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EVALUATION OF FIELD-PRODUCED HOT MIX ASPHALT (HMA) MIXTURES WITH FRACTIONATED RECYCLED ASPHALT PAVEMENT (RAP)

2007 ILLINOIS TOLLWAY FIELD MIX TRIALS

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16. Abstract

To test the fractionated recycled asphalt pavement (FRAP) materials, the Illinois Tollway, working through its contractors and consultants, developed and conducted a project on the applicability and feasibility of using increased RAP contents through FRAP. The goal of the program was to answer two main questions:

- Can the Tollway design, produce, and construct high-quality HMA pavements with high FRAP content mixes?
- Will these materials provide the same or better pavement performance as the standard mixes used by the Tollway and Illinois Department of Transportation (IDOT), and with performance that is consistent with pavement design procedures?

In the summer of 2007, a construction contract was awarded for advance pavement work on the Jane Addams Memorial Tollway (I-90) in the Rockford area. The timing, scope, and circumstances of the I-90 project provided a rare opportunity to evaluate several different HMA concepts directly via plant mixing and field trials. This is a summary report of the field trial production mixes containing high quantities of FRAP sponsored by the Illinois Tollway.

The results of these field trials show that the Tollway can design, produce, and construct high-quality HMA pavements with high FRAP content mixes. Further, the laboratory evaluation of these mixes shows that their performance is expected to be similar to currently used materials and consistent with current pavement design procedures. The issue of asphalt cement grade bumping was evaluated with the field trials and, based on these results, there is no need to double bump the asphalt cement grade within the design criteria.

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- **Illinois Tollway:** Management, funding, and oversight of all aspects of this project.
- **Illinois DOT:** HMA materials testing.
- **Applied Research Associates:** Specification review, mix design review, laboratory data analysis, and reporting.
- **S.T.A.T.E Testing:** Specification review, mix design, and quality assurance (QA) inspection and testing.
- **Rock Road Companies & Rockford Blacktop (joint venture):** Contractor.
- **Seneca Petroleum:** Ground tire rubber (GTR) liquid asphalt supplier.
- **Heritage/Levy Slag:** Slag aggregate for stone matrix asphalt (SMA).
- **Rib Mountain Aggregate:** Trap rock aggregate for SMA.
- **Illinois Center for Transportation:** HMA materials testing (fatigue & dynamic modulus).

DISCLAIMER

The contents of this report reflect the view of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Illinois State Toll Highway Authority, the Illinois Center for Transportation, the Illinois Department of Transportation, or the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

EXECUTIVE SUMMARY

To test the fractionated recycled asphalt pavement (FRAP) materials the Illinois Tollway, working through its contractors and consultants, developed and conducted a project on the applicability and feasibility of using increased RAP contents through FRAP. The goal of the program was to answer two main questions:

- Can the Tollway design, produce, and construct high-quality HMA pavements with high FRAP content mixes?
- Will these materials provide the same or better pavement performance as the standard mixes used by the Tollway and Illinois Department of Transportation (IDOT), and with performance that is consistent with pavement design procedures?

In the summer of 2007, a construction contract was awarded for advance pavement work on the Jane Addams Memorial Tollway (I-90) in the Rockford area. The timing, scope, and circumstances of the I-90 project provided a rare opportunity to evaluate several different HMA concepts directly via plant mixing and field trials. This is a summary report of the field trial production mixes containing high quantities of FRAP sponsored by the Illinois Tollway.

The results of these field trials show that the Tollway can design, produce, and construct high-quality HMA pavements with high FRAP content mixes. Further the laboratory evaluation of these mixes shows that their performance is expected to be similar to currently used materials and consistent with current pavement design procedures. The issue of asphalt cement grade bumping was evaluated with the field trials, and based on these results, there is no need to double bump the asphalt cement grade within the design criteria.

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CHAPTER 1 INTRODUCTION

In the summer of 2007, a construction contract was awarded for advance pavement work on the Jane Addams Memorial Tollway (I-90) in the Rockford area. To test the new fractionated recycled asphalt pavement (FRAP) materials, Rock Road Companies and Rockford Blacktop, the Illinois Tollway, S.T.A.T.E. Testing, and Applied Research Associates, Inc. (ARA), with testing support provided by the Illinois Center for Transportation (ICT), developed and conducted a research project on the applicability and feasibility of using increased RAP contents through FRAP. This is a summary report of the field trial production mixes containing high quantities of FRAP sponsored by the Illinois Tollway.

Hot mix asphalt (HMA) research testing is usually performed with laboratory-prepared mixes. For some circumstances, this is acceptable. For others, it may be all that is available. However, lab-prepared mixes usually are batched with oven-dried aggregates and mixed at relatively low oven temperatures. Lab procedures do a poor job of imitating the high temperatures and material handling that occurs in a plant. A plant-produced mix is better for answering questions like “how does the mixing of RAP with virgin aggregate and liquid asphalt in a plant affect the performance of the final mixture?”

The timing, scope, and circumstances of the I-90 project provided a rare opportunity to evaluate several different HMA concepts directly via plant mixing and field trials. This paper documents the activities involved in developing the mix designs and producing/placing those mixes. The goal of the research program was to determine whether:

- The Tollway design, produce, and construct high-quality HMA pavements with high FRAP content mixes.
- These materials will provide the same or better pavement performance as the standard mixes used by the Tollway and Illinois Department of Transportation (IDOT), and with performance that is consistent with pavement design procedures.

1.1 EVENTS SURROUNDING THIS RESEARCH PROJECT

The Tollway faces an unprecedented rehabilitation/expansion program for its highway network. The financial demand, market conditions, and desire to improve as much of the network as possible require the evaluation of options for minimizing construction costs. In the HMA industry, minimizing costs includes optimizing the selection of materials used in the mixes. The Tollway had been looking at small pieces of this puzzle—new liquid asphalt, different aggregates, and better performing mix designs. Nationally, fractionating RAP is becoming recognized as an efficient way to cut the cost of a new mix and reduce the inconsistencies of the high RAP mix properties without sacrificing quality. In May 2007, FRAP became a serious topic of interest at the Tollway when Don Brock, President of Astec Industries, made a convincing presentation to the Illinois HMA industry and various Illinois government agencies.

In the summer of 2007, a large contract for preliminary work on I-90 was awarded to a joint venture of Rock Road Companies and Rockford Blacktop. They readily agreed to work with the Tollway to test the FRAP concept by processing the mainline overlay grindings containing only high-quality manufactured aggregates into two fractions, category 1 fine portion FRAP (minus #4 sieve) and category 1 coarse portion FRAP (minus ½” sieve to #4 sieve); and by processing any other reclaimed asphalt pavement containing both lower quality natural and manufactured aggregates into two fractions, category 2 fine portion FRAP (minus #4 sieve) and category 2 coarse portion FRAP (minus ½” sieve to #4 sieve). This concept required additional processing and plant equipment and working with several additional material suppliers, all without an increase in their contract price. At the same time, the Tollway authorized S.T.A.T.E. Testing to proceed with mix designs for nine different mixes, each of which would include a significant percentage of FRAP. These mixes typically contained RAP contents 15% higher than the maximum percentages that the current Illinois Department of Transportation (IDOT) or Tollway standard specifications allow. Some of these mixes also included alternative aggregates and/or liquid asphalt.

During late summer and fall 2007, the joint venture produced each of the nine mixes. These mixes replaced standard mixes on the I-90 project. In most cases, each mix was placed over 2 or more days, allowing time for mix adjustments between production runs. The joint venture performed normal quality control (QC) testing. Quality assurance (QA) testing was performed by S.T.A.T.E. Testing. Ultimately, the mixes were sampled for HMA materials testing at IDOT and for more complex performance testing by the Illinois Center for Transportation at the University of Illinois.

1.2 NEW CONCEPTS

As with any research, new specifications, equipment, and procedures were required to conduct this project. These new concepts are noted below:

- A special provision was developed to implement FRAP with Illinois Tollway HMA mixtures. It included specifications for the source material and the production of the different FRAP products. It also included instructions on how to determine the specific gravity of the FRAP and how to accommodate design changes. A copy of the specification is included as appendix B.
- Contractors acquired screening equipment and made modifications to their plants to accommodate the FRAP.
- Mix designs were created for a variety of FRAP mixes that included non-traditional ingredient materials, notably terminally blended ground tire rubber (GTR), modified liquid asphalt, and coarse aggregates for the stone matrix asphalt (SMA) mixes.

CHAPTER 2 MATERIALS TESTED

Nine HMA materials were plant produced and tested as part of this research effort. These mixtures, their type, asphalt grade, FRAP, and other items are listed in table 1. The materials were selected because they are regularly used mixes in Tollway mainline and HMA shoulder expressway pavement sections. More complete descriptions of the mixes and the mix designs are provided in appendix C of this report.

Three different SMA mixtures were produced to evaluate the applicability of using the category 1 fine-graded FRAP as the fine portion of SMA mixtures. The SMA mixtures included two surface mixes, one with trap rock coarse aggregate and another with steel slag coarse aggregate, and one SMA binder that used crushed gravel as the coarse aggregate source. The purpose of these mixtures was to evaluate the use of fine portion FRAP and to determine if the material properties and predicted performance of the resulting mixture were consistent with other SMA mixes previously produced in Illinois using virgin aggregate sources only.

Base, binder, and surface mixes typically used by the Tollway in mainline and shoulder applications were included in the test matrix to gauge their performance with the increased FRAP percentages. These mixes were produced at the maximum permissible RAP content within the Tollway FRAP specification, based on lab trial mixes.

In addition to the evaluation of the properties of the various mixes, one of the HMA base mixes and one of the HMA binder mixes were selected to evaluate the structural performance differences between the single PG grade bump and the double bump. Standard HMA mixes with virgin aggregate sources or with very low RAP quantities require PG 64-22 grade asphalt. The single grade bump was a PG 58-22, and the double grade bump was PG 58-28. These mixture comparisons were done from plant produced mixtures where the only difference was the grade of asphalt; all other variables and conditions were held constant.

Table 1. FRAP Research Mix Matrix.

Research Mix Number	Mix Type	PG grade	FRAP Type	FRAP % Fine/Coarse	Coarse Agg. type	Comments
#1 – SMA Binder	SMA	GTR PG 76-22	1	15 / 0	Crushed Gravel	16 min VMA (new District 1 spec)
#2 – SMA Surface (trap rock)	SMA	GTR PG 76-22	1	15 / 0	Trap Rock	
#3 – SMA Surface (steel slag)	SMA	GTR PG 76-22	1	15 / 0	Steel Slag	
#4 – IL-19.0 Binder N70	N70 19.0	PG 58-22	2	25 / 15	Cr. Gravel & Stone	
#5 – IL-9.5 Surface N70	N70 9.5	PG 64-22	2	15 / 10	Dolomite	4% Air Voids
#6a – IL-19.0 Binder N50 -28	N50 19.0	PG 58-28	2	10 / 30	Dolomite	3% Air Voids
#6b – IL-19.0 Binder N50 -22	N50 19.0	PG 58-22	2	10 / 30	Dolomite	3% Air Voids
#7a – IL-19.0 Base -28	N50 Base	PG 58-28	2	10 / 30	Dolomite	2% Air Voids
#7b – IL-19.0 Base -22	N50 Base	PG 58-22	2	10 / 30	Dolomite	2% Air Voids

CHAPTER 3 SUMMARY OF FIELD NOTES

The following notes summarize the characteristics of the trial mixes and were compiled by S.T.A.T.E. Testing through their experiences from aggregates in mix designs, and through their field observations of trial mix production and compaction. The complete mix design, mix design notes, and QA summary are provided in appendix C for all of the mixes.

3.1 MIX 1 – SMA BINDER

- Quite likely the first Illinois SMA binder to include crushed gravel as the coarse aggregate. Dolomite is the customary coarse aggregate in most SMA binder mixes. Gravel is locally available and may better resist breakdown during compaction. The contractor used a blend of CM13 and CM 14 from two different pits.
- The liquid asphalt was GTR-modified and complied with the PG 76-22 grade, with the exception of the tests on Residue From Rolling Thin Film Oven Test (AASHTO T 240).
- The FRAP proportion was 14% of the total mixture (fine portion category 1 FRAP). SMA mix designs typically require the use of a manufactured fine aggregate and require more liquid asphalt than conventional dense-graded mixes. The fine aggregate FRAP portion source in the SMA test mix was processed from mainline overlay grindings that consisted of high-quality crushed coarse aggregate and manufactured fine aggregate in the original overlay materials.
- Using GTR-modified liquid asphalt eliminated the use of fibers normally used to prevent liquid asphalt draindown during storage and transportation of SMA mixes produced with the SBS polymer modified liquid asphalt.

The contractor used two coarse aggregate products and feeders for control. Production took place over two nights. After the first night, minor proportioning adjustments were made to increase voids. The resulting volumetric properties (air voids, voids in mineral aggregate [VMA] and voids filled with asphalt [VFA]) were within specification tolerances. Limited production quantities restricted further adjustments and testing.

3.2 MIX #2 – SMA SURFACE (TRAP ROCK)

- This is the first Illinois SMA surface mix that includes Diabase (trap rock) as the coarse aggregate. Diabase is a hard, non-absorptive aggregate with excellent friction properties. Most high-volume SMA surface mixes in Illinois have included steel slag as the coarse aggregate. The Diabase consisted of two different gradations—35% CM13 and 46% CM14.
- The liquid asphalt was GTR-modified PG 76-22.
- The FRAP proportion was 14% of the total mixture (fine portion category 1).
- The GTR liquid eliminated the customary use of fibers to prevent liquid draindown during storage and transportation.

The contractor used two coarse aggregate products and feeders for control. Production took place over two nights. Voids were slightly above target. VMA and VFA were within specification limits. Limited production quantities restricted further adjustments and testing.

3.3 MIX #3 – SMA SURFACE (STEEL SLAG)

- This Illinois SMA surface mix included steel slag as the coarse aggregate. The Heritage slag comprised 80% of the aggregate blend—55% CM13 gradation and 25% CM11 gradation.
- The liquid asphalt was GTR-modified PG 76-22.

- The FRAP proportion was 15% of the total mixture (fine portion category 1 FRAP).
- The GTR liquid eliminated the customary use of fibers to prevent draindown during storage and transportation.

The contractor used two coarse aggregate products and feeders for control. Production took place during one day shift. The volumetric properties were within or close to specification tolerances. Limited production quantities restricted further adjustments and testing.

3.4 MIX #4 – IL-19.0 BINDER N70

- The binder mix design included two category 2 FRAP fractions processed from lower quality overlay and HMA shoulder grindings, totaling almost 40 percent of the mix—24% coarse portion category 2 FRAP material retained on the #4 sieve and 14% fine portion category 2 FRAP material passing the #4 sieve.
- The coarse aggregate was conventional—crushed stone and crushed gravel.

Production took place over 2 consecutive days. Aggregate blends and dust return adjustments were made during production. The second day air voids were well within specification tolerances. Limited production quantities restricted further adjustments and testing.

3.5 MIX #5 – IL-9.5 SURFACE N70

- This mix includes almost 25% RAP from two different category 2 FRAP fractions processed from lower quality overlay and HMA shoulder grindings —9.6% coarse portion category 2 FRAP material retained on the #4 sieve and 14.0% fine portion category 2 FRAP material passing the #4 sieve.

