.75 mm Designs (N-50) the maximum rut depth is 9.0 mm at 15,000 repetitions.

1031.07 HMA Production. All HMA mixtures shall be sampled within the first 500 tons on the first day of production or during start up, with a split reserved for the Department. The mix sample shall be tested according to Illinois Modified AASHTO T324 and shall meet the requirements specified herein. The production of such mixture shall not exceed 1,500 tons or one day's production, which ever comes first, until the testing is completed and the mixture is found to be in conformance. The requirement to cease mix production may be waived if the plant produced mixture is demonstrated prior to start of mix production for the contract.

To remove or reduce agglomerated material, a scalping screen, gator, crushing unit, or comparable sizing device approved by the Engineer shall be used in the RAS, RAP and FRAP feed system to remove or reduce oversized material. If material passing the sizing device adversely affects the mix production or quality of the mix, the sizing device shall be set at a size specified by the Engineer.

If the RAS, RAP and FRAP control tolerances or QC/QA test results require corrective action, the Contractor shall cease production of the mixture containing RAs, RAP or FRAP and either switch to the virgin aggregate design or submit a new RAS, RAP or FRAP design.

HMA plants utilizing RAS, RAP and FRAP shall be capable of automatically recording and printing the following information.

(a) Dryer Drum Plants.

(1) Date, month, year, and time to the nearest minute for each print.

(2) HMA mix number assigned by the Department.

(3) Accumulated weight of dry aggregate (combined or individual) in tons (metric tons) to the nearest 0.1 ton (0.1 metric ton).

(4) Accumulated dry weight of RAS, RAP and FRAP in tons (metric tons) to the nearest 0.1 ton (0.1 metric ton).

(5) Accumulated mineral filler in revolutions, tons (metric tons), etc. to the nearest 0.1 unit.

(6) Accumulated asphalt binder in gallons (liters), tons (metric tons), etc. to the nearest 0.1 unit.

(7) Residual asphalt binder in the RAS, RAP and FRAP material as a percent of the total mix to the nearest 0.1 percent.

(8) When producing mixtures with FRAP and/or RAS, a positive dust control system shall be utilized.

(9) Accumulated mixture tonnage.

(10) Dust removed (accumulated to the nearest 0.1ton)

(11) Aggregate RAS, RAP and FRAP moisture compensators in percent as set on the control panel. (Required when accumulated or individual aggregate and RAS, RAP FRAP are printed in wet condition.)

(b) Batch Plants.

(1) Date, month, year, and time to the nearest minute for each print.

(2) HMA mix number assigned by the Department.

(3) Individual virgin aggregate hot bin batch weights to the nearest pound (kilogram).

(4) Mineral filler weight to the nearest pound (kilogram).

(5) RAS, RAP and FRAP weight to the nearest pound (kilogram).

(6) Virgin asphalt binder weight to the nearest pound (kilogram).

(7) Residual asphalt binder in the RAS, RAP and FRAP material as a percent of the total mix to the nearest 0.1 percent.

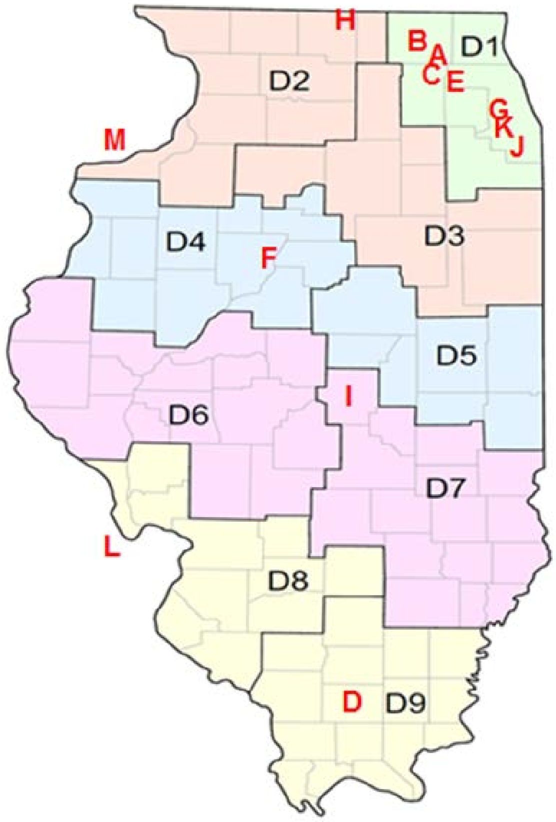
The printouts shall be maintained in a file at the plant for a minimum of one year or as directed by the Engineer and shall be made available upon request. The printing system will be inspected by the Engineer prior to production and verified at the beginning of each construction season thereafter.

