CHAPTER 5

BLENDING AGGREGATES

A good asphalt concrete pavement requires more than asphalt, aggregates and equipment. It also requires knowledge, skill, and workmanship. Part of this knowledge and skill is the ability to blend aggregates to meet a specified target,known as the job-mix formula.

Asphalt concrete requires the combining of two or more aggregates, having different gradations, to produce an aggregate blend that meets gradation specifications for a particular asphalt mix. Refer to the VDOT Road & Bridge Specification Book - Section 211 Asphalt Concrete, Section 211.03 Table II-13 (Figure 5-1, page 5-4) for the design gradations for various types of mixes.

Definition of a Job-Mix Formula

In its simplest form, a job-mix formula consists of two parts:

1. The **Combined Gradation** of the aggregates to be used in the production of the asphalt concrete mixture.
2. The **Asphalt Content** necessary to produce a satisfactory mix meeting all the specification requirements.

Method for Combining Aggregates

Mathematical procedures are available to determine an optimum combination of aggregates, but the "Trial and Error Method" guided by a certain amount of reasoning is the most practical procedure to determine a satisfactory combination and the one we will demonstrate.

Trial and Error Method

Step 1 - Obtain the required data.

a. The gradation of each material must be determined.
b. The design limits for the type of mix must be obtained. See the VDOT Road & Bridge Book, Section 211.03 Table II-13. (See Figure 5-1, page 5-4). Enter this information on the worksheet.

Step 2 - Select a target value for trial blend.

The target value for the combined gradation must be within the design limits of the specifications. This value now becomes the target for the combined gradation.

NOTE: Target values should be provided by the Mix Design Technician.

Step 3 - <u>Estimate the proportions.</u>

Estimate the correct percentage of each aggregate needed to get a combined gradation near the target value. For example, if aggregates are combined, a possible combination may be 30% of Aggregate 1 and 70% of Aggregate 2.

Step 4 - <u>Calculate the combined gradation.</u>

This calculation will show the results of the estimate from <u>Step 3.</u> The method of calculating the combined gradation will be shown in the example problem.

Step 5 - <u>Compare the result with the target value.</u>

If the calculated gradation is close to the target value, no further adjustments need to be made; if not, an adjustment in the proportions must be made and the calculations repeated. The second trial should be closer due to the "education" received from the first. The trials are continued until the proportions of each aggregate are found that will come close to the target value. If the aggregates will not combine within the design range, it may be necessary to use or add different materials.

General Math Conversion:

Convert a percent (%)to a decimal, divide by 100 or move decimal place two places to the left.

Example: 75%: 75/100 = .75

BLENDING WORKSHEET

Use this worksheet to mathematically blend aggregates by hand.

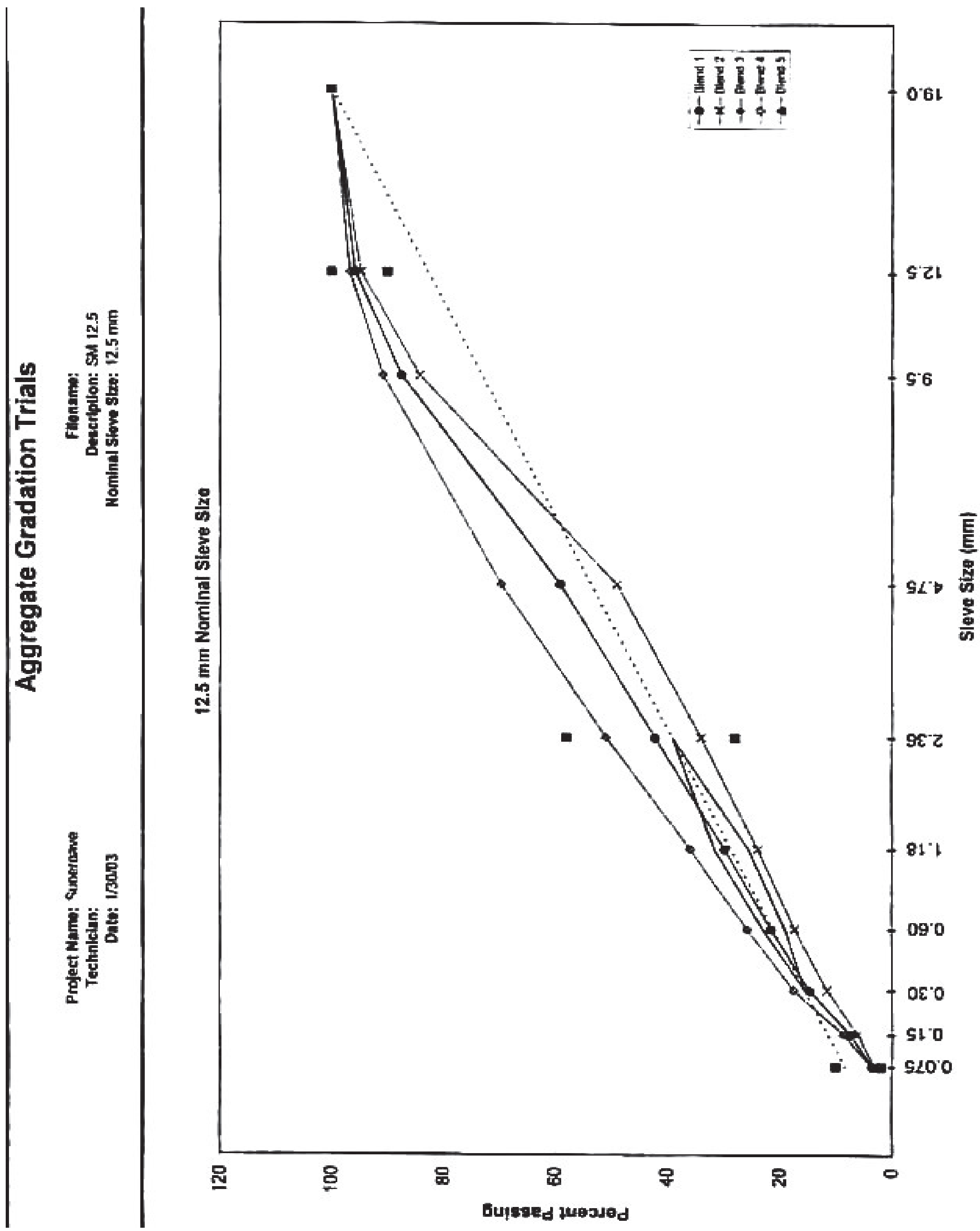
Mat'l									
% Used									
Sieve (in)	% Pass	% Blend	% Pass	% Blend	% Pass	% Blend	Total Blend	Target Value	Design Range
1 1/2									
1									
3/4									
1/2									
3/8									
No. 4									
No. 8									
No. 30									
No. 50									
No. 100									
No. 200									

T A B L E II - 13
ASPHALT CONCRETE MIXTURES-DESIGN RANGE
PERCENTAGE BY WEIGHT PASSING SQUARE MESH SIEVES (in)

Mix Type	2	1 1/2	1	3/4	1/2	3/8	No. 4	No. 8	No. 30	No. 50	No. 200
SM-9.0 A,D,E					100 *	90-100	90 max	47-67			2-10
SM-9.5 A,D,E					100 *	90-100	80 max	38-67			2-10
SM-12.5 A,D,E				100	95-100	90 max	--	34-50			2-10
IM-19.0 A,D			100	90-100	90 max	--	--	28-49			2-8
BM-25.0		100	90-100	90 max	--	--	--	19-38			1-7
C (Curb Mix)					100	92-100	70-75	50-60	28-36	15-20	7-9

Legend SM = Surface Mixture, IM = Intermediate Mixture, BM = Base Mixture, C = Curb Mix
* A production tolerance of 1% will be applied to this sieve, regardless of the number of tests in the lot.

Figure 5-1



Completed 0.45 Gradation Chart
Figure 5-2

Example Problem No. 1

Trial and Error Combination of Two Aggregates

Aggregate 1 and Aggregate 2. The mix type is an SM-12.5 A.

Step 1 - Enter the data (aggregate gradations and design limits) in appropriate columns.

Mat'l % Used	Aggregate 1		Aggregate 2						
Sieve (in)	**% Pass**	% Blend	**% Pass**	% Blend	% Pass	% Blend	Total Blend	Target Value	**Design Range**
1 1/2									
1									
3/4	**100**		**100**						**100**
1/2	**100**		**94**						**95 – 100**
3/8	**94**		**65**						**90 max**
No. 4									
No. 8	**52**		**27**						**34 – 50**
No. 30									
No. 50									
No. 100									
No. 200	**7.1**		**1.2**						**2 – 10**

Example Problem No. 1 (continued)

Step 2 - Determine the target vaue

Target Value must be within design range.
<u>The Target Value is provided by Mix Design Technician.</u>

Mat'l % Used	Aggregate 1		Aggregate 2						
Sieve (in)	% Pass	% Blend	% Pass	% Blend	% Pass	% Blend	Total Blend	**Target Value**	Design Range
1 1/2									
1									
3/4	100		100					**100**	100
1/2	100		94					**98**	95 – 100
3/8	94		65					**88**	90 max
No. 4									
No. 8	52		27					**47**	34 – 50
No. 30									
No. 50									
No. 100									
No. 200	7.1		1.2					**6**	2 – 10

Example Problem No. 1 (continued)

Step 3 - Estimate the proportions.

The first estimate might be 50% of Aggregate 1 and 50% of Aggregate 2. Enter these figures on the line marked "% Used".

Remember the sum of the proportions must always equal 100.

Mat'l	Aggregate 1		Aggregate 2						
% Used	**50**		**50**						
Sieve (in)	% Pass	% Blend	% Pass	% Blend	% Pass	% Blend	Total Blend	Target Value	Design Range
1 1/2									
1									
3/4	100		100					100	100
1/2	100		94					98	95 – 100
3/8	94		65					88	90 max
No. 4									
No. 8	52		27					47	34 – 50
No. 30									
No. 50									
No. 100									
No. 200	7.1		1.2					6	2 – 10

Example Problem No. 1 (continued)

Step 4 - Calculate the individual proportions on each sieve for each of the two aggregates and enter in the column "% blend". Add the two columns for each sieve and enter in the column "Total Blend".

Blend = % Pass x Percent Aggregate Proportion

Remember, change Percent Aggregate Proportion to decimal.

Total Blend = % Blend Aggregate 1 + % Blend Aggregate 2

Calculations:

% Blend:

Sieve	Aggregate 1	Aggregate 2
3/4	100 x .50 = **50**	100 x .50 = **50**
1/2	100 x .50 = **50**	94 x .50 = **47**
3/8	94 x .50 = **47**	65 x .50 = **32.5**
No. 8	52 x .50 = **26**	27 x .50 = **13.5**
No. 200	7.1 x .50 = **3.6**	1.2 x .50 = **0.6**

Total Blend:

Sieve	Aggregate 1	+	Aggregate 2	=	Total Blend
3/4	50	+	50	=	**100**
1/2	50	+	47	=	**97**
3/8	47	+	32.5	=	**79.5 round to 80**
No. 8	26	+	13.5	=	**39.5 round to 40**
No. 200	3.6	+	0.6	=	**4.2**

Example Problem No. 1 (continued)

Step 4 - Continued

Mat'l % Used	Aggregate 1 50		Aggregate 2 50						
Sieve (in)	% Pass	**% Blend**	% Pass	**% Blend**	% Pass	% Blend	**Total Blend**	Target Value	Design Range
1 1/2									
1									
3/4	100	**50**	100	**50**			**100**	100	100
1/2	100	**50**	94	**47**			**97**	98	95 – 100
3/8	94	**47**	65	**32.5**			**80**	88	90 max
No. 4									
No. 8	52	**26**	27	**13.5**			**40**	47	34 – 50
No. 30									
No. 50									
No. 100									
No. 200	7.1	**3.6**	1.2	**0.6**			**4.2**	6	2 – 10

Example Problem No. 1 (continued)

Step 5 - Compare this combined gradation
Compare the Total Blend with the Target Value.

Mat'l % Used	Aggregate 1		Aggregate 2						
	50		50						
Sieve (in)	% Pass	% Blend	% Pass	% Blend	% Pass	% Blend	**Total Blend**	**Target Value**	Design Range
1 1/2									
1									
3/4	100	50	100	50			**100**	**100**	100
1/2	100	50	94	47			**97**	**98**	95 – 100
3/8	94	47	65	32.5			**80**	**88**	90 max
No. 4									
No. 8	52	26	27	13.5			**40**	**47**	34 – 50
No. 30									
No. 50									
No. 100									
No. 200	7.1	3.6	1.2	0.6			**4.2**	**6**	2 – 10

Observations:

Sieves No. 3/8 and No. 8 are not close to target value, therefore an adjustment needs to be made.

Make adjustment to the Aggregate Percentage being used.

Example Problem No. 1 (continued)

Step 5 - Continued

For Adjustment:

Use one sieve to make an adjustment before recalculating all sieves.

This example will use the 3/8 sieve.

Mat'l		**Aggregate 1**	**Aggregate 2**
% Used	Trial 1	50	50
	Trial 2	55	45
	Trial 3	60	40
	Trial 4	70	30
	Trial 5	**75**	**25**
	Trial 6	45	55
	Trial 7	40	60

Sieve (in)		% Pass	% Blend	% Pass	% Blend	% Pass	% Blend	Total Blend	Target Value	Design Range
3/8	Trial 1	94	47	65	32.5			80	88	90 max
	Trial 2	94	51.7	65	29.3			81	88	90 max
	Trial 3	94	56.4	65	26			82	88	90 max
	Trial 4	94	65.8	65	19.5			85	88	90 max
	Trial 5	**94**	**70.5**	**65**	**16.3**			**87**	**88**	**90 max**
	Trial 6	94	42.3	65	35.8			78	88	90 max
	Trial 7	94	37.6	65	39			77	88	90 max

Conclusion from this table; Choose Trial No. 5 and recalculate rest of sieves.

Example Problem No. 1 (continued)

Step 5 - Continued (Recalculated Blend)

Mat'l % Used	Aggregate 1		Aggregate 2						
	75		**25**						
Sieve (in)	% Pass	**% Blend**	% Pass	**% Blend**	% Pass	% Blend	**Total Blend**	**Target Value**	Design Range
1 1/2									
1									
3/4	100	**75**	100	**25**			**100**	**100**	100
1/2	100	**75**	94	**23.5**			**99**	**98**	95 – 100
3/8	94	**70.5**	65	**16.3**			**87**	**88**	90 max
No. 4									
No. 8	52	**39**	27	**6.8**			**46**	**47**	34 – 50
No. 30									
No. 50									
No. 100									
No. 200	7.1	**5.3**	1.2	**0.3**			**5.6**	**6**	2 – 10

Example Problem No. 2

<u>Trial and Error Combinations of more than two Aggregates.</u>

The same basic principals or steps are followed when combining more than two aggregates.
The Mix Type for this example will be IM-19.0 A

Step 1 - Enter the data (aggregate gradations and design limits) in the appropriate columns.

Mat'l % Used	Aggregate 1		Aggregate 2		Aggregate 3				
Sieve (in)	**% Pass**	% Blend	**% Pass**	% Blend	**% Pass**	% Blend	Total Blend	Target Value	**Design Range**
1 1/2									
1	**100.0**		**100.0**		**100.0**				**100**
3/4	**100.0**		**100.0**		**96.0**				**90 – 100**
1/2	**100.0**		**99.0**		**47.0**				**90 max**
3/8									
No. 4									
No. 8	**100.0**		**69.0**		**8.0**				**28 – 49**
No. 30									
No. 50									
No. 100									
No. 200	**28.0**		**0.0**		**0.0**				**2 – 8**

Example Problem No. 2 (continued)

Step 2 - Determine the target value.

Target Value must be within Design Range.
The Target Value will be provided by the Mix Design Technician.

Mat'l % Used	Aggregate 1		Aggregate 2		Aggregate 3				
Sieve (in)	% Pass	% Blend	% Pass	% Blend	% Pass	% Blend	Total Blend	**Target Value**	Design Range
1 1/2									
1	100.0		100.0		100.0			**100**	100
3/4	100.0		100.0		96.0			**98**	90 – 100
1/2	100.0		99.0		47.0			**79**	90 max
3/8									
No. 4									
No. 8	100.0		69.0		8.0			**47**	28 – 49
No. 30									
No. 50									
No. 100									
No. 200	28.0		0.0		0.0			**4.5**	2 – 8

Example Problem No. 2 (continued)

Step 3 - Estimate the proportions.

The first estimate used for this trial blend is **40%** of Aggregate 1 and **30%** of Aggregate 2 and **30%** of Aggregate 3.
Enter these figures on the line marked "% Used".

Remember the sum of the proportions must always equal 100

Mat'l % Used	Aggregate 1		Aggregate 2		Aggregate 3				
	40		**30**		**30**				
Sieve (in)	% Pass	% Blend	% Pass	% Blend	% Pass	% Blend	Total Blend	Target Value	Design Range
1 1/2									
1	100.0		100.0		100.0			100	100
3/4	100.0		100.0		96.0			98	90 – 100
1/2	100.0		99.0		47.0			79	90 max
3/8									
No. 4									
No. 8	100.0		69.0		8.0			47	28 – 49
No. 30									
No. 50									
No. 100									
No. 200	28.0		0.0		0.0			4.5	2 – 8

Example Problem No. 2 (continued)

Step 4 - Calculate the individual proportions on each sieve for each of the three aggregates and enter in the column "% blend". Add the three columns for each sieve and enter in the column "Total Blend".

% Blend = % Pass x Percent Aggregate Proportion

Remember, change Percent Aggregate Proportion to decimal.

Total Blend = % Blend Aggregate 1 + % Blend Aggregate 2 + % Blend Aggregate 3

Calculations:

% Blend:

Sieve	Aggregate 1	Aggregate 2	Aggregate 3
1	100 x .40 = **40**	100 x .30 = **30**	100 x .30 = **30**
3/4	100 x .40 = **40**	100 x .30 = **30**	96 x .30 = **28.8**
1/2	100 x .40 = **40**	99 x .30 = **29.7**	47 x .30 = **14.1**
No. 8	100 x .40 = **40**	66 x .30 = **20.7**	8 x .30 = **2.4**
No. 200	28 x .40 = **11.2**	0 x .30 = **0**	0 x .30 = **0**

Total Blend:

Sieve	Aggregate 1	+	Aggregate 2	+	Aggregate 3	=	Total Blend
1	40	+	30	+	30	=	**100.0**
3/4	40	+	30	+	28.8	=	**98.8 or 99**
1/2	40	+	29.7	+	14.1	=	**83.8 ot 84**
No. 8	40	+	20.7	+	2.4	=	**63.1 or 63**
No. 200	11.2	+	0	+	0	=	**11.2**

Example Problem No. 2 (continued)

Step 4 – Continued

Mat'l % Used	Aggregate 1		Aggregate 2		Aggregate 3				
	40		30		30				
Sieve (in)	% Pass	**% Blend**	% Pass	**% Blend**	% Pass	**% Blend**	**Total Blend**	Target Value	Design Range
1 1/2									
1	100.0	**40**	100.0	**30**	100.0	**30**	**100**	100	100
3/4	100.0	**40**	100.0	**30**	96.0	**28.8**	**99**	98	90 – 100
1/2	100.0	**40**	99.0	**29.7**	47.0	**14.1**	**84**	79	90 max
3/8									
No. 4									
No. 8	100.0	**40**	69.0	**20.7**	8.0	**2.4**	**63**	47	28 – 49
No. 30									
No. 50									
No. 100									
No. 200	28.0	**11.2**	0.0	**0**	0.0	**0**	**11.2**	4.5	2 – 8

Example Problem No. 2 (continued)

Step 5 - Compare this combined gradation
Compare the Total Blend with the Target Value.

Mat'l % Used	Aggregate 1		Aggregate 2		Aggregate 3				
	40		30		30				
Sieve (in)	% Pass	% Blend	% Pass	% Blend	% Pass	% Blend	**Total Blend**	**Target Value**	Design Range
1 1/2									
1	100.0	40	100.0	30	100.0	30	**100.0**	**100**	100
3/4	100.0	40	100.0	30	96.0	28.8	**99**	**98**	90 – 100
1/2	100.0	40	99.0	29.7	47.0	14.1	**84**	**79**	90 max
3/8									
No. 4									
No. 8	100.0	40	69.0	20.7	8.0	2.4	**63**	**47**	28 – 49
No. 30									
No. 50									
No. 100									
No. 200	28.0	11.2	0.0	0	0.0	0	**11.2**	**4.5**	2 – 8

Observation:

Sieves 1/2 in., No. 8 and No. 200 are not close to target value, therefore, an adjustment needs to be made.

Make adjustment to the Aggregate Percentage being used

Example Problem No. 2 (continued)

Step 5 (continued)

Suggestion for Adjustment -

Use one sieve to make an adjustment before recalculating all sieves.

This example, will use No. 8 sieve

Mat'l		**Aggregate 1**	**Aggregate 2**	**Aggregate 3**
% Used	Trial 1	30	30	40
	Trial 2	30	35	35
	Trial 3	25	40	35
	Trial 4	**20**	**35**	**45**
	Trial 5	15	40	45

Sieve (in)		% Pass	% Blend	% Pass	% Blend	% Pass	% Blend	Total Blend	Target Value	Design Range
No. 8	Trial 1	100	30	69	20.7	8.0	3.2	54	47	28 – 49
	Trial 2	100	30	69	24.2	8.0	2.8	57	47	28 – 49
	Trial 3	100	25	69	27.6	8.0	2.8	55	47	28 – 49
	Trial 4	**100**	**20**	**69**	**24.2**	**8.0**	**3.6**	**48**	**47**	**28 – 49**
	Trial 5	100	15	69	27.6	8.0	3.6	46	47	28 – 49

Conclusion from this table; Choose Trial No. 4 and recalculate rest of sieves.

Example Problem No. 2 (continued)

Step 5 continued (Recalculated Blend)

Mat'l % Used	Aggregate 1		Aggregate 2		Aggregate 3				
	20		35		45				
Sieve (in)	% Pass	% Blend	% Pass	% Blend	% Pass	% Blend	**Total Blend**	**Target Value**	Design Range
1 1/2									
1	100.0	20	100.0	35	100.0	45	**100**	**100**	100
3/4	100.0	20	100.0	35	96.0	43.2	**98**	**99**	90 – 100
1/2	100.0	20	99.0	34.7	47.0	21.2	**76**	**79**	90 max
3/8									
No. 4									
No. 8	100.0	20	69.0	24.2	8.0	3.6	**48**	**47**	28 – 49
No. 30									
No. 50									
No. 100									
No. 200	28.0	5.6	0.0	0	0.0	0	**5.6**	**4.5**	2 – 8

This is one possible solution. The Total Blend can be adjusted to be closer to the target value.

Example Problem No. 2 (continued)

Step 5 continued (Recalculated Blend Using Trial 5)

Mat'l % Used	Aggregate 1		Aggregate 2		Aggregate 3				
	15		40		45				
Sieve (in)	% Pass	% Blend	% Pass	% Blend	% Pass	% Blend	**Total Blend**	**Target Value**	Design Range
1 1/2									
1	100.0	15	100.0	40	100.0	45	**100**	**100**	100
3/4	100.0	15	100.0	40	96.0	43.2	**98**	**99**	90 – 100
1/2	100.0	15	99.0	39.6	47.0	21.2	**76**	**79**	90 max
3/8									
No. 4									
No. 8	100.0	15	69.0	27.6	8.0	3.6	**46**	**47**	28 – 49
No. 30									
No. 50									
No. 100									
No. 200	28.0	4.2	0.0	0	0.0	0	**4.2**	**4.5**	2 – 8

Once the % Used has been determined and conforms to the requirements, then a plant can use these percentages to set the gates of the cold feed.

Form TL-127 (Rev. 11/05)

VIRGINIA DEPARTMENT OF TRANSPORTATION

MATERIALS DIVISION

STATEMENT OF ASPHALT CONCRETE OR CENTRAL-MIX AGGREGATE JOB-MIX FORMULA

Submit to the District Administrator, Virginia Department of Transportation. Approval must be received by the contractor from the Materials Division before work is begun. This job-mix design is approved for all projects of the Department for the type of mix and the calendar year shown below.

Contractor Design Mix No. ______ Design Lab No. R - 5

Date 2/8/2007 Job Mix ID No. ______ Calendar Yr. ______ TSR Test No. min. 80

Type Mix / Size Aggregate Im-19.0D w/Rap 25

Producer Name & Plant Location B & D Asphalt - Hayden Plant Phone 555-1234

Materials					Kind	Source
Approval Phase	A	B*	C			
Aggregate	50			%	#26's	LuckyLeaf - Hayden
Aggregate	15			%	#78's	LuckyLeaf - Hayden
Rap	25			%		
Sand	15			%	Grade A	Gravel King - Loafers Glory
Screening	10			%		
Lime				%		
Asphalt Cement					PG-64-22	Chevron or Citgo
Asphalt Prime/Tack						
Additives:	.50					
					Adhere HP+	Armaz Products

Job-Mix Sieves	Total % Passing		Tolerance % + or -	Acceptance Range Average of 4 Test(s)		End of Year Average	Design/Spec. Range
	Lab JMF	Production JMF					
Approval Phase	A	B*		A	B	C	
1"	100		0.0	100			100
3/4"	98		4.0	94 - 100			90 - 100
1/2"	90		4.0	86 - 94			90 max
#8	36		4.0	32 - 40			28 - 49
#200	6		1.0	5.0 - 7.0			2 - 8
Asphalt (%)	5.30		0.30	5.00 - 5.60			

Lay Down Temperatures	250-350 °F(°C)	Muffle Furnace Correction Factor:	0.58
		Field Correction Factor ($G_{se} – G_{sb}$):	0.014
Lab Compaction Temperatures	285-290 °F (°C)	Pill Weight:	4750
		SMA Mixes	
		VCA_{DRC}:	
Producer Technician's Certification Number	xxxxx0229	G_{CA}:	

MATERIALS DIVISION USE ONLY

Remarks							
Nominal Max. Size Aggregate		Application Rates:	Min.	lb/yd² (kg/m²)	Max.	lb/yd² (kg/m²)	
Mix Properties at the Job-Mix Asphalt Content:	Compacted Unit Weight	______ lb/ft³ (kg/m³)	VTM:	______	G_{mm}:	______	
Checked By: _____							

Approved tentatively subject to the production of material meeting all other applicable requirements of the specification.
* Note: Part B 'Production JMF' and corresponding Material percentages will be filled out by the DME upon receipt of the additional requirements of the HMA producer within the first three lots under Section 502.01(b)

Copies: State Materials Engineer District Materials Engineer Project Inspector Sub-Contractor and/or Producer	Approvals		Part A:	Date:
			Part B:	Date:
			Part C:	Date:

Plant Proportioning of Aggregate

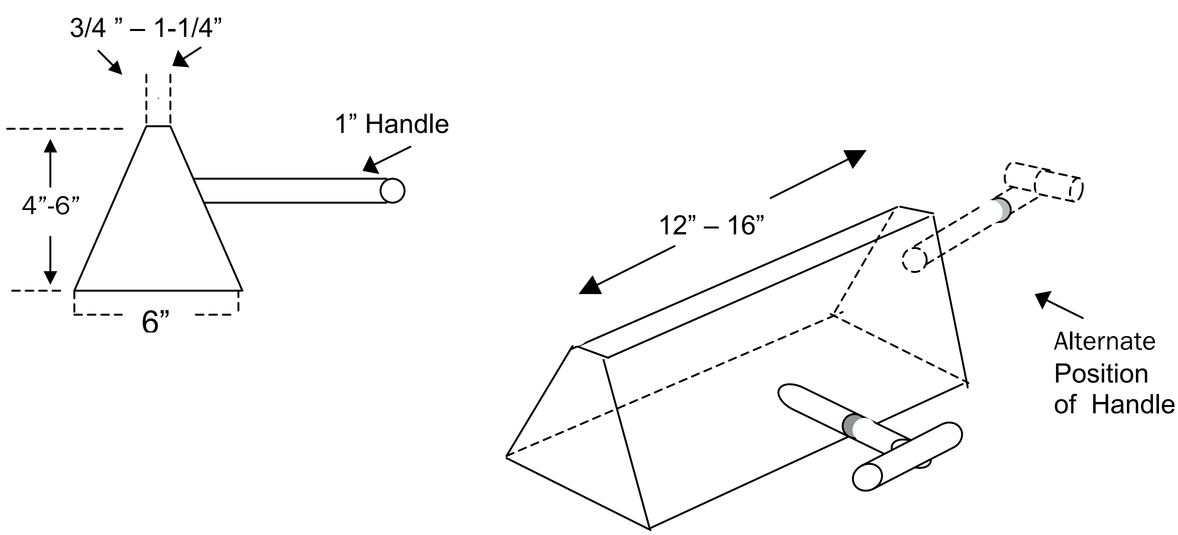
Hot Bin Sampling

Most hot mix asphalt concrete plants are equipped with devices for sampling hot aggregate bins. These vary from sampling “gates” or “windows” in the sides of the bins to devices for diverting the flow of aggregates from the bins into sample containers. In the case of batch plants, however, the best place to obtain a sample is from the bin gates as the material falls in the weigh hopper. It is essential that sampling facilities be constructed and located so that the samples will be representative of the material in the bins.

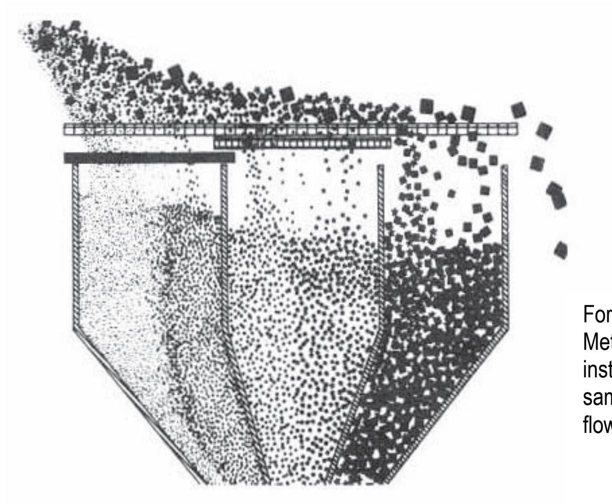
In the flow of materials over the plant screens, the finer particles fall to the near side of the bins and the coarser particles to the far side. When material is drawn from the bins by opening a gate at the bottom, the stream consists predominately of fine material at one edge and coarse material at the other. This condition is critical in the number 1, or fine bin, since the asphalt demand is influenced by the material from this bin. Therefore, the relative position of the sampling device in the stream determines whether the sample will be composed of the fine portion, the coarse portion, or will be an accurate representation of the material in the bin. (See Figures 5-4, 5-5, 5-6). It is most important that the sampling device be properly positioned in the stream of material, so that all the sizes are collected and a representative sample is obtained.

Sieve Analysis

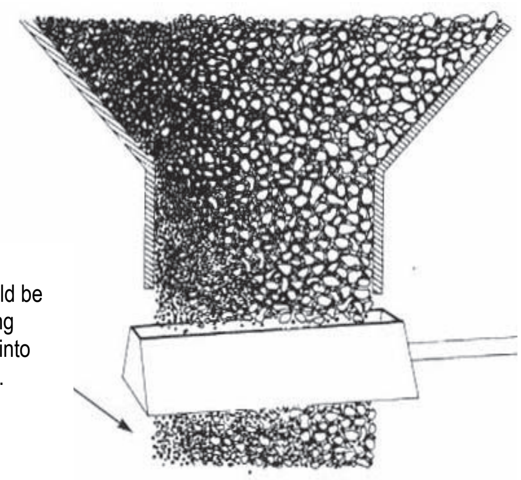
Once the representative samples from each bin and mineral filler (when used) have been properly taken, the sample preparations and sieving are done by the same method as described earlier.



Sampling Device
Figure 5-4



Segregation of Material in the Hot Bins Figure 5-5



Correct Use of Sampling Device Figure 5-6

<u>Hot Bin Proportions by Trial and Error Method</u>

Before the bin weights can be calculated, the proportions (percentages) required from each bin must be determined. **The Trial and Error Method** again is the easiest method to use to determine these proportions and combined gradations for the job-mix formula. The steps for these calculations are the same as that previously covered in the cold feed blending determination except that the target value in Step 2 is that shown on the job-mix formula. Using a blending worksheet as described herein is helpful. The acceptance range is determined by taking the job-mix formula and applying the process tolerances for four (4) tests. These tolerances are found in the Road and Bridge Specifications, Section 211.08 Table II–15. (See page 5-29)

Example Problem - Hot Bin Proportioning

Step 1 – Obtain required data from:
Job-Mix Formula (TL-127)
Hot Bin Gradations

Mat'l % Used	**Bin 1**		**Bin 2**		**Bin 3**		**Bin 4**				
Sieve (in)	**% Pass**	% Blend	**% Pass**	% Blend	**% Pass**	% Blend	**% Pass**	% Blend	Total Blend	Job-Mix Formula	Accep Range
1 1/2	**100**		**100**		**100**		**100**			**100**	
1	**100**		**100**		**100**		**93**			**97**	
3/4	**100**		**100**		**90**		**35**			**84**	
1/2											
3/8											
No. 4											
No. 8	**91**		**10**		**0**		**0**			**36**	
No. 30											
No. 50											
No. 100											
No. 200	**12**		**0**		**0**		**0**			**4**	

Step 2 -Determine Acceptance Range

Use Table II-15 Process Tolerance for 4 tests (plus and minus tolerance) found in Section 211.08 (see on following page)
Remember Upper Acceptance Range cannot be greater than 100.

Sieve	Job-Mix Formula	Process Tolerance	Lower Acceptance Range	Upper Acceptance Range
1 1/2	100	0	100 - 0 = 100	100 + 0 = 100
1	97	± 4	97 - 4 = 93	97 + 4 = ~~101~~ 100
3/4	84	± 4	84 - 4 = 80	84 + 4 = 88
No. 8	36	± 4	36 - 4 = 32	36 + 4 = 40
No. 200	4	± 1	4 - 1 = 3	4 + 1 = 5

Mat'l % Used	**Bin 1**		**Bin 2**		**Bin 3**		**Bin 4**				
Sieve (in)	% Pass	% Blend	% Pass	% Blend	% Pass	% Blend	% Pass	% Blend	Total Blend	Job-Mix Formula	**Accep Range**
1 1/2	100		100		100		100			100	**100**
1	100		100		100		93			97	**93 - 100**
3/4	100		100		90		35			84	**80 - 88**
1/2											
3/8											
No. 4											
No. 8	91		10		0		0			36	**32 - 40**
No. 30											
No. 50											
No. 100											
No. 200	12		0		0		0			4	**3 - 5**

TABLE II-15 PROCESS TOLERANCES

Process Tolerance on Each Laboratory Sieve and Asphalt Content - Percent Plus & Minus

No. Tests	Top Size	1 ½ in	1 in	3/4 in	1/2 in	3/8 in	No. 4	No. 8	No. 30	No. 50	No. 200	AC[1]
1	0.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	6.0	5.0	2.0	.60
2	0.0	5.7	5.7	5.7	5.7	5.7	5.7	5.7	4.3	3.6	1.4	.43
3	0.0	4.4	4.4	4.4	4.4	4.4	4.4	4.4	3.3	2.8	1.1	.33
4	0.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	3.0	2.5	1.0	.30
8	0.0	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.1	1.8	0.7	.21

[1] Asphalt content will be measured as extractable asphalt or mass after ignition

Step 3 – Estimate the Proportions

Remember, the sum of the Bin Percentages must always equal 100

Mat'l	Bin 1		Bin 2		Bin 3		Bin 4				
% Used	**25**		**25**		**25**		**25**				
Sieve (in)	% Pass	% Blend	% Pass	% Blend	% Pass	% Blend	% Pass	% Blend	Total Blend	Job-Mix Formula	Accep Range
1 1/2	100		100		100		100			100	100
1	100		100		100		93			97	93 – 100
3/4	100		100		90		35			84	80 – 88
1/2											
3/8											
No. 4											
No. 8	91		10		0		0			36	32 – 40
No. 30											
No. 50											
No. 100											
No. 200	12		0		0		0			4	3 – 5

Step 4 – Calculate Combined Gradation (Total Blend)

% Blend = % Pass x Percent Aggregate Proportion

Remember, change Percent Aggregate Proportion to decimal.

Total Blend = % Blend Bin 1 + % Blend Bin 2 + % Blend Bin 3 + % Blend Bin4

Step 4 Calculations:

% Blend:

Sieve	Bin 1	Bin 2	Bin 3	Bin 4
1 1/2	100 x .25 = **25**	100 x .25 = **25**	100 x .25 = **25**	100 x .25 = **25**
1	100 x .25 = **25**	100 x .25 = **25**	100 x .25 = **25**	93 x .25 = **23.3**
3/4	100 x .25 = **25**	100 x .25 = **25**	90 x .25 = **22.5**	35 x .25 = **8.8**
No. 8	91 x .25 = **22.8**	10 x .25 = **2.5**	0 x .25 = **0**	0 x .25 = **0**
No. 200	12 x .25 = **3.0**	0 x .25 = **0**	0 x .25 = **0**	0 x .25 = **0**

Total Blend**:**

Sieve	Bin 1	+	Bin 2	+	Bin 3	+	Bin 4	=	Total Blend
1 1/2	25	+	25	+	25	+	25	=	**100**
1	25	+	25	+	25	+	23.3	=	**98.3 or 98**
3/4	25	+	25	+	22.5	+	8.8	=	**81.3 or 81**
No. 8	22.8	+	2.5	+	0	+	0	=	**25.3 or 25**
No. 200	3	+	0	+	0	+	0	=	**3.0**

Mat'l	**Bin 1**		**Bin 2**		**Bin 3**		**Bin 4**				
% Used	**25**		**25**		**25**		**25**				
Sieve (in)	% Pass	**% Blend**	% Pass	**% Blend**	% Pass	**% Blend**	% Pass	**% Blend**	**Total Blend**	Job-Mix Formula	Accep Range
1 1/2	100	**25**	100	**25**	100	**25**	100	**25**	**100**	100	100
1	100	**25**	100	**25**	100	**25**	93	**23.3**	**98**	97	93 – 100
3/4	100	**25**	100	**25**	90	**22.5**	35	**8.8**	**81**	84	80 – 88
1/2											
3/8											
No. 4											
No. 8	91	**22.8**	10	**2.5**	0	**0**	0	**0**	**25**	36	32 – 40
No. 30											
No. 50											
No. 100											
No. 200	12	**3.0**	0	**0**	0	**0**	0	**0**	**3**	4	3 – 5

Step 5 - Compare Combined Gradation (Total Blend) with Target Value (Job-Mix Formula) and Acceptance Range

Mat'l	**Bin 1**		**Bin 2**		**Bin 3**		**Bin 4**				
% Used	**25**		**25**		**25**		**25**				
Sieve (in)	% Pass	% Blend	% Pass	% Blend	% Pass	% Blend	% Pass	% Blend	**Total Blend**	**Job-Mix Formula**	**Accep Range**
1 1/2	100	25	100	25	100	25	100	25	**100**	**100**	**100**
1	100	25	100	25	100	25	93	23.3	**98**	**97**	**93 – 100**
3/4	100	25	100	25	90	22.5	35	8.8	**81**	**84**	**80 – 88**
1/2											
3/8											
No. 4											
No. 8	91	22.8	10	2.5	0	0	0	0	**25**	**36**	**32 – 40**
No. 30											
No. 50											
No. 100											
No. 200	12	3.0	0	0	0	0	0	0	**3**	**4**	**3 – 5**

Observation(s):

No. 8 Sieve is below Job-Mix Formula and outside of Acceptance Range.

Make adjustment to Bin Percentages.

Mat'l	**Bin 1**		**Bin 2**		**Bin 3**		**Bin 4**				
% Used	25		25		25		25				
	30		25		20		25				
	35		**20**		**20**		**25**				
Sieve (in)	% Pass	% Blend	% Pass	% Blend	% Pass	% Blend	% Pass	% Blend	Total Blend	Job-Mix	Accep Range
No. 8	91	22.8	10	2.5	0	0	0	0	25	36	32 – 40
	91	27.3	10	2.5	0	0	0	0	30	36	32 – 40
	91	**31.9**	**10**	**2.0**	**0**	**0**	**0**	**0**	**34**	**36**	**32 – 40**

Conclusion:

Use third trial to recalculate the rest of the sieves.

Step 5 - Continued:

Mat'l	**Bin 1**		**Bin 2**		**Bin 3**		**Bin 4**				
% Used	35		20		20		25				
Sieve (in)	% Pass	**% Blend**	% Pass	**% Blend**	% Pass	**% Blend**	% Pass	**% Blend**	**Total Blend**	**Job-Mix Formula**	**Accep Range**
1 1/2	100	**35**	100	**20**	100	**20**	100	**25**	**100**	**100**	**100**
1	100	**35**	100	**20**	100	**20**	93	**23.3**	**98**	**97**	**93 – 100**
3/4	100	**35**	100	**20**	90	**18**	35	**8.8**	**82**	**84**	**80 – 88**
1/2											
3/8											
No. 4											
No. 8	91	**31.9**	10	**2.0**	0	**0**	0	**0**	**34**	**36**	**32 – 40**
No. 30											
No. 50											
No. 100											
No. 200	12	**4.2**	0	**0**	0	**0**	0	**0**	**4.2**	**4**	**3 – 5**

Batch Weight Calculations

Step 1 – Determine Batch Size
Step 2 – Determine Asphalt Content
Step 3 – Obtain Bin Percentages
Step 4 – Calculate Weight of Asphalt and Aggregate
Step 5 – Calculate Weight of Aggregate per Bin
Step 6 – Calculate Accumulative Weight per Bin

Step 1 – Determine Batch Size

Usually manufacturer's rated pugmill capacity.

Example: 6000 lb pugmill has 6000 lb batch size

Step 2 – Determine Asphalt Content

Obtained off TL-127.

Example: 4.2%

Step 3 – Obtain Bin Percentages

Obtained through Hot Bin Proportioning.

Example: 35, 20, 20, 25

Step 4 – Calculate Weight of Asphalt and Aggregate

Weight of Asphalt = Pugmill Size x Asphalt Content

Remember to change Asphalt Content to Decimal

Weight of Asphalt = 6000 lb x .042 = **252 lb**

Weight of Aggregate = Pugmill Size – Weight of Asphalt

Weight of Aggregate = 6000 lb – 252 lb = **5748 lb**

Step 5 – Calculate weight of Aggregate per Bin

Weight per Bin = Weight of Aggregate x Bin Percentage

Remember to change Bin Percentage to Decimal

Weight Bin 1 = 5748 x .35 = **2011.8**

Weight Bin 2 = 5748 x .20 = **1149.6**

Weight Bin 3 = 5748 x .20 = **1149.6**

Weight Bin 4 = 5748 x .25 = **1437**

Step 6 – Calculate Accumulative Weight per Bin

Bin 1 = Bin 1
Bin 2 = Bin 1 + Bin 2
Bin 3 = Bin 1 + Bin 2 + Bin 3
Bin 4 = Bin 1 + Bin 2 + Bin 3 + Bin 4

Bin 1 = **2011.8**
Bin 2 = 2011.8 + 1149.6 = **3161.4**
Bin 3 = 2011.8 + 1149.6 + 1149.6 = **4311**
Bin 4 = 2011.8 + 1149.6 + 1149.6 + 1437 = **5748**

The final accumulative bin weight should always equal the initial weight of aggregate.

CHAPTER 5
BLENDING AGGREGATES
Study Questions

1. Where are the design range limits found for the different types of asphalt concrete mixtures?

2. If the job-mix on the 1/2 inch sieve is 81% passing, what is the acceptance range for the 4 tests?

3. To whom should the job-mix be submitted?

4. The range from which the job-mix is chosen is called:

   A. standard deviation
   B. design range
   C. process tolerance
   D. acceptance range

5. Asphalt concrete design ranges are found in VDOT Road & Bridge Spec. Section 211.03, Table:

   A. II-5
   B. II-13
   C. II-15

6. The "Trial and Error" method is commonly used to determine the relative proportions of different aggregates needed to produce a final gradation that meets specifications.

   A. True
   B. False

7. The target values for the combined gradation are provided by:

   A. the Asphalt Producer
   B. the District Materials Engineer
   C. the Mix Design Technician
   D. Table II-13 in the Road & Bridge Specifications

CHAPTER 5
Study Problem No. 1
Cold Feed Blending Worksheet

Determine the Job-Mix Formula (Total Blend)

Type Mix: SM-12.5A

Mat'l % Used	Screenings		Stone						
Sieve	% Pass	% Blend	% Pass	% Blend	% Pass	% Blend	Total Blend	Target Value	Design Range
1 1/2 in									
1 in									
3/4 in	100		100					100	
1/2 in	100		98					98	
3/8 in	100		77					88	
No. 4									
No. 8	100		9					49	
No. 30									
No. 50									
No. 200	12		0					5.5	

CHAPTER 5
Study Problem No. 2
Cold Feed Blending Worksheet

Determine the Job-Mix Formula (Total Blend)

Type Mix: IM-19.0D

Mat'l % Used	No. 10		1/2" Cr. Run		No. 68				
Sieve	% Pass	% Blend	% Pass	% Blend	% Pass	% Blend	Total Blend	Target Value	Design Range
1 1/2 in									
1 in	100		100		100			100	
3/4 in	100		99		96			98	
1/2 in	100		89		47			79	
3/8 in									
No. 4									
No. 8	99		41		9			49	
No. 30									
No. 50									
No. 200	10		2.5		0			4.5	

CHAPTER 5
Study Problem No. 3
Cold Feed Blending Worksheet

Determine the Job-Mix Formula (Total Blend)

Type Mix: SM-12.5D

Mat'l % Used	No. 78		No. 10		Sand				
Sieve	% Pass	% Blend	% Pass	% Blend	% Pass	% Blend	Total Blend	Target Value	Design Range
1 1/2 in									
1 in									
3/4 in	100		100		100			100	
1/2 in	96		99		100			98	
3/8 in	75		95		100			88	
No. 4									
No. 8	11		65		100			49	
No. 30									
No. 50									
No. 200	0		14		1.4			5.5	

CHAPTER 5

Study Problem No. 4
Hot Bins Blending Worksheet

Batch Plant set up:

A. Determination of hot bin proportions.

1. Determine the percentage to be pulled from each bin to meet the job-mix formula.
2. Show blend determined under column listed “total blend”.
3. Show acceptance range in column listed “acceptance range”.

Determine the Job-Mix Formula (Total Blend)
Type Mix: BM-25.0

Bin No.	1		2		3		4				
% Used											
Sieve	% Pass	% Blend	% Pass	% Blend	% Pass	% Blend	% Pass	% Blend	Total Blend	Job Mix	Accept. Range
1 1/2 in	100		100		100		100			100	
1 in	100		100		99		91			98	
3/4 in	100		100		88		8			76	
1/2 in											
3/8 in											
No. 4											
No. 8	86		13		3		0.0			32	
No. 30											
No. 50											
No. 200	10		0.0		0.0		0.0			4	

B. Using the percentage determined to be pulled from each bin above and an asphalt content of 4.5%, calculate the weight of asphalt, weight of aggregates from each bin, and accumulative weights per bin to be pulled in an 8000 pound batch.

	Percent	Weight of Aggregates per Bin	Accumulative Weights per Bin
Bin 1			
Bin 2			
Bin 3			
Bin 4			
Weight of Asphalt			

CHAPTER 5

Study Problem No. 5
Hot Bins Blending Worksheet

Batch Plant set up:

A. Determination of hot bin proportions.

1. Determine the percentage to be pulled from each bin to meet the job-mix formula.
2. Show blend determined under column listed “total blend”.
3. Show acceptance range in column listed “acceptance range”.

Determine the Job-Mix Formula (Total Blend)
Type Mix: IM-19.0 A

Bin No.	1		2		3		4				
% Used											
Sieve	% Pass	% Blend	% Pass	% Blend	% Pass	% Blend	% Pass	% Blend	Total Blend	Job Mix	Accept. Range
1 1/2 in											
1 in	100		100		100		100			100	
3/4 in	100		100		93		91			97	
1/2 in	100		92		71		30			72	
3/8 in											
No. 4											
No. 8	87		37		18		5			37	
No. 30											
No. 50											
No. 200	24		1.5		0		0			6.5	

B. Using the percentage determined to be pulled from each bin above and an asphalt content of 4.7%, calculate the weight of asphalt, weight of aggregates from each bin, and accumulative weights per bin to be pulled in a 5500 pound batch.

	Percent	Weight of Aggregates per Bin	Accumulative Weights per Bin
Bin 1			
Bin 2			
Bin 3			
Bin 4			
Weight of Asphalt			