Georgia Department of Transportation
Office of Materials and Testing

Standard Operating Procedure (SOP) 2
Control of Superpave Bituminous Mixture Designs

I. General

Monitoring the quality of Bituminous Mixtures used on Georgia Department of Transportation work is a responsibility of the Bituminous Construction Branch of the Office of Materials and Testing. This branch is under the direction of the State Bituminous Construction Engineer. The Bituminous Construction Branch comprises the Asphalt Design Unit, the Bituminous Control Unit, and the Bituminous Technical Services Unit.

The Asphalt Design Unit performs, verifies, and recommends approval of designs for Superpave mixtures, Open-Graded Friction Course (OGFC), Porous European Mix (PEM) mixtures, Stone Matrix Asphalt (SMA), slurry seals, sand-bituminous bases, micro-surfacing, and other asphalt mixtures as assigned.

The Asphalt Design Engineer oversees design activities statewide, including designs and verifications performed by the Office of Materials and Testing and Branch Laboratories. The Asphalt Design Engineer reviews and recommends approval of designs made in commercial laboratories which have been certified in accordance with SOP 36. Designs submitted by certified laboratories shall be prepared, verified and approved in accordance with this Standard Operating Procedure. The Asphalt Design Engineer forwards acceptable designs to the State Bituminous Construction Engineer with recommendation for approval or approval for provisional use, as appropriate. Once approved, a design shall be published and transmitted to the certified laboratory which performed the design. Designs found to be incorrect or deficient shall be referred back to the designer within two weeks of receipt . Designers may resubmit their designs for approval when appropriate changes or corrections have been made. The State Bituminous Construction Engineer may make field adjustments of the Job Mix formula and may require field verification of mix designs, as discussed below.

II. Approval Process

A. Governing Documents

Commercial laboratories wishing to perform mix designs for use in GDOT projects shall comply with SOP 36, *Certification of Laboratory and Personnel for the Design of Asphaltic Concrete Mixtures.*

All mix designs shall meet current contract specifications and shall be prepared in accordance with applicable standard methods, described below. Mix designs from commercial laboratories shall be approved only for work covered under state funded contracts, and designs for mix types and levels not specified for state work are not eligible for approval.

Aggregates used in Asphaltic Concrete mixes must meet the requirements of Sections 800 and 802 of the Specifications. Asphalt Cement used in the mixture shall meet the requirements of Section 820 for Superpave Asphalt Binder. All designs for publication must meet the requirements of Section 828, "Hot Mix Asphaltic Concrete Mixtures". All ingredients of asphalt mixtures shall be from sources approved by the Department. Approved aggregate sources, except proprietary RAP stockpiles and sand pits, are listed in Qualified Products Lists 1 and 2. Other approved sources are listed in their respective Qualified Products Lists.

Mix designs must be submitted using the GDOT approved mix design software. Completed design studies shall be submitted to the Asphalt Design Engineer by letter request, including the technician's certification required under SOP 36. The letter request should also identify any entity, other than the firm which produced the design, which is authorized to use it. Other required information is as follows:

1. Types and sources of aggregate ingredients
2. Asphalt binder grade and source
3. Gyratory compaction sheets
4. Results of ignition calibration tests, including worksheet and print-out
5. Test results required for the Superpave mix design study
6. RAP stockpile number, if RAP is included
7. Results of permeability test plus sample, as required

Test results for the mix design study shall be entered into the GDOT Mix Design Software and submitted as an Asphaltic Concrete Mix Design Report. Mix designs shall be approved which are correct and complete and which conform to the design criteria set forth in Section 828 of the Specifications.

Approved asphalt mix designs shall be identified by a mix identification number which will identify the designer, aggregate sources, mix type, and design level.