1031.08 RAP in Aggregate Surface Course and Aggregate Shoulders. The use of RAP or FRAP 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.

(b) Gradation. One hundred percent of the RAP material shall pass the 1 1/2 in. (37.5mm) sieve. The RAP material shall be reasonably well graded from coarse to fine. RAP material that is gap-graded, FRAP, or single sized will not be accepted for use as Aggregate Surface Course and Aggregate Shoulders.”

APPENDIX C LOCATIONS OF RECLAIMED ASPHALT SHINGLE SOURCES IN ILLINOIS



Index to Map

Map Label	Source	Location
A	C&D Recycling of Wisconsin	Crystal Lake, IL
B	Falcon Green Resources	Woodstock, IL
C	Beverly Materials/Falcon	West Dundee, IL
D	Short Bros. Construction Co.	Marion, IL
E	Southwind RAS, LLC	Bartlett, IL
F	Southwind RAS, LLC	Peoria, IL
G	Southwind RAS, LLC	Lyons, IL
H	Southwind RAS, LLC	South Beloit, IL
I	Southwind RAS, LLC	Decatur, IL
J	Southwind RAS, LLC	Thornton, IL
K	Southwind RAS, LLC	McCook, IL
L	Hansen's RAS	O'Fallon, MO
M	Waste Commission of Scott County, IA	Davenport, IA

Source: http://www.dot.il.gov/materials/reclaimedasphaltshingles.pdf.

APPENDIX D ILLINOIS DEPARTMENT OF TRANSPORTATION HOT MIX ASPHALT QUESTIONNAIRE ON 2013 PRODUCTION

1. Has your company used RAS in a mix? Yes No
   If No please proceed to Question 6.

2. How would your company rate the gradation variability of the RAS product you receive with 0 being highly inconsistent and 5 being very consistent? 0..1..2..3..4..5

3. How likely are you to continue to use RAS in your HMA mixes in the future with 0 being unlikely and 5 being the highest extent possible? 0..1..2..3..4..5

4. For Local Agency work using local funds (non-State or Federal funded – not a five-digit contract) what would you estimate was your company's RAS tonnage use in 2013?

None under 500 501 to 2,000 2001 to 5,000 Over 5,000

5. For private non-governmental work what would you estimate was your company's RAS tonnage use in 2013?

None under 500 501 to 2,000 2001 to 5,000 Over 5,000

6. If your company is not using RAS in any mixes (public or private), please indicate reasons. Please circle all that apply. *If your company uses RAS go to Question 7.*

Haul Distance Not locally available Plant not set up to use
Quality of RAS concerns Economics
Other – Please Explain ____

7. How would your company rate IDOT's RAP/RAS/ABR specifications with 0 being very confusing and 5 being very straightforward? 0..1..2..3..4..5

8. Did your company use grade bumping to take advantage of higher ABR allowances in 2013? Yes No

9. If not, why? Please circle all that apply.

Failing Hamburg Wheel w/softer AC Limited tanks at facility Availability of softer PG grades

Other reason ____

10. Did your company landfill or dispose of RAP at a Clean Construction Demolition Debris (CCDD) disposal site in 2013? Yes No

If yes, what tonnage of RAP would you estimate?

Under 1,000 1,001 to 2,500 2,501 to 5,000 5,001 to 10,000 over 10,000

If yes, what type of RAP? Circle all that apply.

Steel Slag Surface Millings
Surface Millings (non-steel slag
Surface/Binder combined millings (non-steel slag)
Binder Millings
Surface/Binder combined millings with steel slag
RAP "contaminated" with soil, or other CCDD
Other please describe ____

11. For your company's operation, what are the main plant reasons more RAP is not used in your mixes? Circle all that apply.

Limitation of collar feed
Operation not set up to fractionate RAP
No plant issues
Additional feeder bins needed
Dryer capacity
Other – Please Explain ____

12. What are the specification limiting factors for your company with respect to increasing the amount of RAP/RAS and Fractionated RAP (FRAP)/RAS usage? Circle all that apply.