A very small quantity of mix was produced during one day. QC and QA tests for volumetric properties were variable but within reasonable targets for a new mix design. Limited production quantities restricted further adjustments and testing.

3.6 MIX #6A AND #6B – IL-19.0 BINDER

This is not a normal binder mix. It was designed at 3.0% air voids at N50. This is a mix that might be used for the first lift of full-depth HMA over a normal or rubblized portland cement concrete (PCC) base—the “rich bottom layer” of a long-life HMA pavement, or as an intermediate binder lift in thickened HMA shoulder pavement.

This pair of trial mixes was selected to evaluate two variables:

- The laboratory performance of a binder mix with up to 40% RAP. The IDOT specification maximum percentage is 25%.
- The difference in lab performance might be attributed to using different liquid asphalts in high-RAP mixes. It is conventional practice to use a “softer” liquid asphalt in high-RAP mixes. However, some researchers are finding this to be an unnecessary and costly substitution.

The mixes started with identical aggregate blends. The design includes two different category 2 FRAP fractions processed from lower quality overlay and HMA shoulder grindings—28.9% coarse portion category 2 FRAP material retained on the #4 sieve, and 9.4% fine portion category 2 FRAP material passing the #4 sieve.

A small quantity of each mix was produced during one day. Initial volumetric tests indicated low voids, and adjustments were made. However, limited production quantities restricted further testing and analysis. This should not affect the primary objective of comparing the laboratory performance of different liquid asphalts in high-RAP mixes. Because of the small quantity of material produced and tested, these two mixes may not be as appropriate as mixes #7A and #7B for follow-up testing.

3.7 MIX #7A AND #7B – IL-19.0 BASE

These two mixes are similar to mixes #6A and #6B. These "base course" mixes were designed at a lower (2.0%) air voids level to provide a less permeable and more durable base. They also have similar ingredient aggregates and gradation. They include 40% RAP from the coarse and fine category 2 FRAP fractions processed from lower quality overlay and HMA shoulder grindings: 28.9% coarse portion category 2 FRAP material retained on the #4 sieve, and 9.4% fine portion category 2 FRAP material passing the #4 sieve.

Mixes #7A and #7B also were produced with different liquid asphalt. They will be tested to determine the effect of softening the liquid asphalt in high-RAP mixes. It is conventional practice to use a "softer" liquid asphalt in high-RAP mixes; however, some researchers are finding this to be an unnecessary and costly substitution.

These mixes were produced over several days. There were several minor proportioning adjustments. Volumetric analysis indicates results very near design and well within precision expectations.

CHAPTER 4 PERFORMANCE EVALUATION METHODOLOGY

The goal of this project is to verify through a laboratory testing program whether materials with high FRAP content will show similar pavement performance to currently specified materials. One means of performing this evaluation is to evaluate the material properties as they relate to pavement design.

The design of full-depth HMA pavements relies on two primary HMA material properties, the fatigue performance curve and the HMA modulus (stiffness). The dynamic modulus determines how much the pavement section flexes under the load of a heavy truck, resulting in strain in the asphalt layer. This strain is then evaluated against the fatigue performance curve, which relates the strain to the allowable loads that the pavement section can carry.

Other HMA material properties that are of concern include resistance to rutting and resistance to weathering. Relative rutting resistance is indicated by the dynamic modulus test, which is included in this testing program, and is primarily controlled for most projects through the mix design process and by the selection of raw materials.

CHAPTER 5 ASPHALT MIXTURE PERFORMANCE TESTS

Laboratory testing of HMA materials with high FRAP contents was performed to measure laboratory material properties and determine the expected performance of these mixes in field applications. The laboratory program was conducted on plant-produced mix on the second night of production. The materials were properly sampled, and the HMA tests were performed without incident. All of the identified mixtures were sampled at the plant and taken to the Advanced Transportation Research and Engineering Laboratory (ATREL) at the University of Illinois. ICT research staff reheated and split the mix, prepared test samples, and conducted all materials tests. The tests performed included flexural beam fatigue testing and dynamic modulus testing (AASHTO TP-321 and TP62-08, respectively). The test results are presented below.

5.1 ASPHALT FATIGUE TESTING

Asphalt fatigue is a distress that develops with bottom-up cracking in a full-depth asphalt section. Fatigue test results can also be considered an indication of the fracture toughness of a mixture and its resistance to cracking. Asphalt fatigue testing requires the compaction of asphalt beams that are placed in a testing apparatus and subject to repeated bending. The equipment monitors the loads and deflections during this bending and identifies the failure point as when the sample loses half of its initial stiffness.

Asphalt fatigue tests were performed at between four and six strain levels, corresponding to strains that could be encountered in field conditions. These tests are used to develop a fatigue curve and fatigue slope that can then be compared with the fatigue curve assumed in pavement design. Fatigue curves with a higher fatigue slope than the design slope have the potential to provide a longer fatigue life. The asphalt fatigue slopes for the nine study mixes are presented in figure 1.

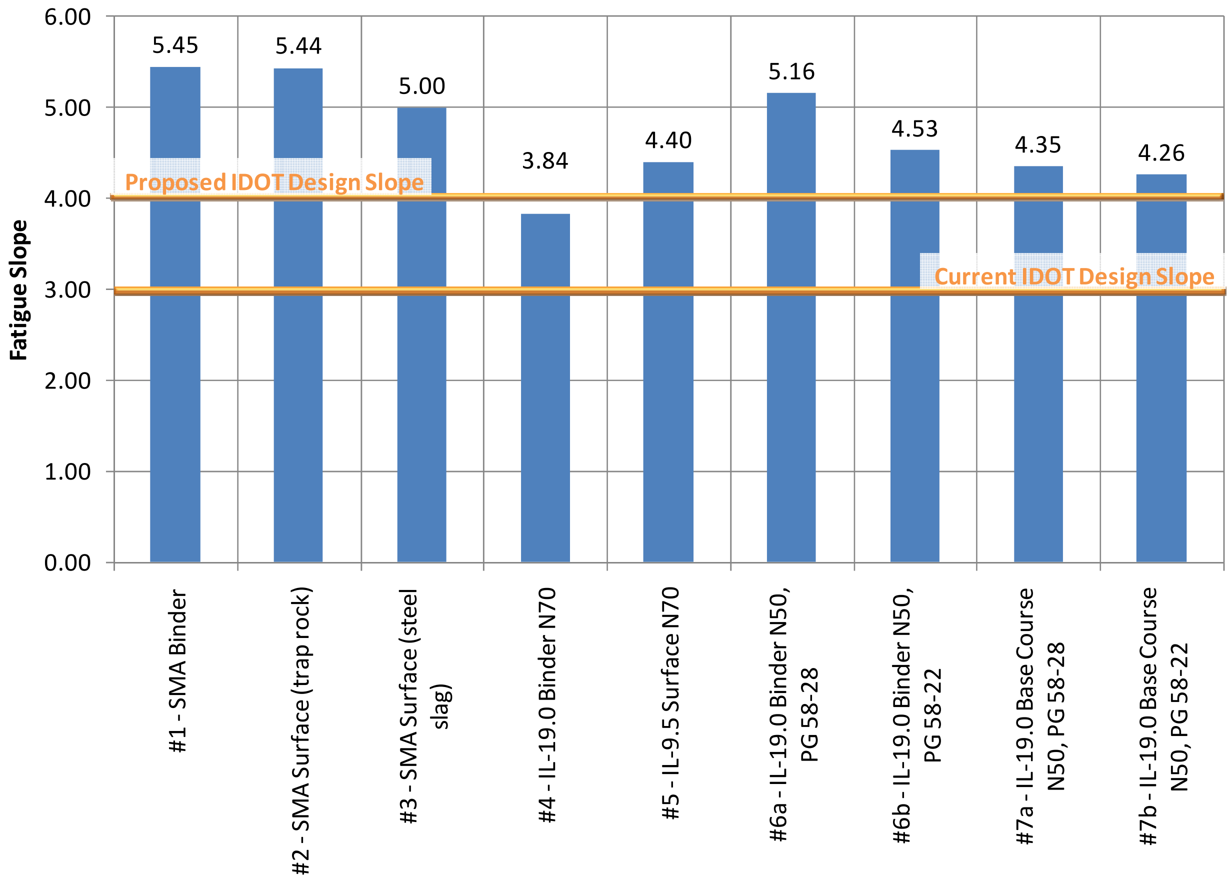

Figure 1. Fatigue slopes for the study mixes plotted with the IDOT current and proposed design values.

The fatigue results for the SMA FRAP mixes show excellent fatigue performance. This result is consistent with the testing of SMA mixtures without RAP, as shown by Carpenter (2007) in testing conducted for IDOT. The high fatigue performance noted in the SMA mixtures is primarily from the GTR-modified liquid that is used in these mixes, combined with the general characteristics of SMA materials.

The other HMA surface, binder, and base mixes have a fatigue slope above the current design value, and all but one have a value above the proposed fatigue slope currently under consideration by IDOT. The N70 binder mix (#4) has a fatigue slope of 3.84, which is below the new proposed pavement design procedure fatigue slope, but as will be shown later, the modulus for this material is sufficiently high that there is not a fatigue issue; this material is suitable as an intermediate layer in a flexible pavement.

Examining the binder and base mixes with single and double bump shows that all of the mixes have a fatigue slope above the design level. For the binder mix, the fatigue slope is higher at the double bump level, showing significantly better fatigue performance. However, the single bump is significantly higher than the current design slope and is above the proposed new design slope. In the N50 base mix, the fatigue slopes for the single and double bump mixes show that there is no significant difference in the fatigue performance between these mixtures. Based on fatigue performance, there is no expected performance difference between the single and double bump mixes.

5.2 DYNAMIC MODULUS (E*)

The modulus of HMA paving materials has long been one of the most important factors in establishing the pavement cross section and thickness. How to determine that modulus has changed over the years, but recent research has shown that the dynamic modulus is an appropriate method to develop comparative values. The dynamic modulus test involves applying a compressive cyclical load to the HMA test sample. The deflection of sample is measured by linear variable differential transformers (LVDT's) mounted on the HMA sample. The dynamic modulus is the maximum stress divided by the maximum strain.

The complete characterization of HMA modulus requires testing at 20°C, 4°C, and -10°C. The frequencies used varied from 0.01 Hz to 25 Hz. This combination of test parameters allows a characterization covering all but the extreme high temperature regime. All design temperatures and traffic speeds are covered by this testing program. Upon completion of the testing, a master curve is developed using the time-temperature superposition techniques.

Dynamic modulus tests were performed on samples with 4% and 7% air voids at the temperatures and frequencies previously noted. These tests were used to develop master curves so that modulus values could be evaluated at a variety of temperatures and frequencies that are expected for in-service pavements. The HMA dynamic modulus at 20°C for each of the mixes is shown in figure 2.

The dynamic modulus test data shows that, for all mixes and all speeds, the modulus of the FRAP mixtures is higher than the values currently assumed for the IDOT mechanistic design procedure. This result demonstrates that high FRAP mixes will not require changes to the pavement thickness and that the performance of the roadway can be expected to be as good as current materials and designs. These values are very similar to values determined in testing of typical IDOT mixtures for an extended life pavement research project (Carpenter, 2007).

In addition to evaluating all of the mixes, the single and double bump materials were evaluated to see if there is a stiffening of the single bump or a softening of the double bump mixes. Table 2 provides the single and double bump dynamic modulus data.

Table 2. Dynamic modulus test results for the single and double bump comparison materials.

Mix	Dynamic Modulus (psi)
IL-19.0 Binder N50, PG 58-28	1,004,711
IL-19.0 Binder N50, PG 58-22	1,065,224
IL-19.0 Base Course N50, PG 58-28	1,192,627
IL-19.0 Base Course N50, PG 58-22	1,047,423

For this field-produced mix there was no significant change in the dynamic modulus at 10 Hz and 20 °C. Therefore, it is expected that the pavement performance as measured by dynamic modulus for single and double bump materials will be similar.

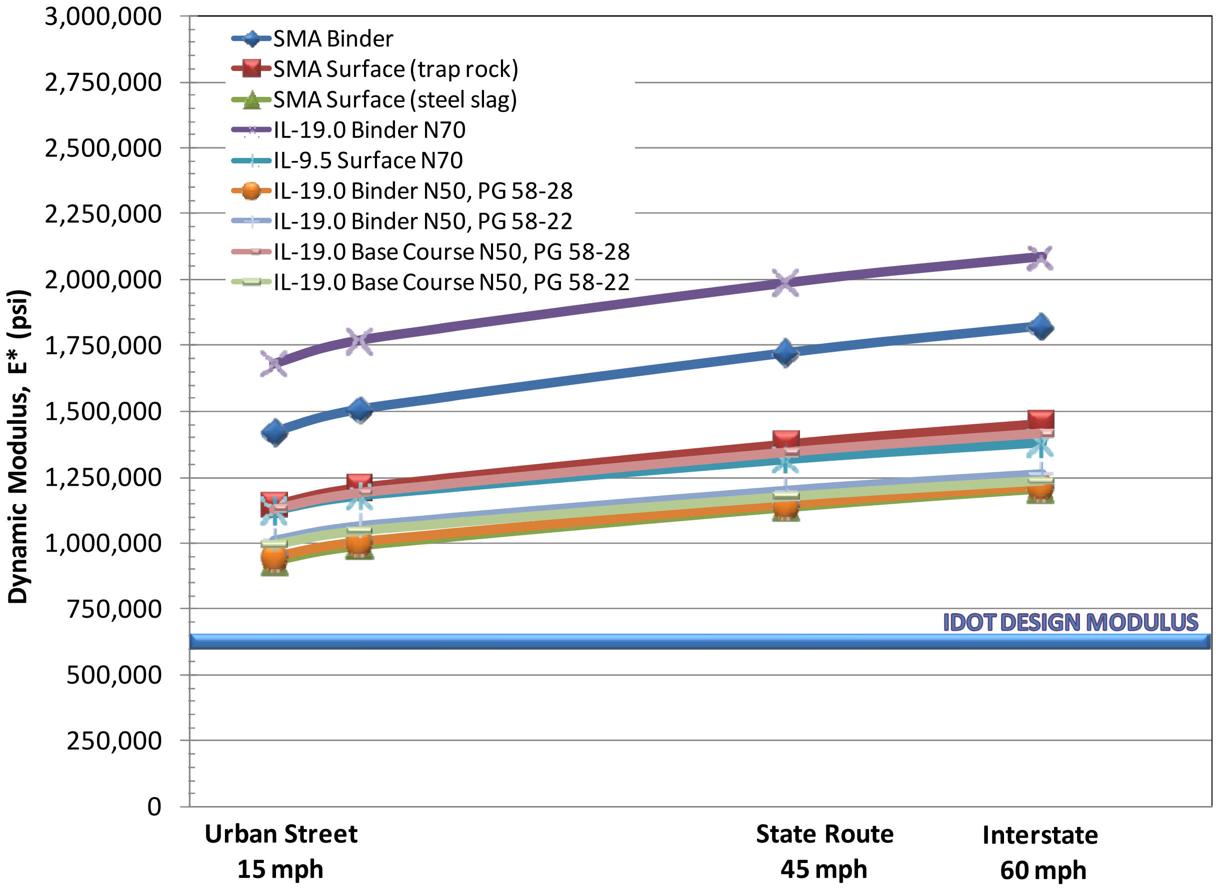

Figure 2. Dynamic modulus test data at 20°C and various highway speeds with the IDOT design range for northern Illinois.

