Kentucky Method 64-411-09
Revised 4/1/09
Supersedes KM 64-411-05
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PREPARING INGREDIENT MATERIALS FOR, AND PERFORMING, A LABORATORY MIX DESIGN OF AN ASPHALT MIXTURE

1. SCOPE:

1.1. This method covers the procedure for preparing the ingredient materials for, and performing, a laboratory design of an asphalt mixture. While determining the design aggregate structure for a given design and in the following laboratory mix design analyses [all as described in AASHTO R 30, *Mixture Conditioning of Hot Mix Asphalt (HMA)*; AASHTO R 35, *Superpave Volumetric Design for Hot Mix Asphalt (HMA)*; AASHTO T 312, *Preparing and Determining the Density of Hot Mix Asphalt (HMA) Specimens by Means of the Superpave Gyratory Compactor*; and ASTM D 4867, *Effect of Moisture on Asphalt Concrete Paving Mixtures*], use this method to prepare the aggregate, asphalt binder, and other applicable materials for laboratory testing.

1.2. This method serves as a supplement to AASHTO R 30, AASHTO R 35, AASHTO T 312, and ASTM D 4867, outlining the preparation of the ingredient materials and the noted deviations from the national standard. The national standards apply unless specifically modified herein.

1.3. This method also establishes the procedure for the initial and continuing approval of mix design laboratories.

2. LABORATORY APPROVAL

2.1. Initial approval

2.1.1. The Department will require laboratories with no previous experience on Department projects to be inspected by Division of Materials (Division) personnel or maintain AASHTO accreditation for the appropriate tests prior to accepting laboratory mix designs.

2.1.2. The Department will grant initial approval only after a sufficient number of mix designs have been submitted and verified to establish satisfactory “between-laboratory” comparisons and confidence in the results generated by the laboratory under evaluation.

2.2. Continuing approval

2.2.1. In order to ensure the continued proficiency of laboratory personnel and equipment, annually participate in the Asphalt Mixture Cooperative Testing Program offered by the Division. This program supplies asphalt mixtures to all laboratories that provide

mix designs for Department projects, analyzes the test results, and returns a comparative evaluation. Investigate ratings of "0", "1", or "2" to discover possible adjustments needed in testing procedures or equipment.

3. LABORATORY EQUIPMENT:

3.1. Mixing Apparatus: Perform mixing mechanically or manually. Provide a metal pan or bowl of sufficient capacity for mixing operations. Maintain the mixture at the required mixing temperature; produce a well-coated, homogeneous mixture of the required amount in the allowable time. Ensure essentially all of the batch can be recovered.

3.2. Scales: Provide scales with a capacity of no less than 10 kg, sensitive to 0.1 g, for weighing aggregates and batching mixtures. Ensure the scales satisfy the requirements of AASHTO M 231, *Weighing Devices Used in the Testing of Materials,* for the type of scales required for the material being tested.

3.3. Provide a minimum of two forced-draft ovens, thermostatically controlled, capable of maintaining the desired temperatures within the applicable tolerances.

3.4. Miscellaneous Equipment:

3.4.1. Provide thermometers, dial-type with metal stems, liquid-in-glass, or digital, for determining temperatures of aggregates, asphalt binders, and asphalt mixtures. Ensure all thermometers provide a range from 50 to 400 ^{o}F, with a sensitivity of 5 ^{o}F.

3.4.2. Provide metal or plastic buckets for storing different sizes and types of aggregates.

4. PREPARATION OF MATERIALS:

4.1. Aggregate:

4.1.1. Determine the bulk oven-dry (BOD) specific gravity of each aggregate component according to AASHTO T 85, *Specific Gravity and Absorption of Coarse Aggregate,* or KM 64-605, , *Specific Gravity and Absorption of Fine Aggregate*, as appropriate.

4.1.2 Obtain samples of aggregate from the field in accordance with AASHTO T 2, *Sampling of Aggregates.* Ensure the aggregate samples represent the actual material that will be supplied to the project. The samples may consist of material: (1) retrieved from the stockpiles at a plant-site; (2) that has been ran through a mixing plant in a "dry process;" (3) obtained from the "hot bins" of a mixing plant; or (4) recovered from any other method approved by the Department of Highways.