Table limits of ABR for RAP/RAS
Grade bumping
Hamburg Wheel Failure
Table limits of ABR for FRAP/RAS
Dust/AC Ratio limitation
Exceeding Max Tensile Strength limit
Other – Please Explain ____

13. Is your company producing WMA on private projects? Yes No

14. Is your company producing WMA on State let (five-digit contracts) projects? Yes No

If no to either 12 or 13 above, what are the reasons? Circle all that apply.

Cost of chemical additive
Equipment cost (water system)
Lack of cost savings or other benefit
Other – Please Explain ____

15. How would your company rate IDOT's Warm Mix Asphalt (WMA) specifications and the approved list of WMA technologies with 0 being very confusing and 5 being very straightforward? 0..1..2..3..4..5

16. With all things being equal (quality, cost, haul distance, etc.) what specific gravity properties of aggregates would you prefer?

High gravity Low gravity Gravity not a consideration
Other Comments: ____
Attach sheets if needed

QUESTIONNAIRE RESULTS

1. Has your company used RAS in a mix?

Yes:	19	**No:**	23	**Total Reponses:**	**42**

2. How would your company rate the gradation variability of the RAS product you receive with 0 being highly inconsistent and 5 being very consistent?

	Rating	Number Responses
	0	0
	1	0
	2	1
	3	5
	4	8
	5	3
Number		**17**
Average	**3.76**	

3. How likely are you to continue to use RAS in your HMA mixes in the future with 0 being unlikely and 5 being the highest extent possible?

	Rating	Number Responses
	0	0
	1	0
	2	0
	3	2
	4	7
	5	9
Number		**18**
Average	**4.39**	

4. For Local Agency work using local funds (non-State or Federal funded – not a five-digit contract) what would you estimate was your company's RAS tonnage use in 2013?

Answer	Number Responses
None	2
under 500	5
501 to 2,000	6
2001 to 5,000	1
Over 5,000	4
Total	**18**

5. For private non-governmental work what would you estimate was your company's RAS tonnage use in 2013?

Answer	Number Responses
None	3
under 500	5
501 to 2,000	7
2001 to 5,000	1
Over 5,000	2
Total	**18**

6. If your company is not using RAS in any mixes (public or private), please indicate reasons. Please circle all that apply. If your company uses RAS go to Question 7.

Answer	Number Responses
Haul Distance	4
Not locally available	4
Plant not set up to use	19
Quality of RAS concerns	3
Economics	13

Other reasons – Please Explain

Future Capital Expenditure Pending	1
Concerned about premature cracking	1
Health hazard/shingle mix performance questionable	1
RAS is too expensive to purchase	1
Only Tollway	1
No cost benefit over RAP or FRAP	1
Getting Designs implemented	1

7. How would your company rate IDOT's RAP/RAS/ABR specifications with 0 being very confusing and 5 being very straightforward?

	Rating	Number Responses
	0	5
	1	3
	2	5
	3	10
	4	10
	5	5
Number		**38**
Average	**2.84**	

8. Did your company use grade bumping to take advantage of higher ABR allowances in 2013?

Yes:	22	**No:**	17	**Total Reponses:**	**39**

If not, why? Please circle all that apply.

Answer	Number Responses
Failing Hamburg Wheel w/softer AC	2
Limited tanks at facility	12
Availability of softer PG grades	2

Other reason

Economics	2
Plant not set up to use	1
Cost Difference in PG Grades	1
Economically not feasable unless we used a very high % of recycled material which we currently can't do with our plant setup	1

9. Did your company landfill or dispose of RAP at a Clean Construction Demolition Debris (CCDD) disposal site in 2013?

Yes:	4	**No:**	36	**Total Reponses:**	**40**

If yes, what tonnage of RAP would you estimate?

Rating	Number Responses
Under 1,000	1
1,001 to 2,500	0
2,501 to 5,000	0
5,001 to 10,000	0
over 10,000	3
Total	**4**

If yes, what type of RAP? Circle all that apply.

Steel Slag Surface Millings	1
Binder Millings	1
Surface Millings (non-steel slag)	3
Surface/Binder combined millings with steel slag	1
Surface/Binder combined millings (non-steel slag)	1
RAP “contaminated” with soil, or other CCDD	2
Other please describe	0

10. For your company's operation, what are the main plant reasons more RAP is not used in your mixes? Circle all that apply.