5.3 IDOT BMPR TESTS AND TEST RESULTS

IDOT Bureau of Materials and Physical Research (BMPR) was provided samples of the three SMA mixtures for evaluation of tensile strength ratio (TSR) and stability and also testing in the asphalt pavement analyzer (APA) and in the Indenter.

5.3.1 Tensile Strength Ratio

TSR testing (Illinois Modified AASHTO T283) was performed on the SMA binder with gravel, SMA surface with steel slag, and SMA surface with trap rock. All tested samples pass the TSR test, with the gravel mix having the lowest TSR and the highest strength. Even after five freeze/thaw cycles, which will generally show a dramatic reduction of strength and TSR on susceptible mixes, the gravel SMA had good strength (103 psi). It had about the same rate of strength loss between the 140°F water bath strength and the freeze/thaw cycle strength as it had between no conditioning strength and the 140°F water bath strength. The TSR after five freeze/thaw cycles was 0.810, which nearly passed the Tollway criteria of 0.85 for 6-in specimens after conditioning in the 140°F water bath only. The other two mixes had appropriate strengths and good TSR’s. Figure 3 shows a chart of the strength and TSR data.

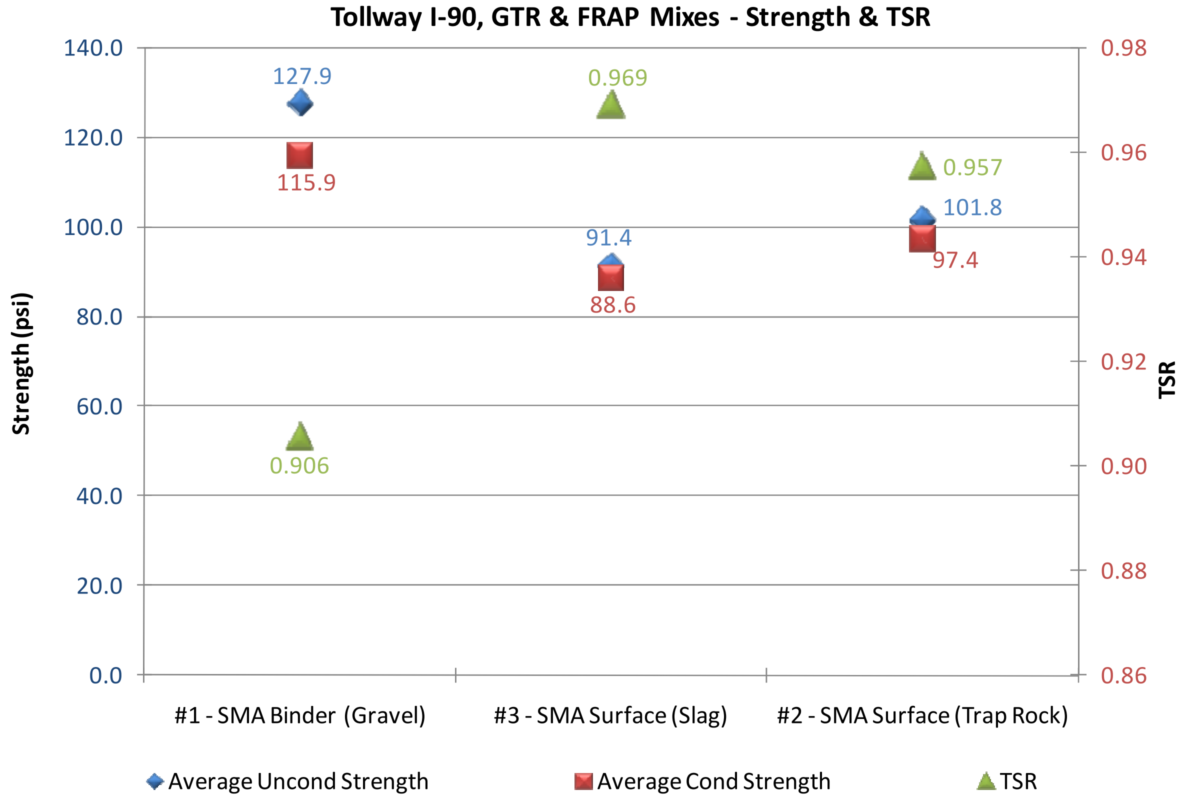

Figure 3. Strength and TSR data for the SMA mixes.

5.3.2 Stability

Both 4-in Marshall and 6-in Superpave gyratory stability tests were performed on the second sample of SMA binder with gravel and the trap rock samples. There was no significant difference between the two mixes. On the 4-in samples, the gravel was slightly higher than the trap rock. For the 6-in samples, the trap rock was somewhat higher than the gravel binder. Figure 4 presents the stability data.

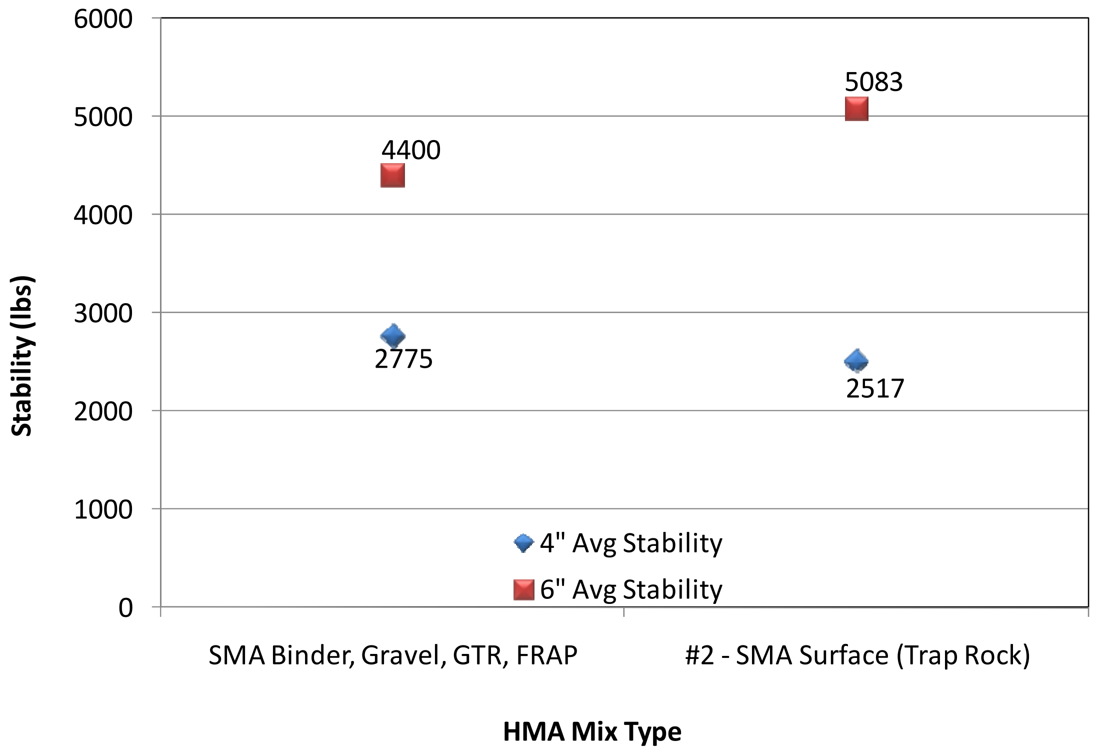

Figure 4. SMA stability for 4- and 6-in samples.

5.5.3 Asphalt Pavement Analyzer

For the APA, IDOT evaluated the number of cycles per mm of rut depth, as well as the rut depth only following the principles in AASHTO TP 63-03. IDOT primarily uses the "cycles per mm" for the steel wheels when both the rut depth and the number of cycles until the end of the test vary. With the hoses and the steel wheels, these mixes easily lasted for the full 8,000 cycles (for the hoses) and 20,000 cycles (for the submerged steel wheels test), so only the rut depth varied.

- Hose: The trap rock had slightly more cycles per mm of rut and a slightly lower rut depth. The steel slag had the least cycles per mm of rut and the greatest rut depth. All the results were close and were good.
- Steel Wheel: The gravel had slightly more cycles per mm of rut and, by a slight amount, had the lowest rut depth. The steel slag had the least cycles per mm of rut and the greatest rut depth. Again, all the results were close and were good.

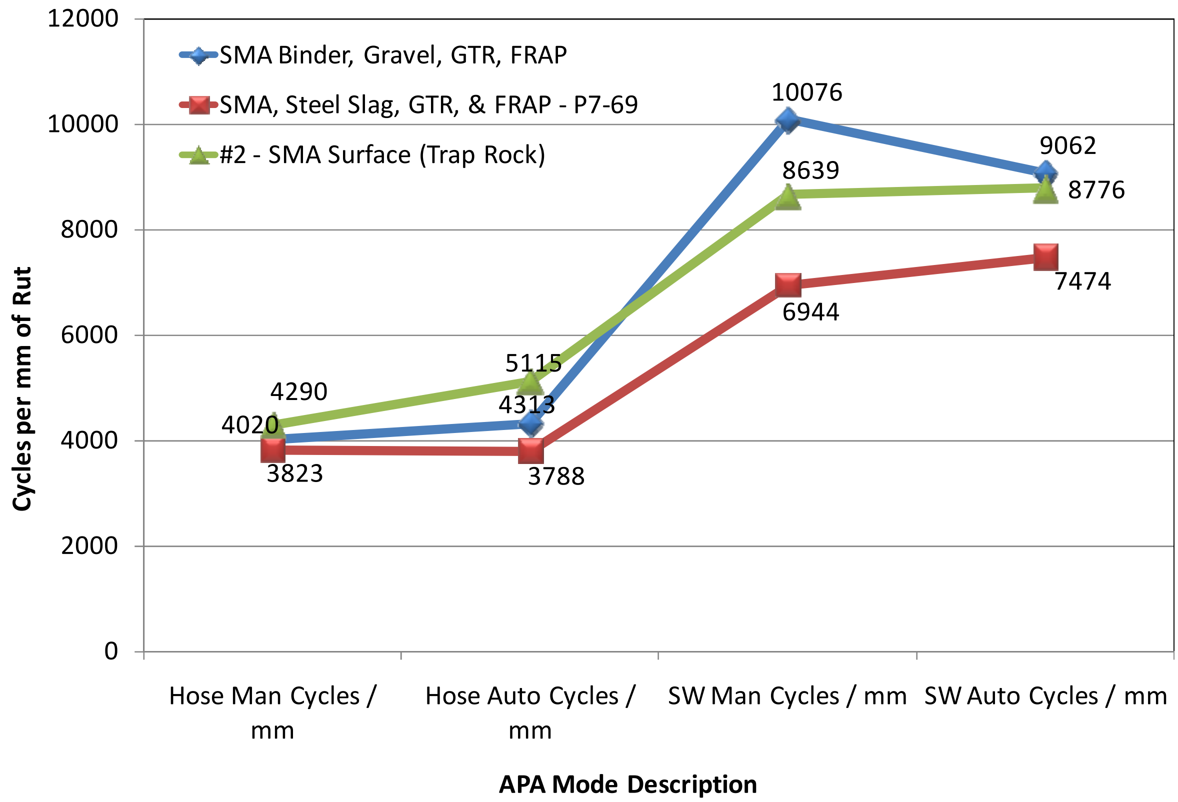

Figure 5. APA performance data for the SMA mixtures.

5.3.4 Indenter

The SMA gravel binder mix and the trap rock mix were tested in the Indenter. The Indenter is a simple inexpensive test that was devised at Iowa State University and that measures deformation of an HMA gyratory specimen at an in-service temperature. All Indenter specimens start off at approximately 152 mm height (115-mm specimen and 36.7 mm for the Indenter). These specimens all ended up around 135-136 mm after 300 gyrations. Compared with all the other Indenter tests IDOT has run for the last 2 or 3 years, this is somewhere in the middle. The deformation/number of gyrations slope is fairly straight throughout the 300 gyrations. Some mixes deform quickly then level out. Since the deformation is fairly gradual, it is better than if it deformed quickly, even if it ended up at the same point.

The testing of the SMA mixtures by the IDOT BMPR was to evaluate the stability of the SMA mixtures. All of the performed tests show that the SMA mixtures with FRAP have similar laboratory test results to other IDOT tested mixes and are therefore expected to give similar performance.

CHAPTER 6 CONCLUSIONS

Given the fatigue and modulus performance test data, the following conclusions can be drawn at this time:

- The fatigue performance of all high FRAP mixes is above the current design criteria.
- The fatigue performance of all but one high FRAP mix is above the proposed new criteria, and that sample has a modulus such that fatigue is not a concern for this mix.
- The SMA materials with GTR and fine FRAP have material properties similar to those of other SMA mixes. It is expected that these high RAP GTR modified SMA mixes will perform similar to other SMA materials produced with virgin aggregate sources and the SBS polymer modified asphalt.
- The issue of single and double bumping of liquid asphalt was investigated with a binder and base mix. In both cases, the material properties were better than the design requirements, and in the case of the base mix, the material properties were nearly identical. Based on these test results, there is no need to double bump the liquid asphalt grade.

Based on the conclusions of these field trials, the Tollway has taken some actions regarding the use of FRAP, as documented in appendix A.

REFERENCES

S. H. Carpenter, “Dynamic Modulus Performance of IDOT Mixtures,” Research Report FHWA-ICT-07-008, Illinois Center for Transportation, December 2007.

APPENDIX A: RESULTANT TOLLWAY ACTIONS

NEW SPECIFICATIONS APPLIED

As a result of the positive data from this study, the Illinois Tollway has adopted new specifications that give the option to apply fractionated RAP in all HMA mixes at increased quantities compared to traditional mixes using standard RAP. As of the date of this report, more than 300,000 tons of high FRAP HMA mixes have been produced in 2008 for numerous Tollway HMA reconstruction and overlay projects with consistent property values and positive QC test data that commonly complies with the specified properties of each mix. By the end of 2009, it is estimated that nearly 1,000,000 tons of high FRAP HMA mixes will be produced and placed on the Tollway system.

ADDITIONAL RESEARCH ON HIGH FRAP MIXTURES

Additional research on high FRAP HMA mixes is in progress to fine tune the Tollway specifications for the lab design of high FRAP mixes and the standards for production of such mixtures.

For at least the last 15 years, HMA mixes placed for Illinois Tollway mainline overlays or shoulders were produced with higher quality aggregate materials compared to IDOT's typical mixes. The Tollway specified requirements for Class "A" quality stone and sand to be used in all HMA mixes, versus IDOT's requirement for Class "B" quality aggregates. As a result, RAP from Tollway roadways is earmarked as higher quality materials and considered easier to recycle into HMA mixes. Some contractors and agency personnel feel the positive results received on high RAP mixes are not relevant to IDOT projects or those of other agencies because of differing RAP aggregate properties.