B. Verification of Designs

Mix designs shall be verified by the Office of Materials and Testing at a minimum frequency of ten percent of the designs submitted by each certified laboratory, or at the discretion of the State Bituminous Construction Engineer. These verifications shall be performed by a GDOT laboratory designated by the Asphalt Design Engineer. A verification will consist of replicating all or part of the design test procedures, as the Asphalt Design Engineer may require. Samples shall be tested at the asphalt and air void contents required for certain design tests or at optimum asphalt content or corrected optimum AC content, as appropriate. Sufficient quantities of stockpile samples shall be retained for at least two weeks after submittal of a design, or until approval of design is granted, whichever comes first. Results of the verification must match the design results within the tolerances below. In addition, when design volumetrics are verified by gyrating a full set of new samples, the resulting VMA and VFA must also fall within the tolerances specified in Section 828.

Test	Verification Tolerance
G_{mb} - AASHTO T-166	±0.03
G_{se} - AASHTO T-209 and T-308	±0.03
% VTM - AASHTO T-312	4% ± 1.0%
% G_{mm} @ N_{ini} - AASHTO T-312	± 1.0%
% G_{mm} @ N_{des} - AASHTO T-312	± 1.0%
VMA - AASHTO R 35	- 0.5% to +0.8%
VFA - AASHTO R 35	± 5%
Dust/AC Ratio - AASHTO T-312	± 0.2
Gradation:	
Upper Control Sieve - % Passing	+ 3.5 %
No. 8 (2.36 mm) Sieve – % Passing	± 2.5 %
No 200 (75 μm) Sieve –% Passing	± 1.6 %
Hamburg Wheel Tracking – T 324 (with GDOT revisions)	±2.0 mm, but not to exceed design limit
Retained Tensile Strength - GDT- 66	(average of three) ± 10 % must also meet design minimum for strength and % retained
Calibration Factor for ignition tests	± 0.12 %

Where G_{mb} is the bulk specific gravity of the mix, G_{se} is the effective specific gravity of the aggregate, and N_{ini} and N_{des} are the numbers of initial gyrations and design gyrations, respectively. VTM and VMA are the percent air voids and percent voids in the mineral aggregate, respectively, and VFA is percent voids filled with asphalt.

In applying the tolerances above for percent of G_{mm} at N_{ini} and percent of G_{mm} at N_{des} , the G_{mm} shall be re-calculated using the G_{se} determined in the verification.

If the verification result does not match the design values within the above tolerances, an investigation shall be initiated by the State Bituminous Construction Engineer. The investigation may include a review of design procedures and equipment calibrations as well as the results of a field verification. If the cause for the discrepancy cannot be resolved, approval of the design may be withdrawn.

C. Field Verification

All mix designs shall be subject to one or more field verifications during production at the discretion of the State Bituminous Construction Engineer. Verification shall consist of replicating certain mix design tests on samples of the mixture delivered to a state project, normally when the design is first used and subsequently in some cases, at the discretion of the State Bituminous Construction Engineer. Additionally, each mix design is to be verified at a minimum of once every two years as detailed in Section 828. Field verification tests shall normally include AASHTO T-209, AASHTO T 324, AASHTO T 166, and AASHTO T-312 to verify design volumetrics and may include, GDT-66, and other tests as the State Bituminous Construction Engineer may require. A field verification shall be acceptable when results fall within the tolerances in the table below. Designs which fail field verification shall be invalid unless an approved revision is made to correct the deficiency, or unless it is shown that the production sample was deficient and that the deficiency has been corrected.