Answer	Number Responses
Limitation of collar feed	2
Additional feeder bins needed	6
Operation not set up to fractionate RAP	5
Dryer capacity	6
No plant issues	13

Other – Please Explain

Use Max Allowed by Spec	4
Dist 1 version forcing RAS use	2
Batch plants limited by plant design/Temp of aggregates - Drum plant max (limited) because of dust	1
Plant not set up	3
Mix Control Variability with increased RAP and PFP/QCP penalties	1
Supply limits RAP content to 15% of mix	1
Volumetrics (VMA)	2
Prefer not to superheat virgin aggregates	0
IDOT only allows 10% (ABR) in polymer mixes	1
Economics	1
Stack Tempature Management	1
Dust to AC Ratio	1
IDOT Spec limits	1
Table limts of ABR	1
Plant Modifications needed	0
Limited (RAP) availability	2

11. What are the specification limiting factors for your company with respect to increasing the amount of RAP/RAS and Fractionated RAP (FRAP)/RAS usage? Circle all that apply.

Answer	Number Responses
Table limits of ABR for RAP/RAS	12
Table limits of ABR for FRAP/RAS	15
Grade bumping	6
Dust/AC Ratio limitation	18
Hamburg Wheel Failure	3
Exceeding Max Tensile Strength limit	3

Other – Please Explain

Limits of Polymer Mixes	4
Econimics/Lack of work in bid area	1
Supply limits RAP content to 15% of mix	1
None- Rap Generated Balances w/RAP incorporated	1
RAP Supply limited	1
Plant not set up to handle that amount of RAP/RAS	1
Dust/AC ration for design @ 1.0 is tougher than 1.2 during production	1

12. Is your company producing WMA on private projects?

Yes:	8	**No:**	33	**Total Reponses:**	**41**

13. Is your company producing WMA on State let (five-digit contracts) projects?

Yes:	6	**No:**	35	**Total Reponses:**	**41**

If no to either 12 or 13 above, what are the reasons? Circle all that apply.

Cost of chemical additive	10
Equipment cost (water system)	11
Lack of cost savings or other benefit	21
Other – Please Explain	9
Plant not set up	3
Contractor liability for failure	1
Not worth risk with PFP/QCP penalties	1
On private side custumers do not like	1
No Projects	1
IDOT not allowing WMA on Contracts	1
Foaming at reg mix temps, just have not supplied yet (to state projects)	1

14. How would your company rate IDOT's Warm Mix Asphalt (WMA) specifications and the approved list of WMA technologies with 0 being very confusing and 5 being very straightforward?

	Rating	Number Responses
	0	3
	1	1
	2	4
	3	15
	4	6
	5	4
Number		**33**
Average	**2.96969697**	

15. With all things being equal (quality, cost, haul distance, etc.) what specific gravity properties of aggregates would you prefer?

Answer	Number Responses
High gravity	26
Low gravity	2
Gravity not a consideration	8
Total	**36**

Other comments

Other comments	Number Responses
RAS should not be given preferential treatment in ABR	2
Actual/accurate Gravity	2
Common sense would dictate higher gravities. Sometimes there is no option.	1
Only uses grade bumping for shoulder mixes - no Hamburg requirement	1
Get rid of shingles and max RAP for all surface and binders - should not exceed 20%. Mixes are getting filled with junk and not lasting. In our area, roads we paved 20 years ago are out performing roads we paved 5 years ago. It's getting rediculous.	1
The FRAP/RAS/RAP Spec is far to ambigious and vauge in certion areas	1
RAP specific gravity too low for our area… other gravities OK	1
The higher the gravity the better (for aggregate)	0
ABR limits should not be determined by the type of recyled product used, but rather by specification testing. RAS should not be give preferential treatment.	1

APPENDIX E TOTAL RECYCLE ASPHALT (D-1)

TOTAL RECYCLE HOT-MIX ASPHALT (D-1)

Effective: January 28, 2013.

Description. This work shall consist of constructing a Hot-Mix Asphalt (HMA) surface course with usable waste materials. Work shall be according to Sections 406, 1030, 1031 and 1032 of the Standard Specifications except as modified herein.

Materials.
Revise Section 1030.02(a) and (b) of the Standard Specifications to read:

“(a) Coarse Aggregate*..1004.03
(b) Fine Aggregate**...1003.03
(c) RAP Material 1031

* Coarse aggregate shall be crushed concrete, crushed slag or crushed steel slag.
** Fine aggregate shall be crushed concrete sand, slag sand or steel slag sand.”