The HMA mixes to be produced by Rock Road Companies for the I-90 Cherry Valley Interchange project will utilize fractionated grindings that were removed from the Jane Addams Tollway (I-90) in 2003 when 25 miles of the Tollway was resurfaced. The overlay was originally placed in 1990 before material or mixture control was developed at the Tollway, and extensive rutting resulted. It is therefore likely these HMA mixes grinded and stockpiled in 2003 were similar to mixes that have been recently removed or that may even remain on many of the IDOT or county roadways in northern Illinois. This fractionated RAP will therefore be categorized as Type 2 FRAP and considered equivalent in quality to the grindings typically taken off the other roadways in IDOT Districts 1 or 2.

The following is a matrix of lab-produced and plant-produced mixes that are to be analyzed as part of the next research phase for physical properties and structural performance:

HMA Mix Type	Category II FRAP* Content (%)	Asphalt Grade
HMA Binder Course, IL-19.0, N70	10	PG 64-22
HMA Binder Course, IL-19.0, N70	10	PG 58-22
HMA Binder Course, IL-19.0, N70	10	PG 58-28
HMA Binder Course, IL-19.0, N70	27.5	PG 64-22
HMA Binder Course, IL-19.0, N70	27.5	PG 58-22
HMA Binder Course, IL-19.0, N70	27.5	PG 58-28
HMA Binder Course, IL-19.0, N70	45	PG 64-22
HMA Binder Course, IL-19.0, N70	45	PG 58-22
HMA Binder Course, IL-19.0, N70	45	PG 58-28
HMA Binder Course, IL-19.0, N90	30	PG 58-22

** both fine and coarse portion FRAP*

The lab mixtures have been produced and tested for volumetric properties. The mixes are being produced using the material ingredient sources form the I-90 Cherry Valley Interchange project. Later this year, the same mixes will be plant-produced by Rock Road at no additional cost to the Illinois Tollway for placement on the I-90 temporary pavements and will be tested for volumetric properties (voids and asphalt content). Samples of the lab-produced mixtures have been provided to the University of Illinois for structural analysis to compare the predicted performance of each mix. The plant-produced mixes will be produced shortly and submitted for the same durability testing. These test results will allow the Tollway to fine-tune the specifications for higher RAP HMA mixes. The primary benefit will be to provide documentation to the other transportation agencies that the modification of current policies can potentially save tens of millions of dollars annually, allow budget for more annual roadway work or repairs, and provide the public with greener, more sustainable roadways.

APPENDIX B: PROJECT SPECIAL PROVISIONS

RECLAIMED ASPHALT PAVEMENT (RAP) (TOLLWAY BDE)

Effective: January 1, 2007
Revised: December 5, 2007

In Article 1030.02(g), delete the last sentence of the first paragraph in (Note 2).

Revise Section 1031 of the Standard Specifications to read:

"**SECTION 1031. RECLAIMED ASPHALT PAVEMENT**

1031.01 Description. Reclaimed asphalt pavement (RAP) is reclaimed asphalt pavement resulting from cold milling or crushing of an existing dense graded hot-mix asphalt (HMA) pavement. The Contractor shall supply written documentation that the RAP originated from routes or airfields under federal, state, or local agency jurisdiction. This special provision provides the option for the use of screened fractionated RAP. Fractionated RAP consists of the fine aggregate portion (material passing the #4 screen) and the coarse aggregate portion, controlled with one-or-more larger screens.

1031.02 Stockpiles. The Contractor shall construct individual, sealed RAP stockpiles meeting one of the definitions for both non-fractionated and fractionated RAP described in the following subsections. 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. Stockpiles shall be identified by signs indicating the type of non-fractionated RAP as listed below (i.e. "Homogeneous Surface"), and by signs indicating the category and size of fractionated RAP (i.e. "Category 1, fine portion – 0 to #4").

(1) When using Non-Fractionated RAP

Prior to milling, the Contractor shall request the District or the Tollway to provide verification of the quality of the RAP to clarify appropriate stockpile.

(a) Homogeneous. Homogeneous RAP stockpiles shall consist of RAP from Class I, Superpave (High ESAL), HMA (High ESAL), or equivalent mixtures and represent: 1) the same aggregate quality, but shall be at least C quality; 2) the same type of crushed aggregate (either crushed natural aggregate, ACBF slag, or steel slag); 3) similar gradation; and 4) similar asphalt binder content. If approved by the Engineer, combined single pass surface/binder millings may be considered "homogenous" with a quality rating dictated by the lowest coarse aggregate quality present in the mixture.

(b) Conglomerate 5/8. Conglomerate 5/8 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 5/8 RAP shall be processed prior to testing by crushing to where all RAP shall pass the 5/8 in. (16 mm) or smaller screen. Conglomerate 5/8 RAP stockpiles shall not contain steel slag or other expansive material as determined by the Tollway or IDOT.

(c) Conglomerate 3/8. Conglomerate 3/8 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 B quality. This RAP may have an inconsistent gradation and/or asphalt binder content prior to processing. All conglomerate 3/8 RAP shall be processed prior to testing by crushing to where all RAP shall pass the 3/8 in. (9.5 mm) or smaller screen. Conglomerate 3/8 RAP stockpiles shall not contain steel slag or other expansive material as determined by the Tollway or IDOT.

(d) Conglomerate "D" Quality (DQ). Conglomerate DQ RAP stockpiles shall consist of RAP from Class I, Superpave (High or Low ESAL), HMA (High or Low ESAL), or equivalent mixtures. 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 Tollway or IDOT.

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

(2) When using Fractionated RAP (mechanical separation of RAP materials into appropriate sizes using an approved separation device)

The Contractor is required to have a QC plan approved by the Tollway Materials Engineer, a fractionation device approved the Tollway Materials Engineer, and sufficient cold feed bins. Fractionated RAP shall be separated by source (category 1 and 2) and size (fine and coarse portions). Separate calibrated cold feed bins are required for each size of fractionated RAP.

Ensure that the fractionated RAP source meets one of the following source categories:

Category 1: Milled Mainline/Ramp RAP – asphalt material milled from mainline pavements or ramps under Tollway jurisdiction.

Category 2: Non-Mainline/Ramp RAP – milled, crushed and screened material removed from Tollway shoulders or from other routes or airfields under federal, state or local agency jurisdiction.

Ensure that the fractionated RAP sizes comply with the following:

Fine Portion: The fine portion of fractionated RAP is the portion of the processed material passing the No. 4 screen. The fine portion of fractionated RAP that contains steel slag or other expansive material as determined by the Tollway shall be stockpiled separately and may be used under this special provision as fractionated RAP in surface friction course mixes.

Coarse Portion: The coarse portion of fractionated RAP is one or more of the coarse portions of the processed material larger than the No. 4 screen. The coarse portion of the fractionated RAP that contains steel slag as determined by the Tollway shall be from Category 1 sources only and stockpiled separately for potential use as fractionated RAP in surface friction course mixes. The maximum top size of the coarse portion of fractionated RAP may not exceed the following:

Nominal HMA Mix Designation	Maximum FRAP Screen Size 100% Passing
25.0 mm	1.5 inch
19.0 mm	1 inch
12.5 mm	3/4 inch
9.5 mm	1/2 inch

Prior to milling for fractionated RAP, the Contractor shall request the Tollway to provide verification of the quality of the RAP to clarify the appropriate category and size (identification) of the fractionated RAP stockpile as detailed below.

(a) Category 1 fine portion without steel slag. Category 1 fine portion RAP shall consist of RAP from Class I, Superpave (High ESAL), HMA (High ESAL), or equivalent mixtures milled from Tollway mainline and ramp pavements. The fine aggregate in this RAP shall be manufactured sand and may represent more than one aggregate type. All category 1 fine portion RAP shall be processed prior to testing by screening to where all RAP shall pass the No. 4 screen. Category 1 fine portion without steel slag stockpiles shall not contain steel slag or other expansive material as determined by the Tollway.

(b) Category 1 fine portion with steel slag. Category 1 fine portion with steel slag RAP stockpiles shall consist of RAP from Class I, Superpave (High ESAL), HMA (High ESAL), or equivalent mixtures milled from Tollway mainline or ramp surface friction course pavements. The fine aggregate in this RAP shall be manufactured sand and may represent more than one aggregate type. The coarse aggregate in this processed RAP shall be crushed aggregate including steel slag sources. All category 1 fine aggregate with steel slag RAP shall be processed prior to testing by screening to where all RAP shall pass the No. 4 screen.

(c) Category 2 fine portion. Category 2 fine portion RAP shall consist of RAP from Class I, Superpave (High ESAL), HMA (High ESAL), or equivalent mixtures removed from Tollway shoulders or from other routes or airfields under federal, state or local agency jurisdiction. The fine aggregate in this RAP shall be manufactured or natural sand and may represent more than one aggregate type. All category 2 fine portion RAP shall be processed prior to testing by screening to where all RAP shall pass the No. 4 screen. Category 2 fine portion stockpiles shall not contain steel slag or other expansive material as determined by the Tollway.

(d) Category 1 coarse portion without steel slag. Category 1 coarse portion RAP stockpiles shall consist of RAP from Class I, Superpave (High ESAL), HMA (High ESAL), or equivalent mixtures milled from Tollway mainline or ramp pavements. 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 B quality. All category 1 coarse aggregate RAP shall be processed prior to testing by screening to where all RAP shall be retained on the No. 4 or larger screen. Category 1 coarse portion RAP stockpiles shall not contain steel slag or other expansive material as determined by the Tollway.

(e) Category 1 coarse portion with steel slag. Category 1 coarse portion with steel slag RAP stockpiles shall consist of RAP from Class I, Superpave (High ESAL), HMA (High

ESAL), or equivalent mixtures milled from Tollway mainline or ramp surface friction course pavements. The coarse aggregate in this RAP shall be crushed aggregate including steel slag sources. All category 1 coarse aggregate with steel slag RAP shall be processed prior to testing by screening to where all RAP shall be retained on the No. 4 or larger screen.

(f) Category 2 coarse portion. Category 2 coarse portion RAP stockpiles shall consist of RAP from Class I, Superpave (High ESAL), HMA (High ESAL), or equivalent mixtures removed from Tollway shoulders or from other routes or airfields under federal, state or local agency jurisdiction. The coarse aggregate in this RAP may be crushed aggregate and may represent more than one aggregate type and/or quality but shall be at least C quality. All category 2 coarse aggregate RAP shall be processed prior to testing by screening to where all RAP shall be retained on the No. 4 or larger screen. Category 2 coarse portion RAP stockpiles shall not contain steel slag or other expansive material and shall not contain uncrushed gravel as determined by the Tollway.

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

1031.03 Testing. When used in HMA, the RAP shall be sampled and tested either during or after 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).

For testing after stockpiling, the Contractor shall submit a plan for approval to the IDOT District or to the Tollway proposing a satisfactory method of sampling and testing the RAP 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 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 Tollway use. The Contractor shall extract the other test sample according to IDOT Department procedure. The Engineer reserves the right to test any sample (split or Department/Tollway-taken) to verify Contractor test results.

(a) Testing Conglomerate 3/8. In addition to the requirements above, conglomerate 3/8 RAP shall be tested for maximum theoretical specific gravity (G_{mm}) at a 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).

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

Parameter	Homogeneous / Conglomerate	Conglomerate "D" Quality	Fractionated – Fine Portion	Fractionated – Coarse Portion
1 in. (25 mm)		± 5 %		
1/2 in. (12.5 mm)	± 8 %	± 15 %		± 8 %
No. 4 (4.75 mm)	± 6 %	± 13 %		± 6 %
No. 8 (2.36 mm)	± 5 %		± 5 %	
No. 16 (1.18 mm)		± 15 %		
No. 30 (600 µm)	± 5 %		± 5 %	
No. 200 (75 µm)	± 2.0 %	± 4.0 %	± 2.0 %	
Asphalt Binder	± 0.4 % 1/	± 0.5 %	± 0.3 %	± 0.3 %
G_{mm}	± 0.02 2/			

1/ The tolerance for conglomerate 3/8 shall be ± 0.3 %.

2/ Applies only to conglomerate 3/8. When variation of the G_{mm} exceeds the ± 0.02 % tolerance, a new conglomerate 3/8 stockpile shall be created which will also require an additional mix design.

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 RAP shall not be used in HMA unless the RAP representing the failing tests is removed from the stockpile. All test data and acceptance ranges shall be sent to the IDOT District / or the Tollway 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)".

1031.04 Quality Designation of Aggregate in RAP. The quality of the RAP shall be set by the lowest quality of coarse aggregate in the RAP stockpile and are designated as follows.

(a) RAP from Class I, Superpave (High ESAL), or HMA (High ESAL) surface mixtures are designated as containing Class B quality coarse aggregate.

(b) RAP from Superpave (Low ESAL)/HMA (Low ESAL) IL-19.0L binder and IL-9.5L surface mixtures are designated as Class D quality coarse aggregate.

(c) 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.

(d) RAP from bituminous stabilized subbase and BAM shoulders are designated as containing Class D quality coarse aggregate.

1031.05 Use of RAP in HMA.

(1) Use of Non-Fractionated RAP in HMA. The use of RAP in HMA shall be as follows.

(a) Coarse Aggregate Size. 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.

(b) Steel Slag Stockpiles. RAP stockpiles containing steel slag or other expansive material, as determined by the Department or the Tollway, shall be homogeneous and will be approved for use in HMA (High ESAL and Low ESAL) surface mixtures only.

(c) Use in HMA Surface Mixtures (High and Low ESAL). RAP stockpiles for use in HMA surface mixtures (High and Low ESAL) shall be either homogeneous or conglomerate 3/8, in which the coarse aggregate is Class B quality or better.

(d) Use in HMA Binder Mixtures (High and Low ESAL), HMA Base Course, and HMA Base Course Widening. RAP stockpiles for use in HMA binder mixtures (High and Low ESAL), HMA base course, and HMA base course widening shall be homogeneous, conglomerate 5/8, or conglomerate 3/8, in which the coarse aggregate is Class C quality or better.

(e) Use in Shoulders and Subbase. RAP stockpiles for use in HMA shoulders and stabilized subbase (HMA) shall be homogeneous, conglomerate 5/8, conglomerate 3/8, or conglomerate DQ.

(f) The use of RAP shall be a contractor's option when constructing HMA in all contracts. When the contractor chooses the RAP option, the percentage of RAP shall not exceed the amounts indicated in the table for a given N Design.

Maximum RAP Percentage Using Non-Fractionated RAP

HMA Mixtures 2/	Maximum %, Non-Fractionated RAP		
Ndesign	Binder/Leveling Binder	Surface	Polymer Modified
50	25 / 50	15	10
70	15 / 40	10 / 25 1/	10
90	10	10	10
105	10	10	10

1/ If more than 10 % RAP is used, at least 50 percent of the fine aggregate fraction shall be stone sand, slag sand, or steel slag sand meeting the FA/FM 20 gradation.

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

(2) Use of Fractionated RAP in HMA. The use of fractionated RAP in HMA shall be as follows.

(a) Coarse Aggregate Size. The coarse aggregate in the coarse portion of fractionated RAP shall be equal to or less than the nominal maximum size requirement for the HMA mixture to be produced.