Test	Field Verification Tolerance
G_{mb} - AASHTO T-166	± 0.03
AASHTO T 324	±2.0 mm, but not to exceed design limit
G_{se} - AASHTO T-209 (and GDT-125)	±0.03
GDT-66 (When required)	not to exceed specified design limits
Design Volumetrics - AASHTO R 35:	
VMA	not to exceed specified design limits
VTM (air voids) @ optimum AC	not to exceed specified design limits

D. Continuity and Cancellation of Mix Designs

An approved and field verified mix design may be used from project to project as long as the design meets current specifications, provided that satisfactory performance of the mixture is obtained, that the properties of the mixture remain consistent with the design values, and that no significant change occurs in the properties or approval status of the ingredients. The State Bituminous Construction Engineer may withdraw approval of a mix design on the basis of unsatisfactory or erratic test results, poor performance of the mixture in place, or evidence that the properties of the mixture differ substantially from the properties predicted in the design. In the case of RAP mixtures, approval will be withdrawn if the RAP stockpile is depleted or if the average gradation of the RAP, based on five random samples, varies to the extent that the combined gradation of the design is altered by more than one-half the mixture control tolerance.

E. Ownership, Use, and Disclosure of Mix Designs

Mix designs shall be made available only to the designer and to users authorized by the designer. Mix designs are considered to be proprietary information. They are not subject to public disclosure under the Georgia Open Records Act by virtue of O.C.G.A. 50-18-72(b)(1), which protects the confidentiality of trade secrets obtained from a business entity that are confidential and required to be submitted to a government agency.

III. Design Process

The object of an Asphaltic Concrete Design is to produce a combination of the proposed ingredients that will perform satisfactorily throughout the design life of the pavement. Such a mixture must contain sufficient asphalt cement to provide a thick film and limited air voids so the mix can resist stripping and weathering due to intrusion of water and air. The mix must also be stable enough to resist permanent deformation, flushing, excessive densification, and loss of friction properties. The volumetric design process is complicated by the facts that asphalt is thermoplastic and that specific elevated temperatures must be maintained in the design work. Superpave Mixtures are to be designed in accordance with AASHTO R 35 except as altered by Georgia Department of Transportation's specifications including but not limited to SOPs, GDTs and GSPs. Many design details are difficult to remember; therefore a ready reference entitled "Asphalt Hot Mix Design Reference Guide" can be found in Appendix A.

A. Sampling and Grading

Sampling of aggregates proposed for use in bituminous mix designs may be initiated by the Contractor, commercial laboratory, or materials supplier. The requesting party should submit the samples to the design laboratory. Materials sampled for design work must be representative of quarry production intended for use on the project. The average ingredient characteristics should be represented in the design. The designer shall resolve any discrepancies in the ingredient properties before beginning any design work.

Each aggregate sample submitted for design is initially dried, and sieve analysis is performed to determine its gradation. Grading of coarse aggregate samples is done using the appropriate sieves for the specific mix type involved. These sieve sizes can be found in Section 828 of the Specifications. In addition, appropriate "breaker" sieves must be used to prevent overloading the sieves. Each ingredient shall be batched individually. Bulk batching of aggregates is prohibited.

Aggregate used for batching Superpave specimens is not separated below the No. 8 (2.36 mm) sieve, with the exception that a washed gradation is performed on minus 2.36 mm portion by washing over the No 200 (75 μm) sieve.

If the coarse or fine aggregate is excessively dusty, soft, easily broken, or shows other signs of potential problems, the Asphalt Design Engineer should be consulted for investigation of the source, stockpiles, and operations. The Revised decision in such matters will rest with the State Materials and Research Engineer.

Once the appropriate blend, meeting requirements established in Section 828 and Appendix B, has been established, batches of Superpave design specimens to determine optimum asphalt content shall be prepared to produce a compacted Superpave specimen 115.0 ± 5.0 mm high and 150 mm in diameter for density testing. The height of test samples should be 95.0 ± 5.0 mm for tensile splitting specimens. Hamburg sample height may vary depending on the test equipment manufacturer. Designers should ensure that all samples, including those for gradation and specific gravities, will meet the minimum sample size requirements for their respective tests.

B. Preparing Superpave Specimens

1. Asphalt Cement

   Samples shall be heated to the appropriate temperature for the asphalt binder being used. Temperatures for preparing Superpave specimens are based on the viscosity of the asphalt cement involved. These values are very important; they can be found in the Asphalt Mixture Control Temperature Chart which is available from the Asphalt Design Engineer.

