ALDOT-384-95

SUPERPAVE MIX DESIGN PROCEDURE FOR ASPHALT MIXTURES

1. Scope

1.1. This procedure provides guidelines for volumetric design of dense-graded bituminous paving mixtures using a Superpave Gyratory Compactor. This procedure determines the proportioning of component aggregates and liquid asphalt binder that when blended together in the laboratory, produces a paving mixture that conforms to ALDOT specification requirements.

2. Reference Documents

2.1. **ALDOT Standard Specifications.**

410 Hot Mix Asphalt Pavements

424 Superpave Bituminous Concrete Base, Binder, and Wearing Surface Layers

801 Coarse Aggregate

802 Fine Aggregate

804 Asphalt Materials

2.2. **ALDOT Procedures**

258 Mechanical Analysis of Extracted Aggregate

361 Resistance of Compacted Bituminous Mixtures to Moisture Induced Damage

372 Approval of Recycled Asphalt Pavement Stockpiles & Reclaimed Asphalt Shingles

2.3. AASHTO Standards

T 2 Sampling of Aggregates

T 11 Materials Finer than 75 µm (No. 200) Sieve in Mineral Aggregates by Washing

T 27 Sieve Analysis of Fine and Coarse Aggregate

T 30 Mechanical Analysis of Extracted Aggregate

T 37 Sieve Analysis of Mineral Filler for Road and Paving Materials

T 84 Specific Gravity and Absorption of Fine Aggregate

T 85 Specific Gravity and Absorption of Coarse Aggregate

T 166 Bulk Specific Gravity of Bituminous Paving Mixtures

T 209 Maximum Specific Gravity of Bituminous Paving Mixtures

T 248 Reducing Samples of Aggregates to Testing Size

T 304 Uncompacted Void Content of Fine Aggregate

T 308 Determining the Asphalt Binder Content of Hot Mix Asphalt by the Ignition Method

T 312 Preparing and Determining the Density of Hot Mix Asphalt (HMA) Specimens by Means of the Superpave Gyratory Compactor

M 231 Weighing Devices Used in the Testing of Materials
R 30 Mix Conditioning of Hot Mix Asphalt
R 35 Standard Practice of Volumetric Mix Design for HMA

2.4. ASTM Procedures

D 5821 Determining the Percentage of Fractured Particles in Coarse Aggregate

3. Definitions

3.1. Air Voids (V_a). The total volume of small pockets of air between the asphalt coated aggregate particles throughout a compacted paving mixture.

3.2. Design Gyrations (N_d). The number of revolutions of a Gyratory compactor required to produce laboratory compacted specimens that represents the compaction of the mixture after 3 to 4 years of traffic. The volumetric properties of the mixture at N_d shall meet the requirements of the specifications.

3.3. Dust Proportion (Dust to Asphalt Ratio (D/A)). It is the percent by mass of aggregate passing the 75 μm (No. 200) sieve divided by the effective asphalt content percent by mass of total mix.

3.4. Effective Asphalt Binder Content (P_{be}). The optimum asphalt binder content of a paving mixture minus the portion of asphalt binder that is absorbed into the aggregate particles.

3.5. FAA. Fine Aggregate Angularity. The volume of uncompacted voids for a given fine aggregate.

3.6. Optimum Liquid Asphalt Binder Content (P_b). The asphalt binder content expressed as a percent by weight of an asphalt paving mixture that satisfies the applicable volumetric design criteria (typically at 4% air voids).

Note: The optimum value is determined during the design process, and becomes the target binder content during production.

3.7. RAP. Recycled asphalt pavement.

3.8. RAS. Reclaimed asphalt shingles.

3.9. TSR. Tensile Strength Ratio. A measure of the change of diametral tensile strength resulting from the effects of saturation and accelerated water conditioning of compacted asphalt specimens.

3.10. VMA. Voids in the Mineral Aggregate. The intergranular void spaces that exist between the aggregate particles in a compacted paving mixture. VMA includes air voids and spaces filled with asphalt.

4. Apparatus

4.1. Gyratory Compactor - An electro-hydraulic or electro-mechanical compactor meeting the requirements in AASHTO T 312.

Note: Experience has indicated that different gyratory compactors set with the same angle of gyration can provide significant differences in the specimen compacted density (G_{mb}). The contractor should conduct correlation studies with the ALDOT field and laboratory compactors to confirm that the compactors give comparable results.

4.2. Specimen Molds, Ram Heads, and Mold Bottoms shall meet the requirements outlined in AASHTO T 312.

4.3. Thermometers - Armored, glass, or dial-type thermometers with metal stems for determining temperature of aggregates, asphalt and asphalt mixtures between 50˚F and 450˚F {10°C and 232°C}.

4.4. Balance - A balance meeting the requirements of AASHTO M 231, Class G5 for determining the mass of aggregates and asphalt.

4.5. Oven - A force draft oven, thermostatically controlled to ± 5 °F {± 3 °C} for heating asphalt mix, asphalt mix components, and equipment as required. The oven(s) shall have sufficient volume to accommodate as a minimum, two gyratory molds, two pans for gyratory pills and two pans for Rice Gravity. The oven(s) shall be capable of maintaining the temperature required of 275 °F {135 °C} for short term aging as per AASHTO R 30.

4.6. Miscellaneous - Flat bottom pans for heating asphalt mix and asphalt mix components. As a minimum, four pans approximately 15 x 15 x 1 inches {375 x 375 x 25 mm} are required. Other miscellaneous equipment includes scoop, transfer equipment (i.e. funnels), mixing bowls, mechanical mixer, beakers, and containers for heating liquid asphalt binder, mixing spoons/spatulas, paper disks, lubricating oil, and insulated gloves.

5. Procedure

5.1. Materials Selection

5.1.1. Aggregates

- Select fine and coarse aggregates from ALDOT approved sources. See List I-1, Sources of Coarse and Fine Aggregates, in the Materials, Sources, and Devices with Special Acceptance Requirements (MSDSAR) manual.
- Obtain field samples of each aggregate selected in accordance with AASHTO T 2.
- Dry aggregates to a constant mass at 230°±9°F (110°±5°C)

5.1.2. RAP/RAS

- Obtain field samples of recycled asphalt pavement (RAP) or reclaimed asphalt shingles (RAS) in accordance with ALDOT-372.
- The handling, testing, and mixture design using RAP/RAS shall be in accordance with ALDOT-372.
- *Refer to Section 410 of the ALDOT specifications for allowable usage of RAP/RAS.*

5.1.3. Asphalt Binder

- The asphalt binder used in the mixture design shall meet the requirements in Section 804 of ALDOT Standard Specifications.
- The asphalt binder shall be from a supplier on List I-4, Producers of Asphalt Products, in the Materials, Sources, and Devices with Special Acceptance Requirements (MSDSAR) manual.

5.2. Gradations

5.2.1. In accordance with ALDOT specifications select an appropriate aggregate gradation based upon the following:

- The mixture purpose - Wearing surface, Binder Layer, or Base layer.
- The specified performance grade of asphalt binder based on the specifications, plans, and proposal.

5.2.2. Reduce aggregate and RAP/RAS field samples to testing size in accordance with AASHTO T 248 for each test performed.

5.2.3. Perform a sieve analysis on each aggregate including any RAP/RAS to be used in the design in accordance to AASHTO T 27, AASHTO T 11, AASHTO T 30, AASHTO T 37 and ALDOT 258.

Note: Gradations used for the mixture design should be based on average stockpile gradations for each of the materials. Good practice is using the average of the last ten (10) gradations.

5.3. Aggregate Specific Gravity

5.3.1. Determine the fine and coarse aggregate specific gravity in accordance with AASHTO T 84 and AASHTO T 85, respectively. Modify AASHTO T 85 as follows:

For Gravel Coarse Aggregates (¾" (19 mm) to No. 4 (4.75 mm)), modify AASHTO T 85 to include a 15-minute vacuum saturation according to AASHTO T 209 prior to the required 15 – 19 hour soaking period.