Revise Section 1031 of the Standard Specifications to read:

“SECTION 1031. FRACTIONATED 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 by 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 Bureau of Materials and Physical Research Policy Memorandum “Reclaimed Asphalt Shingle (RAS) Sources”, by weight of RAS. All RAS used shall come from a Bureau of Materials and Physical Research 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. No additional RAP shall be added to the pile after the pile has been sealed. Stockpiles shall be sufficiently separated to prevent intermingling at the base. All stockpiles (including unprocessed RAP and Processed 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, Superpave 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 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 mix the RAP will be used in.

(2) Restricted FRAP (B quality) stockpiles shall consist of RAP from Class I, Superpave (High ESAL), or HMA (High ESAL). If approved by the Engineer, the aggregate from a maximum 3.0 inch 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, Superpave 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 Superpave (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/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. The Contractor shall construct individual, sealed RAS stockpiles meeting one of the following definitions. No additional RAS shall be added to the pile after the pile has been sealed. 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. RAP/FRAP and RAS testing shall be according to the following.

(a) RAP/FRAP Testing. When used in HMA, the RAP/FRAP shall be sampled and tested either during processing or after stockpiling.

(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) 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 whether RAP or 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 either during or after stockpiling.

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 stockpiled 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.

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 tests results shall be according to the following.

(a) Evaluation of RAP/FRAP Test Results. All of the extraction results shall be compiled and averaged for asphalt binder content and gradation and, when applicable (for slag) Gmm. Individual extraction test results, when compared to the averages, will be accepted if within the tolerances listed below.

Parameter	RAP or FRAP	Conglomerate "D" Quality RAP
1 in. (25 mm)		±5 %
1/2 in. (12.5 mm)	±8 %	±15 %
No. 4 (4.75 mm)	±6 %	±13 %
No. 8 (2.36 mm)	±5 %	
No. 16 (1.18 mm)		±15 %
No. 30 (600 µm)	±5 %	
No. 200 (75 µm)	±2.0 %	±4.0 %
Asphalt Binder	±0.4 % 1/	±0.5 %
Gmm	±0.03 2/	

1/ The tolerance for FRAP shall be ± 0.3 %.

2/ For slag and steel slag

If more than 20 percent of the individual sieves and/or asphalt binder content tests are out of the above tolerances, the RAP/FRAP shall not be used in HMA unless the RAP/FRAP representing the failing tests is removed from the stockpile. All test data and acceptance ranges shall be sent to the District for evaluation.

With the approval of the Engineer, the ignition oven may be substituted for extractions according to the Illinois Test Procedure, "Calibration of the Ignition Oven for the Purpose of Characterizing Reclaimed Asphalt Pavement (RAP)".

(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. Individual test results, when compared to the averages, 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)	± 2.0 %
Asphalt Binder Content	± 1.5 %

If more than 20 percent of the individual sieves and/or asphalt binder content tests are out of the above tolerances, the RAS shall not be used in Department projects unless the RAS, RAP or FRAP representing the failing tests is removed from the stockpile. All test data and acceptance ranges shall be sent to the District for evaluation.

1031.05 Quality Designation of Aggregate in RAP/FRAP.

(a) RAP. The aggregate quality of the RAP for homogenous, 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, Superpave (High ESAL)/HMA (High ESAL), or (Low ESAL) IL-9.5L surface mixtures are designated as containing Class B quality coarse aggregate.

(2) RAP from Superpave (High ESAL)/HMA (Low ESAL) IL-19.0L binder mixture is designated as Class D quality coarse aggregate.

(3) RAP from Class I, Superpave (High ESAL)/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 prequalified by the Department for the specified testing. The consultant 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 BMPR Aggregate Lab for MicroDeval Testing, according to Illinois Modified AASHTO T 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 RAS, RAP or FRAP in HMA.

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

(1) Coarse Aggregate Size (after extraction). The coarse aggregate in all RAP shall be equal to or less than the nominal maximum size requirement for the HMA mixture to be produced.

(2) Steel Slag Stockpiles. RAP/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). RAP/FRAP stockpiles for use in HMA surface mixtures (High and Low ESAL) shall have coarse aggregate that is Class B quality or better. RAP/FRAP shall be considered equivalent to limestone for frictional considerations unless produced/screened to minus 3/8 inch.