(b) Steel Slag Stockpiles. Fractionated RAP stockpiles containing steel slag or other expansive material, as determined by the Tollway, shall be approved for use in HMA (High ESAL) surface mixtures only.

(c) Use in HMA Surface and HMA Binder Mixtures (High ESAL). Fractionated RAP for use in HMA surface mixtures (High ESAL) shall be Category 1 or 2 fractionated RAP, in which the coarse aggregate is Class B quality or better.

(d) Use in HMA Surface Mixtures (Low ESAL). Fractionated RAP for use in HMA surface mixtures (Low ESAL) shall be Category 1 or 2 fractionated RAP, in which the coarse aggregate is Class C quality or better.

(e) Use in HMA Binder Mixtures (Low ESAL) and HMA Base Course. Fractionated RAP for use in HMA binder mixtures (Low ESAL) and HMA base course mixtures shall be Category 1 or 2 fractionated RAP, in which the coarse aggregate is Class C quality or better.

(f) Use in HMA Shoulders and HMA Subbase. Fractionated RAP for use in HMA shoulder mixtures or HMA stabilized subbase mixtures shall be Category 1 or 2 fractionated RAP.

(g) Use in SMA Mixtures. Fractionated RAP for use in SMA surface course and SMA binder course mixtures shall be the fine portion of Category 1 fractionated RAP, in which the fine aggregate is manufactured sand only.

(h) The use of fractionated RAP shall be a contractor’s option when constructing HMA in all contracts. When the contractor chooses the fractionated RAP option, the percentage of fractionated RAP shall not exceed the amounts indicated in the following tables for a given Ndesign or SMA design.

Maximum RAP Percentage Using Category 1 Fractionated RAP

HMA Mixtures	Maximum %, Category 1 Fractionated RAP[2/]	
Ndesign	Binder/Leveling Binder[1/]	Surface[5/]
50	40/50[3/]	25
70	40	25
90	25	25[4/]
105	25	20[4/]

1/ For HMA Shoulder Binder Course N50, the amount of fractionated RAP shall not exceed 40%, and for HMA Base Course N50, the amount of RAP shall not exceed 50% of the mixture.

2/ When RAP exceeds 15% in an HMA mix, the high virgin asphalt binder grade shall each be reduced by one grade (i.e. 25% RAP would require a virgin asphalt binder grade of PG 64-22 to be reduced to a PG 58-22).

3/ For HMA Base Course with 2% air. A virgin asphalt binder grade of PG 58-28 will be required for HMA Base Course.

4/ Category 1 coarse portion fractionated RAP containing steel slag may be blended with virgin steel slag aggregate to obtain the specified properties in HMA surface friction course mixes.

5/ Includes polymer modified surface course mixtures.

Maximum RAP Percentage Using Category 2 Fractionated RAP

HMA Mixtures	Maximum %, Category 2 Fractionated RAP[2/]	
Ndesign	Binder/Leveling Binder[1/]	Surface
50	40/50[3/]	25[4/]
70	35	25[4/]
90	20	10
105	20	10

1/ For HMA Shoulder Binder Course N50, the amount of fractionated RAP shall not exceed 40%, and for HMA Base Course N50, the amount of RAP shall not exceed 50% of the mixture.

2/ When RAP exceeds 15% in an HMA mix, the high virgin asphalt binder grade shall each be reduced by one grade (i.e. 25% RAP would require a virgin asphalt binder grade of PG 64-22 to be reduced to a PG 58-22).

3/ For HMA Base Course with 2% air. A virgin asphalt binder grade of PG 58-28 will be required for HMA Base Course.

4/ If more than 10 % RAP is used, at least 50 percent of the fine aggregate fraction shall be stone sand, slag sand, or steel slag sand meeting the FA/FM 20 gradation.

Maximum RAP Percentage Using Category 1 Fine Portion
Fractionated RAP

SMA Mixtures[1/]	Maximum %, Category 1 Fine Portion Fractionated RAP[2/]
Binder	15
Surface	15

1/ Positive dust control must be used in the production of SMA mixtures.

2/ During production, the maximum RAP percentage could be increased to 20 percent, if changes are warranted by the volumetric test results.

1031.06 HMA Mix Designs. At the Contractor's option, HMA mixtures may be constructed utilizing RAP material meeting the above detailed requirements.

RAP designs shall be submitted for volumetric verification. If additional RAP stockpiles are tested and found that no more than 20 percent of the results, as defined under "Testing" herein, are outside of the control tolerances set for the original RAP stockpile and HMA mix design, and meets all of the requirements herein, the additional RAP stockpiles may be used in the original mix design at the percent previously verified.

The Contractor's mix design shall use a bulk aggregate specific gravity (G_{sb}) of the RAP equal to 2.660. As an option, the Contractor may have the Tollway conduct G_{sb} of the RAP stockpile(s), for possible use in the mix design. If the Contractor chooses this option, the following procedure will be used for determining G_{sb}:

1. Provide the Tollway with a 20,000 gram representative sample of each RAP material.
2. The RAP will be heated to 230ºF, and the RAP agglomerations broken down, as if conducting a maximum specific gravity test.
3. The asphalt content will be determined on a 1,000 – 1,500 gram sample of the RAP.
4. A 3,000 gram sample of the RAP will be dried to a constant weight. One percent virgin asphalt binder will be added to the RAP and mixed thoroughly. The sample will be split into two parts, and the maximum specific gravity (G_{mm}) of each sample determined.
5. The G_{se} of each sample will be calculated and averaged.
6. If historical mix data or the mix design of the RAP source is available, the asphalt absorption from that information will be used to calculate the Gsb of the RAP. If no information is available on the RAP source, an asphalt absorption of 1.0 percent will be used to calculate the G_{sb} of the RAP.

1031.07 HMA Production. The coarse aggregate in all RAP used shall be equal to or less than the nominal maximum size requirement for the HMA mixture being produced.

To remove or reduce agglomerated material, a scalping screen, crushing unit, or comparable sizing device approved by the Engineer shall be used in the RAP 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 RAP control tolerances or QC/QA test results require corrective action, the Contractor shall cease production of the mixture containing RAP and either switch to the virgin aggregate design or submit a new RAP design. When producing SMA mixtures or mixtures containing conglomerate 3/8 RAP, a positive dust control system shall be utilized.

HMA plants utilizing RAP 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 or Tollway.

(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 RAP 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 RAP material as a percent of the total mix to the nearest 0.1 percent.

(8) Aggregate and RAP moisture compensators in percent as set on the control panel. (Required when accumulated or individual aggregate and RAP 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 or Tollway.

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

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

(5) RAP weight to the nearest pound (kilogram).

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

(7) Residual asphalt binder in the RAP 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 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 “Other”. 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. (37.5 mm) sieve. The RAP material shall be reasonably well graded from coarse to fine. RAP material that is gap-graded or single sized will not be accepted.”

APPENDIX C. MIX DESIGN AND MIX INFORMATION

Final AJMF
2007 Fractionated RAP Field Trials

Mix # 90BIT0708 SMA Binder Mix 1

Reported by: Matt Galloy **Date: April 11, 2008**

FINAL BLEND PERCENTAGES

Aggregate Material Code	Aggregate Blend Percent (by Wt.)
031CM14	50.5%
031CM13	30.5%
004MF01	4.0%
Minus #4 FRAP	15.0%
Binder	5.8%

Comments:

MIX 1

DATE: 23-Jul-07

SEQ NO:

Bituminous Mixture Design

Design Number : ---------> RR07001-2

Lab preparing the design ? (PP,PL,IL,etc) — Enter Lab Preparing Design

Producer Name & Number --> 4166-03 Rock Road

Material Code Number ----> 18535 SMA Binder

Agg No.	#1	#2	#3	#4	#5	RAP #1	RAP #2	RAP #3	ASPHALT
Size	031CMM14	031CMM13		4	004MF01	Minus #4			76-22 GRT
Source (PROD #)	52400-49	52400-29			52202-08	4166-03			1757-05
(NAME)	Mann Bros.	Rock Road			Linwood	Rock Road			Seneca
(LOC)	Beloit	Townline Pit			Linwood Mng.	Rock Road			Lemont
						6.0	0.0	0.0	<--%AC in RAP
Total Mix Blend	49.0	30.5			5.5	15.0	0.0	0.0	
Total Agg. Blend	49.5	30.9	0.0	0.0	5.5	14.1	0.0	0.0	

100.0 <-Mix Total 100.0

100.0 <-Agg Total

Agg No. / Sieve Size	#1	#1	#2	#3	#4	#6	#6	#6	Aggregate Blend	Mixture Composition Specification	FORMULA	FORMULA RANGE Min	Max
1" (25.0mm)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0		100		
3/4"(19.0mm)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100	100		
1/2" (12.5mm)	88.4	99.0	100.0	100.0	100.0	100.0	100.0	100.0	93.9	82-100	94		
3/8" (9.5mm)	41.3	82.0	100.0	100.0	100.0	100.0	0.0	97.8	65.4	65max	65		
No.4 (4.75mm)	2.2	30.0	0.0	100.0	100.0	99.6	0.0	73.4	29.9	20-30	30	25	35
No.8 (2.36mm)	1.7	5.0	0.0	100.0	100.0	84.5	0.0	49.0	19.8	16-24	20	15	25
No.16 (1.18mm)	1.6	3.0	0.0	0.0	100.0	57.0	0.0	37.0	15.3		15		
No.30 (600µm)	1.5	2.0	0.0	0.0	100.0	38.7	0.0	28.0	12.3	12-16	12	8	16
No.50 (300µm)	1.5	2.0	0.0	0.0	100.0	25.8	0.0	18.6	10.5	10-15	11		
No.100 (150µm)	1.4	2.0	0.0	0.0	98.0	19.1	0.0	12.6	9.4		9		
No.200(75µm)	1.2	1.9	0.0	0.0	85.0	14.8	0.0	10.2	8.0	8-10	8.0	6.5	9.5

Bulk Sp Gr	2.688	2.681	1.000	1.000	2.750	2.674	1.000	1.000	2.687
Apparent Sp Gr	2.795	2.802	1.000	1.000	2.750	2.752	1.000	1.000	2.789
Absorption, %	1.43	1.61	0.00	0.00	0.00	1.06	0.00	0.00	1.09
									1.047

SUMMARY OF SUPERPAVE GYRATORY DESIGN DATA

MIXTURE AGED 2 HOURS @ 320

Dust/AC Ratio 1.30

DATA for N-initia	9									
	AC, %MIX	(Gmb)	(Gmm)	(Pa)	VMA	VFA	Vbe	Pbe	Pba	Gse
MIX 1	5.0	2.146	2.531	15.2	24.1	36.9	8.91	4.35	0.69	2.735
MIX 2	5.5	2.164	2.519	14.1	23.9	41.0	9.81	4.75	0.80	2.743
MIX 3	6.0	2.179	2.503	13.0	23.8	45.5	10.83	5.20	0.85	2.747
MIX 4	6.5	2.200	2.495	11.8	23.4	49.6	11.62	5.53	1.04	2.761

DATA for N-desiç	80									
		(Gmb)	(Gmm)	(Pa)	VMA	VFA	Vbe	Pbe	Gse	Pba
MIX 1	5.0	2.388	2.531	5.7	15.6	63.7	9.92	4.35	2.735	0.69
MIX 2	5.5	2.403	2.519	4.6	15.5	70.4	10.90	4.75	2.743	0.80
MIX 3	6.0	2.415	2.503	3.5	15.5	77.3	12.00	5.20	2.747	0.85
MIX 4	6.5	2.429	2.495	2.7	15.5	82.9	12.83	5.53	2.761	1.04

	NUMBER OF GYRATIONS	%AC	Gmb	Gmm	%VOIDS (Pa) Target	VMA	VFA	Gse	Gsb	TSR
OPTIMUM DESIGN DATA @Ndes: ---->	80	6.0	2.415	2.503	3.5	15.5	77.4	2.747	2.687	0.90

REMARKS: Draindown @ 350F = 0.1%

Tested by : ____________________

Reviewed by : ____________________

Final Approval : ____________________

S.T.A.T.E. TESTING, LLC

QC/QA DATA

Mix Description: SMA 12.5 mm Binder – GTR, FRAP, Crushed Gravel (Mix 1)
Project: I-90 ISTHA

SPECIFICATION:

N_{DES}	PG Grade	AC%	Fibers	Voids	VMA	VFA
80	GTR 76-22			3.5	16	75-85

MIX DESIGN DATA: Number:

N_{DES}	AC%	G_{MB}	G_{MM}	Voids	VMA	VFA
80	6.0	2.415	2.503	3.5	15.5	77.4

PG Grade	G_{SE}	G_{SB}	TSR	P200:AC	Fibers
GTR 76-22	2.747	2.687	0.9	1.3	0

MIX ADJUSTMENTS:

QC/QA PLANT TESTS:

Date	QC/QA/IA	G_{MB}	G_{MM}	Voids	AC%	Tons
8-14-07	QC	2.426	2.492	2.7	6.0	368.6
		2.444	2.487	1.8	6.2	
	QA (8-15)	2.430	2.501	2.8	6.2	
	1-R				5.6	
	2-I	2.450	2.480	1.2	7.0	
	2-R				5.9	
8-15-07	QC	2.452	2.496	1.8	6.3	414.2
		2.415	2.502	3.5	5.8	
	QA (8-16)	2.458	2.506	1.9	6.2	
	1-R				5.4	
	2-I	2.422	2.510	3.5	5.8	
	2-R				5.2	
		FVMA	FVFA			
8-14-07	QC	14.7	0.82			
		14.0	0.87			
8-15-07		14.0	0.87			
		15.3	0.83			

Final AJMF
2007 Fractionated RAP Field Trials

Mix # 90BIT0712 **SMA Surface (Trap Rock) Mix 2**

Reported by: Matt Galloy **Date:** April 11, 2008

FINAL BLEND PERCENTAGES

Aggregate Material Code	Aggregate Blend Percent (by Wt.)
031CM14 Trap Rock	48.5 %
031CM13 Trap Rock	36.7 %
004MF01	4.9 %
Minus #4 FRAP	14.8%
Binder	6.0 %

Comments:

MIX 2

DATE: 17-Aug-07

SEQ NO:

Bituminous Mixture Design

Design Number : ---------> RR07002-3c

Lab preparing the design ? (PP,PL,IL,etc) — Enter Lab Preparing Design

Producer Name & Number --> 4166-03 Rock Road

Material Code Number ----> 18436 SMA Surface w/FRAP

Agg No.	#1	#2	#3	#4	#5	RAP #1	RAP #2	RAP #3	ASPHALT
Size	CM13	031CM14			004MF01	Minus #4			76-22 GRT
Source (PROD #)	52402-14	52402-14			52202-08	4166-03			1757-05
(NAME)	RME	RME			Linwood	Rock Road			Seneca
(LOC)	Athens, Wi.	Athens, Wi.			Linwood Mng.	Rock Road			Lemont
						6.0	0.0	0.0	<--%AC in RAP
Total Mix Blend	32.5	47.6	0.0		4.9	15.0	0.0	0.0	
Total Agg. Blend	32.9	48.1	0.0	0.0	4.9	14.1	0.0	0.0	