2. Short term Aging

   The short term aging procedure applies to laboratory-prepared loose mix only. The laboratory aging process is necessary to simulate mixture aging during typical plant production and placement. All samples for testing shall be aged by placing the mixture in a pan and spreading it to an even thickness of approximately 55 ± 5 lbs/yd^2 (30 ± 2 kg/m^2) immediately after sample mixing. Place the mixture and pan in a forced draft oven for 2 hours at compaction temperature.

C. Superpave Gyratory Compactor

A gyratory compactor meeting the requirements of AASHTO T-312 shall be used to compact density specimens for testing. The gyratory compactor may also be used for preparing samples for performance testing as detailed in Section 828. The gyratory compactor shall be calibrated and the operation of the data acquisition device shall be checked based on the interval established in AASHTO R18. The compaction pressure should be checked and set to the proper value; 600 ± 18 kPa, and the rate of revolution should be set at 30 gyrations per minute. The internal angle is to be set at 1.16 ±

0.02 degrees. It is recommended that the calibration be done for the internal angle using the Dynamic Angle Validator (DAV) if different brands or models of the gyratory compactor are being used.

Samples shall be gyrated to the number specified for the N_{des} level required in Section 828.

D. Testing Superpave Specimens

All testing shall be in accordance with the appropriate AASHTO or GDT procedure, as follows:

Test	Test Method
Volumetric Properties	**AASHTO T-312,** "Determining the Density of Hot Mix Asphalt (HMA) Specimens by Means of Superpave Gyratory Compactor" AASHTO R 35, "Superpave Volumetric Design for Hot Mix Asphalt (HMA)
Bulk Density	**AASHTO T-166,** "Bulk Specific Gravity of Compacted Bituminous Mixtures Using Saturated Surface-Dry Specimens"
Short Term Aging	**AASHTO R-30,** "Mixture Conditioning of Hot Mix Asphalt (HMA)" Note: The procedure is modified for GDOT mix designs to require only two hours aging.
Maximum Density and Effective gravity	**AASHTO T-209** "Maximum Specific Gravity of Bituminous Paving Mixtures"
Aggregate Gravities	**AASHTO T-84** "Specific Gravity and Absorption of Fine Aggregate" and **AASHTO T-85,** "Specific Gravity and absorption of Coarse Aggregate" (The designer may obtain coarse aggregate gravities from GDOT or perform this test.)
Moisture Susceptibility (when required)	**GDT-66** "Method of Test for Evaluating the Moisture Susceptibility of Bituminous Mixtures by Diametral Tensile Splitting"
Rutting Susceptibility	AASHTO T 324 "Hamburg Wheel-Track Testing of Compacted Hot Mix Asphalt (HMA)"
Permeability	**GDT-1** Measurement of Water Permeability of Compacted Paving Mixtures

Use the design calculations as outlined in AASHTO R 35 and T-312. However, replace G_{sb} with G_{se} when calculating VMA. When designing a Superpave mix containing RAP materials, the effective specific gravity (G_{se}) of the RAP shall be used in place of the bulk specific gravity (G_{sb}) in determining the combined aggregate bulk specific gravity for the blend. A method of calculating batch weights for RAP mixes is presented in Appendix C. Additionally, when designing Superpave mixtures containing RAP and/or RAS; a Corrected Optimum AC Content (COAC) is to be calculated and used as detailed in Appendix D.

E. Moisture Susceptibility

Moisture susceptibility will be determined by the tensile splitting method according to GDT 66. For these tests, the specimens will be fabricated at optimum asphalt cement content. All mixtures containing RAP and/or RAS shall be fabricated at the corrected optimum asphalt cement content **(COAC)**. The compactive effort for the specimens is to be reduced such that the air voids fall in a range required in Section 828. Specimens prepared for this test will include hydrated lime, or anti-stripping additive, or both, as specified for the ingredients proposed. For gyratory specimens that fail moisture susceptibility, Marshall specimens (4 inch) may be substituted.