(b) RAS. RAS meeting Type 1 or Type 2 requirements will be permitted for the HMA applications as specified herein.

(c) RAP/FRAP and/or RAS Usage Limits. When FRAP is used alone or in conjunction with RAS, the following adjustments shall be made:

(1) Type 1 or Type 2 RAS may be used alone or in conjunction with RAP or FRAP in HMA mixtures up to a maximum of 5.0% by weight of the total mix.

(2) When FRAP/RAS Asphalt Binder Replacement (ABR) is 40% or less, the virgin asphalt binder grade shall be PG58-28.

(3) When FRAP/RAS Asphalt Binder Replacement (ABR) exceeds 40%, the high virgin asphalt binder grade shall be reduced by one grade (e.g. 45 percent ABR would require a virgin asphalt binder grade of PG58-28 to be reduced to a PG52-28).

(4) The FRAP/RAS Asphalt Binder Replacement (ABR) shall not exceed 60%.”

HMA Mix Design. Design composition and volumetric requirements for a Total Recycle mixture.

Add the following Total Recycle column to the "High ESAL, Mixtures Composition (%Passing)" table in Article 1030.04(a)(1) of the Standard Specifications:

High ESAL, MIXTURE COMPOSITION (% PASSING) [1/]		
Sieve Size	IL-9.5 mm Total Recycle	
	min	max
1 1/2 in (37.5 mm)		
1 in. (25 mm)		
3/4 in. (19 mm)		
1/2 in. (12.5 mm)		100
3/8 in (9.5 mm).	90	100
#4 (4.75 mm)	28	65
#8 (2.36 mm)	32	52
#16 (1.18 mm)	10	32
#50 (300 µm)	4	15
#100 (150 µm)	3	10
#200 (75 µm)	4	6
Ratio Dust/Asphalt Binder		1.0

1/ Based on percent of total aggregate weight."

Add to Article 1030.04(b) of the Standard Specifications to read:

"(5) Total Recycle Mixtures. The target value for the air voids of the HMA shall be 3.0 percent at the design number of gyrations. The VMA and VFA of the HMA design shall be based on the nominal maximum size of the aggregate in the mix, and shall conform to the following requirements.

VOLUMETRIC REQUIREMENTS Total Recycle		
	Voids in the Mineral Aggregate (VMA), % minimum	Voids Filled with Asphalt Binder (VFA), %
N design	IL-9.5	
50	15	65 – 86

Add the following Total Recycle columns to the “Control Limits” Table in Article 1030.05(d)(4) of the Standard Specifications:

“CONTROL LIMITS		
Parameter	Total Recycle Individual Test	Total Recycle Moving Avg. of 4
% Passing: 1/		
1/2 in. (12.5 mm)	± 6 %	± 4 %
No. 4 (4.75 mm)	± 5 %	± 4 %
No. 8 (2.36 mm)	± 5 %	± 3 %
No. 16 (1.18 mm)		
No. 30 (600 µm)	± 4 %	± 2.5 %
Total Dust Content No. 200 (75 µm)	± 1.5 %	± 1.0 %
Asphalt Binder Content	± 0.3 %	± 0.2 %
Voids	± 1.0 %	± 0.8 %
VMA	-0.7 % 2/	-0.5 % 2/

1/ Based on washed ignition oven

2/ Allowable limit below minimum design VMA requirement”

Add the following to Article 1030.04 of the Standard Specifications:

“(d) Verification Testing. High ESAL mix designs submitted for verification will be tested to ensure that the resulting mix designs will pass the required criteria for the Hamburg Wheel Test (IL mod AASHTO T-324) and the Tensile Strength Test (IL mod AASHTO T-283). The Department will perform a verification test on gyratory specimens compacted by the Contractor. If the mix fails the Department’s verification test, the Contractor shall make the necessary changes to the mix and resubmit compacted specimens to the Department for verification. If the mix fails again, the mix design will be rejected.

(1) Hamburg Wheel Test criteria.

Asphalt Binder Grade	# Repetitions	Max Rut Depth (mm)
PG 64 -XX (or lower)	10,000	12.5

(2) Tensile Strength Criteria. The minimum allowable conditioned tensile strength shall be 415 kPa (60 psi) for non-polymer modified performance graded (PG) asphalt binder and 550 kPa (80 psi) for polymer modified PG asphalt binder. The maximum allowable unconditioned tensile strength shall be 1380 kPa (200 psi).

