Test Procedure for

DESIGN OF ULTRA-THIN BONDED HOT MIX WEARING COURSE (UTBHMWC) MIXTURES

TxDOT Designation: Tex-247-F

Effective Date: August 2008–August 2016.

1. SCOPE

1.1 This test method determines the proper proportions by weight of approved aggregates and asphalt, which, when combined, will produce a UTBHMWC mixture that will satisfy the specification requirements.

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
	P_{ba}	Percent by weight of absorbed asphalt in the mixture
	P_{be}	Percent by weight of effective asphalt in the mixture
G_e	G_{se}	Effective specific gravity of the combined aggregates
	G_{sb}	Bulk specific gravity of the combined aggregates
G_s	G_b	Specific gravity of the asphalt binder determined at 25°C (77°F)
G_r	G_{mm}	Theoretical maximum specific gravity
G_t	$G_{max\text{-}theo}$	Calculated theoretical maximum specific gravity of the mixture at the specified asphalt content
SA	SA	Surface area in m^2/kg of combined aggregate gradation
F_T	F_T	Film thickness in microns of asphalt binder in mixture
% 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

Nomenclatures		Definitions
Conventional	**Superpave**	
% CL_B	-	% retained of Class B aggregate on the 4.75 mm (#4) sieve
VMA	VMA	Voids in mineral aggregates

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 The Mix Design Report is an automated form containing the following worksheets:

- Combined Gradation
- Material Properties (Matl Properties)
- Aggregate Classification Blending (Aggregate Classification)
- Weigh-Up Sheet (Weigh Up)
- Aggregate Bulk Gravity (Bulk Gravity)
- Summary
- Film Thickness
- Power 0.45 Curve (Power 45 Curve)
- Asphalt Content versus Density, VMA, Ga, and Gr (Charts).

2.1.1 The title in parentheses is the worksheet title in the automated program. See examples of these worksheets in Section 5.

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

3. PROCEDURE

3.1 *Selecting Materials:*

3.1.1 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.

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

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

3.1.4 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.

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

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

3.1.7 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.

3.1.7.1 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.

3.1.8 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 1—Consider material availability, mixture strength, handling, compaction, pavement texture, and durability as the primary factors of the combination to be tested.

3.1.9 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.

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

Note 2—Perform the test on the combined aggregates not including lime.

3.1.11 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 4.1.

3.1.12 Plot the combined gradation and specification limits using the Power 45 Curve worksheet. Confirm that the blend meets the specification requirements.

3.2 *Preparing Laboratory Mixed Samples:*

3.2.1 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.

3.2.2 Select two asphalt contents around the anticipated OAC. Select the asphalt contents within the allowed tolerances in accordance with specifications.

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

3.2.3 Calculate individual aggregate and asphalt weights to produce two laboratory-molded samples and one G_r sample for each asphalt content selected in Section 3.2.2.

3.2.4 Prepare the asphalt mixtures in accordance with Tex-205-F. Determine the mixing and compaction temperatures in accordance with Tex-241-F. Oven-cure the mixture for G_r for 2 hr. at the selected compaction temperature.

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

3.2.6 Mold two specimens at each asphalt content selected in Section 3.2.2 in accordance with Tex-241-F. Mold specimens to 50 gyrations or as shown in plans.

3.2.7 Determine the G_a of the specimens in accordance with Tex-207-F, Part VI. Enter the average G_a for each asphalt content in the appropriate column of the Summary worksheet.

3.2.8 Use the Summary worksheet to calculate G_e and G_t for each asphalt content in accordance with Sections 4.2 and 4.3.

3.2.9 Use the Summary worksheet to calculate the density and VMA of the molded samples in accordance with Sections 4.4 and 4.5.

3.3 *Determining the OAC:*

3.3.1 Use the Film Thickness worksheet to calculate the SA and F_T of the mixtures in accordance with Sections 4.6 and 4.7.

3.3.2 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.

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

3.3.4 Prepare the asphalt mixture in accordance with Tex-205-F. Determine the mixing and compaction temperatures in accordance with Tex-241-F. Oven-cure the mixture for G_r for 2 hr. at the selected compaction temperature.

3.3.5 Determine the G_r at the OAC in accordance with Tex-227-F. Enter the OAC and the G_r value in the appropriate column of the Summary worksheet.

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

3.3.7 Determine the G_a of the specimens in accordance with Tex-207-F, Part VI. Enter the average G_a in the appropriate column of the Summary worksheet.

3.3.8 Use the Summary worksheet to recalculate the G_e. 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.

3.3.9 If the density or F_T does not meet the specifications, modify the OAC and repeat procedure, starting with Section 3.3.3.

3.4 *Evaluating the Mixture at the OAC:*

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

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

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

Note 4—Test and report for informational purposes only.

3.4.4 Report all test results in the Summary worksheet.

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

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4. CALCULATIONS

4.1 Calculate % Total CL_A:

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

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.

4.2 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.

4.3 Calculate the G_t:

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

Where:
G_t = calculated theoretical maximum specific gravity
A_g = percentage of aggregate in the mixture.

4.4 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.

4.5 Calculate the 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.

4.6 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*, %.

4.7 Calculate F_T:

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

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

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

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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5. MIX DESIGN EXAMPLE

5.1 The following example describes the process necessary to develop proper mixtures using approved materials for a given application or surface requirement.

5.2 Use the following processed materials to design a gap-graded hot-mix asphalt concrete mix:

- aggregate A—a Type C material with 12.5 mm (1/2 in.) maximum size and surface aggregate classification of class A from Source 1
- aggregate B—a Type D material with 9.3 mm (3/8 in.) maximum size and surface aggregate classification of Class B
- washed screenings
- unwashed screenings
- aggregate C—a Type C material with12.5 mm (1/2 in.) maximum size and surface aggregate classification of Class A from Source 2
- hydrated lime
- PG 70-28.

5.2.1 Combine the five aggregates, lime, and asphalt in proportions that meet the requirements for a Type C Ultra Thin Bonded Wearing Course mixture under the applicable specification.

5.3 *Selecting Materials:*

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

5.3.2 Obtain the washed sieve analysis of each of the proposed materials using the Sieve Analysis of Non-Surface Treatment Aggregates worksheet, as shown in Figure 1. This example shows the gradation of the Type C aggregate used in this sample mix design.

5.3.3 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 28% by weight of aggregate A, 20% by weight of aggregate B, 10% by weight of washed screenings, 16% by weight of unwashed screenings, 25% by weight of aggregate C, and 1% by weight of hydrated lime.

5.3.4 Use the Combined Gradation worksheet to calculate the combined blend gradation in percent passing of each sieve size, as shown in Figure 2. Use the bin percentages selected in Section 5.3.3. This example also shows the individual and cumulative percent retained of the combined blend.

5.3.5 Use the Bulk Gravity worksheet to calculate the combined bulk specific gravity for the aggregate, as shown in Figure 3. The combined bulk specific gravity calculates the asphalt absorption and in turn F_T, as described in Section 5.5.1.

5.3.6 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.

5.4 *Preparing Laboratory Mixed Samples:*

5.4.1 Select two asphalt contents around the anticipated OAC. Select the asphalt contents within the allowed tolerances in accordance with specifications.

5.4.2 Determine the weight of mixture required to produce a specimen height of 115 ± 5 mm (4.5 ± 0.2 in.) at 50 gyrations or as shown in plans.

Note 5—It may be necessary to produce a trial specimen to achieve this height requirement. Generally, 4,500–4,700 g of aggregate are required to achieve this height for aggregates with combined bulk specific gravities (G_a) of 2.55–2.70, respectively.

5.4.3 Calculate individual or cumulative aggregate weights with an asphalt weight. Figure 4 is an example weigh-up showing the aggregate and asphalt weights. Produce a 2000 g sample at each asphalt content for G_r. A mixture size of 5000 g is adequate to produce one mold for G_a when using a large mechanical mixer. Produce two aggregate batch samples at each asphalt content for G_a.

5.4.4 The asphalt contents for these test mixes are 4.8% and 5.2% by weight for this mix design example; therefore, the corresponding percentages by weight of the aggregate in the mixtures will be 95.2% and 94.8%. For this example, the total aggregate weight for a 4543 g batch at 4.8% asphalt will be 4324.9 g, and the weight of the asphalt will be 218.1 g.

5.4.5 Weigh the materials for each of the batches containing 4.8% and 5.2% asphalt content. Mix and mold two test specimens at each asphalt content in accordance with Tex-241-F.

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

5.4.7 Determine the G_a of each of the molded specimens in accordance with Tex-207-F, Part VI. Calculate the average of the two molds and enter the result in the Summary worksheet, as shown in Figure 5. The G_a for this example are 2.241 and 2.304 at 4.8% and 5.2% asphalt content, respectively.

5.4.8 Use the Summary worksheet to calculate VMA, G_e, and G_t for each asphalt content, as shown in Figure 5.

5.5 *Determining the OAC* :

5.5.1 Use the Film Thickness worksheet to calculate the SA and F_T of the mixture, as shown in Figure 6.

5.5.2 Use the graphs in the Film Thickness worksheet to estimate the OAC. Approximate an asphalt content that lies along the plotted curve for the molded specimens and is within the density and film thickness requirements. Enter the estimated asphalt content into the Film Thickness worksheet, as shown in Figure 7. In this example, the estimated asphalt content is 5.0%.

5.6 *Evaluating the Mixture at the OAC:*

5.6.1 Mold two specimens at the estimated OAC.

5.6.2 Determine the G_r of the estimated asphalt content specimen in accordance with Tex-227-F. Enter the result in the Summary worksheet, as shown in Figure 8. The value for this example is 2.503.

5.6.3 Determine the G_a of the molded specimens in accordance with Tex-207-F, Part VI. Calculate the average of the two molds and enter the result in the Summary worksheet, as shown in Figure 8. The G_a for this example is 2.263.

5.6.4 Verify that F_T and density requirements are met for the estimated asphalt content specimens. In this example, an F_T value of 10.5 microns and a density of 90.4% are within tolerance.

5.6.5 Determine the draindown of the mixture at 350 ± 5°F (177 ± 3°C), in accordance with Tex-235-F. Enter values into the Summary worksheet, as shown in Figure 8. The draindown for this example is 0.0%

5.6.6 Determine the moisture resistance of the mixture in accordance with Tex-530-C. Enter values into the Summary worksheet, as shown in Figure 8. The percent stripping in this example is 2%.

5.6.7 Determine the Cantabro abrasion loss of the mixture in accordance with Tex-245-F. Enter the percent loss into the Summary worksheet as shown in Figure 8. The Cantabro Loss in this example is 10%.

TEXAS DEPARTMENT OF TRANSPORTATION

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

Refresh Workbook

File Version: 04/17/08 08:12:59

SAMPLE ID:		SAMPLED DATE:	
TEST NUMBER:		LETTING DATE:	
SAMPLE STATUS:		CONTROLLING CSJ:	
COUNTY:		SPEC YEAR:	2004
SAMPLED BY:		SPEC ITEM:	
SAMPLE LOCATION:		SPECIAL PROVISION:	
MATERIAL CODE:		GRADE:	Type C
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):	1,999.0

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
1/2"	1,120.0	1,120.0	56.0	44.0			
3/8"	680.0	1,800.0	90.0	10.0			
No. 4	160.0	1,960.0	98.0	2.0			
No. 8	20.0	1,980.0	99.0	1.0			
No. 16	0.0	1,980.0	99.0	1.0			
No. 30	0.0	1,980.0	99.0	1.0			
No. 50	0.0	1,980.0	99.0	1.0			
No. 100	0.0	1,980.0	99.0	1.0			
No. 200	0.0	1,980.0	99.0	1.0			

-No. 200	18.0		
	1.0	Sieving Loss, (g) from 'Dry Weight After Washing' weight	
	1.0	Washing Loss, (g)	
Total -No. 200	20.0	2,000.0	100.0
Total Weight:	2,000.0		

Remarks:

Figure 1—Sieve Analysis of Fine and Coarse Aggregates

Refresh Workbook

File Version: 04/17/08 08:13:09

SAMPLE ID:		SAMPLE DATE:	
LOT NUMBER:		LETTING DATE:	
SAMPLE STATUS:		CONTROLLING CSJ:	
COUNTY:		SPEC YEAR:	2004
SAMPLED BY:		SPEC ITEM:	
SAMPLE LOCATION:		SPECIAL PROVISION:	
MATERIAL CODE:		MIX TYPE:	ITEM3142_UTBWC_C
MATERIAL NAME:			
PRODUCER:			
AREA ENGINEER:		PROJECT MANAGER:	

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

	BIN FRACTIONS						
	Bin No.1	Bin No.2	Bin No.3	Bin No.4	Bin No.5	Bin No.6	Bin No.7
Aggregate Source:	Vulcan	Hanson	Vulcan	Laredo	Hanson		
Aggregate Pit:	Brownwood	Brownwood	Brownwood	Brownwood	Brownwood		
Aggregate Number:	0-5519	0-51685	-1098	5-15984	6-*4954		
Sample ID:	Type C	Type D	Screenings	Dry Screenings	Type C	Lime	
Rap?:							

Combined Gradation

	Bin No.1		Bin No.2		Bin No.3		Bin No.4		Bin No.5		Bin No.6		Bin No.7		Total Bin	Lower & Upper Specification Limits			Restricted Zone	
Individual Bin (%):	28.0	Percent	20.0	Percent	10.0	Percent	16.0	Percent	25.0	Percent	1.0	Percent		Percent	100.0%					
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.%	Cum.% Passing	Lower	Upper	Within Spec's	Lower	Upper
3/4"	100.0	28.0	100.0	20.0	100.0	10.0	100.0	16.0	100.0	25.0	100.0	1.0			100.0	100.0	100.0	Yes		
1/2"	44.0	12.3	100.0	20.0	100.0	10.0	100.0	16.0	89.0	22.3	100.0	1.0			81.6	75.0	100.0	Yes		
3/8"	10.0	2.8	88.0	17.6	100.0	10.0	100.0	16.0	47.0	11.8	100.0	1.0			59.2	55.0	80.0	Yes		
No. 4	2.0	0.6	27.0	5.4	100.0	10.0	100.0	16.0	2.0	0.5	100.0	1.0			33.5	22.0	36.0	Yes		
No. 8	1.0	0.3	5.0	1.0	85.0	8.5	82.0	13.1	1.0	0.3	100.0	1.0			24.2	19.0	30.0	Yes		
No. 16	1.0	0.3	1.0	0.2	53.0	5.3	59.0	9.4	1.0	0.3	100.0	1.0			16.5	14.0	24.0	Yes		
No. 30	1.0	0.3	1.0	0.2	31.0	3.1	42.0	6.7	1.0	0.3	100.0	1.0			11.6	10.0	18.0	Yes		
No. 50	1.0	0.3	1.0	0.2	16.0	1.6	32.0	5.1	1.0	0.3	100.0	1.0			8.5	7.0	14.0	Yes		
No. 100	1.0	0.3	1.0	0.2	7.0	0.7	26.0	4.2	1.0	0.3	100.0	1.0			6.6	5.0	10.0	Yes		
No. 200	1.0	0.3	1.0	0.2	6.4	0.6	21.5	3.4	0.8	0.2	100.0	1.0			5.8	4.0	6.0	Yes		

Not within specifications # Not cumulative

Asphalt Source & Grade:	Alon Big Spring 70-28	Binder Percent, (%):	5.0	Asphalt Spec. Grav.:	1.025

Figure 2—Combined Gradation

SAMPLE ID:		SAMPLE DATE:	
LOT NUMBER:		LETTING DATE:	
SAMPLE STATUS:		CONTROLLING CSJ:	
COUNTY:		SPEC YEAR:	2004
SAMPLED BY:		SPEC ITEM:	
SAMPLE LOCATION:		SPECIAL PROVISION:	
MATERIAL CODE:		MIX TYPE:	ITEM3142_UTBWC_C
MATERIAL NAME:			
PRODUCER:			
AREA ENGINEER:		PROJECT MANAGER:	

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

	Bin No.1	Bin No.2	Bin No.3	Bin No.4	Bin No.5	Bin No.6	Bin No.7
Individual Bin (%):	Bin No.1 = 28 %	Bin No.2 = 20 %	Bin No.3 = 10 %	Bin No.4 = 16 %	Bin No.5 = 25 %	Bin No.6 = 1 %	
Aggregate Source:	Vulcan	Hansen	Vulcan	Laredo	Hansen		
Aggregate Number:	0-5583	0-53517	-1083	5-15987	6-*6436		
Sample ID:	Type C	Type D	Screenings	Dry Screenings	Type C	Lime	

Sieve Size: Passing	Sieve Size: Retained	Bin No.1 Individual Ret., %	Bin No.1 Bulk SG	Bin No.2 Individual Ret., %	Bin No.2 Bulk SG	Bin No.3 Individual Ret., %	Bin No.3 Bulk SG	Bin No.4 Individual Ret., %	Bin No.4 Bulk SG	Bin No.5 Individual Ret., %	Bin No.5 Bulk SG	Bin No.6 Individual Ret., %	Bin No.6 Bulk SG	Bin No.7 Individual Ret., %	Bin No.7 Bulk SG
	3/4"														
3/4"	1/2"	56.0	2.687							11.0	2.705				
1/2"	3/8"	34.0	2.687	12.0	2.695					42.0	2.705				
3/8"	No. 4	8.0	2.687	61.0	2.695					45.0	2.705				
No. 4	No. 8	1.0	2.687	22.0	2.695	15.0	2.692	18.0	2.614	1.0	2.705				
No. 8	No. 16			4.0	2.695	32.0	2.692	23.0	2.614						
No. 16	No. 30					22.0	2.692	17.0	2.614						
No. 30	No. 50					15.0	2.692	10.0	2.614						
No. 50	No. 100					9.0	2.692	6.0	2.614						
No. 100	No. 200					0.6	2.692	4.5	2.614	0.2	2.705				
No. 200	Pan	1.0	2.687	1.0	2.695	6.4	2.692	21.5	2.614	0.8	2.705	100.0	2.886		
Totals		100.0	2.687	100.0	2.695	100.0	2.692	100.0	2.614	100.0	2.705	100.0	2.886		

Combined Bulk Specific Gravity:	**2.683**	Specific Gravity of Asphalt:	**1.025**
Coarse Agg. Combined BSG:			

Figure 3—Bulk Gravity

SAMPLE ID:		SAMPLE DATE:	
LOT NUMBER:		LETTING DATE:	
SAMPLE STATUS:		CONTROLLING CSJ:	
COUNTY:		SPEC YEAR:	2004
SAMPLED BY:		SPEC ITEM:	
SAMPLE LOCATION:		SPECIAL PROVISION:	
MATERIAL CODE:		MIX TYPE:	ITEM3142_UTBWC_C
MATERIAL NAME:			
PRODUCER:			
AREA ENGINEER:		PROJECT MANAGER:	

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

Aggregate Weight, g:	4,324.9
4.8% Asphalt by Weight of Aggr, g:	218.1
Total Weight, g:	4543.0

4.8% Asphalt by Weight of Aggregate, g:	218.1
(Alon Big Spring 70-28) Asphalt to Add, g:	218.1

	Passing	Retained	Bin No.1	Bin No.2	Bin No.3	Bin No.4	Bin No.5	Bin No.6	Bin No.7	Total Weights	Individual Retained, %	Cumulative Retained, %
Individual Bin (%):			Bin No.1 - 28%	Bin No.2 - 20%	Bin No.3 - 10%	Bin No.4 - 16%	Bin No.5 - 25%	Bin No.6 - 1%				
Aggregate Source:			Valson	Hanson	Valson	Laredo	Hanson					
Aggregate Number:			8-5585	8-53517	-1885	5-15987	6-15456					
Sample ID:			Type C	Type D	Screenings	Dry Screenings	Type C	Lime				
	Sieve Size:		Aggregate Weight	Aggregate Weight	Aggregate Weight	Aggregate Weight	Aggregate Weight	Aggregate 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"	678.1	0.0	0.0	0.0	118.9	0.0		797.1	18.4	18.4
	1/2"	3/8"	411.7	103.8	0.0	0.0	454.1	0.0		969.6	22.4	40.9
	3/8"	No. 4	96.9	527.6	0.0	0.0	486.6	0.0		1,111.1	25.7	66.5
	No. 4	No. 8	12.1	190.3	64.9	124.6	10.8	0.0		402.6	9.3	75.9
	No. 8	No. 16	0.0	34.6	138.4	159.2	0.0	0.0		332.2	7.7	83.5
	No. 16	No. 30	0.0	0.0	95.1	117.6	0.0	0.0		212.8	4.9	88.5
	No. 30	No. 50	0.0	0.0	64.9	69.2	0.0	0.0		134.1	3.1	91.6
	No. 50	No. 100	0.0	0.0	38.9	41.5	0.0	0.0		80.4	1.9	93.4
	No. 100	No. 200	0.0	0.0	2.6	31.1	2.2	0.0		35.9	0.8	94.2
	No. 200	Pan	12.1	8.6	27.7	148.8	8.6	43.2		249.1	5.8	100.0
	Totals		1,211.0	865.0	432.5	692.0	1,081.2	43.2		###		
Running Total:												
CUMULATIVE	-	3/4"	0.0	1,211.0	2,076.0	2,508.4	3,200.4	4,281.7		0.0		
	3/4"	1/2"	678.1	1,211.0	2,076.0	2,508.4	3,319.4	4,281.7		797.1		
	1/2"	3/8"	1,089.9	1,314.8	2,076.0	2,508.4	3,773.5	4,281.7		1,766.7		
	3/8"	No. 4	1,186.8	1,842.4	2,076.0	2,508.4	4,260.0	4,281.7		2,877.8		
	No. 4	No. 8	1,198.9	2,032.7	2,140.8	2,633.0	4,270.8	4,281.7		3,280.4		
	No. 8	No. 16	1,198.9	2,067.3	2,279.2	2,792.2	4,270.8	4,281.7		3,612.6		
	No. 16	No. 30	1,198.9	2,067.3	2,374.4	2,909.8	4,270.8	4,281.7		3,825.4		
	No. 30	No. 50	1,198.9	2,067.3	2,439.2	2,979.0	4,270.8	4,281.7		3,959.4		
	No. 50	No. 100	1,198.9	2,067.3	2,478.2	3,020.5	4,270.8	4,281.7		4,039.9		
	No. 100	No. 200	1,198.9	2,067.3	2,480.8	3,051.6	4,273.0	4,281.7		4,075.8		
	No. 200	Pan	1,211.0	2,076.0	2,508.4	3,200.4	4,281.7	4,324.9		###		

Figure 4—Weigh Up

TEXAS DEPARTMENT OF TRANSPORTATION

HMACP MIXTURE DESIGN : SUMMARY SHEET

File Version: 04/17/08 08:13:09

SAMPLE ID:		SAMPLE DATE:	
LOT NUMBER:		LETTING DATE:	
SAMPLE STATUS:		CONTROLLING CSJ:	
COUNTY:		SPEC YEAR:	2004
SAMPLED BY:		SPEC ITEM:	
SAMPLE LOCATION:		SPECIAL PROVISION:	
MATERIAL CODE:		MIX TYPE:	ITEM3142_UTBWC_C
MATERIAL NAME:			
PRODUCER:			
AREA ENGINEER:		PROJECT MANAGER:	

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

Number of Gyrations: 50 <<50 Gyrations   CRM* Content

TEST SPECIMENS						
Asphalt Content (%)	Specific Gravity Of Specimen (Ga)	Maximum Specific Gravity (Gr)	Effective Gravity (Ge)	Theo. Max. Specific Gravity (Gt)	Density from Gt (Percent)	VMA (Percent)
4.8	2.241	2.511	2.709	2.511	89.3	21.2
5.2	2.304	2.495	2.708	2.495	92.3	19.4

Figure 5—Summary I

TEXAS DEPARTMENT OF TRANSPORTATION

HMACP MIXTURE DESIGN : SUMMARY SHEET

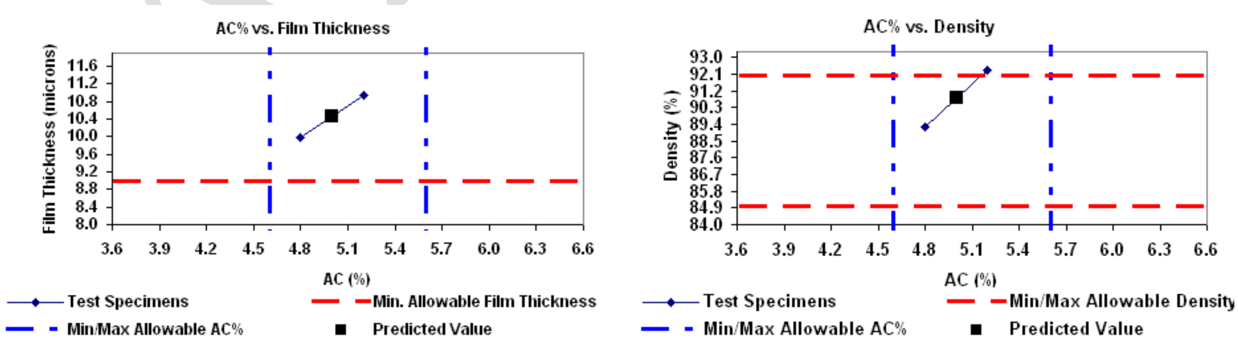
SAMPLE ID:		SAMPLE DATE:	
LOT NUMBER:		LETTING DATE:	
SAMPLE STATUS:		CONTROLLING CSJ:	
COUNTY:		SPEC YEAR:	2004
SAMPLED BY:		SPEC ITEM:	
SAMPLE LOCATION:		SPECIAL PROVISION:	
MATERIAL CODE:		MIX TYPE:	ITEM3142_UTBWC_C
MATERIAL NAME:			
PRODUCER:			
AREA ENGINEER:		PROJECT MANAGER:	

COURSE\LIFT:		STATION:		DIST. FROM CL:	

Sieve Size:	Cumlative % Passing	Suface Area Factor	Surface Area (m²/kg)	Asphalt Absorption
3/4"	100	0.41	0.41	0.36
1/2"	81.57	-	-	
3/8"	59.15	-	-	
No. 4	33.46	0.41	0.14	
No. 8	24.15	0.82	0.20	
No. 16	16.47	1.64	0.27	
No. 30	11.55	2.87	0.33	
No. 50	8.45	6.14	0.52	
No. 100	6.59	12.29	0.81	
No. 200	5.76	32.77	1.89	

Asphalt Content (%)	Specific Gravity Of Specimen (Ga)	Maximum Specific Gravity (Gr)	Effective Asphalt Content (%)	Film Thickness (microns)	Density from Gt (Percent)
4.8	2.241	2.511	4.5	10.0	89.3
5.2	2.304	2.495	4.9	10.9	92.3

Figure 6—Film Thickness I



PREDICTION ESTIMATES		
AC %	Film Thickness (microns)	Density (%)
5.0	10.5	90.8

Figure 7—Film Thickness II

	TEST SPECIMENS						
	Asphalt Content (%)	Specific Gravity Of Specimen (Ga)	Maximum Specific Gravity (Gr)	Effective Gravity (Ge)	Theo. Max. Specific Gravity (Gt)	Density from Gt (Percent)	VMA (Percent)
1	4.8	2.241	2.511	2.709	2.511	89.3	21.2
2	5.2	2.304	2.495	2.708	2.495	92.3	19.4

FINAL SPECIMEN					
Asphalt Content (%)	Specific Gravity Of Specimen (Ga)	Maximum Specific Gravity (Gr)	Effective Gravity (Ge)	Density from Gr (Percent)	Film Thickness (microns)
5.0	2.263	2.503	2.709	90.4	10.5

Suggested Membrane Target App. Rate, gal/yd2:	0.22
Estimated Percent of Stripping, %:	2
Drain-Down, %:	**0.0**
Cantabro Loss, %:	**10.0**

Figure 8—Summary II