100.0 <-Mix Total 100.0

100.0 <-Agg Total

Agg No. / Sieve Size	#1	#1	#2	#3	#4	#6	#6	#6	Aggregate Blend	Mixture Composition Specification	FORMULA	FORMULA RANGE Min	Max
1" (25.0mm)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0		100		
3/4"(19.0mm)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100	100		
1/2" (12.5mm)	92.7	84.2	100.0	100.0	100.0	100.0	100.0	100.0	90.0	82-100	90		
3/8" (9.5mm)	74.8	43.8	100.0	100.0	100.0	100.0	0.0	97.8	64.7	65max	65		
No.4 (4.75mm)	28.9	2.4	0.0	100.0	100.0	99.6	0.0	73.4	29.6	20-30	30	25	35
No.8 (2.36mm)	7.3	1.9	0.0	100.0	100.0	84.5	0.0	49.0	20.1	16-24	20	15	25
No.16 (1.18mm)	2.4	1.8	0.0	0.0	100.0	57.0	0.0	37.0	14.6		15		
No.30 (600µm)	1.9	1.8	0.0	0.0	100.0	38.7	0.0	28.0	11.9	12-16	12	8	16
No.50 (300µm)	1.8	1.7	0.0	0.0	100.0	25.8	0.0	18.6	10.0	10-15	10		
No.100 (150µm)	1.7	1.7	0.0	0.0	98.0	19.1	0.0	12.6	8.9		9		
No.200(75µm)	1.5	1.5	0.0	0.0	85.0	14.8	0.0	10.2	7.5	8-10	7.5	6.0	9.0

Bulk Sp Gr	2.762	2.877	1.000	1.000	2.750	2.674	1.000	1.000	2.802
Apparent Sp Gr	2.810	2.907	1.000	1.000	2.750	2.752	1.000	1.000	2.844
Absorption, %	0.62	0.36	0.00	0.00	0.00	1.06	0.00	0.00	0.62
									1.047

SUMMARY OF SUPERPAVE GYRATORY DESIGN DATA

MIXTURE AGED 2 HOURS @ 320

Dust/AC Ratio 1.30

DATA for N-initial 9

	AC, %MIX	(Gmb)	(Gmm)	(Pa)	VMA	VFA	Vbe	Pbe	Pba	Gse
MIX 1	5.0	2.208	2.611	15.4	25.1	38.6	9.71	4.60	0.42	2.834
MIX 2	5.5	2.217	2.587	14.3	25.2	43.3	10.93	5.16	0.36	2.829
MIX 3	6.0	2.230	2.570	13.2	25.2	47.6	11.98	5.63	0.40	2.832
MIX 4	6.5	2.239	2.551	12.3	25.3	51.6	13.05	6.10	0.43	2.835

DATA for N-desig 80

		(Gmb)	(Gmm)	(Pa)	VMA	VFA	Vbe	Pbe	Gse	Pba
MIX 1	5.0	2.467	2.611	5.5	16.4	66.3	10.85	4.60	2.834	0.42
MIX 2	5.5	2.475	2.587	4.3	16.5	73.9	12.21	5.16	2.829	0.36
MIX 3	6.0	2.486	2.570	3.2	16.6	80.5	13.36	5.63	2.832	0.40
MIX 4	6.5	2.498	2.551	2.1	16.7	87.4	14.56	6.10	2.835	0.43

	NUMBER OF GYRATIONS	%AC	Gmb	Gmm	%VOIDS (Pa) Target	VMA	VFA	Gse	Gsb	TSR
OPTIMUM DESIGN DATA @Ndes: ---->	80	5.9	2.484	2.574	3.5	16.6	78.9	2.833	2.802	0.84

REMARKS: Draindown @ 350F =

Tested by : ____________________

Reviewed by : ____________________

Final Approval : ____________________

S.T.A.T.E. TESTING, LLC

QC/QA DATA

Mix Description: SMA Surface – FRAP, GTR, Diabase MIX2	
Project: I-90 ISTHA	

SPECIFICATION:

N_{DES}	PG Grade	AC%	Fibers	Voids	VMA	VFA
80	PG 76-22			3.5	17	75-85

MIX DESIGN DATA: **Number:**

N_{DES}	AC%	G_{MB}	G_{MM}	Voids	VMA	VFA
80	5.9%	2.484	2.574	3.5	16.6	78.9

PG Grade	G_{SE}	G_{SB}	TSR	P200:AC	Fibers
GTR PG76-22	2.833	2.802	0.84	1.3	No

MIX ADJUSTMENTS:

QC/QA PLANT TESTS:

Date	QC/QA/IA	G_{MB}	G_{MM}	Voids	AC%	Tons
9/26/07	QC01	2.482	2.605	4.7	5.6	358.6
	QC02	2.482	2.596	4.4	5.7	379.9
	QA01	2.488	2.607	4.6	5.8	
	QA02	2.472	2.607	5.2	5.5	738
9/27/07	QC01	2.490	2.600	4.2	5.6	
	QC02	2.477	2.607	5.1	5.5	
	QA01	2.483	2.600	4.5	5.7	
	QA02	2.469	2.602	5.1	5.2	
		FVMA	FVFA			
	QA	16.4				
		17.0				
		16.7				
		17.2				

Final AJMF
2007 Fractionated RAP Field Trials

Mix # **90BIT0718** **SMA Surface (Steel Slag) Mix 3**

Reported by: **Matt Galloy** **Date:** **April 11, 2008**

FINAL BLEND PERCENTAGES

Aggregate Material Code	Aggregate Blend Percent (by Wt.)
039CM11	22.0 %
039CM13	55.0 %
004MF01	5.0 %
Minus #4 FRAP	18.0 %
Binder	6.0 %

Comments:

MIX 3

DATE: 18-Sep-07

SEQ NO:

Bituminous Mixture Design

Design Number : ------> RBT07003

Lab preparing the design ? (PP,PL,IL,etc) | Enter Lab Preparing Design

Producer Name & Number --> 1686-24 Rockford Blacktop

Material Code Number ----> 18436 SMA Surfac w/FRAP and Steel Furnace Slag

Agg No.	#1	#2	#3	#4	#5	RAP #1	RAP #2	RAP #3	ASPHALT (76-22 GTR)
Size	039CMM11	039CMM13		4	004MF01	Minus #4			10131
Source (PROD #)	52103-23	52103-13			52202-08	1868-24			1757-05
(NAME)	Heritage Slag	Heritage Slag			Linwood	Rockford BT			Seneca
(LOC)	Inland	Inland			Linwood Mng.				Lemont
						7.1	0.0	0.0	<--%AC in RAP
Total Mix Blend	25.0	55.0	0.0	0.0	5.0	15.0	0.0	0.0	
Total Agg. Blend	25.3	55.7	0.0	0.0	5.1	13.9	0.0	0.0	

100.0 <-Mix Total 100.0

100.0 <-Agg Total

Agg No. / Sieve Size	#1	#1	#2	#3	#4	#6	#6	#6	Aggregate Blend	Mixture Composition Specification	FORMULA	FORMULA RANGE Min	Max
1" (25.0mm)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0		100		
3/4"(19.0mm)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100	100		
1/2" (12.5mm)	32.3	100.0	100.0	100.0	100.0	100.0	100.0	100.0	82.8	82-100	83		
3/8" (9.5mm)	5.1	81.1	100.0	100.0	100.0	100.0	99.0	100.0	65.4	65max	65		
No.4 (4.75mm)	2.8	19.7	100.0	0.0	100.0	98.0	0.0	0.0	30.4	20-30	30	25	35
No.8 (2.36mm)	2.5	6.3	0.0	0.0	100.0	75.0	0.0	0.0	19.7	16-24	20	15	25
No.16 (1.18mm)	2.0	4.6	0.0	0.0	100.0	49.0	0.0	0.0	15.0		15		
No.30 (600µm)	2.0	3.9	0.0	0.0	100.0	33.0	0.0	0.0	12.4	12-16	12	8	16
No.50 (300µm)	2.0	3.4	0.0	0.0	100.0	22.0	0.0	0.0	10.6	10-15	11		
No.100 (150µm)	1.8	3.1	0.0	0.0	98.0	17.0	0.0	0.0	9.5		10		
No.200(75µm)	1.4	2.3	0.0	0.0	85.0	13.1	0.0	0.0	7.8	8-10	7.8	6.3	9.3
Bulk Sp Gr	3.403	3.391	1.000	1.000	2.750	2.758	1.000	1.000	3.252				
Apparent Sp Gr	3.586	3.612	1.000	1.000	2.828	2.893	1.000	1.000	3.438				
Absorption, %	1.50	1.80	0.00	0.00	1.00	1.69	0.00	0.00	1.67				
									1.030				

SUMMARY OF SUPERPAVE GYRATORY DESIGN DATA

MIXTURE AGED 2 HOURS @ 320

Dust/AC Ratio: 1.30

DATA for N-initia	9									
	AC, %MIX	(Gmb)	(Gmm)	(Pa)	VMA	VFA	Vbe	Pbe	Pba	Gse
MIX 1	5.0	2.466	3.021	18.4	28.0	34.3	9.59	4.01	1.05	3.363
MIX 2	5.5	2.521	2.996	15.9	26.7	40.7	10.87	4.44	1.12	3.371
MIX 3	6.0	2.579	2.967	13.1	25.5	48.6	12.36	4.94	1.13	3.372
MIX 4	6.5	2.601	2.942	11.6	25.2	54.0	13.62	5.40	1.18	3.378

DATA for N-desig	80									
		(Gmb)	(Gmm)	(Pa)	VMA	VFA	Vbe	Pbe	Gse	Pba
MIX 1	5.0	2.842	3.021	5.9	17.0	65.1	11.05	4.01	3.363	1.05
MIX 2	5.5	2.851	2.996	4.8	17.1	71.7	12.29	4.44	3.371	1.12
MIX 3	6.0	2.864	2.967	3.5	17.2	79.8	13.73	4.94	3.372	1.13
MIX 4	6.5	2.877	2.942	2.2	17.3	87.2	15.07	5.40	3.378	1.18

	NUMBER OF GYRATIONS	%AC	Gmb	Gmm	%VOIDS (Pa) Target	VMA	VFA	Gse	Gsb	TSR
OPTIMUM DESIGN DATA @Ndes: --->	80	6.0	2.863	2.966	3.5	17.2	79.7	3.371	3.252	0.94

REMARKS:

Tested by :

Reviewed by :

Final Approval :

Mix Description: (Type, Ndes, NMA Size)
18436 N80 SMA Steel Slag Surface FRAP (GTR) **(90BIT0718)** **FRAP MIX 3**
Project: I-06-5407 I-90 Shoulder Resurfacing

Specification

Project

Ndes	PG Grade	AC%	Fibers	Voids	VMA	VFA
80	76-22 GTR	6.0	GTR	4.0	≥17	75-90

Mix Design Data **90BIT0718**

Ndes	PG Grade	AC%	Fibers	Voids	VMA	VFA
80	76-22	6.0	GTR	3.5	16.8	79.2

PG Grade	Gse	Gsb	TSR	P200:AC	Fibers	
76-22	3.371	3.235	0.94	1.3	GTR	

Mix Adjustments Made: 003-03 Reduced CMM11 3%, Increased -#4 FRAP 3%

QC/QA Plant Test Data

Date	QC/QA/IA	Gmb	Gmm	Voids	AC%	FVMA	FVFA	Tons
10/17/07	QC 001-01	2.792	2.928	4.6	6.0	22.2	79.2	
10/17/07	QC 001-02	2.810	2.947	4.6	6.2	21.7	78.7	926.4
10/17/07	QC 001-03	2.822	2.884	2.1	6.0	21.3	90.1	
	QA-1-1	2.829	2.951	4.1	6.3	18.2		
	1-R				5.9			
	1-Feb				6.5			
	2-R	2.839	2.915	2.6	6.6	17.9		

Final AJMF
2007 Fractionated RAP Field Trials

Mix # 90BIT0713 N70 Binder Mix 4

Reported by: Matt Galloy **Date: April 11, 2008**

FINAL BLEND PERCENTAGES

Aggregate Material Code	Aggregate Blend Percent (by Wt.)
042CM11	29.5 %
031CM16	22.5 %
039FM20	8.0 %
3/16 inch FRAP	20.0 %
Minus 3/16 in. FRAP	20.0 %
Binder	4.8 %

Comments:
First 275 T – Positive dust control on – Metered back 2.0%
Last 225 T – Metered back 0%

Mix 4

DATE: 7-Aug-07

SEQ NO:

Bituminous Mixture Design

Design Number : ---------> RR07003

Lab preparing the design ? (PP,PL,IL,etc) — Enter Lab Preparing Design

Producer Name & Number --> 4166-03 Rock Road

Material Code Number ----> 19522R BIT CONC BC N70 19.0 R

Agg No.	#1	#2	#3	#4	#5	RAP #1	RAP #2	RAP #3	ASPHALT
Size	042CM11	031CM16	039FM20	037FM01	004MF01	3/16" ret	- 3/16"	C	10125
Source (PROD #)	52402-13	52400-26	52400-26	52400-26	52202-08	4166-03	4166-03		5627-02
(NAME)	Rock Road	Rock Road	Rock Road	Rock Road	Linwood	Rock Road	Rock Road		Amoco
(LOC)	Van Allen	Townline	Townline	Townline	Linwood		Rock Road		Whiting
						3.9	6.0	0.0	<--%AC in RAP
Total Mix Blend	27.5	24.0	8.0	0.0	0.5	25.0	15.0	0.0	
Total Agg. Blend	28.2	24.7	8.3	0.0	0.5	24.2	14.2	0.0	

100.0 <-Mix Total 100.0

100.0 <-Agg Total

Agg No.	#1	#1	#2	#3	#4	#6	#6	#6	Aggregate	Mixture Composition	FORMULA	FORMULA RANGE	
Sieve Size									Blend	Specification		Min	Max
1" (25.0mm)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100	100	100	100
3/4"(19.0mm)	88.6	100.0	100.0	100.0	100.0	100.0	100.0	100.0	96.8	82-100	97		
1/2" (12.5mm)	43.4	100.0	100.0	100.0	100.0	100.0	100.0	100.0	84.1	50-85	84		
3/8" (9.5mm)	23.3	97.0	100.0	100.0	100.0	99.3	100.0	100.0	77.5		77		
No.4 (4.75mm)	3.8	24.0	99.1	99.7	100.0	56.6	99.6	100.0	43.5	24-50	44	39	49
No.8 (2.36mm)	3.0	4.0	65.5	87.6	100.0	28.6	84.5	100.0	26.7	20-36	27	22	32
No.16 (1.18mm)	2.9	3.0	34.3	73.4	100.0	21.2	57.0	100.0	18.1	10-25	18		
No.30 (600µm)	2.9	2.0	19.2	52.6	100.0	16.8	38.7	100.0	13.0		13	9	17
No.50 (300µm)	2.9	2.0	10.9	17.7	100.0	12.3	25.8	100.0	9.4	4-12	9		
No.100 (150µm)	2.3	2.0	6.0	1.6	98.0	8.9	19.1	100.0	7.0	3-9	7		
No.200(75µm)	1.8	2.0	4.0	0.6	90.5	6.7	14.8	100.0	5.5	3-6	5.5	4.0	7.0