(3) Cure of Hot-Mix Asphalt. In addition to the basic curing (2 hrs), the designer shall conduct a 4 hour cure at the optimum asphalt binder (AB) content (as outlined in District One HMA Design Guideline). After the 4 hour cure, the voids must be within ±0.5% of the Design Air Voids Target.

(4) Chemical Extraction. Each submitted design shall include a washed chemical extraction according to IL Modified AASHTO T 164 on a compacted briquette.”

Revise the seventh paragraph of Article 406.14 of the Standard Specifications to read:

> "For all mixes designed and verified under the Hamburg Wheel criteria, the cost of furnishing and introducing anti-stripping additives in the HMA will not be paid for separately, but shall be considered as included in the contract unit price of the HMA item involved.
>
> No additional compensation will be awarded to the Contractor because of reduced production rates associated with the addition of the anti-stripping additive."

<u>Plant Requirements.</u> HMA plants 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, RAP 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, RAP and FRAP material as a percent of the total mix to the nearest 0.1 percent.

h. Aggregate RAS, RAP and FRAP moisture compensators in percent as set on the control panel. (Required when accumulated or individual aggregate and RAS, RAP 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)

(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, RAP 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, RAP 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.

To remove or reduce agglomerated material, a scalping screen, gator, crushing unit, or comparable sizing device approved by the Engineer shall be used in the RAS, RAP and FRAP feed system to remove or reduce oversized material. If material passing the sizing device adversely affects the mix production or quality of the mix, the sizing device shall be set at a size specified by the Engineer.

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.

<u>HMA Production.</u>

Add the following to Article 1030.06 of the Standard Specifications:

"(c) Hamburg Wheel Test. The Contractor shall sample the HMA mixture within the first 500 tons (450 metric tons) on the first day of production or during start up with a split reserved for the Department. The mix sample shall be tested according to the Illinois Modified AASHTO T 324 and shall meet the requirements specified herein. Mix production shall not exceed 1500 tons (1350 metric tons) or one day's production, whichever comes first, until the testing is completed and the mixture is found to be in conformance. The requirement to cease mix production may be waived if the plant produced mixture demonstrates conformance prior to start of mix production for a contract.

The Department may conduct additional Hamburg Wheel Tests on production material as determined by the Engineer. If the mixture fails to meet the Hamburg Wheel criteria, no further mixture will be accepted until the Contractor takes such action as is necessary to furnish a mixture meeting the criteria"

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

Hot-mix Storage. The HMA mixture shall have combined silo storage and haul time of not less than 2 hours.

APPENDIX F-1 RICHARDS ROAD DISTRESS SURVEY SUMMARY

Richards Road													
		Pre Overlay Distress Level				Post Overlay Distress Level				Spring 2014 Distress Level			
Distress Type	**Unit**	**Low**	**Med**	**High**	**Total**	**Low**	**Med**	**High**	**Total**	**Low**	**Med**	**High**	**Total**
Alligator or Fatigue Cracking	**Lane-Feet**	-	-	36	**36**	-	-	-	**-**	172	-	-	**172**
Block Cracking	**Lane-Feet**	2,016	1,960	7,440	**11,416**	-	-	-	**-**	-	-	-	**-**
Centerline Cracking	**Linear Feet**	-	-	2,942	**2,942**	-	-	-	**-**	81	-	-	**81**
Longitudinal Cracking	**Linear Feet**	6	-	-	**6**	-	-	-	**-**	300	-	-	**300**
Overlaid Patch Deterioration	**Square Feet**	72	-	60	**132**	-	-	-	**-**	-	-	-	**-**
Permanent Patch Deterioration	**Square Feet**	19,897	204	420	**20,521**	-	-	-	**-**	-	-	-	**-**
Pothole and Localized Distress	**Each**	-	2	10	**12**	-	-	-	**-**	-	-	-	**-**
Raveling/Weathering/ Segregation	**Lane-Feet**	-	-	-	**-**	-	-	-	**-**	-	-	-	**-**
Transverse Cracking	**Linear Feet***	**6,215**	**1,464**	**3,203**	**10,882**	**-**	**-**	**-**	**-**	**720**	**-**	**-**	**720**

