BATCH DESIGN AND INSPECTION

OF

HOT MIX ASPHALTIC CONCRETE

TEXAS HIGHWAY DEPARTMENT
DISTRICT 12

1964

HOT MIX ASPHALTIC CONCRETE SCHOOL

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I. Introduction

Hot mix asphaltic concrete is a plant-produced paving mixture consisting of an individual or combination of mineral aggregate, uniformly mixed and coated with asphalt. To dry the aggregates and to obtain sufficient fluidity of the asphalt for proper mixing, both the aggregate and asphalt must be heated prior to mixing; hence, the term "hot mix."

The various types of aggregates used in the production of hot mix asphaltic concrete in District 12 are: limestone, gravel, iron ore, oyster shell and sand. The use of an individual material, or combination of these materials, depends on the sieve sizes of the aggregates and the specifications governing the type of asphaltic concrete to be produced.

Asphalt is a black cementitious material, naturally present in most crude petroleum. It is separated by various refining processes which also yield gasoline, kerosene, lubricating oils and other valuable petroleum products. There are various types and grades of asphalt produced by the refining process. Type OA-90 is normally used in the production of hot mix asphaltic concrete. The requirements for this type and grade asphalt are described by Item 300 of the 1962 Standard Specifications.

II. Design of Hot Mix Asphaltic Mixes

A. General

The design of asphalt mixes is largely a matter of selecting the most economical proportion of materials, then subjecting the mixture produced to various laboratory tests in order to determine if specification requirements have been met.

The Materials and Tests Division, File D-9, is responsible for sampling, testing, and interpretation of tests results on materials used in construction and maintenance. The Manual of Procedures has been prepared by File D-9 for the purpose of furnishing the field engineers and inspectors with the proper procedures to be followed in the sampling, control and inspection of materials.

The manual gives detailed procedures and explanations regarding sampling of materials, schedules of minimum requirements, control of materials, printed forms and their uses. The manual of procedures is supplemented by the Manual of Testing Procedures which outlines and illustrates the procedure of performing the required laboratory tests. Complete sets of all the above-mentioned manuals are available at the Resident Engineer's office or at the office of the District Construction Engineer.

The application of asphalt mix design to construction practice is described in Bulletin C-14, which has been prepared by the Construction Division of the Texas Highway Department. This manual was prepared in order to furnish field personnel with the proper procedure to be followed in the design and control of asphaltic paving mixtures.

B. Mix Design

Item 340 of the Standard Specifications points out that Hot Mix Asphaltic Concrete Mixes are divided into six types. The main difference between the types is the maximum size aggregate allowed. Since Type "D" mix requires all the details of testing and design and is in more common use than some of the other types, the work in this course of instruction will be confined to Type "D" mix. A special provision to Item 340, permitting the use of oyster shell and iron ore gravel, two local materials not included in the Standard Specifications, will be assumed to be in effect.

The following materials will be used:

Asphalt	Aggregate
OA-90	1. Limestone
	2. Oyster shell
	3. Gravel screenings
	4. Local sand

It is assumed that the necessary samples of each material have been submitted to the Austin Laboratory for quality tests and that these test results meet the specification requirements.

The actual laboratory design of the mixes would begin by performing the preliminary tests as described in Bulletin C-14.

These tests are:

1. Sieve analysis
2. Bulk Specific Gravity
3. Preparation of Asphaltic Concrete Mixes for Test Specimens
4. Standard Method for Molding Asphaltic Concrete Specimens
5. Standard Method for Determining Density
6. Stability Test (Performed in Austin Lab)
7. Extraction Test (Performed on the plant-produced mixture)

The tests will be explained by going through the necessary calculations that are required to show the results of the tests. The application of the test results to the mix design process will also be covered.

1. Sieve analysis: The sieve analysis of a number of samples of each of the aggregates is determined as outlined in C-14 Test No. 1. The following formula is used to calculate sieve analysis.

(1) % passing larger and retained on smaller = Wt. retained x 1/tot wt of sample x 100

Figures 1 and 2 show the results of the sieve analysis from different samples for each of the aggregates. Figure 3 shows the average sieve analysis of each aggregate as determined from their various sieve analyses shown in Figures 1 and 2.

LIMESTONE

Sieve Sizes	Sample No. 1		Sample No. 2	
	Weight in grams retained on sieves.	Percent of sample retained on sieves.	Weight in grams retained on sieves.	Percent of sample retained on sieves.
+ 1/2"	0.0	0.0	0.0	0.0
1/2 - 3/8	394.1	15.6	948.5	24.9
3/8 - No. 4	1902.8	75.1	2746.4	72.0
4 - 10	165.6	6.5	94.0	2.5
10 - 40	26.7	1.1	6.5	0.2
40 - 80	7.9	0.3	3.6	0.1
80 - 200	10.5	0.4	4.8	0.1
Pass 200	26.0	1.0	12.5	0.2
Total	2533.6	100.0	3816.3	100.0

Sieve Sizes	Sample No. 3		Sample No. 4		Average
	Weight in grams retained on sieves.	Percent of sample retained on sieves.	Weight in grams retained on sieves.	Percent of sample retained on sieves.	Sieve Analysis of the 4 samples
+ 1/2	0.0	0.0	0.0	0.0	0.0
1/2 - 3/8	674.0	24.3	420.0	16.8	20.4
3/8 - No. 4	1994.5	72.1	1850.0	74.0	73.3
4 - 10	77.0	2.8	165.0	6.6	4.6
10 - 40	6.2	0.2	32.5	1.3	0.7
40 - 80	2.5	0.1	17.5	0.7	0.3
80 - 200	3.5	0.1	5.0	0.2	0.2
Pass 200	10.5	0.4	10.0	0.4	2.0
Total	2768.2	100.0	2500.0	100.0	100.0

OYSTER SHELL

Sieve Sizes	Sample No. 1		Sample No. 2		Average
	Weight in grams retained on sieves.	Percent of sample retained on sieves.	Weight in grams retained on sieves.	Percent of sample retained on sieves.	Sieve Analysis of the 2 samples.
+ 1/2"	0.0	0.0	0.0	0.0	0.0
1/2 - 3/8	21.7	2.6	20.4	1.9	2.3
3/8 - No. 4	273.0	32.7	484.5	45.2	39.0
4 - 10	367.4	44.0	381.6	35.6	39.8
10 - 40	152.8	18.3	159.7	14.9	16.6
40 - 80	10.0	1.2	14.0	1.3	1.2
80 - 200	7.5	0.9	8.6	0.8	0.8
Pass 200	2.6	0.3	3.2	0.3	0.3
Total	835.0	100.0	1072.0	100.0	100.0

Figure 1

GRAVEL SCREENINGS

Sieve Sizes	Sample No. 1		Sample No. 2	
	Weight in grams retained on sieves	Percent of sample retained on sieves	Weight in grams retained on sieves	Percent of sample retained on sieves
+ 1/2"	0.0	0.0	0.0	0.0
1/2 - 3/8	0.0	0.0	0.0	0.0
3/8 - No. 4	879.1	47.4	845.1	46.7
4 - 10	845.4	45.6	864.1	47.7
10 - 40	78.5	4.2	82.2	4.5
40 - 80	36.1	1.9	11.8	0.7
80 - 200	11.0	0.6	5.0	0.3
Pass - 200	4.7	0.3	2.5	0.1
Total	1854.8	100.0	1810.7	100.0

Sieve Sizes	Sample No. 3		Sample No. 4		Average
	Weight in grams retained on sieves	Percent of sample retained on sieves	Weight in grams retained on sieves	Percent of sample retained on sieves	Sieve analysis of the 4 samples
+ 1/2"	0.0	0.0	0.0	0.0	0.0
1/2 - 3/8	0.0	0.0	0.0	0.0	0.0
3/8 - No. 4	1053.0	44.1	1100.0	43.5	45.4
4 - 10	1209.0	50.7	1283.0	50.8	48.7
10 - 40	105.0	4.4	121.0	4.8	4.5
40 - 80	14.0	0.6	18.0	0.6	1.0
80 - 200	4.0	0.2	4.0	0.2	0.3
Pass - 200	1.0	0.0	1.0	0.1	0.1
Total	2386.0	100.0	2527.0	100.0	100.0

LOCAL SAND

Sieve Sizes	Sample No. 1		Sample No. 2		Average
	Weight in grams retained on sieves	Percent of sample retained on sieves	Weight in grams retained on sieves	Percent of sample retained on sieves	Sieve analysis of the 2 samples
+ 1/2"	0.0	0.0	0.0	0.0	0.0
1/2 - 3/8	0.0	0.0	0.0	0.0	0.0
3/8 - No. 4	0.0	0.0	0.0	0.0	0.0
4 - 10	0.0	0.0	0.0	0.0	0.0
10 - 40	39.0	5.0	55.0	8.0	6.5
40 - 80	412.0	52.5	347.0	50.2	51.4
80 - 200	250.0	31.8	211.0	30.5	31.1
Pass 200	84.0	10.7	78.0	11.3	11.0
Total	785.0	100.0	691.0	100.0	100.0

Figure 2

SIEVE SIZES	LIMESTONE	OYSTER SHELL	GRAVEL SCREENING	LOCAL SAND
+ 1/2"	0.0	0.0		
1/2 - 3/8	20.4	2.3	0.0	
3/8 - No. 4	73.3	39.0	45.4	
4 - 10	4.6	39.8	48.7	0.0
10 - 40	0.7	16.6	4.5	6.5
40 - 80	0.3	1.2	1.0	51.4
80 - 200	0.2	0.8	0.3	31.1
Pass 200	0.5	0.3	0.1	11.0
Total	100.0	100.0	100.0	100.0

Figure 3

The Standard Specifications require that the combined aggregates in Type D Mineral Aggregate conform to the master gradation shown below in Figure 4.