Bulk Sp Gr	2.591	2.673	2.678	2.585	2.750	2.692	2.674	1.000	2.655
Apparent Sp Gr	2.803	2.796	2.792	2.687	2.828	2.770	2.752	1.000	2.785
Absorption, %	2.92	1.65	1.52	1.47	1.00	1.05	1.06	0.00	1.66
									1.025

SUMMARY OF SUPERPAVE GYRATORY DESIGN DATA

MIXTURE AGED 2 HOURS @ 295

Dust/AC Ratio: 1.10

DATA for N-initial	7									
	AC, %MIX	(Gmb)	(Gmm)	(Pa)	VMA	VFA	Vbe	Pbe	Pba	Gse
MIX 1	4.0	2.151	2.529	14.9	22.2	32.7	7.26	3.46	0.56	2.694
MIX 2	4.5	2.163	2.517	14.1	22.2	36.6	8.12	3.85	0.68	2.703
MIX 3	5.0	2.179	2.498	12.8	22.0	42.1	9.26	4.36	0.68	2.702
MIX 4	5.5	2.179	2.479	12.1	22.4	46.0	10.32	4.85	0.68	2.703

DATA for N-desig	70									
		(Gmb)	(Gmm)	(Pa)	VMA	VFA	Vbe	Pbe	Gse	Pba
MIX 1	4.0	2.373	2.529	6.2	14.2	56.5	8.01	3.46	2.694	0.56
MIX 2	4.5	2.395	2.517	4.9	13.9	64.9	8.99	3.85	2.703	0.68
MIX 3	5.0	2.414	2.498	3.4	13.6	75.4	10.26	4.36	2.702	0.68
MIX 4	5.5	2.418	2.479	2.5	13.9	82.1	11.45	4.85	2.703	0.68

	NUMBER OF GYRATIONS	%AC	Gmb	Gmm	%VOIDS (Pa) Target	VMA	VFA	Gse	Gsb	TSR
OPTIMUM DESIGN DATA @Ndes: ---->	70	4.8	2.404	2.504	4.0	13.8	71.0	2.700	2.655	0.88

REMARKS:

Tested by : ____________________

Reviewed by : ____________________ Final Approval : ____________________

S.T.A.T.E. TESTING, LLC

QC/QA DATA

ISTHA FRAP Demonstrations **N70 Binder w/FRAP and GTR MIX 4**
Project: I-90 ISTHA

SPECIFICATION:

N_{DES}	PG Grade	AC%	Fibers	Voids	VMA	VFA
70	GTR 70-22			4.0	13.0	65-75

MIX DESIGN DATA: **Number:**

N_{DES}	AC%	G_{MB}	G_{MM}	Voids	VMA	VFA
70	4.8	2.404	2.504	4.0	13.8	71.0

PG Grade	G_{SE}	G_{SB}	TSR	P200:AC	Fibers
GTR 70-22	2.700	2.655	0.88	1:1	n/a

MIX ADJUSTMENTS:

QC/QA PLANT TESTS:

Date	QC/QA/IA	G_{MB}	G_{MM}	Voids	AC%	Tons
	SPLITS					FVMA
9-27-07	QA 2-R	2.341	2.538	7.8	4.4	16.1
9-28-07	QA 2-R	2.410	2.530	4.7	4.8	13.6

MIX 5

DATE: 3-Aug-07

SEQ NO:

Bituminous Mixture Design

Design Number : ---------> RBT07001

Lab preparing the design ? (PP,PL,IL,etc) — Enter Lab Preparing Design

Producer Name & Number --> 1686-24 Rockford Blacktop

Material Code Number ----> 19524MR Bit Conc SC N70 D Rec

Agg No.	#1	#2	#3	#4	#5	RAP #1	RAP #2	RAP #3	ASPHALT
Size	032CM16	038FM20	037MF01		004MF01	-#4 to 1/2"	Minus #4		10127M
Source (PROD #)	52012-69	52012-69	52010-14		52202-08	1686-24	1868-24		1757-05
(NAME)	Rockford S&G	Rockford S&G	Northshore		Linwood	Rockford BT	Rockford BT		Seneca
(LOC)	Nimtz Quarry	Nimtz Quarry	Roscoe		Linwood Mng.				Lemont
						4.8	7.1	0.0	<--%AC in RAP
Total Mix Blend	54.0	12.0	8.0	0.0	1.0	10.0	15.0	0.0	
Total Agg. Blend	55.0	12.2	8.1	0.0	1.0	9.6	14.0	0.0	

100.0 <-Mix Total 100.0

100.0 <-Agg Total

Agg No. / Sieve Size	#1	#1	#2	#3	#4	#6	#6	#6	Aggregate Blend	Mixture Composition Specification	FORMULA	FORMULA RANGE Min	FORMULA RANGE Max
1" (25.0mm)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0		100		
3/4"(19.0mm)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0		100		
1/2" (12.5mm)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100	100		
3/8" (9.5mm)	93.0	100.0	100.0	100.0	100.0	99.0	100.0	100.0	96.1	90-100	96		
No.4 (4.75mm)	29.0	100.0	98.0	0.0	100.0	57.0	98.0	0.0	56.4	28-65	56	51	61
No.8 (2.36mm)	3.0	84.0	90.0	0.0	100.0	24.0	75.0	0.0	33.1	28-48	33	28	38
No.16 (1.18mm)	3.0	51.0	81.0	0.0	100.0	17.0	49.0	0.0	24.0	10-32	24		
No.30 (600µm)	3.0	32.0	62.0	0.0	100.0	14.0	33.0	0.0	17.6		18	14	22
No.50 (300µm)	3.0	18.0	15.0	0.0	100.0	11.0	22.0	0.0	10.2	4-15	10		
No.100 (150µm)	2.5	7.0	1.0	0.0	98.0	8.0	17.0	0.0	6.4	3-10	6		
No.200(75µm)	2.3	3.0	0.3	0.0	85.0	6.4	13.1	0.0	5.0	4-6	5.0	3.5	6.5

Bulk Sp Gr	2.614	2.640	2.610	1.000	2.750	2.765	2.758	1.000	2.651
Apparent Sp Gr	2.813	2.764	2.680	1.000	2.750	2.908	2.893	1.000	2.814
Absorption, %	2.70	1.70	1.00	0.00	0.00	1.78	1.69	0.00	2.18
									1.030

SUMMARY OF SUPERPAVE GYRATORY DESIGN DATA

MIXTURE AGED 2 HOURS @ 295

Dust/AC Ratio 0.90

DATA for N-initial 7	AC, %MIX	(Gmb)	(Gmm)	(Pa)	VMA	VFA	Vbe	Pbe	Pba	Gse
MIX 1	5.0	2.147	2.531	15.2	23.1	34.2	7.90	3.79	1.27	2.741
MIX 2	5.5	2.159	2.509	13.9	23.0	39.6	9.12	4.35	1.22	2.737
MIX 3	6.0	2.183	2.486	12.2	22.6	46.0	10.40	4.91	1.16	2.733
MIX 4	6.5	2.194	2.473	11.3	22.6	50.1	11.35	5.33	1.26	2.740

DATA for N-desig 70		(Gmb)	(Gmm)	(Pa)	VMA	VFA	Vbe	Pbe	Gse	Pba
MIX 1	5.0	2.383	2.531	5.9	14.6	60.0	8.77	3.79	2.741	1.27
MIX 2	5.5	2.395	2.509	4.5	14.6	69.2	10.11	4.35	2.737	1.22
MIX 3	6.0	2.412	2.486	3.0	14.5	79.4	11.50	4.91	2.733	1.16
MIX 4	6.5	2.430	2.473	1.7	14.3	87.8	12.56	5.33	2.740	1.26

	NUMBER OF GYRATIONS	%AC	Gmb	Gmm	%VOIDS (Pa) Target	VMA	VFA	Gse	Gsb	TSR
OPTIMUM DESIGN DATA @Ndes: ---->	70	5.7	2.401	2.501	4.0	14.6	72.6	2.738	2.651	0.89

REMARKS:

Tested by : ______________________

Reviewed by : ______________________ Final Approval : ______________________

S.T.A.T.E. TESTING, LLC

QC/QA DATA

Mix Description: N70 9.5mm SC “D” with FRAP (Mix 5)
Project: I-90 ISTHA

SPECIFICATION:

N_{DES}	PG Grade	AC%	Fibers	Voids	VMA	VFA
70	PG64-22			4.0	14.0	≥70

MIX DESIGN DATA: Number:

N_{DES}	AC%	G_{MB}	G_{MM}	Voids	VMA	VFA
70	5.7	2.401	2.501	4.0	14.6	72.6

PG Grade	G_{SE}	G_{SB}	TSR	P200:AC	Fibers
PG64-22	2.738	2.651	0.89	1.03	n/a

MIX ADJUSTMENTS:

QC/QA PLANT TESTS:

Date	QC/QA/IA	G_{MB}	G_{MM}	Voids	AC%	Tons
10-24-07	QC					
	001-01	2.342	2.515	6.9	6.0	134.5
	001-02	2.344	2.488	5.8	6.2	
	QA					
10-29-07		2.384	2.497	4.5	5.6	
		2.370	2.497	5.1	5.7	
		FVMA	FVFA			
10-24-07	QC	16.9	59.2			
	QC	16.8	65.5			

Final AJMF
2007 Fractionated RAP Field Trials

Mix # 90BIT0717 **N50 Binder (PG58-22) Mix 6**
90BIT0716 **N50 Binder (PG58-28) Mix 7**

Reported by: Matt Galloy **Date:** April 11, 2008

FINAL BLEND PERCENTAGES

Aggregate Material Code	Aggregate Blend Percent (by Wt.)
042CM11	33.8 %
032CM16	10.5 %
039FM01	10.7 %
#4 FRAP	35.0 %
Minus #4 FRAP	10.0 %
Binder	4.6 %

Comments:

Mix 6

FILE COPY

DATE: 10-Sep-07

SEQ NO:

Bituminous Mixture Design

Design Number : ---------> RBT07002-2

Lab preparing the design ? (PP,PL,IL,etc) — Enter Lab Preparing Design

Producer Name & Number --> 1686-24 Rockford Blacktop

Material Code Number ----> 19522MR Bit Conc BC N50 19.0 Rec - 3.0% Air Voids

Agg No.	#1	#2	#3	#4	#5	RAP #1	RAP #2	RAP #3	ASPHALT
Size	042CM11	032CM16	037FA01			-#4 to 1/2"	Minus #4	C	10126M
Source (PROD #)	52012-69	52012-69	52010-14			1686-24	1686-24		1757-05
(NAME)	Rockford S&G	Rockford S&G	North Shore			Rockford BLT	Rockford BLT		Seneca
(LOC)	Nimtz Quarry	Nimtz Quarry	Roscoe						Lemont
						4.6	7.1	0.0	<--%AC in RAP
Total Mix Blend	36.3	13.0	10.7	0.0	0.0	30.0	10.0	0.0	
Total Agg. Blend	37.3	13.4	11.0	0.0	0.0	28.9	9.4	0.0	

100.0 <-Mix Total 100.0

100.0 <-Agg Total

Agg No.	#1	#1	#2	#3	#4	#6	#6	#6	Aggregate	Mixture Composition	FORMULA	FORMULA RANGE	
Sieve Size									Blend	Specification		Min	Max
1" (25.0mm)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100	100	100	100
3/4"(19.0mm)	74.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	90.3	82-100	90		
1/2" (12.5mm)	25.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	72.0	50-85	72		
3/8" (9.5mm)	10.0	93.0	100.0	100.0	100.0	99.0	100.0	100.0	65.2		65		
No.4 (4.75mm)	5.0	29.0	98.0	0.0	100.0	57.0	98.0	0.0	42.2	24-50	42	37	47
No.8 (2.36mm)	4.5	3.0	90.0	0.0	100.0	24.0	75.0	0.0	26.0	20-36	26	21	31
No.16 (1.18mm)	4.0	3.0	81.0	0.0	100.0	17.0	49.0	0.0	20.3	10-25	20		
No.30 (600µm)	4.0	3.0	62.0	0.0	100.0	14.0	33.0	0.0	15.9		16	12	20
No.50 (300µm)	3.0	3.0	15.0	0.0	100.0	11.0	22.0	0.0	8.4	4-12	8		
No.100 (150µm)	3.0	2.5	1.0	0.0	0.0	8.0	17.0	0.0	5.5	3-9	5		
No.200(75µm)	2.9	2.3	0.3	0.0	0.0	6.4	13.1	0.0	4.5	3-6	4.5	3.0	6.0

Bulk Sp Gr	2.607	2.614	2.610	1.000	1.000	2.765	2.758	1.000	2.666
Apparent Sp Gr	2.797	2.813	2.680	1.000	1.000	2.908	2.893	1.000	2.825
Absorption, %	2.60	2.70	1.00	0.00	0.00	1.78	1.69	0.00	2.12
									1.030

SUMMARY OF SUPERPAVE GYRATORY DESIGN DATA

MIXTURE AGED 2 HOURS @ 295

Dust/AC Ratio 1.00

DATA for N-initia	6									Gse
	AC, %MIX	(Gmb)	(Gmm)	(Pa)	VMA	VFA	Vbe	Pbe	Pba	
MIX 1	4.0	2.214	2.529	12.4	20.3	38.6	7.83	3.64	0.37	2.692
MIX 2	4.5	2.218	2.508	11.5	20.5	43.8	9.00	4.18	0.34	2.689
MIX 3	5.0	2.238	2.488	10.1	20.3	50.4	10.20	4.70	0.32	2.688
MIX 4	5.5	2.243	2.469	9.2	20.5	55.2	11.32	5.20	0.32	2.688

DATA for N-desig	50									
		(Gmb)	(Gmm)	(Pa)	VMA	VFA	Vbe	Pbe	Gse	Pba
MIX 1	4.0	2.424	2.529	4.2	12.7	67.3	8.57	3.64	2.692	0.37
MIX 2	4.5	2.428	2.508	3.2	13.0	75.7	9.85	4.18	2.689	0.34
MIX 3	5.0	2.438	2.488	2.0	13.1	84.6	11.11	4.70	2.688	0.32
MIX 4	5.5	2.445	2.469	1.0	13.3	92.7	12.35	5.20	2.688	0.32

	NUMBER OF GYRATIONS	%AC	Gmb	Gmm	%VOIDS (Pa) Target	VMA	VFA	Gse	Gsb	TSR
OPTIMUM DESIGN DATA @Ndes: ---->	50	4.6	2.429	2.504	3.0	13.1	77.1	2.689	2.666	0.88

REMARKS: Mix Design made using PG 58-28

6

Tested by :

Reviewed by :

Final Approval :

S.T.A.T.E. TESTING, LLC

QC/QA DATA

Mix Description: 19.0 mm Binder Course N50, 3.0%, w/ FRAP and PG58-28 **Mix *6***
Project: I-90 ISTHA

SPECIFICATION:

N_{DES}	PG Grade	AC%	Fibers	Voids	VMA	VFA
50	PG58-28			3.0		

MIX DESIGN DATA: **Number:**

N_{DES}	AC%	G_{MB}	G_{MM}	Voids	VMA	VFA
50	4.6	2.429	2.504	3.0	13.1	77.1

PG Grade	G_{SE}	G_{SB}	TSR	P200:AC	Fibers
PG-58-28	2.689	2.666	0.88	1.00	--

MIX ADJUSTMENTS:

QC/QA PLANT TESTS:

Date	QC/QA/IA	G_{MB}	G_{MM}	Voids	AC%	Tons
10-25-07	QA01				5.7	
	QA01-R	2.480	2.505	1.0	5.5	
		FVMA	FVFA			
	QA01-R	11.8				

FILE COPY

DATE: 13-Sep-07

SEQ NO:

Bituminous Mixture Design

Design Number : ------> RBT07002-2a

Lab preparing the design ? (PP,PL,IL,etc) — Enter Lab Preparing Design

Producer Name & Number --> 1686-24 Rockford Blacktop

Material Code Number ----> 19522MR Bit Conc BC N50 19.0 Rec - 3.0% Air Voids with PG58-22

Agg No.	#1	#2	#3	#4	#5	RAP #1	RAP #2	RAP #3	ASPHALT
Size	042CM11	032CM16	037FA01			-#4 to 1/2"	Minus #4	C	10125M
Source (PROD #)	52012-69	52012-69	52010-14			1686-24	1686-24		1757-05
(NAME)	Rockford S&G	Rockford S&G	North Shore			Rockford BLT	Rockford BLT		Seneca
(LOC)	Nimtz Quarry	Nimtz Quarry	Roscoe						Lemont
						4.6	7.1	0.0	<--%AC in RAP
Total Mix Blend	36.3	13.0	10.7	0.0	0.0	30.0	10.0	0.0	
Total Agg. Blend	37.3	13.4	11.0	0.0	0.0	28.9	9.4	0.0	

100.0 <-Mix Total 100.0

100.0 <-Agg Total

Agg No. / Sieve Size	#1	#1	#2	#3	#4	#6	#6	#6	Aggregate Blend	Mixture Composition Specification	FORMULA	FORMULA RANGE Min	FORMULA RANGE Max
1" (25.0mm)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100	100	100	100
3/4"(19.0mm)	74.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	90.3	82-100	90		
1/2" (12.5mm)	25.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	72.0	50-85	72		
3/8" (9.5mm)	10.0	93.0	100.0	100.0	100.0	99.0	100.0	100.0	65.2		65		
No.4 (4.75mm)	5.0	29.0	98.0	0.0	100.0	57.0	98.0	0.0	42.2	24-50	42	37	47
No.8 (2.36mm)	4.5	3.0	90.0	0.0	100.0	24.0	75.0	0.0	26.0	20-36	26	21	31
No.16 (1.18mm)	4.0	3.0	81.0	0.0	100.0	17.0	49.0	0.0	20.3	10-25	20		
No.30 (600μm)	4.0	3.0	62.0	0.0	100.0	14.0	33.0	0.0	15.9		16	12	20
No.50 (300μm)	3.0	3.0	15.0	0.0	100.0	11.0	22.0	0.0	8.4	4-12	8		
No.100 (150μm)	3.0	2.5	1.0	0.0	0.0	8.0	17.0	0.0	5.5	3-9	5		
No.200(75μm)	2.9	2.3	0.3	0.0	0.0	6.4	13.1	0.0	4.5	3-6	4.5	3.0	6.0

Bulk Sp Gr	2.607	2.614	2.610	1.000	1.000	2.765	2.758	1.000	2.666
Apparent Sp Gr	2.797	2.813	2.680	1.000	1.000	2.908	2.893	1.000	2.825
Absorption, %	2.60	2.70	1.00	0.00	0.00	1.78	1.69	0.00	2.12
									1.030

SUMMARY OF SUPERPAVE GYRATORY DESIGN DATA

MIXTURE AGED 2 HOURS @ 295

Dust/AC Ratio	1.00

DATA for N-initia	6							
	AC, %MIX	(Gmb)	(Gmm)	(Pa)	VMA	VFA	Vbe	Pbe	Pba
MIX 1	4.6	2.203	2.508	12.1	21.2	42.6	9.02	4.22	0.40

Gse
0.000
2.694
0.000
0.000

DATA for N-desig	50									
		(Gmb)	(Gmm)	(Pa)	VMA	VFA	Vbe	Pbe	Gse	Pba
MIX 1	4.6	2.425	2.508	3.3	13.2	75.0	9.93	4.22	2.694	0.40

	NUMBER OF GYRATIONS	%AC	Gmb	Gmm	%VOIDS (Pa)	VMA	VFA	Gse	Gsb	TSR
OPTIMUM DESIGN DATA @Ndes: --->	50	4.6	2.425	2.508	3.3	13.2	75.0	2.694	2.666	N/A

REMARKS: One point check on 3.0% Air Vois using PG 58-22

Tested by :

Reviewed by :

Final Approval :

MIX 7

S.T.A.T.E. TESTING, LLC

QC/QA DATA

Mix Description:
19.0 mm Binder Course N50, 3.0%, w/ FRAP and PG58-22 **Mix 7**

Project: I-90 ISTHA

SPECIFICATION:

N_{DES}	PG Grade	AC%	Fibers	Voids	VMA	VFA
50	PG58-22			3.0		

MIX DESIGN DATA: **Number:**

N_{DES}	AC%	G_{MB}	G_{MM}	Voids	VMA	VFA
50	4.6	2.425	2.508	3.3	13.2	75.0

PG Grade	G_{SE}	G_{SB}	TSR	P200:AC	Fibers
PG-58-22	2.694	2.666	n/a	1.00	--

MIX ADJUSTMENTS:

QC/QA PLANT TESTS:

Date	QC/QA/IA	G_{MB}	G_{MM}	Voids	AC%	Tons
10-25-07	QA01				6.4	
	QA01-R	2.477	2.499	0.9	5.2	
		FVMA	FVFA			
	QA01-R	11.9				

Final AJMF
2007 Fractionated RAP Field Trials

Mix # **90BIT0717** **N50 BAM (PG58-22) Mix 8**
90BIT0716 **N50 BAM (PG58-28) Mix 9**

Reported by: **Matt Galloy** **Date:** **April 11, 2008**

FINAL BLEND PERCENTAGES

Aggregate Material Code	Aggregate Blend Percent (by Wt.)
042CM11	36.3 %
032CM16	13.0 %
039FM01	10.7 %
#4 FRAP	30.0 %
Minus #4 FRAP	10.0 %
Binder	5.2 %

Comments:

701SIT 0111 w/ 58-22
90BIT0716 w/58-28

DATE: 10-Sep-07

SEQ NO:

COPY

Bituminous Mixture Design

Design Number : -------> RBT07002

Lab preparing the design ? (PP,PL,IL,etc) Enter Lab Preparing Design

Producer Name & Number --> 1686-24 Rockford Blacktop

Material Code Number ----> 19522MR 19602R Bit Conc BC N50 19.0 Rec - 2.0% Air Voids

Agg No.	#1	#2	#3	#4	#5	RAP #1	RAP #2	RAP #3	ASPHALT
Size	042CM11	032CM16	037FA01			-#4 to 1/2"	Minus #4	C	10126M
Source (PROD #)	52012-69	52012-69	52010-14			1686-24	1686-24		1757-05
(NAME)	Rockford S&G	Rockford S&G	North Shore			Rockford BLT	Rockford BLT		Seneca
(LOC)	Nimtz Quarry	Nimtz Quarry	Roscoe						Lemont
						4.6	7.1	0.0	<--%AC in RAP
Total Mix Blend	36.3	13.0	10.7	0.0	0.0	30.0	10.0	0.0	
Total Agg. Blend	37.3	13.4	11.0	0.0	0.0	28.9	9.4	0.0	

100.0 <-Mix Total 100.0

100.0 <-Agg Total

Agg No. / Sieve Size	#1	#1	#2	#3	#4	#6	#6	#6	Aggregate Blend	Mixture Composition Specification	FORMULA	FORMULA RANGE Min	FORMULA RANGE Max
1" (25.0mm)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100	100	100	100
3/4"(19.0mm)	74.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	90.3	82-100	90		
1/2" (12.5mm)	25.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	72.0	50-85	72		
3/8" (9.5mm)	10.0	93.0	100.0	100.0	100.0	99.0	100.0	100.0	65.2		65		
No.4 (4.75mm)	5.0	29.0	98.0	0.0	100.0	57.0	98.0	0.0	42.2	24-50	42	37	47
No.8 (2.36mm)	4.5	3.0	90.0	0.0	100.0	24.0	75.0	0.0	26.0	20-36	26	21	31
No.16 (1.18mm)	4.0	3.0	81.0	0.0	100.0	17.0	49.0	0.0	20.3	10-25	20		
No.30 (600μm)	4.0	3.0	62.0	0.0	100.0	14.0	33.0	0.0	15.9		16	12	20
No.50 (300μm)	3.0	3.0	15.0	0.0	100.0	11.0	22.0	0.0	8.4	4-12	8		
No.100 (150μm)	3.0	2.5	1.0	0.0	0.0	8.0	17.0	0.0	5.5	3-9	5		
No.200(75μm)	2.9	2.3	0.3	0.0	0.0	6.4	13.1	0.0	4.5	3-6	4.5	3.0	6.0

Bulk Sp Gr	2.607	2.614	2.610	1.000	1.000	2.765	2.758	1.000	2.666
Apparent Sp Gr	2.797	2.813	2.680	1.000	1.000	2.908	2.893	1.000	2.825
Absorption, %	2.60	2.70	1.00	0.00	0.00	1.78	1.69	0.00	2.12
									1.030

SUMMARY OF SUPERPAVE GYRATORY DESIGN DATA

MIXTURE AGED 2 HOURS @ 295

Dust/AC Ratio 0.90

DATA for N-initia	6									
	AC, %MIX	(Gmb)	(Gmm)	(Pa)	VMA	VFA	Vbe	Pbe	Pba	Gse
MIX 1	4.0	2.214	2.529	12.4	20.3	38.6	7.83	3.64	0.37	2.692
MIX 2	4.5	2.218	2.508	11.5	20.5	43.8	9.00	4.18	0.34	2.689
MIX 3	5.0	2.238	2.488	10.1	20.3	50.4	10.20	4.70	0.32	2.688
MIX 4	5.5	2.243	2.469	9.2	20.5	55.2	11.32	5.20	0.32	2.688

DATA for N-desig	50									
		(Gmb)	(Gmm)	(Pa)	VMA	VFA	Vbe	Pbe	Gse	Pba
MIX 1	4.0	2.424	2.529	4.2	12.7	67.3	8.57	3.64	2.692	0.37
MIX 2	4.5	2.428	2.508	3.2	13.0	75.7	9.85	4.18	2.689	0.34
MIX 3	5.0	2.438	2.488	2.0	13.1	84.6	11.11	4.70	2.688	0.32
MIX 4	5.5	2.445	2.469	1.0	13.3	92.7	12.35	5.20	2.688	0.32

Mix 8

	NUMBER OF GYRATIONS	%AC	Gmb	Gmm	%VOIDS (Pa) Target	VMA	VFA	Gse	Gsb	TSR
OPTIMUM DESIGN DATA @Ndes: --->	50	~~5.0~~ 5.2 (10-8)	2.439	2.489	2.0	13.1	84.7	2.689	2.666	0.88

REMARKS: Mix Design made using PG 58-28

Tested by : [signature]

Reviewed by : [signature]

Final Approval : [signature]

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Mix Description: (Type, Ndes, NMA Size)	**MIX 8**
19602MR N50 Base Course REC 19.0mm **(90BIT0716)**	
Project:	I-06_5407 I-90 Tollway Shoulder Resurfacing

Specification

Ndes	PG Grade	AC%	Fibers	Voids	VMA	VFA
50	58-28	5.0	N/A	2.0	13.0	>70

Mix Design Data — 90BIT0716

Ndes	PG Grade	AC%	Fibers	Voids	VMA	VFA
50	58-28	5.0	N/A	1.9	13.0	85.3

PG Grade	Gse	Gsb	TSR	P200:AC	Fibers	
58-28	2.690	2.666	N/A	0.90	N/A	

Mix Adjustments Made: 002-01 reduce +4 FRAP 5%, Increase -4 FRAP 5%

003-01 FRAP Blends changed back to original blends, reduce CM11 3% reduce CM16 1% increased FA01 3%, increased M.F. 0.5% Add back @ 1.5%

004-01 Increased M.F. by 1.0% Add Back now at 2.5%

QC?QA Plant Test Data

Date	QC/QA/IA	Gmb	Gmm	Voids	AC%	FVMA	FVFA	Tons
10/08/07	QC 001-01	2.441	2.492	2.1	5.5	14.3	85.3	445.1
	QA1-1	2.451	2.505	2.2	5.5	12.8		
	QA1-R				5.3			
10/09/07	QC 002-01	2.429	2.522	3.7	4.8	14.2	73.6	391.6
	QA1-1	2.452	2.524	2.9	5.4	12.8		
	QA1-R				5.3			
10/11/07	QC 003-01	2.451	2.514	2.5	5.2	13.6	81.6	300.0
10/22/07	QC	2.475	2.511	1.5	5.0	12.6	88.1	506.6
10/22/07	QC	2.472	2.512	1.6	5.3	12.7	87.4	
10/25/07	QC 004-01	2.464	2.496	1.3	5.4	13.3	90.2	236.0
10/25/07	QC 004-02	2.470	2.485	0.6	5.6	13.1	95.4	

Mix Description: (Type, Ndes, NMA Size)	**MIX 9**
19602MR N50 Base Course REC FRAP 19.0mm **(90BIT0717)**	
Project:	I-06-5407 I-90 Tollway Shoulder Resurfacing

Specification

Ndes	PG Grade	AC%	Fibers	Voids	VMA	VFA
50	58-22	5.0	N/A	2.0	13.0	>70

Mix Design Data	**90BIT0717**					
Ndes	**PG Grade**	**AC%**	**Fibers**	**Voids**	**VMA**	**VFA**
50	58-22	5.0	N/A	1.9	13.0	85.3

PG Grade	Gse	Gsb	TSR	P200:AC	Fibers	
58-22	2.690	2.666	N/A	0.9	N/A	

Mix Adjustments Made: 002-01 Reduced +4 FRAP 5%, Incresed -4 FRAP 5%
003-01 Back to original FRAP Blends, Reduced CM11 3%, Reduced CM16 1%, Increased FA01 4% Increased M.F. 1.5% Add Back now @ 2.5%,

Increased AC 0.1% Total AC now @ 5.3%

QC?QA Plant Test Data

Date	QC/QA/IA	Gmb	Gmm	Voids	AC%	FVMA	FVFA	Tons
10/08/07	QC 001-01	2.412	2.509	3.9	5.1	14.9	73.8	445.1
10/09/07	QC 002-01	2.429	2.523	3.7	4.9	14.1	74.5	391.6
	QA01-01	2.458	2.528	2.8	5.5	12.6		
	QA01-R				5.1			
10/22/07	QC 003-01	2.475	2.511	1.5	5.0	12.6	88.8	506.6
10/22/07	QC 003-02	2.472	2.512	1.6	5.3	12.7	87.8	"

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