5.3.2. Perform a minimum of three specific gravity tests on each of the aggregates and average the results. Discard any result that varies by more than 0.020 from the average. For each discarded value perform a new specific gravity test to maintain the minimum of three test results average.

Note: If specific gravity tests are periodically performed on stockpiled aggregates, the preferred practice is to use a running average of the results for the mixture design.

5.3.3. Refer to Section 801 of ALDOT Standard Specifications for the required specific gravity of gravel sizes ¾" to No. 4 {19.0 mm to 4.75 mm}.

5.3.4. If an aggregate has more than 25% passing the No. 4 {4.75 mm} sieve and more than 25% retained on the No. 4 {4.75 mm} sieve, perform specific gravity tests on both coarse and fine aggregate fractions separately and determine the Bulk Specific Gravity of the blend using the following equation:

- The total aggregate blend consist of separate fractions of coarse aggregate, fine aggregate, and mineral fillers (if used), all having different specific gravities.
- **Formula:**

$$G_{sb} = \frac{P_1 + P_2 + \ldots + P_n}{\frac{P_1}{G_1} + \frac{P_2}{G_2} + \ldots \frac{P_n}{G_n}}$$

Where,

G_{sb} = Bulk Specific Gravity of the aggregate blend
$P_1, P_2, \ldots, P_n$ = Percentage by weight of aggregates 1, 2, …, n
$G_1, G_2, \ldots, G_n$ = Bulk Specific Gravity of aggregates 1, 2, …, n

Note: The apparent specific gravity of mineral filler shall be used in lieu of the bulk specific gravity in the above equation.

Note: The apparent specific gravity of the blend can be determined using the formula in 5.3.4 and substituting the individual apparent specific gravity values for the individual bulk specific gravity values.

Example:

Material	*Percentage of Material in mix*	*Bulk Specific Gravity of Material*
RAP	*15*	*2.663*
Sand	*16*	*2.602*
#9 Limestone (LS)	*15*	*2.692*
#78 Sandstone (SS)	*40*	*2.611*
Sandstone Screenings (SS Scrn)	*13*	*2.616*
Baghouse Fines (BHF)	*1*	*2.75*

$$G_{sb} = \frac{15+16+15+40+13+1}{\frac{15}{2.663}+\frac{16}{2.602}+\frac{15}{2.692}+\frac{40}{2.611}+\frac{13}{2.616}+\frac{1}{2.75}}$$

G_{sb} = 2.631

5.3.5. Determine the asphalt content of the RAP/RAS in accordance with AASHTO T 308.

5.3.6. Assume the bulk specific gravities of the RAP and RAS are equal to their effective specific gravities. This requires calculating the maximum specific gravities of the RAP and RAS in accordance with AASHTO T 209, and using the following equation:

$$G_{sb,RAP/RAS} = G_{se} = \frac{100 - P_b}{{100}/{G_{mm}} - {P_b}/{G_b}}$$

Where,

G_{se} = effective specific gravity of aggregate

G_{mm} = maximum specific gravity

P_b = asphalt content

G_b = specific gravity of asphalt

5.4. Required Aggregate Blend

5.4.1. Determine the percentages of each aggregate necessary to produce a blended aggregate, including mineral fillers and recycled materials, meeting the grading requirements outlined in Section 424 of the ALDOT Standard Specifications. The percentages of each aggregate are determined by trial and error.

5.4.2. Computer spreadsheets are useful for aggregate blending.

Example:

AGGREGATE TYPE	***BHF***	***RAP***	***SAND***	***#9LS***	***#78SS***	***#810 LS***	***SS Scrn***	***100***
PERCENT GRADATION	***1***	***15***	***16***	***15***	***40***	***0***	***13***	***BLEND***
1 1/2"	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	***100.0***
1"	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	***100.0***
3/4"	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	***100.0***
1/2"	*100.0*	*100.0*	*100.0*	*100.0*	*90.2*	*100.0*	*100.0*	***96.1***
3/8"	*100.0*	*100.0*	*100.0*	*99.6*	*67.0*	*100.0*	*100.0*	***86.7***
#4	*100.0*	*99.9*	*97.5*	*62.2*	*22.8*	*95.8*	*96.6*	***62.6***
#8	*100.0*	*89.3*	*90.1*	*14.5*	*12.9*	*72.0*	*80.5*	***46.6***
#16	*100.0*	*58.5*	*79.4*	*4.5*	*11.6*	*53.1*	*67.7*	***36.6***
#30	*100.0*	*35.3*	*55.4*	*3.0*	*10.8*	*39.8*	*59.0*	***27.6***
#50	*100.0*	*19.2*	*9.4*	*2.4*	*7.9*	*28.5*	*41.7*	***14.3***
#100	*90.1*	*12.5*	*0.5*	*2.0*	*3.7*	*20.3*	*21.3*	***7.4***
#200	*82.3*	*10.0*	*0.2*	*1.7*	*2.3*	*15.4*	*12.7*	***5.2***
AGGREGATE GRAVITY	*2.693*	*2.663*	*2.602*	*2.692*	*2.611*	*2.685*	*2.616*	***2.631***
APPARENT GRAVITY	*2.750*	*2.716*	*2.718*	*2.723*	*2.66*	*2.723*	*2.726*	***2.696***
SAND EQV		*0*	*97*	*0*	*0*	*55*	*36*	***46***
%SAND EQV		*0*	*35*	*0*	*0*	*0*	*11*	
%RAP AC		*6*						

5.5. Preparation of Aggregates

5.5.1. From the required aggregate blend, determine the weight of each aggregate component required to produce a batch that will result in a compacted specimen 6 in. {150 mm} in diameter and 4.5 ± 0.20 in. {115 ± 5 mm} in height.

- Approximately 10 to 10.5 pounds {4500 to 4700 grams} of aggregate for most materials.

  Note: Prepare a trial specimen at the batch weight selected prior to preparing all the aggregate batches. If the trial specimen does not meet the height requirement, adjust the amount of material used for the specimens accordingly.

5.5.2. Separate each of the field sample aggregates into the following sizes:

Retained on 1" {25.0 mm} sieve
retained on ¾" {19 mm} sieve
retained on ½" {12.5 mm} sieve
retained on ⅜" {9.5 mm} sieve
retained on No. 4 {4.75 mm} sieve
retained on No. 8 {2.36 mm} sieve
Passing No. 8 (2.36 mm) sieve
Note: If any of the size fractions represent less than 5 percent of the aggregate, they may be combined with the next smaller fraction.

5.5.3. For each specimen, weigh the required quantity of each aggregate size into a tin/pan. A typical mix design will contain the following:

- 10 Gyratory Test Specimens for determining optimum asphalt content. Specimens are grouped into 5 sets of 2. Four sets are used to determine optimum asphalt content (refer to Section 5.8). One set will be used to verify the optimum asphalt content (refer to Section 6.2.3).
- 2 Specimens for determining theoretical maximum specific gravity, G_{mm} (refer to Section 5.11).

  Note: If RAP and/or RAS are used in the mixture design, weigh the appropriate quantity of RAP/RAS material into separate tins for addition to the batched samples during the mixing process.