4.1.3. Reduce the aggregate samples, according to AASHTO T 248, *Reducing Samples of Aggregate to Testing Size,* to sizes specified in AASHTO T 27, *Sieve Analysis of Fine and Coarse Aggregates*.

4.1.4. Wash and grade each aggregate sample according to AASHTO T 11, *Materials Finer Than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing*, and AASHTO T 27.

4.1.5. Blend the aggregate fractions according to AASHTO R 35.

4.1.6. Prepare a minimum of three aggregate trial blends according to AASHTO R 35. Alternatively, use experience with the given materials to select a design aggregate structure without utilizing the trial blend process.

4.1.7. Conduct the aggregate consensus property tests on the trial blends or the selected design aggregate structure according to AASHTO M 323, *Superpave Volumetric Mix Design*.

4.1.8. Use the instructions given in the following subsections of this method in conjunction with AASHTO R 35 and ASTM D 4867, as applicable, to prepare aggregate for: (1) trial blend gradations; (2) trial blend gyratory specimens and accompanying maximum specific gravity (G_{mm}) samples; (3) design aggregate structure gyratory specimens and accompanying G_{mm} samples; (4) moisture susceptibility specimens and accompanying G_{mm} samples; and (5) aggregate consensus property samples.

4.1.8.1. Dry all aggregate in an oven at 221 to 230 ^{o}F. Next, combine each type and size of aggregate according to the desired percentage, by weight of the total combined aggregate, corresponding to the proposed cold-feed or hot-bin percentages determined in Subsection 4.1.6 of this method.

4.1.8.2. Grade the combined aggregate into each particular sieve size. Grade that quantity of aggregate necessary to produce the desired number of mix-design samples and specimens. Separate each sieve size, and place the material in a distinct container, such as a bucket. Immediately label the size of material in each container.

4.1.8.3. Next, "weigh up" a sample of dry aggregate corresponding to the proposed job-mix formula (JMF). The JMF is a single percentage passing each specified sieve size for the given type of mixture. The proposed JMF may be an attempted trial blend or a selected design aggregate structure; use the same process for both. This "weighing up" process involves the determination, and subsequent weighing, of the amount of material necessary from each sieve size to yield the percentage retained on that sieve size, specified by the proposed JMF, as a part of the total "batch size." This "batch size" for volumetric specimens is the total amount of aggregate necessary to achieve a height of 115.0 $\pm$ 5.0 mm at N_{des} and N_{max} gyrations on each compacted specimen after mixing the dry aggregate with the appropriate amount of asphalt binder. In general, use 4600 g of dry aggregate when producing the first test specimen (see Subsection 5.3 of this method) for a given mixture. The "batch size" for moisture-

susceptibility (ASTM D 4867) specimens is the total amount of aggregate necessary to achieve an air-void content of 7.0 ± 1.0 percent after mixing the dry aggregate with the appropriate amount of asphalt binder.

4.1.8.4. Since the concept of "weighing up" is so very complicated to understand from written instructions alone, follow the example below that demonstrates the calculations involved. This example considers a 1.5-in.-nominal Superpave mixture, tested for volumetric properties, "weighed up" to a total "batch size" of 4600 g of dry aggregate. Calculate the weight per sieve by multiplying the percentage retained on that sieve by the batch size as displayed below:

Sieve Size	Percent Passing (Proposed JMF)	Percent Retained	Batch Size (g)	Weight per Sieve (g)	Cumulative Weight (g)
2 in.	100	0	4600	0	0
1 1/2 in.	92	8	4600	368	368
1 in.	72	20	4600	920	1288
No. 4	25	47	4600	2162	3450
No. 8	16	9	4600	414	3864
No. 16	11	5	4600	230	4094
No. 30	8	3	4600	138	4232
No. 50	6	2	4600	92	4324
No. 200	4.0	2.0	4600	92	4416
PAN	0	4.0	4600	184	4600

4.1.8.5. In reference to the sample to be "weighed up" (mentioned in Subsection 4.1.8.3 of this method earlier), "weigh up" a 4600-g quantity of dry aggregate according to the above values. Specifically, place 368 g of material from the bucket that contains the 1 1/2-in.-size aggregate in a container, then place 920 g of material from the 1-in. bucket in the same container, and so on. After completing the entire 4600-g sample, perform a wet-sieve analysis on the entire sample, in accordance with AASHTO T 11 and T 27. Keep in mind that the 4600-g sample under consideration is just an example; apply the same procedure regardless of the type of mixture and "batch size" involved.