*** Linear feet of cracking measured in lieu of occurrences**

APPENDIX F-2 HARRISON STREET DISTRESS SURVEY SUMMARY

Harrison Street													
		Pre Overlay Distress Level				Post Overlay Distress Level				Spring 2014 Distress Level			
Distress Type	Unit	Low	Med	High	Total	Low	Med	High	Total	Low	Med	High	Total
Alligator or Fatigue Cracking	Lane-Feet	202	-	130	**332**	-	-	-	-	-	-	-	-
Block Cracking	Lane-Feet	-	5,500	500	**6,000**	-	-	-	-	-	-	-	-
Centerline Cracking	Linear Feet	-	6,000	-	**6,000**	-	-	-	-	47	-	-	**47**
Longitudinal Cracking	Linear Feet	-	-	-	-	-	-	-	-	497	-	-	**497**
Overlaid Patch Deterioration	Square Feet	-	336	-	**336**	-	-	-	-	-	-	-	-
Permanent Patch Deterioration	Square Feet	314	108	-	**422**	-	-	-	-	-	-	-	-
Pothole and Localized Distress	Each	-	-	-	-	-	-	-	-	-	-	-	-
Raveling/Weathering/ Segregation	Lane-Feet	-	-	-	-	4	-	-	**4**	4	-	-	**4**
Transverse Cracking	Linear Feet*	**969**	**1,695**	**3,894**	**6,558**	-	-	-	-	**5,472**	**331**	-	**5,803**

*** Linear feet of cracking measured in lieu of occurrences**

APPENDIX F-3 26TH STREET DISTRESS SURVEY SUMMARY

26th Street													
		Pre Overlay Distress Level				Post Overlay Distress Level				Spring 2014 Distress Level			
Distress Type	**Unit**	**Low**	**Med**	**High**	**Total**	**Low**	**Med**	**High**	**Total**	**Low**	**Med**	**High**	**Total**
Alligator or Fatigue Cracking	**Lane-Feet**	2	-	2	**4**	-	-	-	**-**	-	-	-	**-**
Block Cracking	**Lane-Feet**	-	125	138	**263**	-	-	-	**-**	-	-	-	**-**
Centerline Cracking	**Linear Feet**	-	-	9,000	**9,000**	-	-	-	**-**	1,641	10	7,389	**9,040**
Longitudinal Cracking	**Linear Feet**	4,600	94	430	**5,124**	-	-	-	**-**	288	-	-	**288**
Overlaid Patch Deterioration	**Square Feet**	-	-	168	**168**	-	-	-	**-**	-	-	-	**-**
Permanent Patch Deterioration	**Square Feet**	19,958	720	-	**20,678**	-	-	-	**-**	-	-	-	**-**
Pothole and Localized Distress	**Each**	-	-	1	**1**	-	-	-	**-**	-	1	10	**11**
Raveling/Weathering/ Segregation	**Lane-Feet**	-	-	-	**-**	4	-	-	**4**	369	10	-	**379**
Transverse Cracking	**Linear Feet***	**2,362**	**2,557**	**4,990**	**9,909**	**36**	**-**	**-**	**36**	**3,251**	**36**	**-**	**3,287**

*** Linear feet of cracking measured in lieu of occurrences**

APPENDIX F-4 WOLF ROAD DISTRESS SURVEY SUMMARY

Wolf Road													
		Pre Overlay Distress Level				Post Overlay Distress Level				Spring 2014 Distress Level			
Distress Type	Unit	Low	Med	High	Total	Low	Med	High	Total	Low	Med	High	Total
Alligator or Fatigue Cracking	Lane-Feet	-	-	-	-	-	-	-	-	-	-	-	-
Block Cracking	Lane-Feet	-	-	-	-	-	-	-	-	-	-	-	-
Centerline Cracking	Linear Feet	-	-	-	-	-	-	-	-	52	-	-	52
Longitudinal Cracking	Linear Feet	-	-	-	-	-	-	-	-	-	-	-	-
Overlaid Patch Deterioration	Square Feet	-	-	-	-	-	-	-	-	-	-	-	-
Permanent Patch Deterioration	Square Feet	-	-	-	-	-	-	-	-	-	-	-	-
Pothole and Localized Distress	Each	-	-	-	-	-	-	-	-	-	-	-	-
Raveling/Weathering/ Segregation	Lane-Feet	-	-	-	-	-	-	-	-	-	-	-	-
Transverse Cracking	Linear Feet*	-	-	-	-	-	-	-	-	3,080	108	-	3,188

*** Linear feet of cracking measured in lieu of occurrences**

Illinois Department of Transportation

ILLINOIS

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN