Test Procedure for

DESIGN OF BITUMINOUS MIXTURES

TxDOT Designation: Tex-204-F

Effective Date: August 2016

1. SCOPE

1.1 Use the methods in this procedure to determine the proper proportions of approved aggregates, mineral filler, asphalt binder, additives, and recycled materials that, when combined, will produce a mixture that satisfies the specification requirements.

1.1.1 Refer to Part I for the mixture design method of Dense-Graded mixtures. See the example in Part I for a typical mixture design by weight. See Part II for a typical dense-graded design example by volume.

1.1.2 Refer to Part IV for the mixture design method of Superpave mixtures.

1.1.3 Refer to Part V for the mixture design method of Permeable Friction Course (PFC) mixtures.

1.1.4 Refer to Part VI for the mixture design method of Stone Matrix Asphalt (SMA) mixtures.

1.1.5 Refer to Part VIII for the mixture design method of Thin Bonded Wearing Course mixtures.

1.2 Refer to Table 1 for Superpave and conventional mix nomenclature equivalents. Replace conventional nomenclature with Superpave nomenclature when required.

Table 1—Nomenclatures and Definitions

Nomenclatures		**Definitions**
Conventional	**Superpave**	
G_a	G_{mb}	Bulk specific gravity of the compacted mixture
G_t	$G_{max\text{-}theo}$	Calculated theoretical maximum specific gravity of the mixture at the specified asphalt content
A_s	P_b	% by weight of asphalt binder in the mixture
A_g	P_s	% by weight of the aggregate in the mixture
G_e	G_{se}	Effective specific gravity of the combined aggregates
G_s	G_b	Specific gravity of the asphalt binder determined at 77°F (25°C)
G_r	G_{mm}	Theoretical maximum specific gravity

Nomenclatures		**Definitions**
Conventional	**Superpave**	
G_{rc}	G_{mm}	Theoretical maximum specific gravity corrected for water absorption during test
SA	SA	Surface area in m^2/kg of combined aggregate gradation
FT	FT	Film thickness in microns of asphalt binder in mixture
% Density	% G_{mm}	Percentage of the ratio of the G_a to the G_t of the mixture
-	% Air Voids	% of air voids in the compacted mix
VMA	VMA	Voids in mineral aggregates
% Total CL_A	-	Total percentage retained of Class A aggregate on the 4.75 mm (#4) sieve
% CL_A	-	% retained of Class A aggregate on the 4.75 mm (#4) sieve
% CL_B	-	% retained of Class B aggregate on the 4.75 mm (#4) sieve
VCA_{CA}	-	Voids in coarse aggregate (coarse aggregate fraction only)
G_{CA}	-	Bulk specific gravity of the coarse aggregate blend (retained on the 2.36 mm (#8) sieve)
γ_s	-	Unit weight of the coarse aggregate blend fraction in the dry-rodded condition
γ_w	-	Unit weight of water 1000 kg/m^3 (62.4 pcf)
P_{CA}	-	% coarse aggregate in the total mix
VCA_{CA}	-	Voids in the coarse aggregate in the dry-rodded condition
VCA_{Mix}	-	Voids in coarse aggregate for the compacted mixture

1.3 The values given in parentheses (if provided) are not standard and may not be exact mathematical conversions. Use each system of units separately. Combining values from the two systems may result in nonconformance with the standard.

2. REPORT FORMAT

2.1 HMACP Mixture Design: Combined Gradation (2014) is an automated template containing the following worksheets:

- Instructions
- Combined Gradation
- Material Properties (Matl Properties)
- Aggregate Classification
- Weigh Up Sheet (Weigh Up)
- Weigh Up Sheet for Blank Samples (Blank Weigh Up)
- Bulk Gravity

- Film Thickness
- Summary Sheet (Summary)
- Grad Chart.

Note 1—The title in parentheses is the abbreviated title given on the tabs of the workbook.

2.2 Use the Sieve Analysis of Non-Surface Treatment Aggregates template to calculate the washed sieve analysis.

3. APPARATUS

Note 2—Each part of this test method incorporates the use of other test procedures. Each referenced procedure has its own list of apparatus in addition to those listed here.

3.1 *Drying oven*, capable of attaining the temperatures specified in the procedure.

3.2 *Balance*, Class G2 in accordance with Tex-901-K.

PART I—MIX DESIGN FOR DENSE-GRADED HOT-MIX ASPHALT MIXTURES BY WEIGHT

4. SCOPE

4.1 Use this method to determine the proper proportions by weight of approved materials to produce a dense-graded mixture that will satisfy the specification requirements. This mix design procedure incorporates the use of the Texas gyratory compactor (TGC) and the Superpave gyratory compactor (SGC).

4.2 Use this method to determine the proper proportions by weight of approved materials to produce Thin Overlay Mixtures (TOM) that will satisfy the specification requirements. This mix design procedure incorporates the use of the TGC and the SGC.

5. PROCEDURE

5.1 *Selecting Aggregates:*

5.1.1 Select the aggregate per specification requirements.

Note 3—Use the Hot Mix Asphalt Concrete (HMAC) Rated Source Soundness Magnesium (RSSM) listed in the Bituminous Rated Source Quality Catalog (BRSQC) for approved stockpile sources from the Aggregate Quality Monitoring Program (AQMP) to determine compliance with soundness specifications.

Note 4—Enter any available aggregate testing results in the Material Properties worksheet and ensure all aggregate quality requirements are met.

5.1.2 Obtain representative samples consisting of a minimum of 50 lb. of each aggregate in accordance with Tex-221-F.

5.1.3 Dry the aggregate to constant weight at a temperature between 100 and 375°F (38 and 191°C).

5.1.4 When the aggregate stockpile gradation is unknown, obtain the average washed gradation of each proposed aggregate stockpile in accordance with Tex-200-F, Part II. Enter the stockpile gradations on the Combined Gradation worksheet.

Note 5—Use the construction stockpile washed gradation when it is available.

5.1.5 If the specific gravity values for the aggregate sources are known, enter these results on the Bulk Gravity worksheet. Test lightweight aggregate, when applicable, in accordance with Tex-433-A.

Note 6—If the specific gravity values are unknown and deemed necessary, determine the 24-hr. water absorption, the bulk specific gravity, and the apparent specific gravity of individual sizes of each aggregate in accordance with Tex-201-F and Tex-202-F.

Note 7—Proceed to Part II of this test procedure if the aggregate stockpile bulk specific gravities vary by 0.300 or more.

Note 8—Do not determine the specific gravity for aggregate size fractions consisting of less than 15% of the individual aggregate. Assign the water absorption and specific gravity of smaller aggregate size fractions close to the next adjacent size fractions for which values were determined.

5.2 *Selecting Asphalt Binder, Mineral Filler, and Additives:*

5.2.1 Select the asphalt binder per specification requirements.

5.2.2 When applicable, select mineral filler and additives per specification requirements.

5.2.3 Obtain a representative sample of the asphalt binder, mineral filler, and additives. Take asphalt samples in accordance with Tex-500-C. Ensure that you collect enough material for Section 5.2.4.

5.2.4 Confirm the asphalt binder, mineral filler, and additives meet applicable specifications.

Note 9—When using warm mix asphalt (WMA) additives in the mixture design, verify that the additive appears on the Department's Material Producer List (MPL).

5.3 *Selecting Recycled Materials (when applicable):*

5.3.1 Select reclaimed asphalt pavement (RAP) and recycled asphalt shingles (RAS) per specification requirements.

Note 10—Use RAS from shingle sources listed on the Department's MPL.

5.3.2 Obtain representative samples of recycled materials consisting of a minimum of 50 lb. of each material in accordance with Tex-221-F.

5.3.3 Dry RAS per manufacturer's recommendations.

5.3.4 Dry RAP to constant weight at a maximum temperature of 140°F (60°C).

5.3.5 When the recycled material gradation is unknown, extract the asphalt from RAP and RAS samples in accordance with Tex-236-F. Obtain the washed gradation of the burned sample in accordance with Tex-200-F, Part II. Enter the gradations on the Combined Gradation worksheet.

Note 11—Use the recycled material stockpile gradation when it is available.

Note 12—Do not determine the specific gravity for recycled materials.

5.3.6 Determine the asphalt content of the RAP and RAS materials from the average of a minimum of 4 samples (recycled material only) in accordance with Tex-236-F.

5.4 *Selecting the Combined Gradation:*

5.4.1 Enter the anticipated optimum asphalt content (OAC) in the Combined Gradation worksheet based on the mixture type and proposed materials.

5.4.2 Use the Combined Gradation worksheet to calculate the bin percentages with the proposed materials so that the blended combination will fall within the required gradation limits for the specified mixture type. Consider material availability, mixture strength, handling, compaction, pavement texture, and durability as the primary factors for the bin percentages. Follow these instructions when applicable.

- Enter mineral filler or hydrated lime as an aggregate bin. The combined gradation should include the mineral filler and hydrated lime.
  - When using binder substitution, do not use more than 1% hydrated lime unless otherwise shown on the plans or allowed by the Engineer.
  - Enter RAP and RAS gradation and asphalt content in the “Recycled Materials” bin section. Enter their bin percentages by total mixture. (The worksheet calculates the bin percentages by total aggregate.)
  - Do not exceed the maximum percentage of recycled materials allowable per the specification.

5.4.3 When applicable, the worksheet calculates the ratio of the recycled asphalt binder to total binder. Adjust the recycled material and aggregate bins when the ratio exceeds the specification.

Note 13—After making adjustments to the bin percentages, ensure that the total bin is 100.0%.

5.4.4 Test the combined virgin aggregate in accordance with Tex-203-F. Perform the test on the combined aggregates not including lime. Enter these results on the Material Properties worksheet.

5.4.5 Evaluate the aggregate classification of the combined aggregate blend using the Aggregate Classification worksheet when blending Class A with Class B aggregate. Determine whether the percentage of the Class A aggregate in the combined aggregate blend meets the specification or general note requirement.

Note 14—Consider the coarse aggregate from RAP and RAS as Class B aggregate.

5.5 *Preparing Laboratory-Mixed Samples:*

5.5.1 Separate the material larger than the No. 8 sieve into individual sieve sizes for each stockpile as required by the specification.

Note 15—Do not separate RAP or RAS larger than the No. 8 sieve into individual sieve sizes if the gradations are uniformly graded.

5.5.2 Separate the material passing the No. 8 sieve from each stockpile only when high gradation accuracy is needed.

5.5.2.1 Do not separate the material passing the No. 8 sieve from each stockpile if it meets the following conditions.

- The RAP, RAS, and aggregate passing the No. 8 sieve stockpile gradations are uniformly graded.
- The gradation of the material passing the No. 8 sieve is not prone to segregation.

5.5.3 Calculate the weights of the individual aggregates required to produce batches of mix for a minimum of 5 different asphalt contents using the Weigh Up worksheet.

Note 16—When using recycled materials and changing the asphalt content in the Combined Gradation worksheet, adjust a virgin aggregate bin percentage to ensure that the total bin is 100.0%.

Note 17—Batches of mix for a minimum of 3 different asphalt contents may be produced when using materials from a previous mix design.

Note 18—For designs with the TGC, a batch size of 5000 g is adequate to produce 3 laboratory-molded specimens and 1 sample for the Theoretical Maximum Rice Specific Gravity (G_r) when using a large mechanical mixer. If hand mixing, the batch size must be the amount needed for 1 molded specimen or 1 G_r sample.

Note 19—For designs with the SGC, a batch size of 11,500 g is adequate to produce 2 laboratory-molded specimens and 1 sample for the Theoretical Maximum Rice Specific Gravity (G_r) when using a large mechanical mixer. If using a small mechanical mixer, the batch size must be the amount needed for 1 molded specimen or 1 G_r sample.

5.5.4 Vary the asphalt contents in 0.5% increments around the anticipated optimum asphalt content (OAC). Enter the asphalt percentages in the asphalt content column of the Summary worksheet.

5.5.5 Produce a trial sample mixture in the laboratory to verify the height of a compacted specimen. Select the asphalt content closest to the expected OAC using previous mix design experience. Add any recycled materials and additives, such as RAP, RAS, or lime, before mixing the final bituminous mixture. Pre-blend asphalt additives such as liquid anti-stripping or WMA additives into the asphalt binder before laboratory mixing, similar to additive addition at the mixing plant.

5.5.6 Prepare a laboratory mix in accordance with Tex-205-F.

5.5.7 When using the TGC, mold 3 specimens in accordance with Tex-206-F.

Note 20—Use 1000 g of material per molded specimen for this trial mixture.

5.5.7.1 Determine the amount of material necessary to obtain a standard specimen height of 51 ± 1.5 mm (2 ± 0.06 in.) Use the height adjustment formula in Tex-206-F, Part I, to determine the amount of material needed at this asphalt content.

5.5.8 When using the SGC, mold 2 specimens at the design number of gyrations (N_{design}) in accordance with Tex-241-F. Determine the N_{design} as shown on the plans or specification.

Note 21—Use 4500–4700 g of material per molded specimen for this trial mixture. Do not scalp out material larger than the 19.0-mm (3/4-in.) sieve size.

5.5.8.1 Determine the amount of material necessary to obtain a standard specimen height of 115 ± 5 mm (4.5 ± 0.2 in.)

5.5.9 Approximate the total weights for the compacted specimens containing other percentages of asphalt. Use the corrected weight of the trial specimen as a base value.

Note 22—When using the TGC, increasing the asphalt content by 0.5% increases the weight of the mix for molding the specimen by approximately 2.5 g. Decreasing the asphalt content by 0.5% decreases the weight of the mix for molding the specimen by approximately 2.5 g.

Note 23—When using the SGC, increasing the asphalt content by 0.5% increases the weight of the mix for molding the specimen by approximately 10 g. Decreasing the asphalt content by 0.5% decreases the weight of the mix for molding the specimen by 10 g.

5.5.10 Determine the G_r in accordance with Tex-227-F for the mixture produced at each asphalt content. Of these 3 mixtures, 2 should have asphalt contents above the optimum, and 1 mixture should have asphalt content below the optimum. Treat the mix used to perform this test the same as the mix used for molding. For mixtures designed on the TGC, remove the aggregate retained on the 19.0-mm (3/4-in.) sieve from the G_r sample before molding. Oven-cure the mixtures at the selected compaction temperature for 2 hr. Enter the G_r in the Summary worksheet.

5.5.11 Determine the G_a of the molded specimens in accordance with Tex-207-F. Enter the average G_a for each asphalt content in the Summary worksheet.

5.5.12 Use the Mix Design template to calculate the following:

- the average G_e of the blend, in accordance with Section 19.2,
- the G_t for each asphalt content in accordance with Section 19.3, and
- the percent density of the molded specimens for each asphalt content, in accordance with Section 19.4.

5.6 *Determining the OAC:*

5.6.1 Use the Mix Design template to plot the following.

- Densities versus asphalt content for the molded specimens—determine the OAC by interpolating between the asphalt contents above and below the target laboratory-molded density on the Summary worksheet.

- Asphalt content versus VMA, G_a, and G_r—determine the VMA, G_a, and G_r at the OAC.

5.6.2 If the density or VMA is not within the allowable range, redesign by assuming another combination of aggregates or obtaining different materials.

5.7 *Evaluating the Mixture at the OAC:*

5.7.1 When required by the specification, determine the indirect tensile strength in accordance with Tex-226-F.

5.7.2 Determine the rut depth and number of passes in accordance with Tex-242-F.

5.7.3 When required by the specification or requested by the Engineer, determine the number of cycles to failure in accordance with Tex-248-F and percent loss in accordance with Tex-245-F.

5.7.4 If the indirect tensile strength from Section 5.7.1 or the number of passes from Section 5.7.2 is not within specifications, redesign by adding an anti-stripping agent, adjusting the N_{design}, assuming another combination of aggregates, obtaining different materials, or using a different PG grade.

Note 24—The Engineer must approve any changes made to the N_{design} that results in a value different from what is shown on the plans or is allowed in the specification.

5.7.5 Report all data in the Mix Design Template.

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6. MIX DESIGN EXAMPLE BY WEIGHT

6.1 The following example describes the process necessary to develop proper mixtures using approved materials for a given application or surface requirement where material weight is the primary consideration.

6.2 Use the following processed materials to design a dense-graded hot-mix asphalt mix by weight:

- aggregate A—a limestone dolomite Type D rock with a surface aggregate classification of class A;
- aggregate B—a limestone dolomite Type F rock with a surface aggregate classification of class B;
- limestone dolomite manufactured sand;
- hydrated lime;
- fractionated RAP;
- recycled asphalt shingles (RAS);
- warm mix additive treated as WMA;
- specified binder: PG 70-22; and
- substitute binder: PG 64-22.

6.2.1 Combine the six bins and asphalt in proportions that meet the requirements for a Type D hot-mix asphalt mixture under the applicable specification.

6.3 *Selecting Materials:*

6.3.1 Verify that all the materials comply with the project specifications.

6.3.2 Obtain the average washed sieve analysis of each of the proposed materials as shown in Figure 1 using the Sieve Analysis of Non-Surface Treatment Aggregates template. The example shown in Figure 1 shows the gradation of the crushed limestone dolomite aggregate used in this sample mix design.

6.3.3 Consider all factors relating to the production of the available materials and desired mixture properties. Assume that the best combination of the aggregates for this mix design example will consist of 23% by weight of aggregate A, 35.4% by weight of aggregate B, 34% by weight of manufactured sand, 1% by weight of hydrated lime, 5.5% by total weight of mix of fractionated RAP, and 1.2% by weight of total mix of RAS.

6.3.4 Use the Combined Gradation worksheet to calculate the combined blend gradation in percent passing of each sieve size. Figure 2 shows an example of a completed worksheet. Use the bin percentages selected in Section 6.3.3. This worksheet also shows the individual and cumulative percent retained of the combined blend.

6.3.5 Use the Aggregate Classification worksheet to check the proposed bin percentages for compliance when blending Class A and B aggregates. At least 50% by weight of material retained on the 4.75 mm (No. 4) sieve from the Class A aggregate source is required, as shown in Figure 4.

6.4 *Preparing Laboratory-Mixed Samples:*

6.4.1 Calculate individual or cumulative aggregate weights with an asphalt weight. Figure 5 is an example weigh-up worksheet that shows the aggregate and asphalt weights for a 5000-g sample at 6% asphalt. A mixture size of 5000 g is adequate to produce 3 molds and 1 sample for G_r, when using a large mechanical mixer. If hand mixing, the mixture size must be the amount needed for one molded specimen or one G_r.

6.4.2 The asphalt contents for these test mixes are 4.0, 5.0, 6.0, 7.0, and 8.0% by weight for this mix design example. Therefore, the corresponding percentages by weight of the aggregate in the mixtures will be 96.0, 95.0, 94.0, 93.0, and 92.0%. For this example, the total aggregate weight for a 5000-g batch at 6.0% asphalt will be 4700 g, and the weight of the asphalt will be 300 g.

6.4.3 Mix one batch using weights calculated in Section 6.4.1 in accordance with Tex-205-F. Use previous mix design experience or select the mixture at the midpoint of the design asphalt contents, which is 6.0% for this example.

Note 25—Select the batch expected to be closest to the OAC.

6.4.4 Determine the weight of mixture required to produce a specimen height of 51 ± 1.5 mm (2 ± 0.06 in.) by molding 3 samples of 1000 g each in accordance with Tex-206-F. Measure the height of the specimen. Divide 51 mm (2 in.) by the molded height and multiply by 1000 g to give the corrected weight to produce one 51-mm (2-in.) specimen. Refer to the height adjustment formula in Tex-206-F.

6.4.5 Subtract 5 g from the weight at each asphalt content above the trial specimen. Add 5 g to the weight at each asphalt content below the trial specimen. For this example, a 1000-g sample with 6.0% asphalt produced a molded specimen with a height of 53.8 mm (2.12 in.) Therefore, the amount of mixture required to produce a 51-mm (2-in.) molded specimen would be (51 mm/53.8 mm) × 1000 g or (2 in./2.11 in.) × 1000 g = 948 g. The mix weights for molding specimens with the different asphalt contents for this example are:

- asphalt content 4% = 938 g
- asphalt content 5% = 943 g
- asphalt content 6% = 948 g
- asphalt content 7% = 953 g
- asphalt content 8% = 958 g.

6.4.6 Weigh the materials for each of the batches containing 4.0, 5.0, 6.0, 7.0, and 8.0% asphalt content. Mix and mold the test specimens in accordance with Tex-205-F and Tex-206-F.

6.4.7 Determine the G_r of the mixtures at 5.0, 6.0, and 7.0% asphalt content in accordance with Tex-227-F. Treat the mix used to perform this test the same as the samples for molding. Remove aggregates retained on the 19.0-mm (3/4-in.) sieve from the G_r sample. Cure the G_r sample at the compaction temperature specified for the PG binder (PG 70-22 for this example) for 2 hr. in a manner similar to curing the hot-mix asphalt before molding. Enter G_r values in the worksheet as shown in Figure 6.

6.4.8 Determine the G_a of each of the molded specimens in accordance with Tex-207-F. Calculate the average of the 3 molds and enter the result in the Summary worksheet.

6.4.9 Use the Mix Design template to calculate the following, as shown in Figure 6:

- G_e for the blend at each of the 3 asphalt contents tested for G_r,
- the G_t,
- the percent density of the molded specimens, and
- the VMA of the molded specimens.

6.5 *Determining the OAC:*

6.5.1 Use Figure 6 to determine which asphalt content meets the target density. In this example, the OAC is 6.0%.

6.6 *Evaluating the Mixture at the OAC:*

6.6.1 Determine the indirect tensile strength of 4 specimens molded at the OAC to 93 ± 1% density in accordance with Tex-226-F. Enter the average strength as shown in Figure 6.

6.6.2 Determine the rut depth and number of passes on 2 specimens molded at the OAC to 93 ± 1% density in accordance with Tex-242-F. Enter the results as shown in Figure 6.

SIEVE ANALYSIS OF NON-SURFACE TREATMENT AGGREGATES
Tex-200-F

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SAMPLE ID:		SAMPLED DATE:	
TEST NUMBER:		LETTING DATE:	
SAMPLE STATUS:		CONTROLLING CSJ:	
COUNTY:		SPEC YEAR:	2014
SAMPLED BY:		SPEC ITEM:	
SAMPLE LOCATION:		SPECIAL PROVISION:	
MATERIAL CODE:		GRADE:	D-Rock Limestone Dolom
MATERIAL NAME:			
PRODUCER:			
AREA ENGINEER:		PROJECT MANAGER:	

COURSE\LIFT:		STATION:		DIST. FROM CL:	

SIEVE ANALYSIS
Tex-200-F: Part I

Original Dry Weight, (g):	2,000.0
Dry Weight After Washing, (g):	1,975.0

Sieve Size	Individual Weight Retained, (g)	Cumulative Weight Retained, (g)	Cumulative Percent Retained, (%)	Cumulative Percent Passing, (%)	Limits as Percent: Lower Limit of Grading (%)	Upper Limit of Grading (%)	Within Grading Limits
3/4"	0.0	0.0	0.0	100.0			
1/2"	20.0	20.0	1.0	99.0			
3/8"	572.0	592.0	29.6	70.4			
No. 4	1,345.0	1,937.0	96.9	3.1			
No. 8	30.0	1,967.0	98.4	1.6			
No. 16	3.0	1,970.0	98.5	1.5			
No. 30	0.0	1,970.0	98.5	1.5			
No. 50	0.0	1,970.0	98.5	1.5			
No. 200	0.0	1,970.0	98.5	1.5			
-No. 200	5.0						
	0.0	Sieving Loss, (g) from 'Dry Weight After Washing' weight					
	25.0	Washing Loss, (g)					
Total -No. 200	30.0	2,000.0	100.0				
Total Weight:	2,000.0						

Figure 1—Sieve Analysis of Fine and Coarse Aggregates

HMACP MIXTURE DESIGN : COMBINED GRADATION

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SAMPLE ID:		SAMPLE DATE:	
LOT NUMBER:		LETTING DATE:	
SAMPLE STATUS:		CONTROLLING CSJ:	
COUNTY:		SPEC YEAR:	2014
SAMPLED BY:		SPEC ITEM:	
SAMPLE LOCATION:		SPECIAL PROVISION:	
MATERIAL CODE:		MIX TYPE:	344-SP-D
MATERIAL NAME:			
PRODUCER:			
AREA ENGINEER:		PROJECT MANAGER:	

COURSE\LIFT:	Surface	STATION:		DIST. FROM CL:	

WMA Additive in Design?	Yes
Target Discharge Temp., °F:	250
WMA TECHNOLOGY:	
WMA RATE: / UNITS:	
CONTRACTOR DESIGN # :	

Maximum Allowable, %	
Frac RAP:	20.0
Unfrac RAF	10.0
RAS:	5.0
RB Ratio:	30.0

Use this value in the QC/QA template>>

Recycled Binder, %	
Bin No. 8 :	0.3
Bin No. 9 :	0.2
Bin No. 10 :	0.0
Total	***0.500***

Ratio of Recycled to Total Binder, % *(based on binder percent (%) entered below in this worksheet)*
8.3

	AGGREGATE BIN FRACTIONS							"RECYCLED MATERIALS"			
Aggregate	Bin No.1	Bin No.2	Bin No.3	Bin No.4	Bin No.5	Bin No.6	Bin No.7	Bin No.8	Bin No.9	Bin No.10	
Source:	nestone_Dolom	nestone_Dolom	nestone_Dolom					Fractionated RAP	RAS		Material Type
Pit:	TxDOT	TxDOT	TxDOT					TxDOT	TxDOT		Material Source
Number:	TxDOT	TxDOT	TxDOT								RAS Type
Producer:	TxDOT	TxDOT	TxDOT					TxDOT	TxDOT		RAP/RAS Producer
Sample ID:	D-Rock	F-Rock	Manufactured Sand								Sample ID

	Bin No.1		Bin No.2		Bin No.3		Bin No.4		Bin No.5		Bin No.6		Bin No.7	
Hydrated Lime?:							Yes							
Individual Bin (%):	23.0	Percent	35.4	Percent	34.0	Percent	1.0	Percent		Percent		Percent		Percent
Sieve Size:	Cum.% Passing	Wtd Cum. %	Cum.% Passing	Wtd Cum. %	Cum.% Passing	Wtd Cum. %	Cum.% Passing	Wtd Cum. %	Cum.% Passing	Wtd Cum. %	Cum.% Passing	Wtd Cum. %	Cum.% Passing	Wtd Cum. %
3/4"	100.0	23.0	100.0	35.4	100.0	34.0	100.0	1.0						
1/2"	99.0	22.8	100.0	35.4	100.0	34.0	100.0	1.0						
3/8"	70.4	16.2	99.9	35.4	100.0	34.0	100.0	1.0						
No. 4	3.1	0.7	75.2	26.6	99.6	33.9	100.0	1.0						
No. 8	1.6	0.4	15.3	5.4	86.6	29.4	100.0	1.0						
No. 16	1.5	0.3	5.2	1.8	55.8	19.0	100.0	1.0						
No. 30	1.5	0.3	2.8	1.0	35.7	12.1	100.0	1.0						
No. 50	1.5	0.3	2.3	0.8	20.8	7.1	100.0	1.0						
No. 200	1.5	0.3	1.9	0.7	7.3	2.5	100.0	1.0						

	Bin No.8		Bin No.9		Bin No.10	
Recycled Asphalt Binder (%)	5.0		20.0			
	5.5	% of Tot. Mix	1.2	% of Tot. Mix		% of Tot. Mix
	5.6	% of Aggreg	1.0	% of Aggreg		% of Aggreg
Sieve Size:	Cum.% Passing	Wtd Cum. %	Cum.% Passing	Wtd Cum. %	Cum.% Passing	Wtd Cum. %
3/4"	100.0	5.6	100.0	1.0		
1/2"	100.0	5.6	100.0	1.0		
3/8"	100.0	5.6	100.0	1.0		
No. 4	98.6	5.5	100.0	1.0		
No. 8	85.5	4.8	100.0	1.0		
No. 16	70.2	3.9	99.8	1.0		
No. 30	51.2	2.9	99.2	1.0		
No. 50	14.5	0.8	97.6	1.0		
No. 200	1.0	0.1	62.8	0.6		

Combined Gradation										
Total Bin 100.0%	Lower & Upper Specification Limits			Restricted Zone			Individual % Retained	Cumulative % Retained	Sieve Size	
Cum. % Passing	Lower	Upper	Within Spec's	Lower	Upper	Within Spec's				
100.0	100.0	100.0	Yes				0.0	0.0	3/4"	
99.8	98.0	100.0	Yes				0.2	0.2	1/2"	
93.2	90.0	100.0	Yes				6.6	6.8	3/8"	
68.7	32.0	90.0	Yes				24.4	31.3	No. 4	
42.0	32.0	67.0	Yes	47.2	47.2	Yes	26.7	58.0	No. 8	
27.1	2.0	67.0	Yes	31.6	37.6	Yes	14.9	72.9	No. 16	
18.3	2.0	67.0	Yes	23.5	27.5	Yes	8.8	81.7	No. 30	
11.0	2.0	67.0	Yes	18.7	18.7	Yes	7.3	89.0	No. 50	
5.2	2.0	10.0	Yes				5.8	94.8	No. 200	

(Bold Italic) Not within specifications ***(Bold Italic)*** Not within specificaitons- Restricted Zone *(Italic)* Not cumulative

Lift Thickness, in:		Binder Substitution?	Yes	Binder Originally Specified:	PG 70-22	Substitute Binder:	PG 64-22
Asphalt Source:		Binder Percent, (%):	6.0	Asphalt Spec. Grav.:	1.029		
Antistripping Agent:		Percent, (%):					

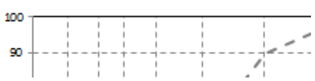

Figure 2—Combined Gradation

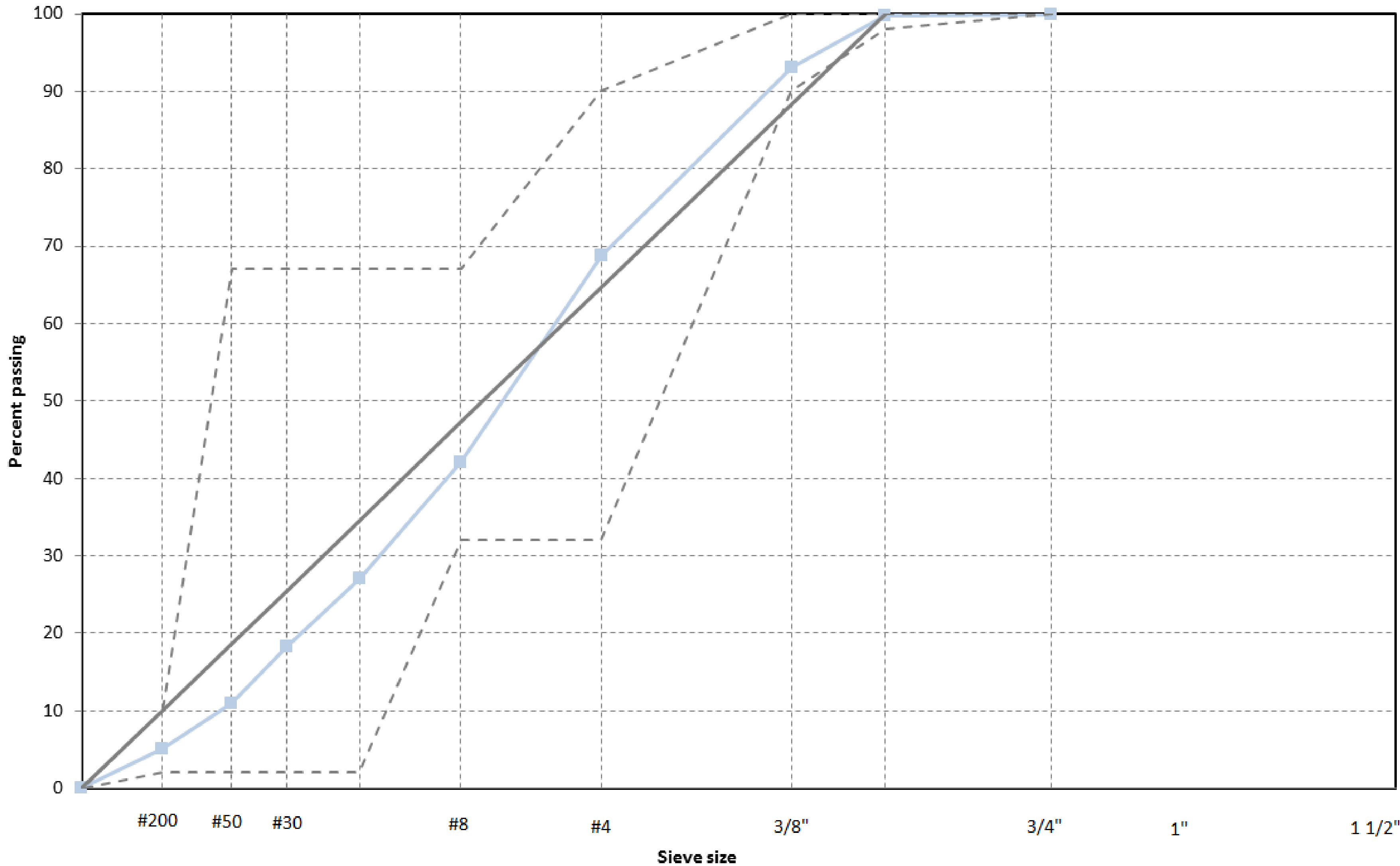

Figure 3—Power 0.45 Curve

HMACP MIXTURE DESIGN : Aggregate Classification

SAMPLE ID:		SAMPLE DATE:	
LOT NUMBER:		LETTING DATE:	
SAMPLE STATUS:		CONTROLLING CSJ:	
COUNTY:		SPEC YEAR:	2014
SAMPLED BY:		SPEC ITEM:	
SAMPLE LOCATION:		SPECIAL PROVISION:	
MATERIAL CODE:		MIX TYPE:	344-SP-D
MATERIAL NAME:			
PRODUCER:			
AREA ENGINEER:		PROJECT MANAGER:	

COURSE\LIFT:	Surface	STATION:		DIST. FROM CL:		CONTRACTOR DESIGN # :	

Aggregate Classification

		Bin No.1	Bin No.2	Bin No.3	Bin No.4	Bin No.5	Bin No.6	Bin No.7	Bin No.8	Bin No.9	Bin No.10
Individual Bin (%):		Bin No.1 = 23 %	Bin No.2 = 35.4 %	Bin No.3 = 34 %	Bin No.4 = 1 %				Bin No.8 = 5.6 %	Bin No.9 = 1 %	
Aggregate Source:		Limestone_Dolomite	Limestone_Dolomite	Limestone_Dolomite					Fractionated RAP	RAS	
Aggregate Number:		TxDOT	TxDOT	TxDOT							
Class (A) Rock (Y/N):		Yes									
Sieve Size:											
Passing	Retained	Individual Ret., %	Individual Ret., %	Individual Ret., %	Individual Ret., %	Individual Ret., %	Individual Ret., %	Individual Ret., %	Individual Ret., %	Individual Ret., %	Individual Ret., %
-	3/4"	0.0	0.0	0.0	0.0				0.0	0.0	
3/4"	1/2"	0.2	0.0	0.0	0.0				0.0	0.0	
1/2"	3/8"	6.6	0.0	0.0	0.0				0.0	0.0	
3/8"	No. 4	15.5	8.7	0.1	0.0				0.1	0.0	
No. 4	No. 8	0.3	21.2	4.4	0.0				0.7	0.0	
No. 8	No. 16	0.0	3.6	10.5	0.0				0.9	0.0	
No. 16	No. 30	0.0	0.8	6.8	0.0				1.1	0.0	
No. 30	No. 50	0.0	0.2	5.1	0.0				2.1	0.0	
No. 50	No. 200	0.0	0.1	4.6	0.0				0.8	0.3	
No. 200	Pan	0.3	0.7	2.5	1.0				0.1	0.6	
Total:		23.0	35.4	34.0	1.0				5.6	1.0	
Percent of plus No. 4		22.3	8.8	0.1	0.0				0.1	0.0	
Percent of plus No. 8		22.6	30.0	4.6	0.0				0.8	0.0	

Percent of plus No. 4 from class (A) Rock:	22.3
Total Percent of plus No. 4	31.3
Percent of plus No. 4 from class (A) Rock:	**71.2**

Percent of plus No. 8 from class (A) Rock:	22.6
Total Percent of plus No. 8	58.0
Percent of plus No. 8 from class (A) Rock:	39.0

Figure 4—Aggregate Classification

Aggregate Weight, g:	4,700.0
6% Asphalt by Total Weight, g:	300.0
Total Weight, g:	5000.0

6% Asphalt by Total Weight, g:	300.0
Less Asphalt by Weight of Recycled Material, g:	*25.6*
() Asphalt to Add, g:	**274.4**

		Bin No.1	Bin No.2	Bin No.3	Bin No.4	Bin No.5	Bin No.6	Bin No.7	Bin No.8	Bin No.9	Bin No.10			
Individual Bin (%):		Bin No.1 = 23 %	Bin No.2 = 35.4 %	Bin No.3 = 34 %	Bin No.4 = 1 %				Bin No.8 = 5.5 %	Bin No.9 = 1.2 %				
Aggregate Source:		Limestone_Dolomite	Limestone_Dolomite	Limestone_Dolomite					Fractionated RAP	RAS				
Aggregate Number:		TxDOT	TxDOT	TxDOT					TxDOT	TxDOT		Total Weights	Individual Retained, %	Cumulative Retained, %
Sample ID:		D-Rock	F-Rock	Manufactured Sand										
Sieve Size: Passing	Retained	Aggregate Weight	Aggregate Weight	Aggregate Weight	Hydrated Lime Weight				Fractionated RAP Weight	RAS Weight				
INDIVIDUAL														
-	3/4"	0.0	0.0	0.0	0.0				0.0	0.0		0.0	0.0	0.0
3/4"	1/2"	10.8	0.0	0.0	0.0				0.0	0.0		10.8	0.2	0.2
1/2"	3/8"	309.2	1.7	0.0	0.0				0.0	0.0		310.8	6.6	6.8
3/8"	No. 4	727.5	411.0	6.4	0.0				3.9	0.0		1,148.7	24.3	31.1
No. 4	No. 8	16.2	996.6	207.7	0.0				36.3	0.0		1,256.9	26.6	57.7
No. 8	No. 16	1.1	168.0	492.2	0.0				42.4	0.1		703.8	14.9	72.6
No. 16	No. 30	0.0	39.9	321.2	0.0				52.6	0.4		414.1	8.8	81.4
No. 30	No. 50	0.0	8.3	238.1	0.0				101.7	0.9		349.0	7.4	88.8
No. 50	No. 200	0.0	6.7	215.7	0.0				37.4	20.4		280.2	5.9	94.7
No. 200	Pan	16.2	31.6	116.7	47.0				2.8	36.9		251.1	5.3	100.0
Totals		1,081.0	1,663.8	1,598.0	47.0				277.1	58.8		**4,725.6**	Total includes asphalt from the recycled material	
Running Total:														
CUMULATIVE														
-	3/4"	0.0	1,081.0	2,744.8	4,342.8				4,389.8	4,666.9		0.0		
3/4"	1/2"	10.8	1,081.0	2,744.8	4,342.8				4,389.8	4,666.9		10.8		
1/2"	3/8"	320.0	1,082.7	2,744.8	4,342.8				4,389.8	4,666.9		321.6		
3/8"	No. 4	1,047.5	1,493.6	2,751.2	4,342.8				4,393.7	4,666.9		1,470.4		
No. 4	No. 8	1,063.7	2,490.2	2,958.9	4,342.8				4,430.0	4,666.9		2,727.2		
No. 8	No. 16	1,064.8	2,658.3	3,451.1	4,342.8				4,472.4	4,667.0		3,431.1		
No. 16	No. 30	1,064.8	2,698.2	3,772.3	4,342.8				4,525.0	4,667.3		3,845.2		
No. 30	No. 50	1,064.8	2,706.5	4,010.4	4,342.8				4,626.7	4,668.3		4,194.2		
No. 50	No. 200	1,064.8	2,713.2	4,226.1	4,342.8				4,664.1	4,688.7		4,474.5	Total includes asphalt from the recycled material	
No. 200	Pan	1,081.0	2,744.8	4,342.8	4,389.8				4,666.9	4,725.6		4,725.6		

Figure 5—Weigh Up Sheet

HMACP MIXTURE DESIGN : SUMMARY SHEET

SAMPLE ID:		SAMPLE DATE:	
LOT NUMBER:		LETTING DATE:	
SAMPLE STATUS:		CONTROLLING CSJ:	
COUNTY:		SPEC YEAR:	2014
SAMPLED BY:		SPEC ITEM:	
SAMPLE LOCATION:		SPECIAL PROVISION:	
MATERIAL CODE:		MIX TYPE:	344-SP-D
MATERIAL NAME:			
PRODUCER:			
AREA ENGINEER:		PROJECT MANAGER:	

COURSE\LIFT:	Surface	STATION:		DIST. FROM CL:		CONTRACTOR DESIGN # :	

Target Density, %:	**96.0**
Number of Gyrations:	**50**

CRM Content, %

Note: This mix design requires an asphalt content of at least ***1.7%*** ***to meet the Maximum Ratio of Recycled to Total Binder requirement.***

	TEST SPECIMENS								Mixture Evaluation @ Optimum Asphalt Content			
										Hamburg Wheel Tracking Test		
	Asphalt Content (%)	Binder Ratio (%)	Specific Gravity Of Specimen (Ga)	Maximum Specific Gravity (Gr)	Effective Gravity (Ge)	Theo. Max. Specific Gravity (Gt)	Density from Gt (Percent)	VMA (Percent)	Indirect Tensile Strength (psi)	Number of cycles	Rut depth (mm)	*Overlay Tester Min. Number of Cycles*
1	4.0	12.5	2.241			2.454	91.3	17.4	126.4	20,000	8.2	
2	5.0	10.0	2.262	2.415	2.599	2.419	93.5	17.5				
3	6.0	8.3	2.292	2.380	2.598	2.385	96.1	17.3				
4	7.0	7.1	2.312	2.360	2.615	2.352	98.3	17.4				
5	8.0	6.3	2.307			2.320	99.4	18.5				

Effective Specific Gravity:	2.604
Optimum Asphalt Content :	**6.0**
Binder Ratio @ OAC:	8.3
VMA @ Optimum AC:	17.3
VFA @ Optimum AC:	**76.8**
Interpolated Values	
Specific Gravity (Ga):	*2.291*
Max. Specific Gravity (Gr):	*2.381*
Theo. Max. Specific Gravity (Gt):	*2.386*
Dust/Asphalt Ratio:	**0.9**

<Not meeting VFA requirement

Estimated Percent of Stripping, %:	

STONE-ON-STONE CONTACT

VCA(CA, calc.)	
VCA(MIX, calc.)	

Mixing Temp,°F:	
Molding Temp,°F:	

Figure 6—Summary Sheet

PART II—MIX DESIGN FOR DENSE-GRADED HOT-MIX ASPHALT MIXTURES USING THE TEXAS GYRATORY COMPACTOR (TGC) BY VOLUME

7. SCOPE

7.1 Use this method to determine the proper proportion by volume of approved materials to produce a dense-graded mixture that will satisfy the specification requirements. This mix design procedure incorporates the use of the TGC for dense-graded mixtures, such as Type A, B, C, D, and F.

7.2 Determine the proper proportions volumetrically when the aggregate stockpile bulk specific gravities vary by 0.300 or more. Volumetric proportioning is always the most correct method; however, when aggregate specific gravities are similar, consider the error introduced by designing by weight as inconsequential.

8. MIX DESIGN EXAMPLE BY VOLUME

8.1 The following example describes the process necessary to develop proper mixtures using approved materials for a given application or surface requirement where material volume is the primary consideration.

8.2 Use the following processed materials to design a dense-graded hot-mix asphalt mix by volume:

- aggregate A—a lightweight aggregate with 12.5 mm (1/2 in.) maximum size and surface aggregate classification of class A;
- aggregate B—a crushed limestone with 9.5 mm (3/8 in.) maximum size and surface aggregate classification of class B;
- limestone screenings;
- field sand; and
- PG 64-22.

8.2.1 Combine the 4 aggregates and asphalt in proportions that meet the requirements for a dense-graded Type D hot-mix asphalt mixture under the applicable specification.

8.3 *Selecting Materials:*

8.3.1 Verify that all the materials comply with the project specifications.

8.3.2 Obtain the average washed gradation of each proposed aggregate stockpile in accordance with Tex-200-F, Part II, using the Sieve Analysis of Fine and Coarse Aggregates template. Figure 1 shows the hypothetical sample gradations of the proposed aggregates.

8.3.3 Consider all factors relating to the production of the available materials and desired mixture properties. Assume that the best combination of the aggregates for this mix design example will consist of 39% by volume of aggregate A, 23% by volume of aggregate B, 26% by volume of stone screening, and 12% by volume of field sand.

8.3.4 Determine the 24-hr. water absorption, the bulk specific gravity, and the apparent specific gravity for the individual sizes of each aggregate in accordance with Tex-201-F and Tex-202-F. Test the proposed lightweight aggregate in accordance with Tex-433-A.

8.3.4.1 Normally, specific gravities are not determined for RAP aggregate size fractions consisting of less than 15% of the individual aggregate.

8.3.5 Calculate the average water absorption, average stockpile bulk gravities, and the bulk specific gravity of the combined gradation. Design the mix by volume, since the stockpile specific gravities vary by as much as 1.119, which exceeds 0.300.

8.3.5.1 Assume the differences in the specific gravities of the size fractions within a given stockpile will not have a significant effect on the proportioning of actual materials. This allows the use of the average bulk specific gravity for each stockpile in later calculations.

8.3.6 Calculate the combined volumetric job-mix formula using the assumption that the specific gravities of the size fractions within a given stockpile will not have a significant effect on the proportioning. Table 4 shows the volumetric combined gradation, which results from combining 39% by volume lightweight aggregate A, 23% by volume aggregate B, 26% by volume screenings, and 12% by volume sand. The resulting combined gradation meets the specification master gradation limits, which are identical for volumetric and weight proportioning.

8.3.7 Check the proposed aggregate proportioning for compliance with blending requirements. Check aggregate classification in accordance with Section 5.4.4.

8.3.8 Plot the proposed combined volumetric gradation and specification master limits on a 0.45 power curve.

8.4 *Preparing Laboratory-Mixed Samples:*

8.4.1 Calculate individual aggregate and asphalt weights for the test mixtures. Since all of the calculations to this point have been volumetric, convert to weight percentages so that the necessary weights of individual materials can be determined. Refer to Table 2 for conversion of the stockpile percentages.

8.4.1.1 This is the second application of the assumption that the differences in specific gravities of individual size aggregates within a stockpile will not have a significant effect on the proportioning for the combined gradation.

8.4.1.2 Use the values in the last column of Table 2 to calculate the weight percentage of each aggregate size fraction. See the example shown in Table 5.

8.4.2 Calculate individual aggregate and asphalt weights for the test mixtures as shown in Table 6. The presence of lightweight aggregate in this example means a specimen with a height of 51 mm (2 in.) will weigh less than if all natural aggregate were used.

8.4.2.1 The asphalt contents for the test mixes chosen are 4.0, 5.0, 6.0, 7.0, and 8.0% by weight. Therefore, the corresponding percentages by weight of the aggregate in the mixtures will be 96.0, 95.0, 94.0, 93.0, and 92.0%.

8.4.3 Mix one of the batches calculated in Section 8.4.2 in accordance with Tex-205-F.

8.4.4 Determine the weight of mixture required to produce a specimen height of 51 ± 1.5 mm (2 ± 0.06 in.) by molding a 900-g sample in accordance with Tex-206-F. Measure the height of the specimen. Divide 51 mm (2 in.) by the molded height and multiply by 900 g to give the corrected weight to produce one 51-mm (2-in.) specimen. Refer to the height adjustment formula in Tex-206-F.

8.4.5 Subtract 5 g from the weight of the mix at each asphalt content above that of the trial specimen. Add 5 g to the weight of the mix at each asphalt content below that of the trial specimen. For this example, a 900-g sample with 4.0% asphalt produced a molded specimen with a height of 55.9 mm (2.20 in.). Therefore, the amount of mixture required to produce a 51-mm (2-in.) molded specimen would be (51.0 mm/ 55.9 mm) × [900 g or (2.00 in./2.19 in.) × 900 g] = 821 g. The mix weights for molding specimens with the different asphalt contents for this example are:

- asphalt content 4% ≥ 821 g
- asphalt content 5% ≥ 826 g
- asphalt content 6% ≥ 831 g
- asphalt content 7% ≥ 836 g
- asphalt content 8% ≥ 841 g.

8.4.6 Weigh up the materials for each of the batches containing 4.0, 5.0, 6.0, 7.0, and 8.0% asphalt content. Mix and mold the test specimens in accordance with Tex-205-F and Tex-206-F.

8.4.7 Determine the G_r of the mixtures at 5.0, 6.0, and 7.0% asphalt content in accordance with Tex-227-F. Two of the 3 mixtures should have asphalt contents above the optimum, and one mixture should have asphalt content below the optimum.

8.4.7.1 Perform the dry-back procedure to determine if water absorption has introduced error in the initial G_r result when testing mixtures containing lightweight aggregate.

8.4.7.2 Treat the mix used to perform this test the same as the samples for molding. Remove aggregates retained on the 19.0-mm (3/4-in.) sieve from the G_r sample. Cure the G_r sample for 2 hr. at the compaction temperature for the PG binder used (PG 64-22 for this example) similar to curing the mix before molding.

8.4.8 Determine the G_a of each of the molded specimens in accordance with Tex-207-F.

8.4.9 Calculate the average G_e of the blend in accordance with Section 19.2.

8.4.10 Calculate the G_t in accordance with Section 19.3.

8.4.11 Calculate the percent density of the molded specimens in accordance with Section 19.4.

8.4.12 Calculate the VMA of the specimens to the nearest 0.1% in accordance with Section 19.5.

8.5 *Determining the OAC:*

8.5.1 Plot densities on the vertical axis, versus asphalt content on the horizontal axis for each set of molded specimens. Draw a line at the target laboratory-molded density to where it intersects with the density curve. Draw a vertical line down from this point to where it intersects the horizontal axis to determine the OAC. Alternatively, calculate the OAC by interpolating between the asphalt contents above and below the target density.

8.5.2 Plot asphalt content versus VMA, G_a, and G_r. Report and verify all properties of the combined blend at the determined OAC.

8.6 *Evaluating the Mixture at the OAC*:

8.6.1 Determine the indirect tensile strength of 4 specimens molded at the OAC to 93 ± 1% density in accordance with Tex-226-F.

8.6.2 Determine the rut depth and number of passes of 2 specimens molded at the OAC to 93 ± 1% density in accordance with Tex-242-F.

Table 2—Stockpile Conversion Percentages (Volume to Weight)

Stockpile	**Proportions % by Volume**		**Bulk Specific Gravity**		**Weight, g**	**Proportions % by Weight**
Lightweight	39.0	×	1.502	=	58.578	27.4
Aggregate B	23.0	×	2.539	=	58.397	27.3
Screenings	26.0	×	2.524	=	65.624	30.6
Sand	12.0	×	2.621	=	31.452	14.7
TOTAL	**100.0**		—		**214.051**	**100.0**

Table 3—Sieve Analysis Worksheet (No. 2)

Project:					**Highway:**				
County:					**Item No.:**				
	Sieve Size								
	1/2"	**3/8"**	**#4**	**#8**	**#30**	**#50**	**#200**	**Pass #200**	**TOTAL**
Lightweight									
Weight (g)	0	21.2	622.7	71.9	3.3	0.7	0.8	2.3	**722.9**
Ind. % Ret.	0	2.9	86.2	9.9	0.5	0.1	0.1	0.3	**100.0**
Cum. % Ret.	0	2.9	89.1	99.0	99.5	99.6	99.7	---	---
Cum. % Pass.	100.0	97.1	10.9	1	0.5	0.4	0.3	---	---
Aggregate B									
Weight (g)	0	0	2.4	1145.9	37.0	12.4	8.1	11.9	**1217.7**
Ind. % Ret.	0	0	0.2	94.1	3.0	1.0	0.7	1.0	**100.0**
Cum. % Ret.	0	0	0.2	94.3	97.3	98.3	99.0	---	---
Cum. % Pass.	100.0	100.0	99.8	5.7	2.7	1.7	1.0	---	---
Screenings									
Weight (g)	0	0	0	194.2	471.1	367.0	144.1	65.6	**1242.0**
Ind. % Ret.	0	0	0	15.6	37.9	29.6	11.6	5.3	**100.0**
Cum. % Ret.	0	0	0	15.6	53.5	83.1	94.7	---	---
Cum. % Pass.	100.0	100.0	100.0	84.4	46.5	16.9	5.3	---	---
Sand									
Weight (g)	0	0	0	0	480.0	468.1	172.0	74.0	**1194.1**
Ind. % Ret.	0	0	0	0	40.2	39.2	14.4	6.2	**100.0**
Cum. % Ret.	0	0	0	0	40.2	79.4	93.8	---	---
Cum. % Pass.	100.0	100.0	100.0	100.0	59.8	20.6	6.2	---	---

Table 4—Job-Mix Formula Gradation Worksheet (Volumetric % Passing)

Project:				**Highway:**			
County:				**Item No.:**			
	Sieve Size						
	1/2"	**3/8"**	**#4**	**#8**	**#30**	**#50**	**#200**
Lightweight							
100%	100.0	97.0	7.9	0.4	0.3	0.2	0.1
39%	39.0	37.8	3.1	0.2	0.1	0.1	0.0
Aggregate B							
100%	100.0	100.0	99.8	5.7	2.7	1.7	1.0
23%	23.0	23.0	23.0	1.3	0.6	0.4	0.2
Screenings							
100%	100.0	100.0	100.0	84.4	46.5	16.9	5.3
26%	26.0	26.0	26.0	21.9	12.1	4.4	1.4
Sand							
100%	100.0	100.0	100.0	100.0	59.8	20.6	6.2
12%	12.0	12.0	12.0	12.0	7.2	2.5	0.7
Combined Analysis	100.0	98.8	64.1	35.4	20.0	7.4	2.3
Specification	100	85-100	50-70	32-42	11-26	4-14	1-6[1]

1. Dry sieve analysis

Table 5—Job-Mix Formula Gradation Worksheet (Volumetric Converted to Weight)

Project:				**Highway:**			
County:				**Item No.:**			
	Sieve Size						
	1/2"	**3/8"**	**#4**	**#8**	**#30**	**#50**	**#200**
Lightweight							
100%	100.0	97.0	10.9	1.0	0.5	0.4	0.3
27.4%	27.4	26.6	3.0	0.3	0.1	0.1	0.1
Aggregate B							
100%	100.0	100.0	99.8	5.7	2.7	1.7	1.0
27.3%	27.3	27.3	27.2	1.6	0.7	0.5	0.3
Screenings							
100%	100.0	100.0	100.0	84.4	46.5	16.9	5.3
30.6%	30.6	30.6	30.6	25.8	14.1	5.2	1.6
Sand							
100%	100.0	100.0	100.0	100.0	59.8	20.6	6.2
12%	12.0	12.0	12.0	12.0	7.2	2.5	0.7
Combined Analysis	100.0	99.2	75.5	42.4	23.8	8.8	2.9
Specification[1]	100	85-100	50-70	32-42	11-26	4-14	1-6

1. Volumetric specification limits are not applicable to converted weight percentages.

Table 6—Weigh-Up for 4000g Batch at 4% Asphalt

Material ID	% of Aggregate	% of Mix	Cumulative %	1000 g Cumulative Wt.	4000 g Cumulative Batch Weigh-Up
Lightweight					
1/2" - 3/8"	0.8	0.8	0.8	8	32
3/8" - #4	23.6	22.7	23.5	235	940
#4 - #8	2.7	2.5	26.0	260	1040
Pass #8	0.3	0.3	26.3	263	1052
Aggregate B					
1/2" - 3/8"	0	0	---	---	---
3/8" - #4	0.1	0.1	26.4	264	1056
#4 - #8	25.6	24.6	51.0	510	2040
Pass #8	1.6	1.5	52.5	525	2100
Screenings					
Plus + #8	4.8	4.6	57.1	571	2284
Pass - #8	25.8	24.8	81.9	819	3276
Sand					
Pass - #8	14.7	14.1	96.0	960	3840
Asphalt					
%	---	4.0	(4.0)	(40)	(160)
TOTAL	**100.0**	**100.0**	**100.0**	**1000**	**4000**

PART III—MIX DESIGN FOR LARGE STONE DENSE-GRADED HOT-MIX ASPHALT MIXTURES USING THE SUPERPAVE GYRATORY COMPACTOR (SGC)

9. SCOPE

9.1 Part III has been removed from this test procedure. Refer to Part I, "Mix Design for Dense-Graded Hot-Mix Asphalt Mixtures by Weight."

PART IV—MIX DESIGN FOR SUPERPAVE MIXTURES

10. SCOPE

10.1 Use this method to determine the proper proportions by weight of approved materials to produce a Superpave mixture that will satisfy the specification requirements. This mix design procedure incorporates the use of the SGC.

11. PROCEDURE

11.1 *Selecting Materials:*

11.1.1 Select the necessary type and source for each aggregate. Obtain representative samples consisting of a minimum of 23 kg (50 lb.) of each aggregate. Take samples in accordance with Tex-221-F.

11.1.2 Obtain an adequate quantity of the asphalt and additives. Take samples in accordance with Tex-500-C.

11.1.3 Dry the aggregate to constant weight at a minimum temperature of 100°F (38°C). Dry the RAP, when applicable, at a maximum of 140°F (60°C).

11.1.4 If the stockpile gradation is unknown, obtain the average washed gradation of each proposed aggregate stockpile in accordance with Tex-200-F, Part II. Enter the stockpile gradations on the Combined Gradation worksheet. Use the construction stockpile gradation when it is available. Extract asphalt from RAP, when applicable, in accordance with Tex-210-F or Tex-236-F before performing a sieve analysis.

11.1.5 When applicable, estimate the binder content of the RAP from the average of 4 samples (RAP only) in accordance to Tex-236-F. Heat the RAP at 140°F (60°C), break apart until friable, and quarter to obtain a representative sample.

11.1.6 Check the aggregate gradations for compliance with the applicable specifications.

11.1.7 Check the asphalt and additives for compliance with the applicable specifications.

11.1.8 If the specific gravity values for the aggregate sources are known, enter these results on the Bulk Gravity worksheet. Test lightweight aggregate, when applicable, in accordance with Tex-433-A.

Note 26—If the specific gravity values are unknown and deemed necessary, determine the 24-hr. water absorption, the bulk specific gravity, and the apparent specific gravity of individual sizes of each aggregate in accordance with Tex-201-F and Tex-202-F.

11.1.8.1 Normally, specific gravities are not determined for RAP or aggregate size fractions consisting of less than 15% of the individual aggregate. Assign the water absorption and specific gravity of smaller aggregate size fractions close to the next adjacent size fractions for which values were determined.

11.1.9 Determine the unit weight in accordance with Tex-404-A and the bulk specific gravity of the combined gradation for the aggregate retained on the No. 8 sieve in accordance with Tex-201-F to verify stone-on-stone contact when shown on the plans.

11.1.10 Use the Combined Gradation worksheet to calculate the bin percentages with the proposed aggregate so that the blended combination will fall within the specified gradation ranges for the specified hot-mix asphalt type. Use hydrated lime, when applicable, as an aggregate type when determining the bin percentages for the combined aggregate blend. The combined gradation will include the hydrated lime.

11.1.11 When applicable, check specification compliance for the proposed blend of recovered asphalt from RAP and virgin asphalt cement or recycling agents before the laboratory-mixture preparation stage. Base the percentage of recovered asphalt in the blend on the percentage of RAP material proposed in the job-mix formula and the average extracted asphalt content of the RAP determined in Section 11.1.5.

11.1.12 Test the combined virgin aggregate in accordance with Tex-203-F. Perform the test on the combined aggregates not including lime. Enter these results on the Material Properties worksheet.

11.1.13 Check the aggregate classification of the combined aggregate blend using the Aggregate Classification worksheet when blending Class A with Class B aggregate. Determine whether the percentage of the Class A aggregate in the combined aggregate blend meets the specification requirements in accordance with Section 19.1.

11.2 *Preparing Laboratory Mixed Samples:*

11.2.1 Separate the material larger than the No. 8 sieve into individual sieve sizes for each stockpile as required by the specification.

11.2.1.1 Do not separate the material passing the No. 8 sieve from each stockpile if it meets the following conditions.

- The RAP and aggregate passing the No. 8 sieve stockpile gradations are uniformly graded.
- The gradation of the material passing the No. 8 sieve is not prone to segregation.

11.2.2 Combine the aggregates to create a trial blend that falls within the master gradation band required in the specification.

Note 27—Mix designs typically use 3–5 stockpiles to produce a combined gradation meeting gradation specifications.

11.2.3 Plot the combined gradation and specification limits on the Grad Chart worksheet.

11.2.4 Select and vary asphalt contents in 0.5% increments. Enter the asphalt percentages in the Summary worksheet.

Note 28—Select 3 or 5 asphalt contents to determine the OAC depending on experience and knowledge of materials used.

11.2.5 Calculate the weights of individual aggregates required to produce batches of mix at each chosen asphalt content from Section 11.2.4. Calculate weights for 2 laboratory-molded specimens and one G_r sample for each asphalt content. Generally, 4500–4700 g of aggregate are required to achieve the specified molded specimen height of 115 ± 5 mm (4.5 ± 0.2 in.) It may be necessary to produce a trial specimen to achieve this height requirement. 1900–2000 g of aggregate are required for a sample for the G_r.

11.2.6 Prepare the asphalt mixtures in accordance with Tex-205-F.

11.2.7 Mold 2 specimens for each asphalt content at the design number of gyrations, N_{design}, in accordance with Tex-241-F. Determine the N_{design} according to the specification or as shown on the plans.

11.2.8 Determine the G_a of the specimens at each asphalt content in accordance with Tex-207-F. Enter the average G_a for each asphalt content in the Summary worksheet.

11.2.9 Determine the G_r of the mixtures at each asphalt content in accordance with Tex-227-F. Enter the G_r for each asphalt content in the Summary worksheet.

11.2.10 Use the Mix Design template to calculate the following:

- the average G_e of the blend in accordance with Section 19.2,
- the G_t for each asphalt content in accordance with Section 19.3,
- the percent density of the molded specimens in accordance with Section 19.4, and
- the VMA of the specimens in accordance with Section 19.5.

11.3 *Determining the OAC:*

11.3.1 Use the Mix Design template to plot the following.

- Densities versus asphalt content for the molded specimens—determine the OAC by interpolating between the asphalt contents above and below the target laboratory-molded density on the Summary worksheet.
- Asphalt content versus VMA—determine the VMA at the OAC.

11.3.2 If the VMA is not within the allowable specification range, redesign by assuming another combination of aggregates or by obtaining different materials.

11.4 *Evaluating the Stone-on-Stone Contact (when required by general note):*

11.4.1 Verify stone-on-stone contact when shown on the plans. Calculate the VCA_{CA} in accordance with Section 19.7.

11.4.2 Calculate the VCA_{Mix} in accordance with Section 19.8. Stone-on-stone contact is verified when the VCA_{Mix} is less than the VCA_{CA}.

11.4.3 Adjust the gradation if the stone-on-stone contact VCA_{Mix} is not less than the VCA_{CA}. Alternatively, use the Bailey Method to verify stone-on-stone contact.

11.5 *Evaluating the Mixture at the OAC:*

11.5.1 Calculate the weights of individual aggregates for laboratory molded specimens at the OAC determined in Section 11.3.1.

11.5.2 Determine the indirect tensile strength in accordance with Tex-226-F.

11.5.3 Determine the rut depth and number of passes in accordance with Tex-242-F.

11.5.4 When requested by the Engineer or shown on the plans, determine the number of cycles to failure in accordance with Tex-248-F and percent loss in accordance with Tex-245-F.

11.5.5 If the rut depth or indirect tensile strength is not within specification, redesign by adding an antistripping agent, adjusting the N_{design}, assuming another combination of aggregates, obtaining different materials, or using a different PG grade.

Note 29—The Engineer must approve any changes made to the N_{design} that results in a value different from that shown on the plans or allowed in the specification.

PART V—MIX DESIGN FOR PERMEABLE FRICTION COURSE (PFC) AND THIN BONDED PERMEABLE FRICTION COURSE (TBPFC) MIXTURES

12. SCOPE

12.1 Use this method to determine the proper proportions by weight of approved materials to produce PFC and PFC-R mixtures that will satisfy the specification requirements. This mix design procedure incorporates the use of the SGC.

13. PROCEDURE

13.1 *Selecting Materials:*

13.1.1 Select the necessary type and source for each aggregate. Obtain representative samples consisting of a minimum of 23 kg (50 lb.) of each aggregate. Take samples in accordance with Tex-221-F.

13.1.2 Obtain an adequate quantity of the asphalt and additives. Take samples in accordance with Tex-500-C.

Note 30—Polymer-modified asphalt binder with a PG of 76-XX or higher is required or Asphalt Rubber (A-R), Type I or II. Use of fibers is required for mixes with PG 76-XX. Use loose fibers for mixtures prepared in the laboratory. Provide the Engineer the A-R binder blend design with the mix design (JMF1) submittal.

13.1.3 Dry the aggregate to constant weight at a minimum temperature of 100°F (38°C).

13.1.4 If the stockpile gradation is unknown, obtain the average washed gradation of each proposed aggregate stockpile in accordance with Tex-200-F, Part II. Enter the stockpile gradations on the Combined Gradation worksheet. Use the construction stockpile gradation when it is available.

13.1.5 Check the aggregate gradations for compliance with the applicable specifications. Check the individual aggregate stockpiles for compliance with the applicable specifications.

13.1.6 Check the asphalt and additives for compliance with the applicable specifications.

13.1.7 If the specific gravity values for the aggregate sources are known, enter these results on the Bulk Gravity worksheet. Test lightweight aggregate, when applicable, in accordance with Tex-433-A.

Note 31—If the specific gravity values for the aggregate sources are unknown and deemed necessary, determine the 24-hr. water absorption, bulk specific gravity, and apparent specific gravity of individual sizes of each aggregate in accordance with Tex-201-F and Tex-202-F.

13.1.7.1 Normally, specific gravities are not determined for aggregate size fractions consisting of less than 15% of the individual aggregate. Assign the water absorption and specific gravity of smaller aggregate size fractions close to the next adjacent size fraction for which values were determined.

13.1.8 Use the Combined Gradation worksheet to calculate the bin percentages with the proposed aggregate so that the blended combination will fall within the specified gradation ranges for the specified mixture type.

Note 32—Consider material availability, mixture strength, handling, compaction, pavement texture, and durability as the primary factors of the combination to be tested.

13.1.9 Add 1% hydrated lime as a mineral filler for mixes with PG 76-XX. Use hydrated lime as an aggregate type when determining the bin percentages for the combined aggregate blend. The combined gradation will include the hydrated lime for mixes with PG 76-XX.

13.1.10 Check the aggregate classification of the combined aggregate blend using the Aggregate Classification worksheet when blending Class A with Class B aggregate. Determine whether the percentage of the Class A aggregate in the combined aggregate blend meets the specification requirement in accordance with Section 19.1.

13.1.11 Plot the combined gradation and specification limits on the Grad Chart worksheet.

13.2 *Preparing Laboratory-Mixed Samples:*

13.2.1 Separate the material larger than the No. 8 sieve into individual sizes for each stockpile for preparation of laboratory mixtures. Separate the material passing the No. 8 sieve into individual sizes if it is prone to segregation.

13.2.2 Start the mixture design with the minimum allowable percentage of loose fibers for mixes with PG 76-XX. Increase this percentage when necessary to achieve the required mixture properties.

13.2.3 Select a minimum of 3 asphalt binder contents in increments of 0.5% for the laboratory-molded specimens. Start at an asphalt content of 6.0% or greater for PFC mixtures with

PG 76-XX. Start at an asphalt content of 8.0% or greater for PFC mixtures with A-R binder. Lower asphalt contents are allowed when using an aggregate with a bulk specific gravity greater than 2.750.

13.2.4 Select 3 asphalt binder contents in increments of 0.5% for the G_r samples. Start at an asphalt content of 2.0–3.0%. Ensure all samples are thoroughly coated with asphalt binder.

Note 33—Perform this Section to determine accurate G_r values at the higher asphalt contents selected in Section 13.2.3 for the laboratory-molded specimens. The G_r values for the mixtures with the higher asphalt contents are back-calculated using the equation in Section 19.2.

13.2.5 Calculate the weights of individual aggregates required to produce the specimens and samples specified in Sections 13.2.3 and 13.2.4. Generally, 3500–3700 g of aggregate are required to achieve the specified molded specimen height of 115 ± 5 mm (4.5 ± 0.2 in.); however, this may vary. It may be necessary to produce a trial specimen to achieve this height requirement.

13.2.6 Prepare the asphalt mixtures in accordance with Tex-205-F. Determine the mixing and compaction temperatures per Tex-241-F, Table 1.

13.2.7 Mold 2 specimens at each asphalt content selected in Section 13.2.3 in accordance with Tex-241-F. Mold specimens to 50 gyrations.

13.2.8 Determine the G_r at the asphalt contents selected in Section 13.2.4 in accordance with Tex-227-F. Enter the G_r in the Summary worksheet.

13.2.9 Determine the G_a of the specimens using dimensional analysis in accordance with Tex-207-F, Part VIII. Enter the G_a in the Summary worksheet.

13.2.10 Use the Mix Design template to calculate the following:

- the average G_e of the blend in accordance with Section 19.2 (Use the equation in Section 19.2 and the average G_e for the combined blend to back-calculate the G_r value for the mixtures with the higher asphalt contents used for the laboratory-molded specimens.);
- the G_t in accordance with Section 19.3; and
- the percent density of the molded specimens in accordance with Section 19.4.

13.3 *Determining the OAC:*

13.3.1 Use the Mix Design template to plot densities versus asphalt content for the molded specimens. Determine the OAC by interpolating between the asphalt contents above and below the target laboratory-molded density on the Summary worksheet.

13.3.2 When applicable, adjust the percentage of coarse aggregate or fibers to achieve an OAC that meets the minimum asphalt binder content requirement according to the specification.

13.4 *Evaluating the Mixture at the OAC:*

13.4.1 Evaluate draindown of the optimum mixture in accordance with Tex-235-F.

13.4.2 Evaluate moisture resistance of the optimum mixture in accordance with Tex-530-C.

13.4.3 When required, requested by the Engineer, or shown on the plans, determine the number of cycles to failure in accordance with Tex-248-F and the rut depth and number of passes in accordance with Tex-242-F.

13.4.4 Evaluate the durability of the optimum mixture in accordance with Tex-245-F.

13.4.5 Report all data in the Mix Design Template.

PART VI—MIX DESIGN FOR STONE MATRIX ASPHALT (SMA) MIXTURES

14. SCOPE

14.1 Use this method to determine the proper proportions by weight of approved materials to produce SMA and SMAR mixtures that will satisfy the specification requirements. This mix design procedure incorporates the use of the SGC.

15. PROCEDURE

15.1 *Selecting Materials:*

15.1.1 Select the necessary type and source for each aggregate. Obtain representative samples consisting of a minimum of 23 kg (50 lb.) of each aggregate. Take samples in accordance with Tex-221-F.

15.1.2 Obtain an adequate quantity of the asphalt and additives. Take samples in accordance with Tex-500-C.

Note 34—Polymer-modified asphalt binder with a PG 76-XX or higher is required or Asphalt Rubber (A-R), Type I or II. Use of fibers is required for mixes with PG 76-XX. Use loose fibers for mixtures prepared in the laboratory. Provide the Engineer the A-R binder blend design with the mix design (JMF1) submittal.

15.1.3 Dry the aggregate to constant weight at a minimum temperature of 100°F (38°C). Dry the RAP, when applicable, at a maximum of 140°F (60°C).

15.1.4 If the stockpile gradation in unknown, obtain the average washed gradation of each proposed aggregate stockpile in accordance with Tex-200-F, Part II. Enter the stockpile gradations on the Combined Gradation worksheet. Use the construction stockpile gradation when it is available. Extract asphalt from RAP, when applicable, in accordance with Tex-210-F or Tex-236-F before performing a sieve analysis.

15.1.5 When applicable, estimate the binder content of the RAP from the average of 4 samples (RAP only) in accordance with Tex-236-F. Heat the RAP at 140°F (60°C), break apart until friable, and quarter to obtain a representative sample.

15.1.6 Check the aggregate gradations for compliance with the applicable specifications. Check the individual aggregate stockpiles for compliance with the applicable aggregate specifications.

15.1.7 Check the asphalt and additives for compliance with the applicable specifications.

15.1.8 If the specific gravity values for the aggregate sources are known, enter these results on the Bulk Gravity worksheet. Test lightweight aggregate, when applicable, in accordance with Tex-433-A.

Note 35—If the specific gravity values for the aggregate sources are unknown and deemed necessary, determine the 24-hr. water absorption, the bulk specific gravity, and the apparent specific gravity of individual sizes of each aggregate in accordance with Tex-210-F and Tex-202-F.

15.1.8.1 Normally, specific gravities are not determined for aggregate size fractions consisting of less than 15% of the individual aggregate. Assign the water absorption and specific gravity of smaller aggregate size fractions close to the next adjacent size fraction for which values were determined.

15.1.8.2 Determine the unit weight in accordance with Tex-404-A and the bulk specific gravity of the combined gradation for the aggregate retained on the No. 8 sieve in accordance with Tex-201-F to verify stone-on-stone contact.

15.1.9 Use the Combined Gradation worksheet to calculate the bin percentages with the proposed aggregate such that the blended combination will fall within the specified gradation ranges for the specified mixture type. Use hydrated lime, when applicable, as an aggregate type when determining the bin percentages for the combined aggregate blend. The combined gradation will include the hydrated lime.

Note 36—Consider material availability, mixture strength, handling, compaction, pavement texture, and durability as the primary factors of the combination to be tested.

15.1.10 When applicable, check specification compliance for the proposed blend of recovered asphalt from RAP and virgin asphalt cement or recycling agents before the laboratory-mixture preparation stage. Base the percentage of recovered asphalt in the blend on the percentage of RAP material proposed in the job-mix formula and the average extracted asphalt content of the RAP determined in Section 15.1.5.

15.1.11 Test the combined virgin aggregate in accordance with Tex-203-F. Perform the test on the combined aggregates not including lime. Enter these results on the Material Properties worksheet.

15.1.12 Check the aggregate classification of the combined aggregate blend using the Aggregate Classification worksheet when blending Class A with Class B aggregate. Determine whether the percentage of the Class A aggregate in the combined aggregate blend meets the specification requirements in accordance with Section 19.1.

15.2 *Preparing Laboratory Mixed Samples:*

15.2.1 Separate aggregate larger than the No. 8 sieve into individual sizes for each stockpile for preparation of laboratory mixtures. Separate the material passing the No. 8 sieve into individual sizes if it is prone to segregation.

15.2.2 For SMA, start the mixture design with the minimum allowable percentage of loose fibers for mixes with PG 76-XX. Increase this percentage when necessary to achieve the required mixture properties.

15.2.3 Select 3 asphalt contents in increments of 0.5%. Start at the minimum asphalt content based on the bulk specific gravity of the aggregate. Locate the table in the specification that lists the minimum asphalt content based on the bulk specific gravity of the aggregate.

15.2.4 Calculate the weights of individual aggregates required to produce 2 laboratory-molded specimens and one G_r sample for each asphalt content selected in Section 15.2.3. Generally, 4500–4700 g of aggregate are required to achieve the specified molded specimen height of 115 ± 5 mm (4.5 ± 0.2 in.) It may be necessary to produce a trial specimen to achieve this height requirement.

15.2.5 Prepare the asphalt mixtures in accordance with Tex-205-F. Determine the mixing and compaction temperatures per Tex-241-F, Table 1.

15.2.6 Mold 2 specimens at each asphalt content selected in Section 15.2.3 in accordance with Tex-241-F. Mold specimens to 50 gyrations.

15.2.7 Determine the G_a of the specimens at each asphalt content in accordance with Tex-207-F. Enter the average G_a for each asphalt content in the Summary worksheet.

15.2.8 Determine the G_r of the mixtures at each asphalt content in accordance with Tex-227-F. Enter the G_r for each asphalt content in the Summary worksheet.

15.2.9 Use the Mix Design template to calculate the following:

- average G_e of the blend in accordance with Section 19.2,
- the G_t in accordance with Section 19.3,
- the percent density of the molded specimens in accordance with Section 19.4, and
- the VMA of the specimens in accordance with Section 19.5.

15.3 *Determining the OAC:*

15.3.1 Use the Mix Design template to plot the following.

- Densities versus asphalt content for the molded specimens—determine the OAC by interpolating between the asphalt contents above and below the target laboratory-molded density on the Summary worksheet.
- Asphalt content versus VMA—determine the VMA at the OAC.

15.3.2 Redesign by assuming another combination of aggregates or by obtaining different materials if the VMA is not within the allowable specification range.

15.4 *Evaluating the Stone-on-Stone Contact:*

15.4.1 Calculate the VCA_{CA} in accordance with Section 19.7.

15.4.2 Calculate the VCA_{Mix} in accordance with Section 19.8. Stone-on-stone contact is verified when the VCA_{Mix} is less than the VCA_{CA}.

15.4.3 Adjust the gradation if the stone-on-stone contact VCA_{Mix} is not less than the VCA_{CA}. Alternatively, use the Bailey Method to verify stone-on-stone contact.

15.5 *Evaluating the Mixture at the OAC:*

15.5.1 Determine the number of cycles to failure in accordance with Tex-248-F.

15.5.2 Determine the rut depth and number of passes in accordance with Tex-242-F.

15.5.3 If the rut depth or number of cycles is not within specification, redesign by assuming another combination of aggregates, by obtaining different materials, or by using a different PG grade.

15.5.4 Evaluate draindown of the optimum mixture in accordance with Tex-235-F.

15.5.5 Evaluate the moisture resistance of the optimum mixture in accordance with Tex-530-F.

15.5.6 Report all data in the Mix Design template.

PART VII—MIX DESIGN FOR STONE-MATRIX ASPHALT RUBBER (SMAR) MIXTURES

16. SCOPE

16.1 Part VII has been combined with Part VI of the test procedure. Refer to Part VI, “Mix Design for Stone-Matrix Asphalt (SMA) Mixtures.”

PART VIII—MIX DESIGN FOR THIN BONDED WEARING COURSE MIXTURES

17. SCOPE

17.1 Use this method to determine the proper proportions by weight of approved aggregates and asphalt, which, when combined, will produce a thin bonded wearing course mixture that will satisfy the specification requirements.

17.2 Refer to Table 1 for Superpave and conventional mix nomenclature equivalents. Replace conventional nomenclature with Superpave nomenclature when required.

18. PROCEDURE

18.1 *Selecting Materials:*

18.1.1 Select the necessary type and source for each aggregate. Obtain representative samples consisting of a minimum of 23 kg (50 lb.) of each aggregate. Sample the aggregates in accordance with Tex-221-F.

18.1.2 Obtain an adequate quantity of the asphalt and additives in accordance with Tex-500-C.

18.1.3 Dry the aggregate to constant weight at a minimum temperature of 100°F (38°C).

18.1.4 If the stockpile gradation is unknown, obtain the average washed gradation of each proposed aggregate stockpile in accordance with Tex-200-F, Part II. Enter the stockpile gradations on the Combined Gradation worksheet. Use the construction stockpile washed gradation when it is available.

18.1.5 Check the aggregate gradations for compliance with the applicable specifications. Check the individual aggregate stockpiles for compliance with the applicable specifications.

18.1.6 Check asphalt and additives for compliance with the applicable specifications.

18.1.7 If the specific gravity values for the aggregate sources are unknown, determine the 24-hr. water absorption, the bulk specific gravity, and the apparent specific gravity of individual sizes of each aggregate in accordance with Tex-201-F and Tex-202-F. Enter the results or the known values from previous history on the Bulk Gravity worksheet.

18.1.7.1 Normally, specific gravities are not determined for aggregate size fractions consisting of less than 15% of the individual aggregate. Assign the water absorption and specific gravity of smaller aggregate size fractions close to the next adjacent size fractions for which values are determined.

18.1.8 Use the Combined Gradation worksheet to calculate the bin percentages with the proposed aggregate so that the blended combination will fall within the specified gradation ranges for the specified mixture type.

Note 37—Consider material availability, mixture strength, handling, compaction, pavement texture, and durability as the primary factors of the combination to be tested.

18.1.9 Consider the use of hydrated lime when necessary. Use hydrated lime as an aggregate type when determining the bin percentages for the combined aggregate blend. The combined gradation will include the hydrated lime.

18.1.10 Calculate the sand equivalent value of the combined virgin aggregate in accordance with Tex-203-F. Enter the value on the Material Properties worksheet.

Note 38—Perform the test on the combined aggregates not including lime.

18.1.11 Check the aggregate classification of the combined aggregate blend using the Aggregate Classification worksheet when blending Class A with Class B. Determine whether the percentage of the Class A aggregate in the combined aggregate blend meets the specification requirement in accordance with Section 19.1.

18.1.12 Plot the combined gradation and specification limits using the Grad Chart worksheet. Confirm that the blend meets the specification requirements.

18.2 *Preparing Laboratory Mixed Samples:*

18.2.1 Separate the material larger than the 2.36 mm (No. 8) sieve into individual sizes for each stockpile for preparation of laboratory mixtures. Separate the material passing the 2.36-mm (No. 8) sieve into individual sizes if it is prone to segregation.

18.2.2 Select 2 asphalt contents around the anticipated OAC. Select the asphalt contents within the allowed tolerances in accordance with specifications.

Note 39—Select the asphalt contents to determine the OAC depending on experience and knowledge of materials used.

18.2.3 Calculate individual aggregate and asphalt weights to produce 2 laboratory-molded samples and one G_r sample for each asphalt content selected in Section 18.2.2.

18.2.4 Prepare the asphalt mixtures in accordance with Tex-205-F. Determine the mixing and compaction temperatures in accordance with Tex-241-F.

18.2.5 Determine the G_r of the 2 mixtures in accordance with Tex-227-F. Enter the asphalt content and the G_r values in the appropriate column of the Summary worksheet.

18.2.6 Mold 2 specimens at each asphalt content selected in Section 18.2.2 in accordance with Tex-241-F. Mold specimens to 50 gyrations or as shown in plans.

18.2.7 Determine the G_a of the specimens in accordance with Tex-207-F, Part VIII. Enter the height and dry weight for each asphalt content in the appropriate column of the Summary worksheet to calculate the G_a.

18.2.8 Use the Summary worksheet to calculate G_e and G_t for each asphalt content in accordance with Sections 19.2 and 19.3.

Note 40—The worksheet uses the equation in Section 19.2 and the average G_e for the combined blend to back-calculate the G_r value for all other laboratory-molded specimens.

18.2.9 Use the Summary worksheet to calculate the density of the molded samples in accordance with Sections 19.4 and 19.5.

18.3 *Determining the OAC:*

18.3.1 Use the Film Thickness worksheet to calculate the SA and F_T of the mixtures in accordance with Sections 19.9 and 19.10.

18.3.2 Use the graphs in the Film Thickness worksheet to determine the OAC. The mixture at the OAC must meet the density and film thickness requirements, while staying within the limits for asphalt content as outlined in the specification. If this is not possible according to the predicted estimates, redesign by assuming another combination of aggregates or by obtaining different materials.

18.3.3 Calculate individual aggregate and asphalt weights to produce 2 laboratory-molded samples and one G_r sample at the OAC.

18.3.4 Prepare the asphalt mixture in accordance with Tex-205-F. Determine the mixing and compaction temperatures in accordance with Tex-241-F.

18.3.5 Mold 2 specimens at the OAC in accordance with Tex-241-F. Mold specimens to 50 gyrations or as shown on the plans.

18.3.6 Determine the G_a of the specimens in accordance with Tex-207-F, Part VIII. Enter the heights and dry weights in the appropriate column of the Summary worksheet.

18.3.7 Use the Summary worksheet to backcalculate the G_r, and calculate the density of the molded samples and the F_T for the combined aggregate at the OAC. The calculated density and F_T must meet the specifications.

18.3.8 If the density or F_T does not meet the specifications, modify the OAC and repeat the procedure, starting with Section 18.3.3.

18.4 *Evaluating the Mixture at the OAC:*

18.4.1 Evaluate the draindown of the mixture in accordance with Tex-235-F. Use 350 ± 5°F (177 ± 3°C) for testing temperature.

18.4.2 Evaluate the moisture resistance of the mixture in accordance with Tex-530-C.

18.4.3 Evaluate the durability of the mixture in accordance with Tex-245-F. Mold 2 specimens at the OAC to 50 gyrations. The density of the specimens must meet the specifications.

18.4.4 Report all test results in the Summary worksheet.

18.4.5 If any of the test results does not meet specifications, redesign by assuming another combination of aggregates, by obtaining different materials, or by using a different OAC.

19. CALCULATIONS

19.1 Calculate %Total CL_A:

$$\%\ \text{Total}\ \text{CL}_A = \frac{\%\ CL_A}{\left(\%\ CL_A + \%\ CL_B\right)}$$

Where:

% Total CL_A = total percentage retained of Class A aggregate on the 4.75 mm (No. 4) sieve

$\% \, CL_A$ = percentage retained of Class A aggregate on the 4.75 mm (No. 4) sieve
$\% \, CL_B$ = percentage retained of Class B aggregate on the 4.75 mm (No. 4) sieve.

19.2 Calculate G_e:

$$G_e = \frac{(100 - A_s)}{\left[\left(\frac{100}{G_r}\right) - \left(\frac{A_s}{G_s}\right)\right]}$$

Where:
G_e = effective specific gravity
A_s = asphalt content, %
G_r = theoretical maximum specific gravity
G_s = specific gravity of the asphalt binder.

19.3 Calculate the G_t:

$$G_t = \frac{100}{\left[\left(\frac{A_g}{G_{e(avg)}}\right) + \left(\frac{A_s}{G_s}\right)\right]}$$

Where:
$G_{e(avg)}$ = average of the effective specific gravities obtained
G_t = calculated theoretical maximum specific gravity
A_g = percentage of aggregate in the mixture.

19.4 Calculate the percent density of the molded samples:

$$\% \text{ Density} = \left(\frac{G_a}{G_t}\right) \times 100$$

Where:
% Density = percentage of the ratio of G_a to G_t
G_a = bulk specific gravity.

19.5 Calculate the design VMA:

$$VMA = \left\{100 - \left[\left(\frac{G_a}{G_t}\right) \times 100\right]\right\} + \left[\frac{G_a \times A_s}{G_s}\right]$$

Where:
VMA = voids in mineral aggregates.

19.6 Calculate the production VMA:

$$VMA = \left\{100 - \left[\left(\frac{G_a}{G_r}\right)\times 100\right]\right\} + \left[\frac{G_a \times A_s}{G_s}\right]$$

19.7 Calculate the VCA_{CA}:

$$VCA_{CA} = \left\{\frac{\left[\left(G_{CA}\times\gamma_w\right)-\gamma_s\right]}{\left(G_{CA}\times\gamma_w\right)}\right\}\times 100$$

Where:

VCA_{CA} = voids in the coarse aggregate in the dry-rodded condition

G_{CA} = bulk specific gravity of the coarse aggregate blend (retained on the 2.36 mm (No.8) sieve)

γ_w = unit weight of water

γ_s = unit weight of the coarse aggregate blend fraction in the dry-rodded condition.

19.8 Calculate the VCA_{Mix}:

$$VCA_{Mix} = 100 - \left[\left(\frac{G_a}{G_{CA}}\right)\times P_{CA}\right]$$

Where:

VCA_{Mix} = voids in coarse aggregate for the compacted mixture

P_{CA} = percentage coarse aggregate in the total mix.

19.9 Calculate SA:

$$SA = \frac{0.41 + (\%P\#4)0.41 + (\%P\#8)0.82 + (\%P\#16)1.64 + (\%P\#30)2.87 + (\%P\#50)6.14 + (\%P\#100)12.29 + (\%P\#200)32.77}{100}$$

Where:

SA = surface area, m^2/kg

$\%Pi$ = Aggregate passing sieve # i, %.

Note 41—*%P#30* and *%P#100* are automatically interpolated in the DATA_Film Thickness worksheet by using the *%P#16–%P#50* and *%P#50–%P#200*, respectively.

19.10 Calculate F_T:

$$P_{ba} = 100 * G_s\left(\frac{G_e - G_{sb}}{G_{sb} * G_e}\right)$$

$$P_{be} = A_s - P_{ba}\left(\frac{100 - A_s}{100}\right)$$

$$F_T = \frac{\left(\dfrac{P_{be}/100}{1 - P_{be}/100}\right)}{SA * G_s * 1000} * 10^6$$

Where:

P_{ba} = absorbed asphalt in mixture, %

G_{sb} = bulk specific gravity of combined aggregates

P_{be} = effective asphalt in mixture, %

F_T = film thickness of asphalt binder in mixture, microns.

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20. ARCHIVED VERSIONS

20.1 Archived versions are available.