4.1.8.6. After performing the wet-sieve analysis on the aforementioned sample, analyze the results to define the dry gradation to be used for "weighing up" the remainder of the mix-design specimens and samples. The goal of this exercise is the determination of the dry gradation that, when subjected to a wet-sieve analysis, will yield a gradation identical to the proposed wet-sieve JMF. Continuing with the values considered previously, the following table displays the results from the wet-sieve analysis performed on the 4600-g sample ("weighed up" to correspond with the proposed JMF):

Sieve Size	Wet-Sieve Gradation	Gradation "Weighed Up"	Difference
2 in.	100	100	0
1 1/2 in.	93	92	+ 1
1 in.	73	72	+ 1
No. 4	25	25	0
No. 8	17	16	+ 1
No. 16	12	11	+ 1
No. 30	9	8	+ 1
No. 50	8	6	+ 2
No. 200	6.0	4.0	+ 2.0

4.1.8.7. Following this process, perform a comparison of the wet-versus-dry gradation values, and estimate an adjustment. The goal of this adjustment is the determination of the particular dry JMF that, when analyzed by wet-sieve procedures, will return a gradation which matches the proposed JMF. Normally, the smaller sieves (e. g., No. 50 and smaller) reveal the greatest change between dry and wet gradations, as the above example displays. Also, these sieves are usually the only ones that require any adjustment in gradation. In fact, unless the difference between the wet- and dry-sieve gradations is dramatic (e. g., more than 3 percent) on the larger sieves (i. e., No. 30 and above), do not make an adjustment on these sieves. Listed below is the trial gradation to use as a first effort in the "trial-and-error" process, based on the differences observed in the wet-versus-dry comparison above:

Sieve Size	Adjusted Dry Gradation
2 in.	100
1 1/2 in.	92
1 in.	72
No. 4	25
No. 8	16
No. 16	11
No. 30	8
No. 50	4
No. 200	2.0

4.1.8.8. As the preceding example exhibits, only adjust the No. 50 and No. 200 sieves. The amount of adjustment on those sieves is equal to the difference between the wet- and dry-sieve analyses displayed in Subsection 4.1.8.6 of this method previously. Presumably, a wet-sieve analysis, performed in accordance with AASHTO T 11 and T 27 on the above gradation presented in Subsection 4.1.8.7 of this method, would yield results that very closely match the proposed

JMF. Accordingly, a check of that agreement is the next step in the process. Perform a wet-sieve analysis on the adjusted gradation displayed above, and hopefully, the result of that analysis will be a gradation identical to the proposed JMF. If such an agreement is the case, having then determined the final "weigh-up" gradation, proceed with the testing process. If, however, the wet-sieve analysis of the adjusted JMF is not in reasonable conformance (i. e., within $\pm$ 1 percent on all sieves) with the proposed gradation, then make another adjustment to the trial dry gradation, and repeat the process. Continue this "fine-tuning" procedure until determining a dry gradation that, when subjected to a wet-sieve analysis, yields results that are reasonably similar to the proposed JMF. Use this gradation to "weigh up" all volumetric and moisture-susceptibility (ASTM D 4867) specimens for the mixture in question. When submitting mix designs to the Division, include both the dry, "weigh-up" gradation and the resulting wet gradation with the mixture submittal.

4.1.8.9. As an option, when desiring to simulate the gradation of the mixture after mixing at the asphalt plant, add some amount of fine material. Typically, this fine aggregate is from the containers holding the "No. 50," "No. 200," and "pan" material. Determine the amount of fine material to add based on experience with the aggregates and asphalt mixing plant involved, but do not vary the "weigh up" gradation by more than 1.0 percent on the No. 50 sieve or by more than 1.5 percent on the No. 200 sieve. When performing this gradation adjustment on mix designs submitted to the Division, include both the adjusted dry, "weigh-up" gradation and the resulting wet gradation with the mixture submittal as required in Subsection 4.1.8.8 of this method.

4.2. Asphalt Binder:

4.2.1. Obtain the sample of asphalt binder to be utilized for further testing from the appropriate asphalt binder shipping terminal, preferably from the very material to be shipped to the project for which the particular mix design is being completed. When the acquisition of a sample of asphalt binder dedicated for the project in question is either impossible or impractical, then at the very least, ensure the asphalt binder to be utilized is relatively fresh and originates from the appropriate shipping terminal.

4.2.2. Minimize the number of times that the asphalt binder is heated from a semi-solid state. If, during the entire process of obtaining a sample of asphalt binder, it is necessary to heat the material more than once before utilizing the asphalt binder for testing, then obtain approval for this deviation from the normally accepted practice from the Engineer.

4.2.3. The mixing and compaction temperatures to observe for each mix-design specimen are a function of the particular asphalt binder and are selected according to the application [i.e., hot mix asphalt (HMA) or warm mix asphalt (WMA)]. See

Subsection 5.2 of this method for these values.

4.2.4. Calculate the grams of asphalt binder required to produce a gyratory specimen or G_{mm} sample by the following formula:

$$Grams\ of\ asphalt\ binder = \frac{(Aggregate\ Batch\ Weight\ in\ g)(Asphalt\ Binder\ Content\ in\ \%)}{100 - Asphalt\ Binder\ Content\ in\ \%}.$$

4.2.5. As an example, determine the grams of asphalt binder required for 4600 g of dry aggregate to produce an asphalt binder content (AC) of 5.0 percent. See the calculation below:

$$Grams\ of\ asphalt\ binder = \frac{(4600)(5.0)}{100 - 5.0} = 242\ g.$$

4.3. Anti-Stripping Additive:

4.3.1. Experience reveals that, for most mixtures, the addition of a normal amount of an anti-stripping additive to a mixture containing an otherwise unmodified asphalt binder will not significantly affect the volumetric properties of that mixture. The Department reserves the right, however, to request the Contractor to furnish additional mixture specimens and/or G_{mm} samples produced at the optimum AC with asphalt binder that contains anti-stripping additive.

5. SPECIMEN PRODUCTION:

5.1. *Required Compaction (number of gyrations)*: In general, consult the mixture's bid item to determine the required number of gyrations for volumetric specimens. The ESAL Class given in the bid item corresponds to the ESAL range given in Subsection 403.03.03 of the *Standard Specifications*. Compact the specimen to N_{des} and N_{max} gyrations as specified in Subsection 403.03.03 of the *Standard Specifications* and AASHTO T 312.

5.2. Mixing and Conditioning/Compaction Temperatures:

5.2.1. Mix and condition/compact specimens at the following temperatures ± 10 °F, depending on the performance grade (PG) of the asphalt binder in the mixture and application (HMA or WMA):

Asphalt Binder	HMA Mixing Temp. (°F)	HMA Conditioning/Compaction Temp. (°F)
PG 64-22	300	265
PG 76-22	330	300

Asphalt Binder	WMA Mixing Temp. (°F)	WMA Conditioning/Compaction Temp. (°F)

PG 64-22	265	245
PG 76-22	290	275

5.2.2. Use these values for laboratory mix designs and volumetric testing of plant-produced mixture. Adjust these temperatures and tolerances for mixing at the plant or compaction at the paving site as necessary, but always conform to the ranges given in Subsection 401 of the Department's *Standard Specifications for Road and Bridge Construction*.

5.3. Initial Batch and Test Specimen for Volumetric Testing:

5.3.1. Before any mixing occurs for the actual volumetric analysis, produce an initial batch for the purpose of "buttering" the mixture bowl and related mixing equipment. Empty this batch after mixing, and clean the sides of the bowl and stirrers of mixture residue by scraping with a small limber spatula, but do not wipe the apparatus with a cloth or wash it clean with solvent, except when making a change in the asphalt binder or at the end of a run.