F. Hamburg Wheel-Track Testing of Compacted Hot Mix Asphalt (HMA)

Results of tests, including graphs and tables, shall be provided for all Superpave, SMA and 4.75 mm mixtures. The Hamburg Wheel-Tracking test will be conducted according to AASHTO T 324 and Section 828. For these tests, the specimens will be fabricated at optimum asphalt cement content. All mixtures containing RAP and/or RAS shall be fabricated at the corrected optimum asphalt cement content **(COAC)**. Two sets of two gyratory specimens should be tested for each mix design. If the average rut depth for the two sets exceeds specified limits, the asphaltic concrete mixture shall not be used in the work. The compactive effort for the specimens is reduced such that the air voids fall in a range required in Section 828. Test temperature for this test shall be 122 °F (50 °C)

G. Fatigue Testing

The Office of Materials and Testing may conduct a fatigue test on any Superpave asphalt mixture design or Superpave asphalt mixture used in construction to determine acceptability of the materials. The test shall be performed according to test procedure AASHTO T 321, or other procedure approved by the Office of Materials and Testing. All mixtures containing RAP and/or RAS; shall be fabricated at the corrected optimum asphalt cement content **(COAC)**.

H. Calibration Factor for Ignition Test

The designer shall, as part of the design process, perform calibration tests for use when testing the mixture in the ignition furnace, according to GDT 125. All results, including the worksheet and the print-out from the ignition furnace, shall be submitted with the design study and request for approval. All mixtures containing RAP and/or RAS shall be fabricated at the corrected optimum asphalt cement content (COAC).

Verification. The approved calibration factor shall remain in use unless, in the judgment of the State Bituminous Construction Engineer, the accuracy of the testing technique, calibration, or apparatus is found to be invalid or unreliable.

The contractor shall provide samples of the mix ingredients to the Department for verification of the CF on request. On receiving evidence that invalid or unreliable test results have been obtained, the State Bituminous Construction Engineer may suspend use of the ignition test on the mixture being produced until a correct calibration is obtained and until all other discrepancies involving calibration, apparatus and technique have been resolved. Where an incorrect CF has been applied in acceptance testing, results shall be corrected by applying a valid CF.

When a Job Mix Formula is submitted for approval prior to beginning production, the calibration factor of the mixture shall be included in the submittal. (This shall apply in all cases, regardless of the test method to be used for quality control testing.)

IV. Changes in Established Design Procedures, Criteria, or Mix Requirements

Changes in established procedures, criteria, and mix requirements are the prerogative of the State Materials and Research Engineer. Specifications, procedures, and other changes may apply to all bituminous mixtures, or only to a particular mixture. Any certified laboratory designing mixes for use in GDOT work will be placed on a list to receive information on revisions pertaining to bituminous mix design specifications and procedures.

V. Revisions of Approved Designs

Generally, when a particular ingredient of a mix design becomes unavailable, the contractor must provide a different design in order to continue work on a project. While the contractor is always responsible for the supply of materials, it is recognized that certain aggregate sizes may become unavailable due to unforeseeable causes. Often this interrupts paving work in progress, causing inconvenience to the public. In some instances, it may be possible to substitute one coarse aggregate ingredient for a similar material from a different source without affecting the quality of the mixture. In these cases only, the laboratory which designed the mix may submit a design revision for consideration. Design revisions will be subject to the following conditions:

A. Actual Shortage Required

The revision must be necessitated by an actual shortage, sufficient to delay work in progress, of a coarse aggregate ingredient of an approved design.

B. Similar Substitute Ingredient

The substitute ingredient must be similar to the replaced ingredient in mineralogy, particle size and shape, specific gravity, and abrasion resistance.

C. Revised Design Support Requirements

The proposed revised design shall be supported by volumetric tests on a minimum of two pairs of specimens, at asphalt content checkpoints above and below the optimum asphalt content of the original design. The State Bituminous Construction Engineer may require verification of previous tests for susceptibility to rutting, fatigue, and moisture when these properties of the design are marginal.

State Materials Engineer

Director of Construction

Appendix A

Hot Mix Asphalt Design Reference Guide

(Note: Preparation and Testing requires the use of metric units only)

Sequence No.	Description
1	Dry incoming aggregate as described in AASHTO: T 27-93.
2	Grade aggregates as described in AASHTO: T 27-93. Use Gilson shaker and shake at least 10 minutes.
3	Calculate gradation of each aggregate type. Carry calculations to the nearest 0.1%. Compare to source average values and consider plant breakdown.
4	Calculate blend, keeping within control limits. Use AASHTO R 35 as a reference.
5	Batch aggregates as described in AASHTO 312 and AASHTO R 35. The design specimens must be 115 ± 5 mm high (95 mm for moisture susceptibility and manufacturers' requirements for Hamburg). Thoroughly mix the minus 2.36 mm aggregate during batching. Sample weights for AASHTO T-209 (maximum theoretical specific gravity) and gradation must be 2000 grams, except samples for 25 mm mixtures, which shall weigh at least 2500 g.
6	Heat the pans of aggregate to temperature specified on Mixing and Compaction Temperature Control Chart for the source of asphalt cement being used.
7	Heat the asphalt cement to temperature specified on Mixing and Compaction Temperature Control Chart for the source of asphalt cement being used. Heat only a half day's run. Never overheat or reheat AC.
8	Add and mix RAP material, if required, with the hot aggregates. Mix only until the RAP material is blended with the aggregate.
9	Add and mix hydrated lime. Add 1.0% by weight of the aggregate for virgin mixes or as calculated in Appendix C for RAP mixes. Add hydrated lime to the heated aggregate and mix until the aggregate is coated with lime.
10	Mix the heated AC and aggregate in a preheated bowl. The temperature at the time of mixing is very important. Care should be exercised to thoroughly coat the aggregate with AC.
11	When sample has been thoroughly mixed, place the mixture in a pan and spread it uniformly to approximately55 ± 5 lbs/yd^2 (30 ± 2 kg/m^2). Place the mixture and pan in a forced draft oven for 2 hours at the upper limit of the compaction temperature range. All samples for testing (with the exception of moisture susceptibility samples) shall be aged.
12	At least 30 minutes before compaction of the first specimen, place the compaction molds and base plates in an oven at compaction temperature.
13	At the end of the aging process, remove a mold and base plate from the oven. Assemble base plate and mold. Place a paper disk on top of the base plate. Place the aged mixture in the mold (do not spade). Be extremely careful to keep segregation to a minimum when transferring the sample to the heated mold. Place a paper disk on top of the sample.
14	Compact specimen using the Superpave Gyratory Compactor in accordance with AASHTO 312.
15	Remove the mold containing the compacted specimen from the compactor and extrude the specimen from the mold. A short cooling period is allowable to facilitate specimen removal to minimize sample damage. Remove the paper disks from the top and bottom of the specimen. Place the specimen on a flat, well supported surface where it will not be disturbed during cooling. A fan can be used to accelerate cooling, if necessary. Repeat this procedure for each specimen.
16	Determine G_{mb} in accordance with AASHTO T-166. Use balance accurate to 1.0 g. Be sure the water is clean and at correct temperature. Beware of specimens that release excessive bubbles when submerged. Such samples may prove misleading density values. Be sure the basket and suspension wire do not contact anything.

Appendix B

Ensure that Superpave Asphalt Concrete Mixtures Designs meet the following mix design limits:

Sieve Size	Design Gradation Limits, Percent Passing				
	9.5 mm Superpave Type I	**9.5 mm Superpave Type II**	**12.5 mm Superpave**	**19 mm Superpave**	**25 mm Superpave**
1½ in (37.5 mm)					100*
1- in (25.0 mm)			100*	100*	90-100
3/4 in (19.0 mm)	100*	100*	98-100****	90-100	55-89** (85 – 89)$_1$
1/2 in (12.5 mm)	98-100****	98-100****	90-100	60-89*** (85 – 89)$_1$	50-70
3/8 in (9.5 mm)	90-100	90-100	70-89 (85 – 89)$_1$	55-75	
No. 4 (4.75 mm) s	65-85	55-75			
No. 8 (2.36 mm)	48-55	42-47	38-46 (42 – 45)$_1$	32-36 (33 – 35)$_1$	30-36 (33 – 35)$_1$
No. 200 (75 µm)	5.0-7.0 (5.5 – 6.5)$_1$	5.0-7.0 (5.5 – 6.5)$_1$	4.5-7.0 (5.0 – 6.0)$_1$	4.0-6.0 (4.5 – 5.2)$_1$	3.5-6.0 (4.5 – 5.2)$_1$
Range for % AC (Note 4)	5.4-7.25	5.25-7.00	5.00-6.25	4.25-5.50	4.00-5.25

Note 1 details the desired Mix Design combined gradation for each referenced sieve

Appendix C
Method of Calculating Batch Weights for Mix Designs With Recycled Asphalt

PURPOSE: To calculate the weights of reclaimed asphalt pavement (RAP), virgin aggregate, and liquid asphalt cement (AC) for preparing volumetric samples of asphalt mixtures.

Example calculations are for an aggregate batch weight of 4800 g. Assume mix will contain 30% RAP and RAP contains 6.3% AC by extraction. For this example, assume one point of the design will use 5.5% total AC.

#1. Total weight of mix = $\frac{\text{Agg. Wt.}}{100 - \%\ AC}$

Example: $\frac{4800g}{(100\% - 5.5\%)/100} = 5079g$

#2. Grams of RAP to batch = (Total Wt of mix)(% RAP)

Example: (5079)(30%) = (5079)(.30) = 1524 grams RAP

#3. (2)(% AC in RAP) = Grams of old AC from RAP

Example: (1524 grams)(6.4%) = (1524)(.064) = 97.5 grams old AC

#4. (#1) – Agg. Wt. – (#3) = Grams of new AC to add

Example: 5079 – 4800 –97.5 = 181.5 grams of new AC to add

#5. (#2) – #(3) = Grams of aggregate in RAP

Example: 1524 – 97.5 = 1426.5 grams

#6. % Aggregate contributed by RAP = $\frac{(5)}{\text{Agg. Batch}}$

Example: $\left(\frac{1426.5}{4800}\right)(100) = 29.7\%$ total aggregate from RAP

#7. % lime in mix = [100% - (#6)][1.0 %] + [(#6)][0.5%]

Example: (1.0%)(100% – 29.7%) + (0.5%)(29.7%) = 0.9 % Lime

NOTE: This step assumes 50% of RAP will have fractured faces which need to be treated with hydrated lime.

#8. % Aggregate available for other sizes = 100 – (#6) – (#7)

Example: 100 – 29.7 – 0.9 = 69.4% available for virgin aggregate

#9. Calculate Blend

Example: For this example, assume the following blend will be used:

29.7% - RAP aggregate

20.0% - 89 stone

25.0% - 810 screenings

24.4% - 777 (manufactured sand)

0.9% - hydrated lime

100% - Total aggregate

#10. Calculate Batch Weights

Batch wt. of virgin agg. = agg. batch wt. times % of blend

RAP	= (#2)	= 1524 grams
#89	= 4800 X 20%	= 960
#810	= 4800 X 25%	= 1200
#777	= 4800 X 24.4%	= 1171
Lime	= 4800 X 0.9%	= 43
New AC (for 5.5%)	= (4)	= 181.5
Total Wt.		= 5,079.5 grams (Differs from (#1) above due to round-off error.)

NOTE: As the total weight for each point of the design changes (Step #1), the grams of RAP to batch up in Step #2 will also change slightly, as will the available aggregate in Step #8. Therefore, use the AC content nearest the anticipated optimum (usually the third point of the design) as the value to use in Step #1 and on which the blend percentages and batch weights are to be calculated.

Steps #1 through #4 should be repeated for each point in the design to determine the amount of new AC.

NOTE: Use the extracted gradation (or gradation after burning in the ignition oven) of the RAP to calculate the mix blends; use the gradation of the RAP "as is" (from the Gilson shaker) to determine individual sizes for the batch weight. (See pages 1 and 3 of the design software.)

Appendix D

Method of Calculating Credited Asphalt Cement Content for Corrected Optimum AC Content for Asphaltic Concrete Mixtures Incorporating Reclaimed Asphalt Pavement (RAP) or Pre- or Post-Consumer Recycled Asphalt Shingles (RAS),

Purpose: To calculate the Credited AC Content (**CAC**) and Not Credited AC Content (**NCAC**) to be used to determine the Corrected Optimum AC Content **COAC** of Asphaltic Concrete Mixtures incorporating RAP and/or Pre- or Post-Consumer Recycled Asphalt Shingles (RAS), for all mixtures. The **CAC** and **NCAC** shall be used to determine the amount of additional new AC required to be added to an Asphaltic Concrete Mix Design's Original Optimum AC Content (**OOAC** as determined in AASHTO R 35-09 Section 10.5 at VTM = 4.0% air voids. **OOAC must meet the requirements of Section 828.2.03.A.** The **CAC** and **NCAC** shall be calculated using an applied factor as follows: the **CAC** shall be calculated using a factor of 0.60 while the **NCAC** is equivalent to 0.40 where 1.0 – 0.60 equals 0.40

The **COAC,** as determined using this procedure, shall be used in fabricating samples for all performance tests established in Section 828.2.B.2. Additionally, the **COAC** is to be listed on the Mix Design Summary Sheet **(as a note)** and used for JMF purposes.

Example:

Example calculations detailed are for a 12.5 mm Superpave Mix Type. Assume mix will contain 25% RAP and RAP contains 5.75% AC (RAP Stockpile Specific) determined using GDT-83 or GDT-125. For this example, assume the **OOAC**, as determined in AASHTO R 35-09 Section 10.5 is 5.10% total AC.

12.5 mm Superpave Mix with 5.10% **OOAC** (AASHTO R 35-09 Section 10.5 @ VTM 4% Air Voids). RAP = 25 % with 5.75% AC in RAP

1. Using Standard Mix Design Procedure RAP contributes 5.75 % x 0.25 = 1.44 % AC to the blended total AC of mix
2. Using factor to calculate **CAC** = 1.44 % x 0.60 = 0.864% AC
3. Using factor to calculate **NCAC** = 1.44 % - 0.864 % = 0.576 % AC
4. Add the 0.576 % **NCAC** to 5.10 % **OOAC** = 5.68 %
5. The **COAC** = 5.68 %
6. 5.68 % **COAC** shall be used for specimen fabrication for all performance test required in Section 828.2.B.2
7. **COAC** of 5.68 % will be listed as Corrected Optimum on Mix Design Summary Sheet as a note at the bottom.

Note: For asphaltic concrete mix designs incorporating RAP approved prior to December 1, 2018, the new COAC may be recalculated from an existing approved mix design. Upon first production of the recalculated surface mix design, field verifications using asphalt plant produced mixture will be required. Final approval of the recalculated surface mix design will be dependent on the field verified mixture meeting specified criteria using AASHTO T 324.

Note: All Required Performance Test as specified in Section 828.2.B.2 shall be conducted at the Corrected Optimum AC Content (COAC). Mix Design Summary Sheet will list the COAC as the Corrected Optimum AC Content.