5.6. Asphalt Binder(AC) Batch Weights

5.6.1. **For Virgin Mixtures:** Calculate the weight of the liquid asphalt binder using the following equation:

Liquid Asphalt Binder Weight:

$$= \frac{\boldsymbol{Wt.of\ Agg.Batch}}{\boldsymbol{((100 - P_b)/100)}} - \boldsymbol{Wt.of\ Agg.Batch}$$

***Example*:**

Percent Asphalt Binder (P_b) = 4.2%

Weight of Aggregate Batch = 5000 g

$$Asphalt\ Binder\ Weight = \frac{5000}{((100-4.2)/100)} - 5000$$

$$= \frac{5000}{0.958} - 5000$$

= 219.2 g

5.6.2. **For RAP/RAS Mixtures:** Calculate the weight of virgin asphalt binder using the following procedure:

Step 1: Determine the weight of RAP/RAS in the batch

- *Wt. of RAP = % RAP * Wt. of Batch*
- *Wt. of RAS = % RAS * Wt. of Batch*

Step 2: Determine the weight of RAP/RAS AC

- *Wt. of RAP AC = % RAP AC * Wt. of RAP*
- *Wt. of RAS AC = % RAS AC * Wt. of RAS*

***Step 3*: Determine the weight of total Aggregate**

- *Wt. of Total Aggregate = Wt. of Aggregate Batch – Wt. of RAP AC – Wt. of RAS AC*

Step 4: Determine the weight of the total liquid asphalt binder (AC) required

- *Wt. of Total AC =* $\frac{Wt.\ of\ Total\ Agg.}{(100-P_b)/100} - Wt.of\ Total\ Agg.$

Step 5: Determine the weight of New (Virgin) AC required

- *Wt. of Virgin AC = Wt. of Total AC – Wt. of RAP AC – Wt. of RAS AC*

Example:

Total Percent Asphalt Binder Required (%AC) = 5.1
Weight of Batch = 5000 g
Percent of RAP in Batch = 15.0
Percent of Asphalt Binder in RAP = 6.0
Percent of RAS in Batch = 5.0
Percent of Asphalt Binder in RAS = 20.0

Step 1

- *Weight of RAP in Batch = 15% x 5000 =* ***750.0 g***
- *Weight of RAS in Batch = 5% x 5000 =* ***250.0 g***

Step 2

- *Weight of RAP AC = 6.0% x 750 =* ***45.0 g***
- *Weight of RAS AC = 20% x 250 =* ***50.0 g***

Step 3

- *Weight of Total Aggregate = 5000 – 45 - 50 =* ***4905.0 g***

Step 4

- *Weight of Total Liquid Asphalt Binder (AC)*
  = {4905 / ((100 - 5.1)/100)} – 4905
  = ***263.6 g***

Step 5

- *Weight of Virgin AC* *= 263.6 – 45 – 50*
  *=**168.6 g***

5.7. Mixture Preparation for Gyratory Test Specimens

5.7.1. Place the asphalt binder to be used in an oven and heat to mixing temperature (heat to produce a kinematic viscosity of 170 ± 20 mm^2/sec).

- The temperature shall be determined by a temperature-viscosity chart representing current asphalt binder production provided by the AC supplier.
- For polymer modified asphalt binders, use the manufacturer's recommended mixing temperature.

5.7.2. Heat each tin/pan of aggregate in an oven at the required mixing temperature for a minimum of 3 hours.

5.7.2.1. If applicable, place each tin/pan of RAP/RAS in the same oven for a maximum of 2 hours.

5.7.3. Pour the heated aggregate and RAP/RAS into the mixing bowl and dry-mix thoroughly.

5.7.4. Form a crater in the dry-blended aggregate, and weigh the required amount of liquid asphalt binder into the mix.

5.7.5. Mechanically mix the aggregate and asphalt binder as quickly and thoroughly as possible to yield a paving mixture having a uniform distribution of asphalt binder.

5.7.6. After mixing, place the mixture in a flat pan to a maximum depth of 2 in. {50 mm}.

5.7.7. Place the pan in a curing oven at 10 to 20 °F {5 to 10 °C} above compaction temperature for approximately 2 hours to allow for asphalt absorption.

5.8. Gyratory Test Specimens

5.8.1. Prepare Gyratory specimens in accordance with AASHTO T 312.

5.8.2. A minimum of 4 sets of gyratory specimens with asphalt binder content at 0.5% increments shall be made for testing. Each set consists of 2 specimens.

5.8.3. Specimens shall be prepared such that at least one set is above the optimum asphalt content and one set is below the optimum asphalt contents.

<u>Note:</u> When slag aggregate is used in the mixture design, three (3) specimens shall be prepared for each set (discard the specimen with the bulk specific gravity (G_{mb}) farthest from the average bulk specific gravity (G_{mb}) of the three specimens and calculate a new average

bulk specific gravity (G_{mb}) from the two remaining specimens for design calculations.

5.9. Compaction of Gyratory Test Specimens

5.9.1. Turn on Gyratory compactor, verify settings, and warm-up prior to starting the test.

5.9.2. Verify calibration of Gyratory compactor in accordance with the operation manual.

5.9.3. Verify ram pressure with load cell and angle tilt setting in accordance with Section 424 of ALDOT Standard Specifications.

5.9.4. Verify that molds and transfer equipment have been heated to the compaction temperature for at least 30 minutes prior to starting compaction.

5.9.5. Follow AASHTO T 312 for compaction procedure of test specimens.

5.9.6. After compacted specimen is extracted from the mold and cools to room temperature, weigh and record the weight of the specimen.

Note: One should exercise caution when handling the molded specimens as some mixes are still malleable even after some cooling has occurred.

5.10. Bulk Specific Gravity of Compacted Specimens (G_{mb})

5.10.1. Determine the bulk specific gravity of the compacted specimen in accordance with AASHTO T 166 using the following equation:

$$\boldsymbol{G_{mb} = \frac{A}{B - C}}$$

And, the percent (by volume) of water absorbed by the specimen is as follows:

$$Percent\ of\ Water\ Absorbed\ by\ Volume = \frac{B - A}{B - C} \times 100$$

Where,

G_{mb}	=	Bulk Specific Gravity
A	=	Mass of the specimen in air, g
B	=	Mass of the surface-dry specimen in air, g
C	=	Mass of the specimen in water, g

***Example*:**

A	=	4821.6 g
B	=	4824.4 g
C	=	2804.6 g

$$G_{mb} = \frac{4821.6}{4824.4 - 2804.6} = \mathbf{2.387}$$

And,

$$Percent\ of\ Water\ Absorbed\ by\ Volume = \frac{4824.4-4821.6}{4824.4-2804.6} \times 100$$

$$= \underline{\boldsymbol{0.14\%}}$$

5.11. Theoretical Maximum Specific Gravity (G_{mm})

5.11.1. Determine the batch weights of two samples at different asphalt binder contents that are closest to the expected optimum asphalt binder content.

5.11.2. Samples for determining the theoretical maximum specific gravity shall have the absorption curing period completed as per Article 5.7.8.

5.11.3. Use the following minimum sample sizes for the Maximum Specific Gravity test:

ALDOT Mixture – Max. Size	Minimum Sample – grams
3/8" (9.5 mm)	1000
1/2" (12.5 mm)	1500
3/4" (19.0 mm)	2000
1" (25.0 mm)	2500
1-1/2" (37.5 mm)	4000

5.11.4. Prepare the samples and determine the theoretical maximum specific gravity in accordance with AASHTO T 209 using the following equation:

$$\boldsymbol{G_{mm} = \frac{A}{D-E}}$$

Where,

G_{mm} = maximum specific gravity of paving mixture (no air voids)

A = Mass of oven dried sample in air

D = Mass of container filled with water @ 77° F

E = Mass of water displaced by the sample at 77° F

Example:

A = 1504.3

D = 5203.5

E = 4593.4

$$G_{mm} = \frac{1504.3}{5203.5-4593.4} \quad \underline{\boldsymbol{= 2.466}}$$

5.12. Effective Specific Gravity of Aggregate

Calculate G_{se} as follows:

$$G_{se} = \frac{P_{mm} - P_b}{\frac{P_{mm}}{G_{mm}} - \frac{P_b}{G_b}}$$

Where,

G_{se} = Effective specific gravity of aggregate
G_{mm} = Theoretical maximum specific gravity
P_{mm} = Percent by mass of total loose mixture = 100%
P_b = Asphalt binder content
G_b = Specific gravity of asphalt binder

Example:

G_{mm} = 2.466
P_{mm} = 100 %
P_b = 5.1 %
G_b = 1.038

$$G_{se} = \frac{100 - 5.1}{\frac{100}{2.466} - \frac{5.1}{1.038}} \quad \textbf{= 2.663}$$

5.12.1. If the two G_{se} test results are within 0.014 of each other, average the results and use the average as the effective specific gravity.

5.12.2. If the difference between the two G_{se} test results exceeds 0.014, recalculate and verify accuracy of all variables.

5.12.3. If no errors are found, repeat the theoretical maximum specific gravity tests and recalculate the G_{se}; then, compare the four values of G_{se}. Discard the value farthest from the average and use the average of the remaining three Gse values for further calculations.

5.13. Maximum Specific Gravity (G_{mm}) of Mixtures with Different Asphalt Binder Contents

5.13.1. In designing a paving mixture with given aggregates, the G_{mm} at different asphalt binder contents is needed to calculate the percentage of air voids.

5.13.2. Compute the G_{mm} of Bituminous mixtures at other asphalt contents at the design number of gyrations as follows:

$$\mathbf{G_{mm}} = \frac{P_{mm}}{\frac{P_s}{G_{se}} + \frac{P_b}{G_b}}$$

Where,

G_{mm} = maximum specific gravity of paving mixture (no air voids)

P_{mm} = total loose mixture, percent by weight of mixture = 100%

P_s = aggregate, percent by total weight of mixture = (100 - P_b)

P_b = asphalt binder, percent by total weight of mixture

G_{se} = effective specific gravity of aggregate

G_b = specific gravity of asphalt binder

Example:

P_{mm} = 100%

P_s = (100 - 5.1) = 94.9%

P_b = 5.1%

G_{se} = 2.663

G_b = 1.038

$$G_{mm} = \frac{100}{\frac{94.9}{2.663}+\frac{5.1}{1.038}} = \mathbf{2.466}$$

5.13.3. If the two G_{se} results calculated in 5.12 are within 0.014 of each other, average the results and use it as the effective specific gravity (G_{se}) to determine the maximum specific gravity (G_{mm}) for all other asphalt binder contents using the equation in 5.13.2, varying the P_b term of the equation.

5.14. Asphalt Binder Absorption (P_{ba})

Asphalt binder absorption expressed as a percentage by weight of aggregate is determined as follows:

$$\boldsymbol{P_{ba} = 100 \times \left[\frac{G_{se} - G_{sb}}{G_{sb} \times G_{se}}\right] \times G_b}$$

Where,

P_{ba} = Absorbed asphalt binder, percent by weight of aggregate

G_{se} = Effective specific gravity of aggregate

G_{sb} = Bulk specific gravity of aggregate

G_b = Specific gravity of asphalt binder

Example:

G_{se} = 2.663

G_{sb} = 2.631

G_b = 1.038

$$P_{ba} = 100 \times \left[\frac{2.663 - 2.631}{2.631 \times 2.663}\right] \times 1.038 \quad \textbf{= 0.47\%}$$

5.15. Effective Asphalt Binder Content (P_{be})

The effective asphalt binder content of a paving mixture is determined as follows:

$$\boldsymbol{P_{be} = P_b - \left[\frac{P_{ba}}{100} \times P_s\right]}$$

Where,

P_{be} = Effective asphalt binder content, percent by weight of mixture

P_b = Total asphalt binder content, percent by weight of mixture

P_{ba} = Absorbed asphalt binder, percent by weight of aggregate

P_s = Aggregate, percent by weight of mixture, = (100 – P_b)

Example:

P_b = 5.1 %

P_{ba} = 0.47 %

P_s = 94.9 %

$$P_{be} = 5.1 - \left[\frac{0.47}{100} \times 94.9\right] \quad \textbf{= 4.65\%}$$

5.16. Dust Proportion (DP)

The dust proportion of the asphalt mixture is determined as follows:

$$\boldsymbol{DP = \left[\frac{Percent\ Passing\ 75\mu m\ (No.200)\ Sieve}{P_{be}}\right]}$$

Where,

DP = Dust proportion (dust to asphalt binder ratio)

P_{be} = Effective asphalt binder content, % by weight of mixture

Example:

$$DP = \left[\frac{5.2}{4.65}\right] \quad \textbf{= 1.12}$$

5.17. Percent Voids in the Mineral Aggregate (VMA) in Compacted Mixture

The VMA is determined as follows:

$$\boldsymbol{VMA = 100 - \left[\frac{G_{mb} \times P_s}{G_{sb}}\right]}$$

Where,

VMA = Voids in mineral aggregate (percent of bulk volume)
G_{sb} = Bulk specific gravity of aggregate
G_{mb} = Bulk specific gravity of compacted mixture (AASHTO T 166)
P_s = Aggregate, percent by total weight of mixture, = (100 - P_b) where P_b is the percent total asphalt binder content by weight of the mixture

Example:

G_{sb} = 2.631
G_{mb} = 2.361
P_s = 94.9

$$VMA = 100 - \left[\frac{2.361 \times 94.9}{2.631}\right] = \mathbf{14.8\%}$$

5.18. Percent Air Voids in Compacted Mixture (V_a)

The air voids in a compacted mixture is determined as follows:

$$\boldsymbol{V_a = 100 \times \left[\frac{G_{mm} - G_{mb}}{G_{mm}}\right]} \quad \textbf{Or} \quad \boldsymbol{V_a = 100 \times \left[1 - \frac{G_{mb}}{G_{mm}}\right]}$$

Where,

V_a = Air voids in compacted mixture, percent of total volume
G_{mm} = Maximum specific gravity of paving mixture
G_{mb} = Bulk specific gravity of compacted mixture

Example:

G_{mm} = 2.466
G_{mb} = 2.361

$$V_a = 100 \times \left[\frac{2.466 - 2.361}{2.466}\right] \quad \text{Or} \quad V_a = 100 \times \left[1 - \frac{2.361}{2.466}\right]$$

V_a = ***4.3%***

5.19. Fine Aggregate Angularity (FAA) or Uncompacted Voids of the Fine Aggregate

Perform the FAA testing in accordance with AASHTO T 304 using the following equation to calculate the uncompacted voids.

$$\boldsymbol{U = \left[\frac{V - [F/G]}{V}\right] X\ 100}$$

Where,

V = volume of cylindrical, (ml)

F = net mass, g, of fine aggregate in the measure (Gross mass minus the mass of the empty measure)

G = bulk dry specific gravity of fine aggregate

U = uncompacted voids, percent, in the material

Example:

V = 99.99 ml

F = 145.6 g

G = 2.631

U = uncompacted voids, percent, in the material

$$U = \left[\frac{99.99 - [145.6/2.631]}{99.99}\right] X\ 100$$

$$= \left[\frac{99.99 - (55.3)}{99.99}\right\} x\ 100\%$$

$$= \left[\frac{44.7}{99.99}\right] x\ 100$$

$$= [0.447] \times 100$$

= 44.7%

Note: Perform the Uncompacted Voids test at least two times and average the results. Use the average result in the design.

6. Determination of Optimum Asphalt Binder Content

6.1. Plot the following values at the various percentages of asphalt binder used in the mixture design:

- Air Voids vs. Liquid Asphalt Binder Content
- VMA vs. Liquid Asphalt Binder Content

6.2. Procedure for determining the optimum liquid asphalt binder content.

6.2.1. From the plot of air voids vs. asphalt binder content, select the asphalt binder content corresponding to the design criteria in Section 424 of the ALDOT Standard Specifications. The mixture shall be redesigned if the criteria cannot be met.
Note: Asphalt mixtures containing RAS have a different air void content requirement than those asphalt mixtures with no RAS.

6.2.2. Prepare two specimens at the design asphalt content and compact to the number of gyrations for N_d. Verify that the mixture meets the required design criteria in Section 424 of the ALDOT Standard Specifications.

7. Determining Mixture Resistance to Moisture Damage (Stripping).

7.1. Determine Tensile Strength Ratio (TSR) and visual stripping in accordance with ALDOT-361.

Note: TSR must be greater than or equal to 0.80 for approval of mix design.

8. Submittals

8.1. Contractors shall submit all items listed in Section 8.2 – 8.4 for job mix formula verification to the following address:

Bureau of Materials and Tests
(Attn: HMA Laboratory)
3704 Fairground Road
Montgomery, AL 36110

8.2. Mixture information (i.e. mix type, intended use, ESAL Range)

8.3. Materials. The following samples for the materials used in the mixture design shall be submitted with each design.

8.3.1. Aggregate

- Six virgin aggregate batches that will produce 115 mm tall gyratory specimens. These will be used to verify gyratory specimens at optimum AC content and to verify aggregate angularities.
- Six virgin aggregate batches that will produce 100 mm gyratory specimens. These will be used to verify TSR results.
- Two virgin aggregate batches that will produce the required size for the Maximum Specific Gravity test.

8.3.2. Recycled Asphalt Pavement (RAP). A minimum of 50 pounds (23 kg) to produce the batches required in 8.2.1.

8.3.3. Reclaimed Asphalt Shingles (RAS). A minimum of 10 pounds (5 kg) to produce the batches required in 8.2.1.

8.3.4. Asphalt Binder. Four quarts (one gallon) of liquid asphalt binder used in the mix design.

8.4. Reports

8.4.1. Cover Letter.

8.4.2. Aggregate Blend Sheet. Including all the individual weights for each batch of material.

8.4.3. RAP/RAS Materials Data Sheet.

- The Contractor shall sample and test each source of RAP/RAS material to be used on the project according to ALDOT-372.

- The Contractor shall submit the results from RAP/RAS testing as outlined in Section 410 of the ALDOT Standard Specifications.

8.4.4. Provide a copy of the blended aggregate gradation plotted on the 0.45 power graph paper.

8.4.5. Provide a summary sheet showing the volumetric properties for each trial batch with varying asphalt contents.

8.4.6. Provide graphs of the mixture volumetric properties versus asphalt contents.

8.4.7. Provide a copy of the laboratory data sheet for the Maximum Specific Gravity data and a summary of the Effective Specific Gravity calculations. Show the percent moisture content of the Maximum Specific Gravity sample at the completion of the dry back.

8.4.8. Provide a copy of the laboratory data sheet for the Apparent Specific Gravity.

8.4.9. Provide a copy of the Fine Aggregate Angularity Index Sheet.

8.4.10. TSR Worksheet. Show the sample weight used to make the specimens.

8.4.11. When producing Warm Mix Asphalt (WMA), specify which of the approved technologies listed on List II-27 of the Department's *Materials, Sources, and Devices with Special Acceptance Requirements Manual* shall be used.

8.5. Contractor may request a revision to a JMF or a redesign of the JMF may be required for any of the following:

8.5.1. Changes in aggregate/RAP/RAS source, quantity, or properties.

8.5.2. Changes in the Performance Grade (PG) of the liquid asphalt binder.

8.5.3. Changes in the source or quantity of additives (i.e. WMA, fiber, antistripping agents, etc.).

APPENDIX A

COMPANY NAME
COMPANY ADDRESS
CITY, STATE ZIP

OFFICE: **Ph Number**
FAX: **Fax Number**

PLANT: COMPANY NAME
SPECIAL PROVISION: **SP Number**

PROJECT NO. Project number
COUNTY County

DEAR SIR:

The job mix shown below will be used only at the plant noted and for the materials listed. The plant mix will be manufactured in compliance with the applicable specifications, plan notes and special provisions.

MIX: 424 MAX AGG SIZE: 3/4" ESALCATEGORY: RANGE: C/D
USAGE: **Used for which layer** BINDER GRADE: PG 67-22 HUNT REFINERIES

MATERIALS: (% APPROX.)		DESCRIPTION & SOURCE	ID #	BPN
40	#78SS	SOURCE 1, MONT	ID#1	
15	#9LS	SOURCE 2, MONT	ID#2	**28**
0	#810 LS	SOURCE 3, MONT	ID#3	
13	SS Scrn	SOURCE 4, MONT	ID#4	
16	SAND	SOURCE 5, MONT	ID#5	
15	RAP	STOCKPILE		
1	BHF	PLANT		

JOB MIX:

SIEVE	% PASS
1 1/2"	100
1"	100
3/4"	100
1/2"	96
3/8"	87
#4	63
#8	46.6
#16	36.6
#30	27.6
#50	14.3
#100	7.4
#200	5.2

OTHER INFORMATION

% AC REQUIRED	5.10
AC REQED (LBS/TON)	102
MAX SP. GR. MIX	2.466
MASS (LBS/ CU. FT.)	147.3
STABILITY (LBS.)	N/A
TSR	0.84
% ANTISTRIP(DATA)	**0.25%**
EFFECTIVE AC	4.63
DUST/ASPHALT RATIO	1.12
FINE AGG. ANGL.	45
COARSE AGG. ANGL.	**100/100**
SAND EQUIVALENT	46
% VMA	0.0
BULK SG OF AGG	2.631

NOTE:
4.23% AC MUST BE ADDED TO THE MIX

THE REMAINING **0.89%** COMES FROM THE RAP.

GYRATIONS:

Nd
60
95.72

LEVEL 3 DESIGNER _____ _____
Exp Date: _____

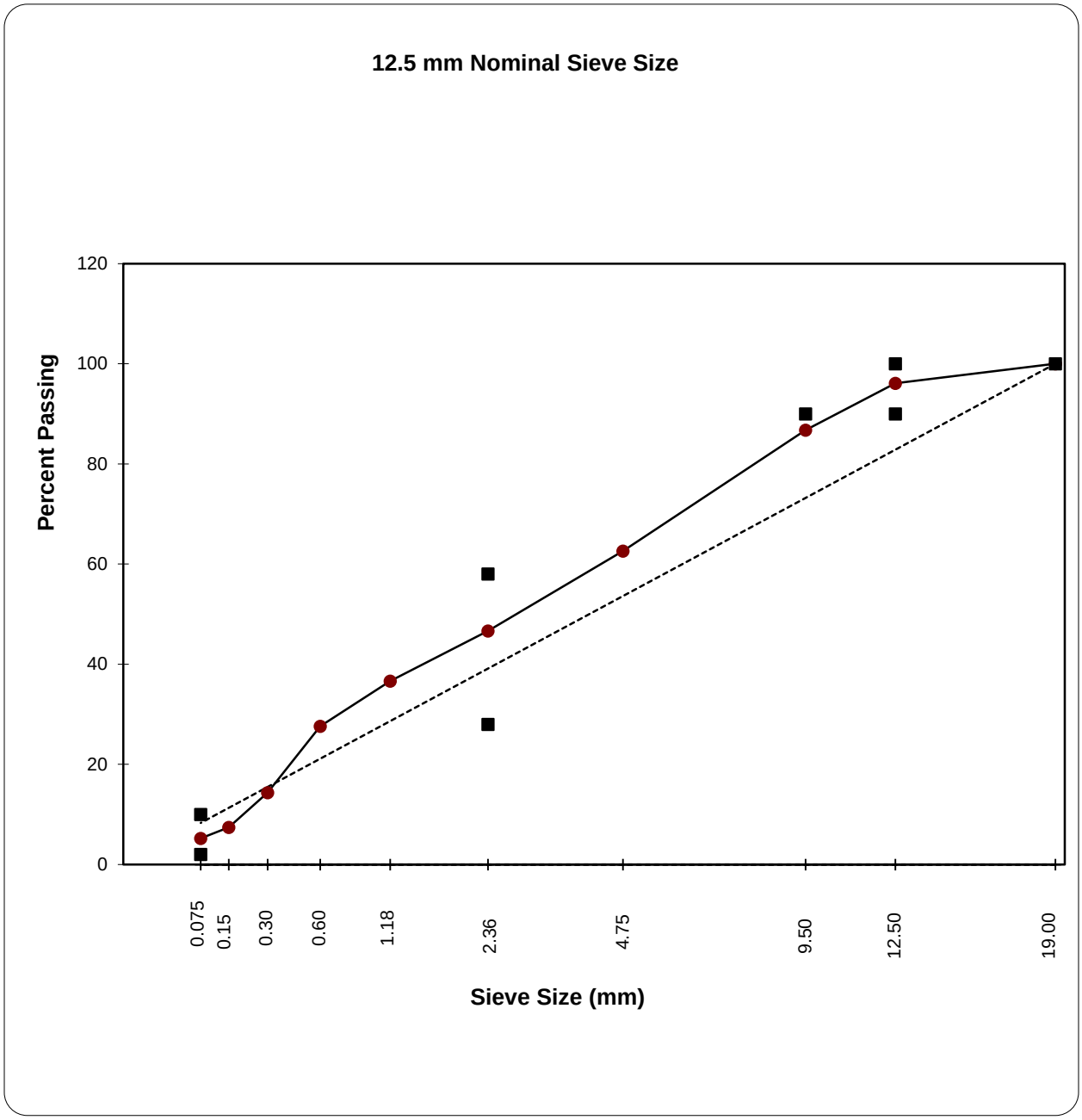
HMA ENGINEER _____ _____

COMPANY NAME

MIX: **424** **3/4"** ESAL RANGE: **C/D**

MATERIALS:	SOURCE:	DESCRIPTION:	APPR.%
#78SS	**ID#1**	**SOURCE 1, MONT**	40
#9LS	**ID#2**	**SOURCE 2, MONT**	15
#810 LS	**ID#3**	**SOURCE 3, MONT**	0
SS Scrn	**ID#4**	**SOURCE 4, MONT**	13
SAND	**ID#5**	**SOURCE 5, MONT**	16
RAP		**STOCKPILE**	15
BHF	**PLANT**		1
PG 67-22	**HUNT REFINERIES**	**DECATUR, AL**	**5.10**
		VIRGIN AC ADDED	4.23% AC

	7	6	5	2	1	3	4	
AGG TYPE	**BHF**	**RAP**	**SAND**	**#9LS**	***#78SS***	**#810 LS**	**SS Scrn**	**100**
PERCENT	**1**	**15**	**16**	**15**	**40**	**0**	**13**	BLEND
GRADATION								
1 1/2"	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	100.0
1"	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	100.0
3/4"	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	100.0
1/2"	**100.0**	**100.0**	**100.0**	**100.0**	**90.2**	**100.0**	**100.0**	96.1
3/8"	**100.0**	**100.0**	**100.0**	**99.6**	**67.0**	**100.0**	**100.0**	86.7
#4	**100.0**	**99.9**	**97.5**	**62.2**	**22.8**	**95.8**	**96.6**	62.6
#8	**100.0**	**89.3**	**90.1**	**14.5**	**12.9**	**72.0**	**80.5**	46.6
#16	**100.0**	**58.5**	**79.4**	**4.5**	**11.6**	**53.1**	**67.7**	36.6
#30	**100.0**	**35.3**	**55.4**	**3.0**	**10.8**	**39.8**	**59.0**	27.6
#50	**100.0**	**19.2**	**9.4**	**2.4**	**7.9**	**28.5**	**41.7**	14.3
#100	**90.1**	**12.5**	**0.5**	**2.0**	**3.7**	**20.3**	**21.3**	7.4
#200	**82.3**	**10.0**	**0.2**	**1.7**	**2.3**	**15.4**	**12.7**	5.2
AGG GRAV	**2.693**	**2.663**	**2.602**	**2.692**	**2.611**	**2.685**	**2.616**	2.631
APP GRAV	**2.75**	**2.716**	**2.718**	**2.723**	**2.66**	**2.723**	**2.726**	2.696
SAND EQV		**0**	**97**	**0**	**0**	**55**	**36**	46
%SAND EQV		0	35	0	0	0	11	
%RAP AC		**6**						


12.5 mm Nominal Sieve Size
Percent Passing
120
100
80
60
40
20
0
0.075
0.15
0.30
0.60
1.18
2.36
4.75
9.50
12.50
19.00
Sieve Size (mm)

Gyratory Laboratory Worksheet

Section	424	Point No.	Check Point
Producer	COMPANY NAME	Project No.	**Project number**
Plant	**Plant id or location**	County	**County**

Effective Specific Gravity of Agg.	2.663	Mixing Temp.	**320**
Bulk Specific Gravity of Agg.	2.631	Compaction Temp.	**300**
Specific Gravity of AC	**1.038**	Asphalt Content	5.10

Ndes
60

SPECIMEN 1				
Number of	Sample Weight =	4821.6	grams	
Gyrations	Height	Gmb(calc)	%Gmm (calc)	%Gmm(corr)
Ndes	**116.6**	2.340	94.9	95.9
Nmax	**115.5**	2.362	95.8	96.8
Gmb(meas)	2.387	%Gmm(meas	96.8	

Gmm = 2.466

Ave % Gmm (corr)		VMA @
Ndes	95.72	Ndes

SPECIMEN 2				
Number of	Sample Weight =	4819.9	grams	
Gyrations	Height	Gmb(calc)	%Gmm (calc)	%Gmm(corr)
Ndes	**116.7**	2.337	94.8	95.6
Nmax	**115.5**	2.361	95.8	96.5
Gmb(meas)	2.381	%Gmm(meas	96.5	

Avg.BSG@Ndes= 2.361

Bulk Specific Gravity

	Specimen #1	Specimen #2
Dry Weight	**4821.6**	**4819.9**
SSD Weight	**4824.4**	**4821.7**
Wet Wt.:	**2804.6**	**2797.4**
Bulk Gravity	2.387	2.381

VMA 0.00
AV 4.28

Gyratory Laboratory Worksheet

Section	424	Point No.	1
Producer	COMPANY NAME	Project No.	Project number
Plant		County	County

Effective Specific Gravity of Agg.	2.663	Mixing Temp.	320
Bulk Specific Gravity of Agg.	2.631	Compaction Temp.	300
Specific Gravity of AC	1.038	Asphalt Content	4.00

Ndes
60

SPECIMEN 1				
Number of	Sample Weight =	4748.5	grams	
Gyrations	Height	Gmb(calc)	%Gmm (calc	%Gmm(corr)
Ndes	**118**	2.277	90.86	92.48
Gmb(meas)	2.318	%Gmm(mea	92.48	

SPECIMEN 2				
Number of	Sample Weight =	4735.2	grams	
Gyrations	Height	Gmb(calc)	%Gmm (calc	%Gmm(corr)
Ndes	**117.5**	2.280	90.99	92.75
Gmb(meas)	2.325	%Gmm(mea	92.75	

Gmm = 2.506

Ave % Gmm (corr)		VMA @
Ndes	92.62	15.3

Comments:

AIR VOIDS		**Bulk Specific Gravity**		
			Specimen #1	Specimen #2
Ndes	7.38	Dry Weight	**4748.5**	**4735.2**
VMA	15.29	SSD Weigh	**4756.9**	**4744.9**
		Wet Wt.:	**2708.2**	**2707.9**
		Bulk Gravity	2.318	2.325

Gyratory Laboratory Worksheet

Section	424	Point No.	2
Producer	COMPANY NAME	Project No.	Project number
Plant		County	County

Effective Specific Gravity of Agg.	2.663	Mixing Temp.	320
Bulk Specific Gravity of Agg.	2.631	Compaction Temp.	300
Specific Gravity of AC	1.038	Asphalt Content	4.50

Ndes
60

SPECIMEN 1				
Number of	Sample Weight =	4759.0	grams	
Gyrations	Height	Gmb(calc)	%Gmm (calc	%Gmm(corr)
Ndes	**117.5**	2.292	92.12	94.04
Gmb(meas)	2.340	%Gmm(mea	94.04	

Gmm = 2.488

Ave % Gmm (corr)		VMA @
Ndes	94.01	15.1

SPECIMEN 2				
Number of	Sample Weight =	4660.7	grams	
Gyrations	Height	Gmb(calc)	%Gmm (calc	%Gmm(corr)
Ndes	**115.2**	2.289	92.02	93.98
Gmb(meas)	2.338	%Gmm(mea	93.98	

Comments:

AIR VOIDS		**Bulk Specific Gravity**		
			Specimen #1	Specimen #2
Ndes	5.99	Dry Weight	**4759.0**	**4660.7**
VMA	15.09	SSD Weigh	**4769.8**	**4670.8**
		Wet Wt.:	**2735.8**	**2677.4**
		Bulk Gravity	2.340	2.338

Gyratory Laboratory Worksheet

Section	424	Point No.	3
Producer	COMPANY NAME	Project No.	Project number
Plant		County	County

Effective Specific Gravity of Agg.	2.663	Mixing Temp.	320
Bulk Specific Gravity of Agg.	2.631	Compaction Temp.	300
Specific Gravity of AC	1.038	Asphalt Content	5.00

Ndes
60

SPECIMEN 1				
Number of	Sample Weight =	4802.7	grams	
Gyrations	Height	Gmb(calc)	%Gmm (calc	%Gmm(corr)
Ndes	**117.6**	2.311	93.57	95.42
Gmb(meas)	2.357	%Gmm(mea	95.42	

Gmm = 2.470

Ave % Gmm (corr)		VMA @
Ndes	95.60	14.7

Comments:

SPECIMEN 2				
Number of	Sample Weight =	4796.4	grams	
Gyrations	Height	Gmb(calc)	%Gmm (calc	%Gmm(corr)
Ndes	**116.9**	2.322	94.01	95.79
Gmb(meas)	2.366	%Gmm(mea	95.79	

AIR VOIDS		**Bulk Specific Gravity**		
			Specimen #1	Specimen #2
Ndes	4.40	Dry Weight	**4802.7**	**4796.4**
VMA	14.73	SSD Weigh	**4807.9**	**4799.7**
		Wet Wt.:	**2770.0**	**2772.3**
		Bulk Gravity	2.357	2.366

Gyratory Laboratory Worksheet

Section	424	Point No.	4
Producer	COMPANY NAME	Project No.	Project number
Plant		County	County

Effective Specific Gravity of Agg.	2.663	Mixing Temp.	320
Bulk Specific Gravity of Agg.	2.631	Compaction Temp.	300
Specific Gravity of AC	1.038	Asphalt Content	5.50

Ndes
60

SPECIMEN 1				
Number of	Sample Weight =	4831.5	grams	
Gyrations	Height	Gmb(calc)	%Gmm (calc	%Gmm(corr)
Ndes	**117.3**	2.331	95.06	96.83
Gmb(meas)	2.374	%Gmm(mea	96.83	

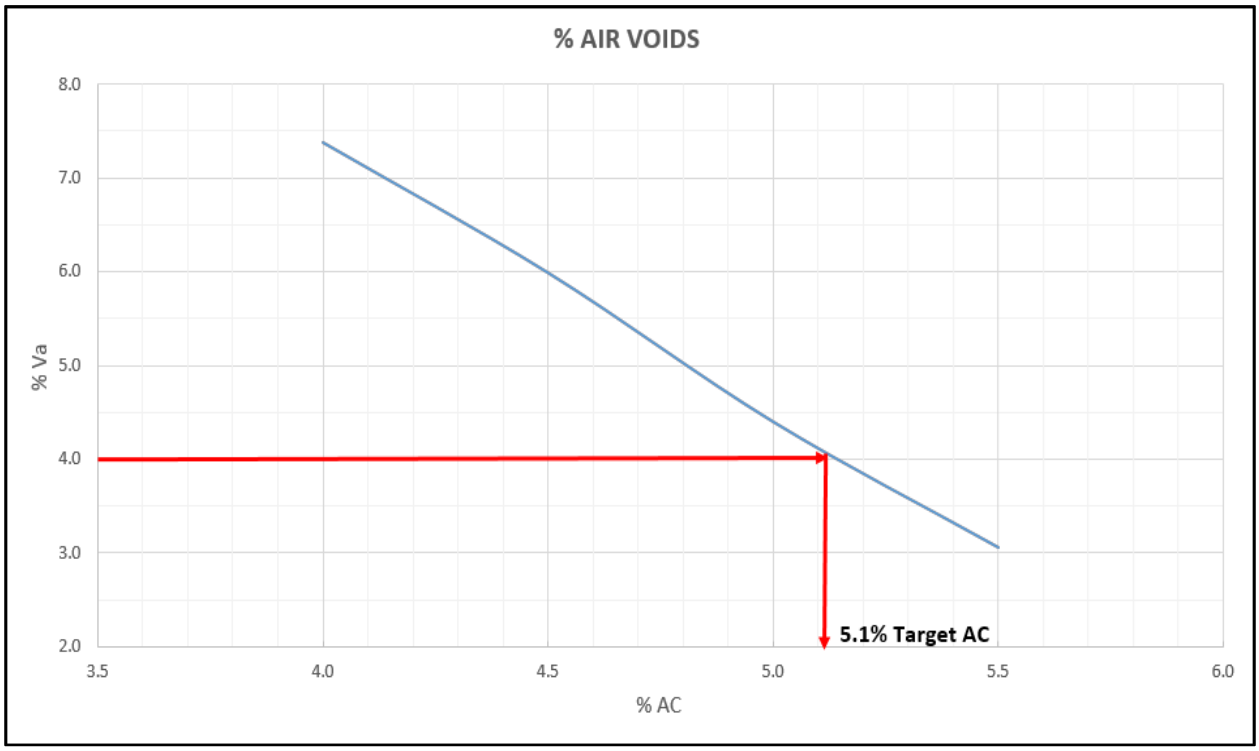
Gmm = 2.452

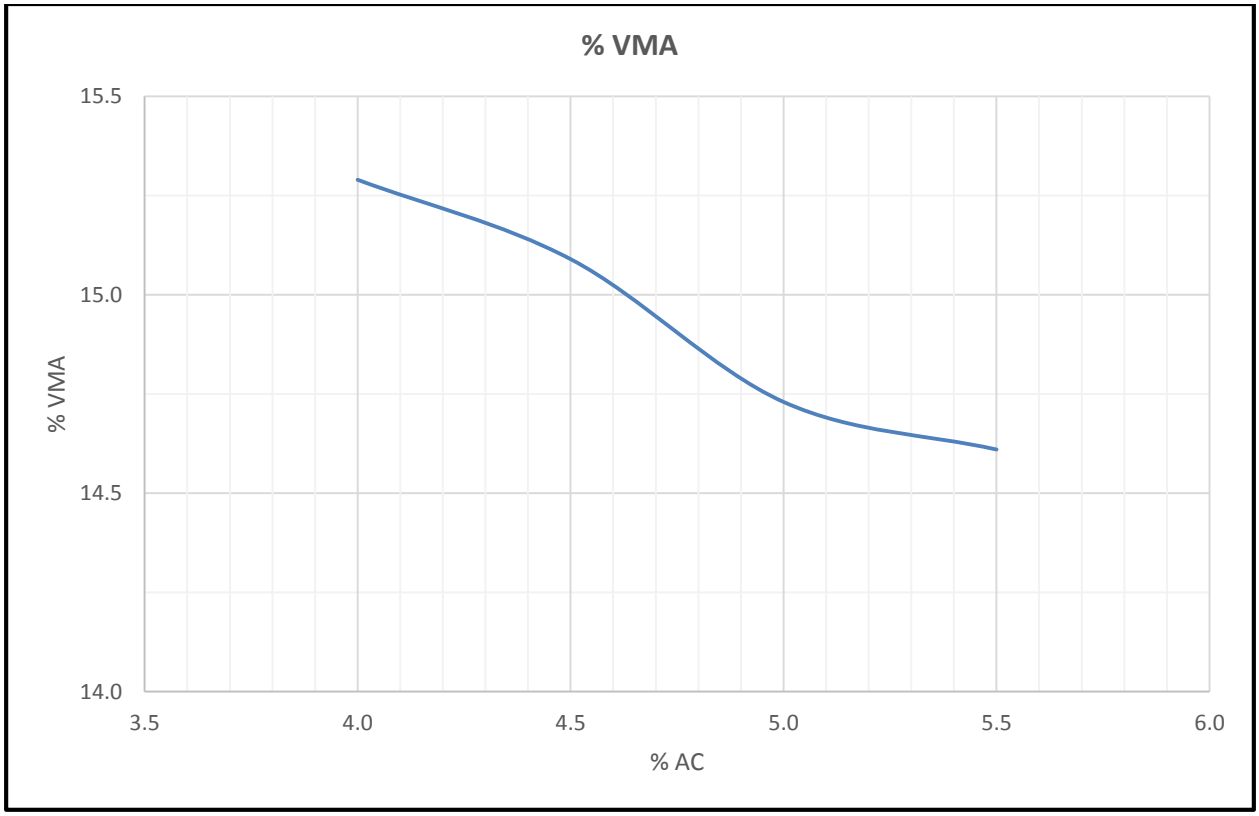
Ave % Gmm (corr)		VMA @
Ndes	96.94	14.6

Comments:

SPECIMEN 2				
Number of	Sample Weight =	4838.6	grams	
Gyrations	Height	Gmb(calc)	%Gmm (calc	%Gmm(corr)
Ndes	**117.4**	2.332	95.12	97.06
Gmb(meas)	2.380	%Gmm(mea	97.06	

AIR VOIDS		**Bulk Specific Gravity**		
			Specimen #1	Specimen #2
Ndes	3.06	Dry Weight	**4831.5**	**4838.6**
VMA	14.61	SSD Weigh	**4833.2**	**4840.5**
		Wet Wt.:	**2798.2**	**2807.4**
		Bulk Gravity	2.374	2.380


% AIR VOIDS
8.0
7.0
6.0
5.0
4.0
3.0
2.0
% Va
3.5
4.0
4.5
5.0
5.5
6.0
% AC
5.1% Target AC


% VMA
15.5
15.0
14.5
14.0
% VMA
3.5
4.0
4.5
5.0
5.5
6.0
% AC

AC BATCH SHEET Wt of Batch **5000**

% RAP	15
%AC IN RAP	6
WT OF RAP ADDED	797.9

					CK PT
% AC	4.00	4.50	5.00	5.50	5.10
AGG WT	5000	5000	5000	5000	5000
WT. OF AC (TOTAL)	208.3	235.6	263.2	291.0	268.7
WT. OF AC (RAP)	47.9	47.9	47.9	47.9	47.9
WT. OF AC ADDED	160.5	187.7	215.3	243.1	220.8
% AC ADDED	3.11	3.62	4.13	4.64	4.23

COMPANY NAME

MIX: 424 3/4" PG 67-22 1.038

GRAVITY DATA AND EFFECTIVE

%AC	**5.00**		**5.50**
MIX DRY:	**2088**		**2092.3**
CAL WT:	**5934.9**		5934.6
F+M+W:	**7177.4**		**7175.5**
SSD WT:	2089.1		2093
RICE W/O DRYBACK:	2.470		2.457
RICE W/ DRYBACK:	2.466		2.455
	AVG:	2.461	
EFFECTIVE GRAV:	2.659		2.667

AVG. EFFECTIVE GRAV: 2.663

DRYBACK

%AC	5.00			%AC	5.50		
Org wt		2088		Org wt		2092.3	
Pan Wt		**717.2**		Pan Wt		**717.2**	
Wt 1	**2878.3**	73.1	DIFFERENCE	Wt 1	**2922.7**	113.2	DIFFERENCE
Wt 2	**2864.1**	58.9	14.2	Wt 2	**2911.8**	102.3	10.9
Wt 3	**2857.6**	52.4	6.5	Wt 3	**2896**	86.5	15.8
Wt 4	**2842.7**	37.5	14.9	Wt 4	**2879.4**	69.9	16.6
Wt 5	**2838.5**	33.3	4.2	Wt 5	**2849.7**	40.2	29.7
Wt 6	**2830.9**	25.7	7.6	Wt 6	**2828.7**	19.2	21.0
Wt 7	**2825.7**	20.5	5.2	Wt 7	**2819.8**	10.3	8.9
Wt 8	**2815.7**	10.5	10.0	Wt 8	**2814.5**	5.0	5.3
Wt 9	**2809.7**	4.5	6.0	Wt 9	**2812**	2.5	2.5
Wt 10	**2806.3**	1.1	3.4	Wt 10	**2810.2**	0.7	1.8
Wt 11				Wt 11			
Wt 12				Wt 12			
Wt 13				Wt 13			
Wt 14				Wt 14			
Wt 15				Wt 15			
Wt 16				Wt 16			
	SSD Wt=	2089.1			SSD Wt=	2093	

COMPANY NAME

FINE AGGREGATE ANGULARITY/GRAVITY WORKSHEET

Proj #: Project number
Date: **1/1/2004**
Mix: 424 3/4"
Tech: **Name**

Fine Aggreate Angularity

	1	2	3
Wt of Cylinder + Agg: (A)	**333.2**	**332.8**	**333.1**
Wt of Cylinder: (B)	**187.6**	187.6	187.6
Wt of Agg: (C)=(A-B)	145.6	145.2	145.5
Avg: (D)=(C1+C2+C3)/3)	145.4		
Vol of Container (ml): (E)	**99.9900**		

Fine Aggreate Gravity

1. Wt of Flask + SSD	**745.7**
2. Wt of Flask	**163.5**
SSD Wt (1 - 2) = (B)	582.2
3. Wt of F + SSD + H2O	**1090.5**
4. Wt of F + H2O	**728.5**
SSD in H2O (3 - 4) = (C)	362.0
5. Wt of Pan + Agg	**1015.0**
6. Wt of Pan	**436.9**
Dry Wt of Agg (5 - 6) = (A)	579.4
Bluk Dry SG = A/(B-C)	2.631

Uncompacted Voids

% VOIDS	**44.72**	**44.72**

TSR WORKSHEET

		PROJ. N0.	Project number
ANALYSIS ON SPLIT TENSILE FOR SECTION:		COUNTY	County
424	3/4"	DATE	**1/1/2004**
PRODUCER:	COMPANY NAME		
SOURCE OF MATERIAL:	SOURCE 1, MONT	#78SS	40%
	SOURCE 2, MONT	#9LS	15%
	SOURCE 3, MONT	#810 LS	0%
	SOURCE 4, MONT	SS Scrn	13%
	SOURCE 5, MONT	SAND	16%
		RAP	15%
	PLANT	BHF	1%
ASPHALT:	HUNT REFINERIES	PG 67-22	5.10%
ANTISTRIP:	DECATUR, AL	ANTI-STRIP	0.25%

TEST RESULTS

		WET		WET		WET
SAMPLE ID	1	2	3	4	5	6
DIAMETER (INCHES)	6	6	6	6	6	6
THICKNESS (INCHES)	3.75	3.75	3.75	3.75	3.75	3.75
DRY WT. IN AIR	**4022.6**	**3853.1**	**3794.3**	**3799.2**	**3793.6**	**3791.2**
SSD WT.	**4024.6**	**3855.8**	**3776.6**	**3782.7**	**3775.1**	**3793.2**
WEIGHT IN WATER	**2321**	**2150.2**	**2168.7**	**2173.1**	**2167.2**	**2166.2**
VOLUME	1703.6	1632.9	1607.9	1609.6	1607.9	1608.3
BULK SP. GR.	2.361	2.360	2.360	2.360	2.359	2.357
MIX SP. GR.	2.539	2.539	2.539	2.539	2.539	2.539
% AIR VOID	7.00	7.06	7.06	7.04	7.08	7.16
VOLUME AIR VOID		115.3		113.3		115.1
65 TARGETED		75.0		73.6		74.8
TARGETED WT.		3928.1		3872.8		3866.0
LOAD POUNDS	**7875**		**7725**		**7800**	

SATURATED 2 MINUTES @ 20 " HG

SSD WEIGHT		**3930.2**		**3875.2**		**3872.4**
VOL. ABS. WATER		77.1		76		81.2
% SATURATION		66.8		67.1		70.5

CONDITIONED 24 HRS. IN 140 F WATER

LOAD, POUNDS		**6625**		**6600**		**6525**
VISUAL STRIPPING		**0.03**		**0.05**		**0.02**
DRY STRENGTH	222.9		218.7		220.8	
WET STRENGTH		187.5		186.8		184.7
AVG. DRY STRENGTH	220.8					
AVG. WET STRENGTH	186.4			TSR	0.84	

SAMPLE DOES MEET THE REQUIREMENT OF THE ALDOT SPECIFICATION FOR TSR