5.3.2. After completing the initial batch and cleaning the mixing equipment of residue, produce a test specimen. Using the "weigh-up" gradation determined in Subsection 4.1.8.8 or 4.1.8.9 of this method, weigh the amount of each size fraction required to produce a batch that will result in a compacted specimen 115.0 $\pm$ 5.0 mm in height (approximately 4600 g) at N_{des} and N_{max} gyrations. Estimate the AC at which this test specimen is mixed as a value typical of optimum AC values for such an aggregate source and gradation. See Subsection 4.2.4 of this method for instructions to calculate the appropriate amount of asphalt binder to mix with the aggregate.

5.3.3. Heat, mix, condition, and compact the material according to AASHTO R 30, R 35, Subsection 403.03.03 of the *Standard Specifications*, and AASHTO T 312. Use separate ovens to heat the materials to be mixed and condition the mixture at the appropriate temperatures. Determine the height of the completed test specimen from the gyratory compactor.

5.3.4. Determine the corrected aggregate weight according to the following equation:

$$Corrected\ Aggregate Weight = \frac{115.0\,(Estimated\ Aggregate Weight\ in\ g)}{Height\ of\ Specimen\ in\ mm}$$

NOTE 1: When considering compacted mixture specimens, use the formula above to correct the height of a specimen by replacing "Corrected Aggregate Weight" with "Corrected Specimen Weight," and "Estimated Aggregate Weight" with "Actual Specimen Weight." Remember to adjust the asphalt binder weight to correlate with the new aggregate weight. Use this corrected weight as the value to which to weigh the remainder of the volumetric specimens during a given analysis.

5.4. Heating of Materials and Equipment and Mixing of Volumetric Specimens:

5.4.1. After "weighing-up" the dry aggregate for each specimen, using the gradation determined in Subsection 4.1.8.8 or 4.1.8.9 of this method and the weight determined in Subsection 5.3.4 of this method, place the dry aggregate blend on a hot plate or in the oven. Heat the aggregate to a temperature not exceeding the mixing temperature from Subsection 5.2 of this method by more than 50 ^{o}F. Also, heat the asphalt binder to a temperature such that the specimen can be mixed at the mixing temperature required in Subsection 5.2 of this method. Next, clean the specimen mold assembly, and heat it to the applicable compaction temperature.

5.4.2. Charge the mixing bowl with the heated aggregate. Form a crater in the dry blended aggregate, and weigh the preheated required amount of asphalt binder, as well as any solid additives, into the mixing bowl. Exercise care to prevent loss of the mix during mixing and subsequent handling. At this point, ensure the temperature of the aggregate and asphalt binder, as well as any solid additives, is within the limits of the mixing temperature from Subsection 5.2 of this method. Mix these materials rapidly until thoroughly coated.

5.4.3. Complete the heating, mixing, conditioning, and compacting process according to AASHTO R 30, R 35, Subsection 403.03.03 of the *Standard Specifications*, AASHTO T 312, and the applicable portions of this method for all gyratory specimens and accompanying G_{mm} samples. Use separate ovens to heat the materials to be mixed and condition the mixture at the appropriate temperatures. Contrary to AASHTO R 35, produce three G_{mm} samples at the midpoint of the AC range chosen for the volumetric portion of the overall analysis. After testing these G_{mm} samples, average the values, and calculate the effective specific gravity of the aggregate (G_{se}) from the average according to Kentucky Method (KM) 64-438, *Asphalt Binder Content Determination of Asphalt Mixtures Based on the Maximum Specific Gravity*. Using the G_{se} value, "back-calculate" the G_{mm} values for the particular AC values at which the design was performed as described in KM 64-438.

5.5. Heating of Materials and Equipment and Mixing of Moisture-Susceptibility (ASTM D 4867) Specimens:

5.5.1. Conform to the same procedure as given in Subsection 5.4 of this method, except use an aggregate weight that will produce an air-void content of 7.0 $\pm$ 1.0 percent after mixing the dry aggregate with the appropriate amount of asphalt binder.

5.5.2. Complete the heating, mixing, conditioning, and compacting process according to AASHTO R 30, R 35, Subsection 403.03.03 of the *Standard Specifications*, AASHTO T 312, ASTM D 4867, and the applicable portions of this method for all moisture-susceptibility specimens and accompanying G_{mm} samples. Use separate ovens to heat the materials to be mixed and condition the mixture at the appropriate temperatures.

APPROVED _____

DIRECTOR
DIVISION OF MATERIALS

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