	Minimum percent by weight		Maximum percent by weight
Passing 1/2" sieve			100
Passing 3/8" sieve	95	to	100
Passing 3/8" sieve, retained on No. 4 sieve	20	to	50
Passing No. 4 sieve, retained on No. 10 sieve	10	to	30
Total retained on No. 10 sieve	50	to	70
Passing No. 10 sieve, retained on No. 40 sieve	0	to	30
Passing No. 40 sieve, retained on No. 80 sieve	4	to	25
Passing No. 80 sieve, retained on No. 200 sieve	3	to	25
Passing No. 200 sieve	0	to	8

Figure 4

Note that the master gradation requires that from 50% to 70% of the mineral aggregate should be retained on the No. 10 sieve. Ordinarily, the materials are combined to produce approximately 60% retained on the No. 10 sieve. Using a trial-and-error procedure as set out in Bulletin C-14, pp. 1-5, 65% was found to be retained on the No. 10 sieve by combining 12% limestone, 25% oyster shell, 35% gravel screenings and 28% local sand. The 65% retained on the No. 10 will be acceptable, since the addition of asphalt to the aggregate to form the total mix will reduce the percentage of plus 10 material to the approximate midpoint of the master grading requirement.

The following calculations show the percentage of the various sieve sizes furnished by each aggregate:

SIEVE SIZES		AVERAGE				
		Sieve analysis of limestone				
1/2" - 3/8"	=	20.4	x	12.0%	=	2.5%
3/8" - 4	=	73.3	x	12.0%	=	8.8%
4 - 10	=	4.6	x	12.0%	=	0.5%
10 - 40	=	0.7	x	12.0%	=	0.1%
40 - 80	=	0.3	x	12.0%	=	0.0%
80 - 200	=	0.2	x	12.0%	=	0.0%
Pass 200	=	0.5	x	12.0%	=	0.1%
Total		100.0	x	12.0%	=	12.0%

Oyster shell will furnish 25.0 per cent of each of its various sizes to the combination of the aggregates.

SIEVE SIZES		AVERAGE				
		Sieve analysis of oyster shell				
1/2" - 3/8"	=	2.3	x	25.0%	=	0.6%
3/8" - 4	=	39.0	x	25.0%	=	9.8%
4 - 10	=	39.8	x	25.0%	=	9.9%
10 - 40	=	16.6	x	25.0%	=	4.1%
40 - 80	=	1.2	x	25.0%	=	0.3%
80 - 200	=	0.8	x	25.0%	=	0.2%
Pass 200	=	0.3	x	25.0%	=	0.1%
Total		100.0	x	25.0%	=	25.0%

Gravel screenings will furnish 35.0 per cent of each of its various sizes to the combination of the aggregates.

SIEVE SIZES		AVERAGE Sieve analysis of gravel screenings				
1/2"-3/8"	=	0.0				
3/8"- 4	=	45.4	x	35.0%	=	15.9%
4 - 10	=	48.7	x	35.0%	=	17.0%
10 - 40	=	4.5	x	35.0%	=	1.6%
40 - 80	=	1.0	x	35.0%	=	0.4%
80 - 200	=	0.3	x	35.0%	=	0.1%
Pass 200	=	0.1	x	35.0%	=	0.0%
Total		100.0	x	35.0%	=	35.0%

Local sand will furnish 28.0 per cent of each of its various sizes to the combination of the aggregates.

SIEVE SIZES		AVERAGE Sieve analysis of local sand				
1/2"-3/8"	=	0.0				
3/8"- 4	=	0.0				
4 - 10	=	0.0				
10 - 40	=	6.5	x	28.0%	=	1.8%
40 - 80	=	51.4	x	28.0%	=	14.4%
80 - 200	=	31.1	x	28.0%	=	8.7%
Pass 200	=	11.0	x	28.0%	=	3.1%
Total		100.0	x	28.0%	=	28.0%

By combining the aggregates in the above percentages, a theoretical sieve analysis of the combination of the aggregates is calculated as shown on Form 544, Figure 5.

Texas Highway Department
Form No. 544

TEXAS HIGHWAY DEPARTMENT
ASPHALTIC CONCRETE SCREEN AND SIEVE ANALYSIS
WORK SHEET

Date May 13, 1963 Stencil No. ______ Design No. Selection of Grading

Time ______ Type "D" Station No. ______

Spec. Item 340---010 Proj. No. ______

Size	Limestone Bin No. 1 Total %	x (a) 12.0 %	Oyster Shell Bin No. 2 Total %	x (b) 25.0 %	Gravel Screenings Bin No. 3 Total %	x (c) 35.0 %	Local Sand Bin No. 4 Total %	x (d) 28.0 %	Combined Analysis % (a+b+c+d)
+1"									
1" — 3/4"									
3/4" — 1/2"									
+5/8"									
5/8" — 1/2"									
+1/2"									
1/2" — 3/8"	20.4	2.4	2.3	0.6					3.0
1/2" — 1/4"									
+3/8"									
3/8" — ~~1/4"~~ 4"	73.3	8.8	39.0	9.8	45.4	15.9			34.5
4" ~~1/4"~~ — 10	4.6	0.6	39.8	9.9	48.7	17.0			27.5
10 — 40	0.7	0.1	16.6	4.1	4.5	1.6	6.5	1.8	7.6
40 — 80	0.3	0.0	1.2	0.3	1.0	0.4	51.4	14.4	15.1
80 — 200	0.2	0.0	0.8	0.2	0.3	0.1	31.1	8.7	9.0
Pass 200	0.5	0.1	0.3	0.1	0.1	0.0	11.0	3.1	3.3
Total	100.0 %	12.0 %	100.0 %	25.0 %	100.0 %	35.0 %	100.0 %	28.0 %	100.0 %

65.0
Total +10

Asphaltic Binder = ______ = ______ %

Total = 100.0 %

FIG. 5

______
Inspector

2. Bulk Specific Gravity:

Having determined that the aggregates can be combined to produce a sieve analysis that will meet the specifications, the bulk specific gravities must be calculated.

The bulk specific gravity of the individual material is determined from the bulk specific gravity of designated groups of sieve sizes of the material as follows:

1. Plus #4
2. #4 to #10
3. #10 to #80
4. Passing #80

The bulk specific gravity tests of the sieve sizes of each aggregate are generally made in the Austin Laboratory. It is not always feasible to determine the specific gravity for each of the designated sizes, especially in cases where only small amounts of material are retained on some of the sieves. When this condition exists, the range in sieve sizes can be varied to eliminate processing excessive amounts of material. To illustrate the bulk specific gravity calculation for material retained on selected sieve sizes for the different aggregates, values will be substituted in the following formulae:

For plus 80 material

(1) $G = X_1 \div (X + Y - Z)$

where:

G = Bulk (oven-dry) specific gravity of the material

X_1 = Wt. (gms.) of oven-dry sample

X = Wt. (gms.) of saturated surface-dry sample

Y = Wt. (gms.) of pycnometer, filled with water calibrated at the approximate temperature of water used in determining weight "Z."

Z = Wt. (gms.) of pycnometer containing saturated, surface-dry sample and water to fill

For aggregates passing the 80 sieve

$G = X \div (X + Y - Z)$

where:

X = Wt. (gms.) of dry material

Y = Wt. (gms.) of volumetric flask filled to mark with water

Z = Wt. (gms.) of volumetric flask containing aggregate and water to fill to mark.

SIEVE SIZES	LIMESTONE
1/2" - 3/8"	$G = \frac{1798.0}{1831.5+2705.5-3886.7} = \frac{1798.0}{4537.0-3886.7} = \frac{1798.0}{650.3} = 2.765$
3/8" - 4	$G = \frac{1610.0}{1640.1+2705.5-3760.0} = \frac{1610.0}{4345.6-3760.1} = \frac{1610.0}{585.5} = 2.750$

SIEVE SIZES	OYSTER SHELL
1/2" - 4	$G = \frac{1805.4}{1913.7+2705.5-3913.7} = \frac{1805.4}{4619.2-3913.7} = \frac{1805.4}{705.5} = 2.559$
4 - 10	$G = \frac{1516.2}{1607.2+2705.5-3717.9} = \frac{1516.2}{4312.7-3717.9} = \frac{1516.2}{594.8} = 2.549$
10 - 80	$G = \frac{990.2}{1054.6+2705.5-3367.5} = \frac{990.2}{3760.0-3367.5} = \frac{990.2}{392.6} = 2.522$
Minus 80	$G = \frac{60.225}{60.225+161.332-199.760} = \frac{60.225}{221.557-199.760} = \frac{60.225}{21.797} = 2.763$

SIEVE SIZES	GRAVEL SCREENINGS
3/8" - 4	$G = \frac{1810.6}{1844.3+2705.5-3845.6} = \frac{1810.6}{4549.8-3845.6} = \frac{1810.6}{704.2} = 2.571$
4 - 10	$G = \frac{1594.3}{1626.6+2705.5-3711.5} = \frac{1594.3}{4332.1-3711.5} = \frac{1594.3}{620.6} = 2.569$
10 - 80	$G = \frac{1025.6}{1051.2+2705.5-3361.0} = \frac{1025.6}{3756.7-3361.0} = \frac{1025.6}{395.7} = 2.592$
Minus 80	$G = \frac{55.216}{55.216+161.332-195.561} = \frac{55.216}{216.548-195.561} = \frac{55.216}{20.987} = 2.631$

SIEVE SIZES	LOCAL SAND
+ 80	$G = \frac{960.0}{1022.4+2705.5-3364.4} = \frac{960.0}{3727.9-3364.4} = \frac{960.0}{363.5} = 2.641$
Minus 80	$G = \frac{46.324}{46.324+161.332-190.215} = \frac{46.324}{207.656-190.215} = \frac{46.324}{17.441} = 2.656$

For convenience, the results of the bulk specific gravity tests for each aggregate are listed in the following table:

*(1) Sieve Size
**(2) Specific Gravity

Limestone		Oyster Shell		Gravel Screenings		Local Sand	
*(1)	**(2)	*(1)	**(2)	*(1)	**(2)	*(1)	**(2)
1/2"-3/8"	= 2.765	1/2"- 4	= 2.559	3/8"- 4	= 2.571	10-80	= 2.641
3/8"- 4	= 2.750	4 -10	= 2.549	4 - 10	= 2.569	-80	= 2.656
		10 -80	= 2.522	10 - 80	= 2.592		
		-80	= 2.763	- 80	= 2.631		

From the bulk specific gravity of the various sieve sizes calculated for each aggregate, the bulk specific gravity for that particular aggregate may be calculated.

Beginning with the limestone, it is noted that specific gravities are shown for two sieve sizes limits only, the 1/2" to 3/8" and the 3/8" to No. 4. Referring to the selection of grading tabulated on Form 544, it is noted that the limestone is tabulated as follows:

1/2" - 3/8" - 20.4% retained
3/8" - 4 - 73.3% retained
93.7% Total retained on No. 4

Thus, specific gravities have been obtained on 93.7% of the material and no gravities have been determined on the 6.3% which passed the No. 4 sieve. Since the bulk specific gravity can only be calculated on the basis of the total aggregate, the 6.3% is added to the 73.3% between the 3/8" and No. 4 sieve. This makes a total of 79.6% of the material represented by the specific gravity shown for the 3/8" to No. 4 sieve limits.

Bulk specific gravity of limestone $= \dfrac{100}{\dfrac{20.4}{2.765} + \dfrac{79.6}{2.750}} = \dfrac{100}{7.378 + 28.945} = \dfrac{100}{36.323} = 2.753$

By similar methods, the bulk specific gravities of the remaining aggregates are computed.

Bulk specific gravity of oyster shell $= \dfrac{100}{\dfrac{41.3}{2.559} + \dfrac{39.8}{2.549} + \dfrac{17.8}{2.522} + \dfrac{1.1}{2.763}} = \dfrac{100}{16.139+15.614+7.058+0.398}$

$$= \frac{100}{39.209} = 2.550$$

Bulk specific gravity of gravel screenings $= \dfrac{100}{\dfrac{45.4}{2.571} + \dfrac{48.7}{2.569} + \dfrac{5.5}{2.592} + \dfrac{0.4}{2.631}} = \dfrac{100}{17.658+18.957+2.122+0.152}$

$$= \frac{100}{38.889} = 2.571$$

Bulk specific gravity of local sand $= \dfrac{100}{\dfrac{57.9}{2.641} + \dfrac{42.1}{2.656}} = \dfrac{100}{21.924 + 15.851} = \dfrac{100}{37.775} = 2.647$

a. <u>Specific Gravity of OA-90 Asphalt Cement</u>

The specific gravity of asphalt cement is expressed as the ratio of the weight of a given volume of asphalt cement at 77° to that of an equal volume of water at the same temperature. The specific gravity of asphalt cements is determined by laboratory personnel in the Austin laboratory and these results are available upon request. The specific gravity of asphalt cement at 77°F is required because the specific gravity and density test results of a molded asphalt mixture specimen are determined from the weight loss of the specimen obtained by weighing it in water at 77°F, as described in Test No. 5 of Bulletin C-14. The specific gravity of asphalt cements will vary in specific gravity, but for the design of these mixtures, assume the specific gravity of the OA-90 asphalt to be 1.008 at 77°F.

b. <u>Specific Gravity of Paraffin</u>

Test No. 5 of Bulletin C-14 requires the asphalt mixture specimen to be coated with a thin layer of paraffin when testing the specimen for density. This will require a specific gravity value for the paraffin before the density of the specimen can be calculated. The method of determining the specific gravity of paraffin is described in Test No. 5. The test values obtained from performing the test are then substituted in the following formula to calculate the specific gravity of the paraffin.

$$G_p = \frac{F - D}{F - G - D + E}$$

G_p = Specific gravity of paraffin

D = Weight (gram) of bulb in air

E = Weight (gram) of bulb in water

F = Weight (gram) of paraffin - coated bulb in air

G = Weight (gram) of paraffin - coated bulb in water

To illustrate the specific gravity calculation of paraffin and to have a specific gravity value which can be used in the specimen density calculations, assumed values are substituted in the following formula:

$$G_p = \frac{1005.5 - 967.7}{1005.5 - 314.4 - 967.7 + 318.6} = \frac{37.8}{42.0} = \underline{\underline{0.90}}$$

c. Bulk Specific Gravity of Combined Aggregate

The following table lists the bulk specific gravities of the aggregates and the specific gravity of the OA-90 Asphalt Cement and paraffin.

Limestone Av Bulk	Oyster Shell Av Bulk	Gravel Screenings Av Bulk	Local Sand Av Bulk	OA-90 Asph Cement	Paraffin
Sp Gr/	Sp Gr/	Sp Gr/	Sp Gr/	Sp Gr/	Sp Gr/
2.753	2.550	2.571	2.647	1.008	0.900

After determining the per cent that each aggregate is to furnish to the total mixture and the specific gravities of each material, the design of the laboratory mixes may proceed

The average bulk (oven-dry) specific gravity of the combined aggregates, in this case consisting of 12% limestone,25% oyster shell, 35% gravel screenings and 28% local sand, is calculated from the following formula:

$$G = \frac{100}{\frac{W_1}{G_1} + \frac{W_2}{G_2} + \frac{W_3}{G_3} + \frac{W_4}{G_4}}$$

Where:

G = Average bulk (oven-dry) specific gravity of the combined aggregate
W_1 = Per cent by weight of aggregate No. 1 (Based on total weight of combination)
W_2 = Per cent by weight of aggregate No. 2
W_3 = Per cent by weight of aggregate No. 3
W_4 = Per cent by weight of aggregate No. 4
G_1 = Bulk specific gravity of aggregate No. 1
G_2 = Bulk specific gravity of aggregate No. 2
G_3 = Bulk specific gravity of aggregate No. 3
G_4 = Bulk specific gravity of aggregate No. 4

By substituting previously determined values for each aggregate in the formula in their appropriate places, the bulk (oven-dry) specific gravity of the combined aggregates is calculated as follows:

$$G = \frac{100}{\frac{12}{2.753} + \frac{25}{2.550} + \frac{35}{2.571} + \frac{28}{2.647}} = \frac{100}{4.359 + 9.804 + 13.613 + 10.578} = \frac{100}{38.354} = 2.607$$

The following table lists the bulk specific gravities of the combined aggregates,OA-90 asphalt cement and paraffin.

Combined aggregates Av. Bulk	OA-90 asphalt Cement	Paraffin
Sp gr/	Sp gr/	Sp gr/
2.607	1.008	0.900

3. Preparation of Asphaltic Concrete Mixes for Test Specimens

The specifications require that asphaltic concrete test mixtures containing five different asphalt contents be made and tested. Three specimens of each asphalt content will be mixed, molded and tested for density and stability. The average value of the three specimens will be used in determining the optimum asphalt content. Type "D" mixture requires that the asphaltic material furnish not less than 4.0 or more than 8.0 per cent of the mixture by weight. From past experience, the optimum asphalt content for these aggregate combinations is approximately 5.5 per cent by weight of the mixture.

In order to select the optimum asphalt content for the grading selected, we will design the following mixes:

Mix No.	Asphalt Per cent by weight	Aggregate Per cent by weight
1	4.5	95.5
2	5.0	95.0
3	5.5	94.5
4	6.0	94.0
5	6.5	93.5

The test mixtures are designed, using the above percentages.

The design procedure of all the above mixes is identical; therefore, Mix No. 1 will be designed as an example. The previously calculated individual percentages of the various aggregates add up to 100%. The above table denotes the fact that only 95.5% of Mix No. 1 will be aggregate; therefore, each of the previously calculated percentages must be reduced proportionately so they will total 95.5% instead of 100%

This is done as follows:

Aggregate and asphalt combination for Mix No. 1

Aggregate	Individual percent by weight of total Aggregate (combined grading)				Individual Per cent by weight of total mix
Limestone	12	x	95.5	=	11.5
Oyster Shell	25	x	95.5	=	23.9
Gravel Screenings	35	x	95.5	=	33.4
Local Sand	28	x	95.5	=	26.7
Total	100				95.5
				Asphalt	4.5
					100.0

By applying the above method of calculation to the remaining mixes, the proportionate parts of the aggregates and asphalt are obtained.

Mix No.	Limestone	Gravel Screenings	Oyster Shell	Local Sand	Asphalt
1	11.5%	33.4%	23.9%	26.7%	4.5%
2	11.4	33.2	23.8	26.6	5.0
3	11.3	33.1	23.6	26.5	5.5
4	11.3	32.9	23.5	26.3	6.0
5	11.2	32.7	23.4	26.2	6.5

Texas Highway Department
Form No. 544

TEXAS HIGHWAY DEPARTMENT
ASPHALTIC CONCRETE SCREEN AND SIEVE ANALYSIS
WORK SHEET

Date 5-13-63 Stencil No. ______ Design No. 4.5% Asphalt

Time ______ Type "D" Station No. ______

Spec. Item 340---010 Proj. No. ______

Size	Limestone Bin No. 1 Total %	(a) x 11.5%	Oyster Shell Bin No. 2 Total %	(b) x 23.9 %	Gravel Screenings Bin No. 3 Total %	(c) x 33.4%	Local Sand Bin No. 4 Total %	(d) x 26.7 %	Combined Analysis % (a+b+c+d)
+1"									
1" — 3/4"									
3/4" — 1/2"									
+5/8"									
5/8" — 1/2"									
+1/2"									
1/2" — 3/8"	20.4	2.3	2.3	0.6					2.9
1/2" — 1/4"									
+3/8"									
3/8" — 4	73.3	8.4	39.0	9.3	45.4	15.2			32.9
4 — 10	4.6	0.5	39.8	9.5	48.7	16.3			26.3
10 — 40	0.7	0.1	16.6	4.0	4.5	1.5	6.5	1.7	7.3
40 — 80	0.3	0.1	1.2	0.3	1.0	0.3	51.4	13.7	14.4
80 — 200	0.2	0.0	0.8	0.2	0.3	0.1	31.1	8.3	8.6
Pass 200	0.5	0.1	0.3	0.0	0.1	0.0	11.0	3.0	3.1
Total	100.0 %	11.5 %	100.0 %	23.9 %	100.0 %	33.4 %	100.0 %	26.7 %	95.5 %

62.1
Total+10

Asphaltic Binder = OA90 = 4.5 %

Total = 100.0 %

FIG. 6

Inspector ______

Texas Highway Department
Form No. 544

TEXAS HIGHWAY DEPARTMENT
ASPHALTIC CONCRETE SCREEN AND SIEVE ANALYSIS
WORK SHEET

Date 5-13-63 Stencil No. ________ Design No. 5.0% Asphalt

Time ________ Type "D" Station No. ________

Spec. Item 340---010 Proj. No. ________

Size	Limestone Bin No. 1 Total %	(a) x 11.4 %	Oyster Shell Bin No. 2 Total %	(b) x 23.8 %	Gravel Screenings Bin No. 3 Total %	(c) x 33.2 %	Local Sand Bin No. 4 Total %	(d) x 26.6 %	Combined Analysis % (a+b+c+d)
+1"									
1" — 3/4"									
3/4" — 1/2"									
+5/8"									
5/8" — 1/2"									
+1/2"									
1/2" — 3/8"	20.4	2.3	2.3	0.5					2.8
1/2" — 1/4"									
+3/8"									
3/8" — ~~1/4~~ 4	73.3	8.4	39.0	9.3	45.4	15.1			32.8
~~1/4~~ 4 — 10	4.6	0.5	39.8	9.4	48.7	16.2			26.1 61.7 Total+10
10 — 40	0.7	0.1	16.6	4.0	4.5	1.5	6.5	1.7	7.3
40 — 80	0.3	0.0	1.2	0.3	1.0	0.3	51.4	13.7	14.3
80 — 200	0.2	0.0	0.8	0.2	0.3	0.1	31.1	8.3	8.6
Pass 200	0.5	0.1	0.3	0.1	0.1	0.0	11.0	2.9	3.1
Total	100.0 %	11.4 %	100.0 %	23.8 %	100.0 %	33.2 %	100.0 %	26.6 %	95.0 %

Asphaltic Binder = OA90 = 5.0 %

Total = 100.0 %

FIG.7

________ Inspector

Texas Highway Department
Form No. 544

TEXAS HIGHWAY DEPARTMENT
ASPHALTIC CONCRETE SCREEN AND SIEVE ANALYSIS
WORK SHEET

Date 5-13-63 Stencil No. ____ Design No. 5.5% Asphalt

Time ____ Type "D" Station No. ____

Spec. Item 340---010 Proj. No. ____

Size	Limestone Bin No. 1 Total %	(a) x 11.3 %	Oyster Shell Bin No. 2 Total %	(b) x 23.6 %	Gravel Screenings Bin No. 3 Total %	(c) x 33.1 %	Local Sand Bin No. 4 Total %	(d) x 26.5 %	Combined Analysis % (a+b+c+d)
+1"									
1" — 3/4"									
3/4" — 1/2"									
+5/8"									
5/8" — 1/2"									
+1/2"									
1/2" — 3/8"	20.4	2.3	2.3	0.5					2.8
1/2" — 1/4"									
+3/8"									
3/8" — ~~1/4~~ 4	73.3	8.3	39.0	9.2	45.4	15.0			32.5
4 ~~1/4~~ — 10	4.6	0.5	39.8	9.4	48.7	16.1			26.0
10 — 40	0.7	0.1	16.6	3.9	4.5	1.5	6.5	1.7	7.2
40 — 80	0.3	0.0	1.2	0.3	1.0	0.3	51.4	13.6	14.2
80 — 200	0.2	0.0	0.8	0.2	0.3	0.1	31.1	8.3	8.6
Pass 200	0.5	0.1	0.3	0.1	0.1	0.1	11.0	2.9	3.2
Total	100.0 %	11.3 %	100.0 %	23.6 %	100.0 %	33.1 %	100.0 %	26.5 %	94.5 %

61.3 Total+10

Asphaltic Binder = OA90 = 5.5 %

Total = 100.0 %

FIG. 8

____ Inspector

Texas Highway Department
Form No. 544

TEXAS HIGHWAY DEPARTMENT
ASPHALTIC CONCRETE SCREEN AND SIEVE ANALYSIS
WORK SHEET

Date 5-13-63 Stencil No. ______ Design No. 6.0% Asphalt

Time ______ Type "D" Station No. ______

Spec. Item 340---010 Proj. No. ______

Size	Limestone Bin No. 1 Total %	(a) x 11.3 %	Oyster Shell Bin No. 2 Total %	(b) x 23.5 %	Gravel Screenings Bin No. 3 Total %	(c) x 32.9 %	Local Sand Bin No. 4 Total %	(d) x 26.3 %	Combined Analysis % (a+b+c+d)
+1"									
1" – 3/4"									
3/4" – 1/2"									
+5/8"									
5/8" – 1/2"									
+1/2"									
1/2" – 3/8"	20.4	2.3	2.3	0.5					2.8
1/2" – 1/4"									
+3/8"									
3/8" – 4	73.3	8.3	39.0	9.2	45.4	14.9			32.4
4 – 10	4.6	0.5	39.8	9.4	48.7	16.0			25.9
10 – 40	0.7	0.1	16.6	3.9	4.5	1.5	6.5	1.7	7.2
40 – 80	0.3	0.0	1.2	0.3	1.0	0.3	51.4	13.5	14.1
80 – 200	0.2	0.0	0.8	0.2	0.3	0.1	31.1	8.2	8.5
Pass 200	0.5	0.1	0.3	0.0	0.1	0.1	11.0	2.9	3.1
Total	100.0 %	11.3 %	100.0 %	23.5 %	100.0 %	32.9 %	100.0 %	26.3 %	94.0 %

61.1 Total+10

Asphaltic Binder = OA90 = 6.0 %

Total = 100.0 %

Inspector ______

FIG. 9

Texas Highway Department
Form No. 544

TEXAS HIGHWAY DEPARTMENT
ASPHALTIC CONCRETE SCREEN AND SIEVE ANALYSIS
WORK SHEET

Date 5-13-63 Stencil No. ______ Design No. 6.5% Asphalt

Time ______ Type "D" Station No. ______

Spec. Item 340---010 Proj. No. ______

Size	Limestone Bin No. 1 Total %	(a) x 11.2 %	Oyster Shell Bin No. 2 Total %	(b) x 23.4 %	Gravel Screenings Bin No. 3 Total %	(c) x 32.7 %	Local Sand Bin No. 4 Total %	(d) x 26.2 %	Combined Analysis % (a+b+c+d)
+1"									
1" — 3/4"									
3/4" — 1/2"									
+5/8"									
5/8" — 1/2"									
+1/2"									
1/2" — 3/8"	20.4	2.3	2.3	0.5					2.8
1/2" — 1/4"									
+3/8"									
3/8" — 4	73.3	8.2	39.0	9.1	45.4	14.9			32.2
4 — 10	4.6	0.5	39.8	9.3	48.7	15.9			25.7
10 — 40	0.7	0.1	16.6	3.9	4.5	1.5	6.5	1.7	7.2
40 — 80	0.3	0.0	1.2	0.3	1.0	0.3	51.4	13.5	14.1
80 — 200	0.2	0.0	0.8	0.2	0.3	0.1	31.1	8.1	8.4
Pass 200	0.5	0.1	0.3	0.1	0.1	0.0	11.0	2.9	3.1
Total	100.0 %	11.2 %	100.0 %	23.4 %	100.0 %	32.7 %	100.0 %	26.2 %	93.5 %

60.7 / Total+10

Asphaltic Binder = OA90 = 6.5 %

Total = 100.0 %

______
Inspector

FIG. 10

Figures 6 through 10 show the percentage by sieve sizes that each aggregate will furnish to the combined grading sieve analysis for the five mixes.

To eliminate segregation of the aggregates furnishing proportionate parts to the mixture, the materials are proportioned to the mixture according to the following sieve sizes when possible: 1/2"-3/8", 3/8"-4, 4-10. Aggregates whose sizes are predominately smaller than 10 mesh will be proportioned as they are, since a minimum of segregation occurs in the smaller sizes.

The following weight calculations by sieve sizes shown on pages 24 to 28, required to mold one specimen for each different per cent of asphalt, are based on an assumed total weight for each specimen. In the actual design of the mixes, the weight required for a specimen is that amount of the mixture which will produce a molded specimen 4" in diameter and a height ranging between 1-15/16" to 2-1/16". Therefore, in most cases, it is necessary to mold a trial specimen of the mixture to determine the weight which will produce the specimen with the above-mentioned tolerance. Generally, a mixture weight between 900 and 975 grams will produce a specimen within the specified tolerance. If the weight selected fails to produce a specimen within the specified tolerance, the actual dimensions of the specimen can be substituted in the formula shown on page 29 of Bulletin C-14 and used to calculate the correct mixture weight required.

4.5% ASPHALT

Sieve sizes	Per cent of sieve size		Total wt of specimen in grams		Sieve size weight in grams	Accum. total weight in grams
Limestone						
1/2"-3/8"	2.3	x	930	=	21.4	21.4
3/8"- 4	8.4	x	930	=	78.1	99.5
- 4	0.8	x	930	=	7.5	107.0
Subtotal	11.5	x	930	=	107.0	107.0
Oyster Shell						
1/2"- 4	9.9	x	930	=	92.1	199.1
4 - 10	9.5	x	930	=	88.4	287.5
- 10	4.5	x	930	=	41.8	329.3
Subtotal	23.9	x	930	=	222.3	329.3
Gravel Screening						
3/8"- 4	15.2	x	930	=	141.4	470.1
4 - 10	16.3	x	930	=	151.6	622.3
- 10	1.9	x	930	=	17.6	639.9
Subtotal	33.4	x	930	=	310.6	639.9
Local Sand						
- 10	26.7	x	930	=	248.3	888.2
Subtotal	26.7	x	930	=	248.3	888.2
Asphalt	5.00	x	930	=	41.8	930.0
TOTAL	100.0	x	930	=	930.0	930.0

5.0% ASPHALT

Sieve sizes	Per cent of sieve size		Total wt of specimen in grams		Sieve size weight in grams	Accum. total weight in grams
Limestone						
1/2"-3/8"	2.3	x	935	=	21.5	21.5
3/8"- 4	8.4	x	935	=	78.5	100.0
- 4	0.7	x	935	=	6.6	106.6
Subtotal	11.4	x	935		106.6	106.6
Oyster Shell						
1/2"- 4	9.8	x	935	=	91.6	198.2
4 - 10	9.4	x	935	=	87.9	286.1
- 10	4.6	x	935	=	43.0	329.1
Subtotal	23.8	x	935	=	222.5	329.1
Gravel Screening						
3/8"- 4	15.1	x	935	=	141.2	470.3
4 - 10	16.2	x	935	=	151.5	621.8
- 10	1.9	x	935	=	17.7	639.5
Subtotal	33.2	x	935	=	310.4	639.5
Local Sand						
- 10	26.6	x	935	=	248.7	888.2
Subtotal	26.6	x	935	=	248.7	888.2
Asphalt	5.0	x	935	=	46.8	935.0
TOTAL	100.0	x	935	=	935.0	935.0

5.5% ASPHALT

Sieve sizes	Per cent of sieve size		Total wt of specimen in grams		Sieve size weight in grams	Accum. total weight in grams
Limestone						
1/2"-3/8"	2.3	x	945	=	21.8	21.8
3/8"- 4	8.3	x	945	=	78.4	100.2
- 4	0.7	x	945	=	6.6	106.8
Subtotal	11.3	x	945	=	106.8	106.8
Oyster Shell						
1/2"- 4	9.7	x	945	=	91.7	198.5
4 - 10	9.4	x	945	=	88.8	287.3
- 10	4.5	x	945	=	42.5	329.8
Subtotal	23.6		945		223.0	329.8
Gravel Screening						
3/8"- 4	15.0	x	945	=	141.8	471.6
4 - 10	16.1	x	945	=	152.1	623.7
- 10	2.0	x	945	=	18.9	642.6
Subtotal	33.1	x	945	=	312.8	642.6
Local Sand						
- 10	26.5	x	945	=	250.4	893.0
Subtotal	26.5		945		250.4	893.0
Asphalt	5.5	x	945	=	52.0	945.0
TOTAL	100.0	x	945	=	945.0	945.0

6.0% ASPHALT

Sieve sizes	Per cent of sieve size		Total wt of specimen in grams		Sieve size weight in grams	Accum. total weight in grams
Limestone						
1/2"-3/8"	2.3	x	950	=	21.9	21.9
3/8"- 4	8.3	x	950	=	78.8	100.7
- 4	0.7	x	950	=	6.7	107.4
Subtotal	11.3	x	950	=	107.4	107.4
Oyster Shell						
1/2"- 4	9.7	x	950	=	92.1	199.5
4 - 10	9.4	x	950	=	89.3	288.8
- 10	4.4	x	950	=	41.8	330.6
Subtotal	23.5	x	950	=	223.2	330.6
Gravel Screening						
3/8"- 4	14.9	x	950	=	141.5	472.1
4 - 10	16.0	x	950	=	152.0	624.1
- 10	2.0	x	950	=	19.0	643.1
Subtotal	32.9	x	950	=	312.5	643.1
Local Sand						
- 10	26.3	x	950	=	249.9	893.0
Subtotal	26.3	x	950	=	249.9	893.0
Asphalt	6.0	x	950	=	57.0	950.0
TOTAL	100.0	x	950	=	950.0	950.0

6.5% ASPHALT

Sieve sizes	Per cent of sieve size		Total wt of specimen in grams		Sieve size weight in grams	Accum. total weight in grams
Limestone						
1/2"-3/8"	2.3	x	960	=	22.1	22.1
3/8"- 4	8.2	x	960	=	78.7	100.8
- 10	0.7	x	960	=	6.7	107.5
Subtotal	11.2	x	960	=	107.5	107.5
Oyster Shell						
1/2"- 4	9.6	x	960	=	92.2	199.7
4 - 10	9.3	x	960	=	89.3	289.0
- 10	4.5	x	960	=	43.2	332.2
Subtotal	23.4	x	960	=	224.7	332.2
Gravel Screenings						
3/8"- 4	14.9	x	960	=	143.0	475.2
4 - 10	15.9	x	960	=	152.7	627.9
- 10	1.9	x	960	=	18.2	646.1
Subtotal	32.7	x	960	=	313.9	646.1
Local Sand						
- 10	26.2	x	960	=	251.5	897.6
Subtotal	26.2	x	960	=	251.5	897.6
Asphalt	6.5	x	960	=	62.4	960.0
TOTAL	100.0	x	960	=	960.0	960.0

To prepare the three specimens for each of the different asphalt mixtures, the weights calculated by sieve sizes for one specimen of each asphalt content are used and the specimens are prepared according to Test Number 3 described in Bulletin C-14.

4. Standard Method for Molding Asphaltic Concrete Specimens

After the samples have been prepared for each asphalt content, they will be molded according to Test Number 4 described in Bulletin C-14.

5. Standard Method for Determining Density

When the samples have been molded, they will be tested for density according to Test Number 5 described in Bulletin C-14.

To illustrate the calculations necessary to determine the average density of the three molded specimens containing 4.5 per cent asphalt, laboratory-determined values are substituted in the following formulae:

Calculate the actual specific gravity of each specimen of the 4.5 per cent asphalt mixture by the formula as follows:

$$G_a = \frac{A}{B - C - \frac{(B - A)}{G_p}}$$

Where:

G_a = Actual Specific gravity of specimen

A = Weight (gram) of specimen in air

B = Weight (gram) of paraffin-coated specimen in air

C = Weight (gram) of paraffin-coated specimen in water

G_p = Specific gravity of paraffin

SPECIMEN #1

$$G_a = \frac{928.4}{973.6-512.4-\frac{(973.6-928.4)}{0.90}} = \frac{928.4}{461.2-\frac{45.2}{0.90}} = \frac{928.4}{461.2-50.2} = \frac{928.4}{411.0} = 2.259$$

SPECIMEN #2

$$G_a = \frac{930.0}{980.5-514.3-\frac{(980.5-930.0)}{0.90}} = \frac{930.0}{466.2-\frac{50.5}{0.90}} = \frac{930.0}{466.2-56.1} = \frac{930.0}{410.1} = 2.268$$

SPECIMEN #3

$$G_a = \frac{926.2}{974.2-511.8-\frac{(974.2-926.2)}{0.90}} = \frac{926.2}{462.4-\frac{48.0}{0.90}} = \frac{926.2}{462.4-53.3} = \frac{926.2}{409.1} = 2.264$$

Calculate the theoretical specific gravity of the specimen as follows:

$$G_t = \frac{100}{\frac{W}{G} + \frac{W_1}{G_1}}$$

Where:

G_t = Theoretical specific gravity of the specimen

G = Average bulk specific gravity of combined aggregate grading

G_1 = Specific gravity of asphaltic binder at 77° F

W = Per cent by weight of aggregate in mixture

W_1 = Per cent by weight of asphaltic binder in the mixture

Note: $W + W_1 = 100\%$

4.5% ASPHALT

$$G_t = \frac{100}{\frac{95.5}{2.607}+\frac{4.5}{1.008}} = \frac{100}{36.632+4.464} = \frac{100}{41.096} = 2.433$$

5.0% ASPHALT

$$G_t = \frac{100}{\frac{95.0}{2.607}+\frac{5.0}{1.008}} = \frac{100}{36.440+4.960} = \frac{100}{41.400} = 2.415$$

5.5% ASPHALT

$$G_t = \frac{100}{\frac{94.5}{2.607}+\frac{5.5}{1.008}} = \frac{100}{36.249+5.456} = \frac{100}{41.705} = 2.398$$

6.0% ASPHALT

$$G_t = \frac{100}{\frac{94.0}{2.607} + \frac{6.0}{1.008}} = \frac{100}{36.057 + 5.952} = \frac{100}{42.009} = 2.380$$

6.5% ASPHALT

$$G_t = \frac{100}{\frac{93.5}{2.607} + \frac{6.5}{1.008}} = \frac{100}{35.865 + 6.448} = \frac{100}{42.313} = 2.363$$

Calculate the density (per cent compaction) of the specimen as follows:

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

Where:

G_a = Actual specific gravity of the specimen

G_t = Theoretical specific gravity of the specimen

SPECIMEN #1 4.5% ASPHALT

$$\text{Density (\%)} = \frac{2.259}{2.433} = 92.8$$

SPECIMEN #2 4.5% ASPHALT

$$\text{Density (\%)} = \frac{2.268}{2.433} = 93.2$$

SPECIMEN #3 4.5% ASPHALT

$$\text{Density (\%)} = \frac{2.264}{2.433} = 93.0$$

Average actual specific gravity of the three specimens =

$$\frac{2.259 + 2.268 + 2.264}{3} = \frac{6.791}{3} = 2.264$$

Average density (%) of the three specimens =

$$\frac{92.8 + 93.2 + 93.1}{3} = \frac{279.1}{3} = 93.0$$

The densities for the remaining four asphalt mixtures would be determined by the same method. Form 545, Figures 11 through 15, includes the densities for each of the five mixes and the information necessary to determine them.

TEXAS HIGHWAY DEPARTMENT
ASPHALTIC CONCRETE DATA SHEET ON MOLDED SPECIMENS AND ROAD SAMPLES

Actual Specific Gravity $= \frac{A}{D}$

* Density of Specimen (%) $= \frac{100\ G_a}{G_t}$

Where:

G_a = Actual Specific Gravity of Specimen

A = Weight of Specimen in Air

B = Weight of Specimen + Paraffin in Air

C = Weight of Specimen + Paraffin in Water

G_p = Specific Gravity of Paraffin

G_t = Theoretical Specific Gravity of Specimen

$D = B - C - \left(\frac{B-A}{G_p}\right)$ = Actual Volume of Specimen

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Date May 14, 1963 Stencil No. ______ Design No. 4.5% Asphalt

Spec. Item 340---010 Type "D" Station No. ______

Proj. No. ______

DATA AND CALCULATIONS G_t = 2.433 G_p = 0.90

		Laboratory Specimens			Road Samples		
Spec. No.							
Spec. Height							
Actual Specific Gravity of Spec.	A	928.4 gm.	930.0 gm.	926.2 gm.	gm.	gm.	gm.
	B	973.6 gm.	980.5 gm.	974.2 gm.	gm.	gm.	gm.
	C	512.4 gm.	514.3 gm.	511.8 gm.	gm.	gm.	gm.
	B−C	461.2	466.2	462.4			
	$\frac{B-A}{G_p}$	50.2	56.1	53.3			
	D	411.0 cc	410.1 cc	409.1 cc	cc	cc	cc
	G_a	2.259	2.268	2.264			
	*	92.8	93.2	93.1			

	Laboratory Specimens	Road Samples
Average Actual Specific Gravity	2.264	
Average Density (%)	93.0	

______ Inspector

FIG. 11

Texas Highway Department
Form No. 545

TEXAS HIGHWAY DEPARTMENT
ASPHALTIC CONCRETE DATA SHEET ON MOLDED SPECIMENS AND ROAD SAMPLES

Actual Specific Gravity $= \frac{A}{D}$

* Density of Specimen (%) $= \frac{100\ G_a}{G_t}$

Where:

G_a = Actual Specific Gravity of Specimen

A = Weight of Specimen in Air

B = Weight of Specimen + Paraffin in Air

C = Weight of Specimen + Paraffin in Water

G_p = Specific Gravity of Paraffin

G_t = Theoretical Specific Gravity of Specimen

D = $B - C - \left(\frac{B-A}{G_p}\right)$ = Actual Volume of Specimen

Date May 14, 1963 Stencil No. ______ Design No. 5.0% Asphalt

Spec. Item 340---010 Type "D" Station No. ______

Proj. No. ______

DATA AND CALCULATIONS G_t = 2.415 G_p = 0.90

		Laboratory Specimens			Road Samples		
Spec. No.							
Spec. Height							
Actual Specific Gravity of Spec.	A	934.2 gm.	935.0 gm.	933.1 gm.	gm.	gm.	gm.
	B	984.6 gm.	983.8 gm.	985.8 gm.	gm.	gm.	gm.
	C	516.1 gm.	519.2 gm.	518.0 gm.	gm.	gm.	gm.
	B−C	468.5	464.6	467.8			
	$\frac{B-A}{G_p}$	56.0	54.2	58.5			
	D	412.5 cc	410.4 cc	409.3 cc	cc	cc	cc
	G_a	2.265	2.278	2.280			
		* 93.8	* 94.3	* 94.4			

	Laboratory Specimens	Road Samples
Average Actual Specific Gravity	2.274	
Average Density (%)	94.2	

______ Inspector

FIG. 12

Texas Highway Department
Form No. 545

TEXAS HIGHWAY DEPARTMENT
ASPHALTIC CONCRETE DATA SHEET ON MOLDED SPECIMENS AND ROAD SAMPLES

Actual Specific Gravity $= \frac{A}{D}$

* Density of Specimen (%) $= \frac{100\ G_a}{G_t}$

Where:

G_a = Actual Specific Gravity of Specimen

A = Weight of Specimen in Air

B = Weight of Specimen + Paraffin in Air

C = Weight of Specimen + Paraffin in Water

G_p = Specific Gravity of Paraffin

G_t = Theoretical Specific Gravity of Specimen

$D = B - C - \left(\frac{B-A}{G_p}\right)$ = Actual Volume of Specimen

---

Date May 14, 1963 Stencil No. ______ Design No. 5.5% Asphalt

Spec. Item 340---010 Type "D" Station No. ______

Proj. No. ______

DATA AND CALCULATIONS G_t = 2.398 G_p = 0.90

		Laboratory Specimens			Road Samples		
Spec. No.							
Spec. Height							
Actual Specific Gravity of Spec.	A	944.6 gm.	943.0 gm.	944.2 gm.	gm.	gm.	gm.
	B	1000.7 gm.	1001.0 gm.	1004.4 gm.	gm.	gm.	gm.
	C	525.6 gm.	523.9 gm.	522.6 gm.	gm.	gm.	gm.
	B−C	475.1	477.1	481.8			
	$\frac{B-A}{G_p}$	62.3	64.4	66.9			
	D	412.8 cc	412.7 cc	414.9 cc	cc	cc	cc
	G_a	2.288	2.285	2.276			
		* 95.4	* 95.3	* 94.9			

	Laboratory Specimens	Road Samples
Average Actual Specific Gravity	2.283	
Average Density (%)	95.2	

______ Inspector

FIG. 13

Texas Highway Department
Form No. 545

TEXAS HIGHWAY DEPARTMENT
ASPHALTIC CONCRETE DATA SHEET ON MOLDED SPECIMENS AND ROAD SAMPLES

$$\text{Actual Specific Gravity} = \frac{A}{D}$$

$$* \text{ Density of Specimen (\%)} = \frac{100\,G_a}{G_t}$$

Where:

G_a = Actual Specific Gravity of Specimen

A = Weight of Specimen in Air

B = Weight of Specimen + Paraffin in Air

C = Weight of Specimen + Paraffin in Water

G_p = Specific Gravity of Paraffin

G_t = Theoretical Specific Gravity of Specimen

$D = B - C - \left(\frac{B-A}{G_p}\right)$ = Actual Volume of Specimen

Date May 14, 1963 Stencil No. ______ Design No. 6.0% Asphalt

Spec. Item 340---010 Type "D" Station No. ______

Proj. No. ______

DATA AND CALCULATIONS G_t = 2.380 G_p = 0.90

		Laboratory Specimens			Road Samples		
Spec. No.							
Spec. Height							
Actual Specific Gravity of Spec.	A	950.0 gm.	955.0 gm.	952.0 gm.	gm.	gm.	gm.
	B	1005.5 gm.	1005.0 gm.	1000.0 gm.	gm.	gm.	gm.
	C	530.4 gm.	532.7 gm.	533.5 gm.	gm.	gm.	gm.
	B−C	475.1	472.3	466.5			
	$\frac{B-A}{G_p}$	61.7	55.6	53.3			
	D	413.4 cc	416.7 cc	413.2 cc	cc	cc	cc
	G_a	2.298	2.292	2.304			
		* 96.6	* 96.3	* 96.8			

	Laboratory Specimens	Road Samples
Average Actual Specific Gravity	2.298	
Average Density (%)	96.6	

______ Inspector

FIG. 14

Texas Highway Department
Form No. 545

TEXAS HIGHWAY DEPARTMENT
ASPHALTIC CONCRETE DATA SHEET ON MOLDED SPECIMENS AND ROAD SAMPLES

$$\text{Actual Specific Gravity} = \frac{A}{D}$$

$$* \quad \text{Density of Specimen (\%)} = \frac{100\ G_a}{G_t}$$

Where:

G_a = Actual Specific Gravity of Specimen

A = Weight of Specimen in Air

B = Weight of Specimen + Paraffin in Air

C = Weight of Specimen + Paraffin in Water

G_p = Specific Gravity of Paraffin

G_t = Theoretical Specific Gravity of Specimen

D = $B - C - \left(\frac{B-A}{G_p}\right)$ = Actual Volume of Specimen

Date May 14, 1963 Stencil No. ______ Design No. 6.5% Asphalt

Spec. Item 340---010 Type "D" Station No. ______

Proj. No. ______

DATA AND CALCULATIONS G_t = 2.363 G_p = 0.90

		Laboratory Specimens			Road Samples		
Spec. No.							
Spec. Height							
Actual Specific Gravity of Spec.	A	960.0 gm.	958.0 gm.	956.0 gm.	gm.	gm.	gm.
	B	1014.2 gm.	1006.4 gm.	1014.0 gm.	gm.	gm.	gm.
	C	538.4 gm.	538.2 gm.	538.9 gm.	gm.	gm.	gm.
	B–C	475.8	468.2	475.1			
	$\frac{B-A}{G_p}$	60.2	53.8	64.4			
	D	415.6 cc	414.4 cc	410.7 cc	cc	cc	cc
	G_a	2.310	2.312	2.328			
		* 97.8	* 97.8	* 98.5			

	Laboratory Specimens	Road Samples
Average Actual Specific Gravity	2.317	
Average Density (%)	98.0	

______ Inspector

FIG. 15

6. <u>Standard Method for Stability Test:</u>

Because of the equipment required, the stability determination is made by the Austin Laboratory in accordance with THD-40. Therefore, it will be necessary to send the molded specimens to the Texas Highway Laboratory, Austin, Texas, for stability determination. In shipping specimens to the Laboratory, all of the paraffin must be removed from the specimens and they should be packed carefully in a one-gallon cement bucket. Three specimens can be placed in a bucket with paper between specimens and rags or paper between the specimens and the sides, top and bottom of the bucket.

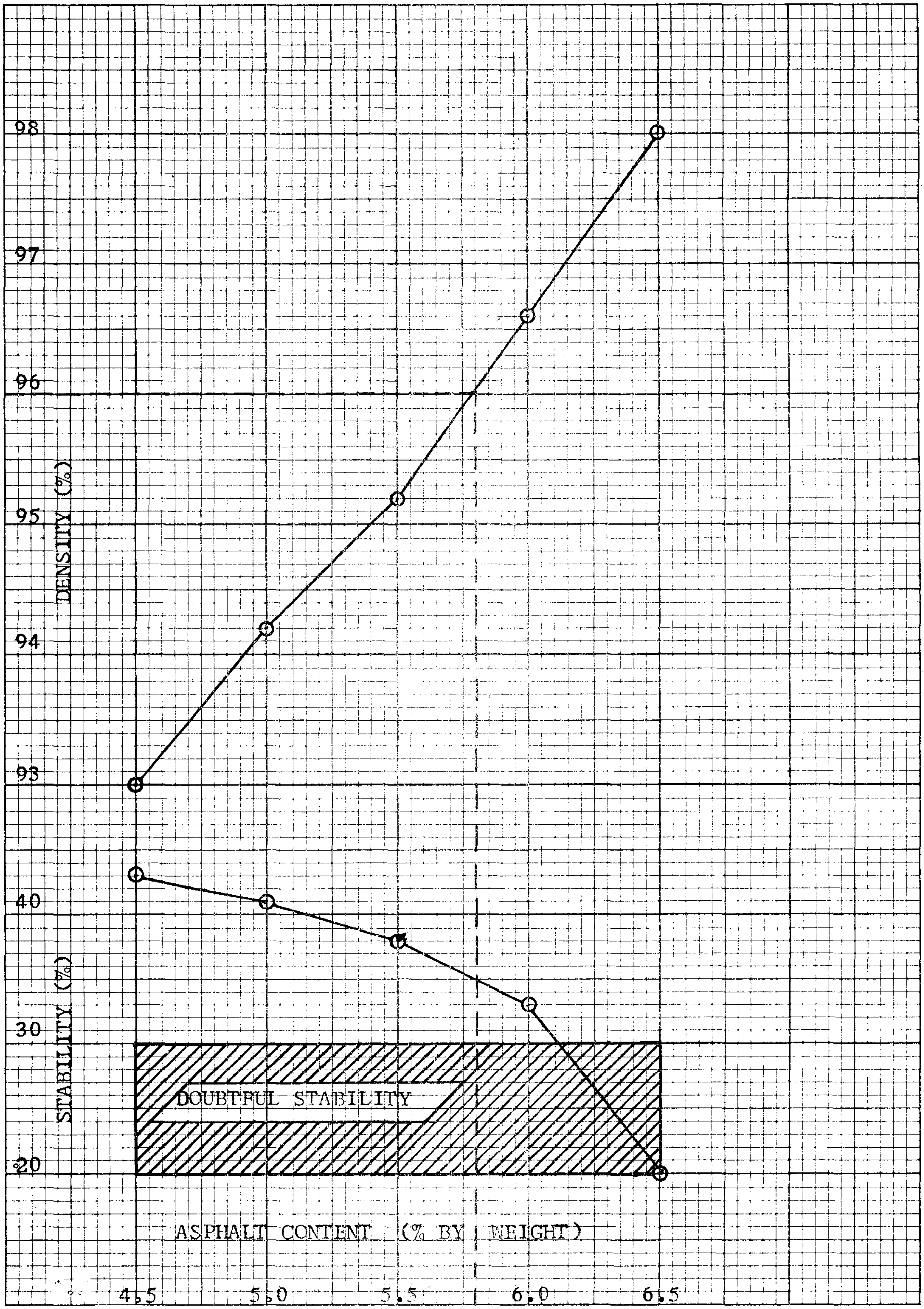
<u>CAUTION:</u> The paraffin must be removed from the specimens immediately after completion of the density test. If paraffin is left on the specimen, it will not be satisfactory for determining the stability. To facilitate removal of the paraffin, the specimen should be cooled to approximately 80° F prior to coating with paraffin. Cooling can be done very effectively by placing the specimen in a one-gallon cement bucket, putting the lid on tight and immersing in 70° - 80° F water for one hour. The specimen should not become wet or be cooled to a point that it will sweat.

SUMMARY OF TEST DATA

Mix No.	Asphalt content % by weight	Actual sp gr of specimens (Av of three specimens G_a)	Theo sp gr specimens (G_t)	Av % density	Av % stability
1	4.5	2.264	2.433	93.0	43
2	5.0	2.274	2.415	94.2	41
3	5.5	2.283	2.398	95.2	38
4	6.0	2.298	2.380	96.6	33
5	6.5	2.317	2.363	98.0	20

The intent of this design procedure was to make five laboratory mixes ranging from 94 to 99 per cent density. The highest density obtained was 98 per cent which will be satisfactory since the optimum density of 97 per cent is within the range of the test values.

Figure 16 shows the average density and stability values for each of the five laboratory design mixes. According to the graph, 97 per cent density would require 6.15 per cent asphalt, but the stability would be 29 per cent which is below the 30 per cent minimum required by the specifications. Density values determined from laboratory mixes are generally one per cent lower than mixes of the same asphalt per cent that have been mixed in the plant pugmill. Based on past experience, 96 per cent density is chosen from the graph which requires 5.8 per cent asphalt and the Contractor is ready to begin stockpiling the aggregates.



98
97
96
95
94
93
40
30
20
DENSITY (%)
STABILITY (%)
DOUBTFUL STABILITY
ASPHALT CONTENT (% BY WEIGHT)
4.5
5.0
5.5
6.0
6.5

FIG. 16

III. Stockpiling and Storage of Materials

A. Field Laboratory

One of the first requirements of the plant site is a field laboratory, furnished by the Contractor, in which to house and use the field testing equipment. It should be furnished before the preliminary testing is started and located at some convenient place where plant operations are in full view from one window and where the dust nuisance will be at a minimum.

The plant inspector and his assistants will be supplied with one complete set of laboratory equipment to perform the required tests in the production of asphaltic concrete. This equipment is furnished by the Texas Highway Department.

B. Stockpiling of Materials

After all preliminary design tests of the asphaltic concrete mixtures have been completed and the test results indicate that an asphaltic concrete mixture can be produced to meet the specifications, the Contractor will be permitted to start stockpiling materials.

Plans for stockpiling and handling of aggregates should be discussed by the plant inspector and the plant foreman before any material is delivered to the jobsite. Care should be taken to provide ample area on which to place the materials with provisions for receiving and handling aggregates without contamination or intermingling. The inspector should satisfy himself that stockpile uniformity will not suffer when new material is added.

1. Stockpiling of Aggregates under Item 340.5

Prior to stockpiling aggregates, the area shall be cleaned of trash, weeds and grass and be relatively smooth. Aggregates shall be stockpiled in such a manner as to prevent the mixing of one aggregate with another. Coarse aggregates for Type "A," "B," and "C" shall be separated into at least two stockpiles of different gradation, such as a large coarse aggregate and a small coarse aggregate stockpile in order that the grading requirements of the specified type will be met when the piles are combined in asphaltic mixture. No coarse aggregate stockpile shall contain more than 15% by weight of materials that will pass a No. 1 sieve, except as noted on the plans or provided by special provision. Fine aggregate stockpiles may contain small coarse aggregate in the amount of up to 20% by weight, 100% of which shall pass a 1/4-inch sieve; however, the coarse aggregate shall meet the quality test specified herein for "coarse aggregates." Suitable equipment of acceptable size shall be furnished by the Contractor to work the stockpile and prevent segregation of the aggregates.

2. Storage and Heating of Asphaltic Materials under Item 340.5

The asphaltic materials storage shall be sufficient to meet the requirements of the plant. Asphalt shall not be heated to a temperature in excess of $400^{o}F$. All equipment used in the storage and handling of asphaltic material shall be kept in a clean condition at all times and shall be operated in such a manner that there will be no contamination with foreign matter.

3. <u>Asphaltic Material Heating Equipment under Item 340.4</u>

Asphaltic material heating equipment shall be adequate to heat the amount of asphaltic material to the desired temperature. Asphaltic material may be heated by steam coils which shall be absolutely tight. Direct fire heating of asphaltic materials will be permitted, provided the heater used is manufactured by a reputable concern and there is positive circulation of the asphalt throughout the heater. Agitation with steam or air will not be permitted. The heating apparatus shall be equipped with a recording thermometer with a 24-hour chart that will record the temperature of the asphaltic material.

4. <u>Records and Laboratory Testing of Materials</u>

As the materials are received at the plant site, the Plant Inspector should keep an accurate daily record of all railroad or truck shipments and the quantity of material received.

Sufficient sieve analyses of each aggregate should be run when stockpiling to be sure that the grading is reasonably close to that of the aggregates used in determining the combined grading for the design asphaltic concrete mixtures. Variation in the sieve analyses of any aggregate being stockpiled that cannot be controlled to produce a mixture comparable to the design mix should be rejected. Decantation, plastic index and sand equivalent test should be run on the aggregates to assure compliance with the specifications.

COLD AGGREGATE FEEDER

Stores up to four sizes of aggregate, accurately feeds the required amount of each size to maintain constant balance of aggregate in gradation unit.

DRYER

Continuous flow of aggregate receives maximum drying through direct contact with flame and hot gases. Each aggregate particle is repeatedly exposed for greatest drying efficiency.

DUST COLLECTOR

Recovers valuable fines that would otherwise be lost in dryer exhaust and returns them to mix.

GRADATION CONTROL UNIT

Separates and stores up to four sizes of dried aggregate. Automatically measures and feeds the required percentage of each size. Individual aggregate samples easily taken without interrupting plant production.

MIXER

Automatically meters the correct amount of asphalt, pre-coats the aggregate, and thoroughly mixes the material in the twin-shaft pugmill. Aggregate and asphalt feeds are positively interlocked.

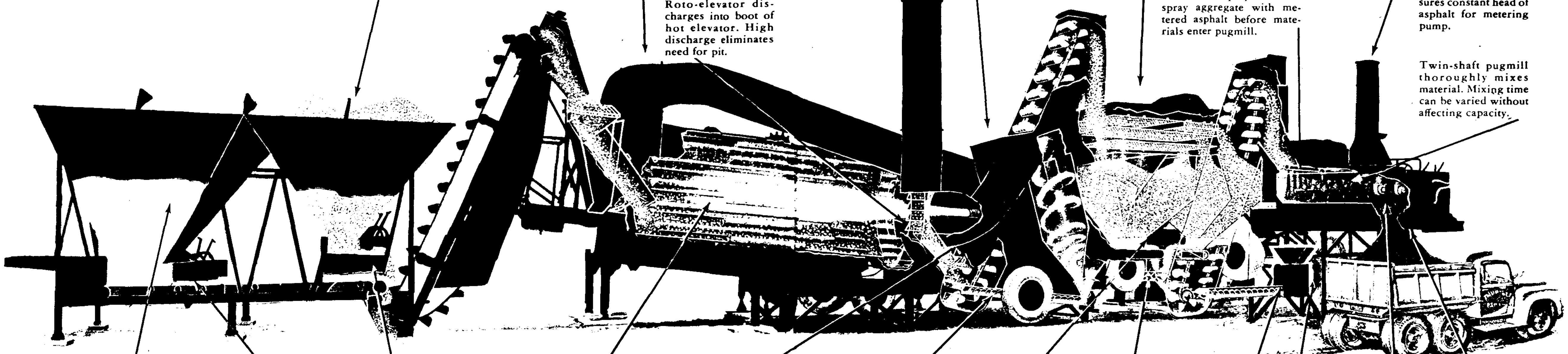
Roto-elevator discharges into boot of hot elevator. High discharge eliminates need for pit.

Flop gates divert aggregates to desired bins and discard chutes.

Nozzles in spray chamber spray aggregate with metered asphalt before materials enter pugmill.

Transfer pump assures constant head of asphalt for metering pump.

Twin-shaft pugmill thoroughly mixes material. Mixing time can be varied without affecting capacity.



Negative angle of slope of bin walls minimizes arching.

Belt feeder under sand bins has adjustable gates. Wide angle of contact between sand and belt minimizes bridging.

Reciprocating feeder under stone bins has adjustable gates.

Curved flights drop aggregate in uniform, thin veil through flame and hot gases for greatest drying efficiency.

Fan controls air flow for dryer combustion system and dust collector.

Collected fines fed by screw conveyor to boot of hot elevator.

Four individually adjusted gates accurately proportion required percentage of each aggregate.

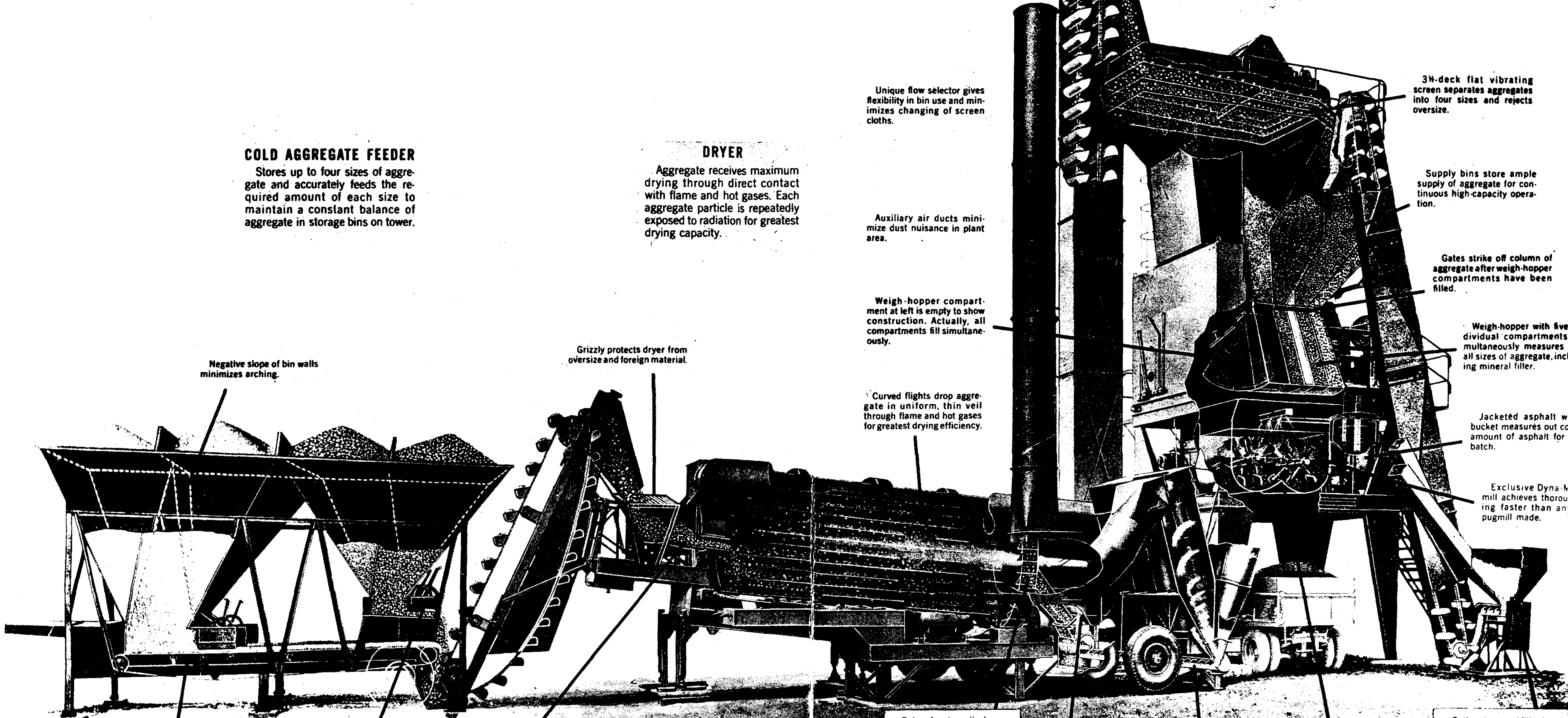
Individual aggregate samples quickly and easily taken by diverting flow of material into test boxes.

Positive displacement metering pump, interlocked with aggregate feed, accurately proportions asphalt to spray chamber.

Discharge hopper with hydraulically activated clamshell gate allows operation between trucks, prevents segregation.

Fines feeder adds required fines through screw conveyor.

Pugmill jacketed for steam or hot oil to maintain correct temperatures for thorough mixing.


DUST COLLECTOR
Recovers valuable fines that would otherwise be lost in dryer exhaust and gives more efficient dryer operation.
TOWER
Screens the aggregate and stores up to four sizes, automatically measures out the correct weight of each aggregate size, asphalt, and, where required, the correct weight of mineral filler, thoroughly mixes the materials, and discharges into truck.
COLD AGGREGATE FEEDER
Stores up to four sizes of aggregate and accurately feeds the required amount of each size to maintain a constant balance of aggregate in storage bins on tower.
DRYER
Aggregate receives maximum drying through direct contact with flame and hot gases. Each aggregate particle is repeatedly exposed to radiation for greatest drying capacity.
Unique flow selector gives flexibility in bin use and minimizes changing of screen cloths.
Auxiliary air ducts minimize dust nuisance in plant area.
Weigh-hopper compartment at left is empty to show construction. Actually, all compartments fill simultaneously.
Curved flights drop aggregate in uniform, thin veil through flame and hot gases for greatest drying efficiency.
3½-deck flat vibrating screen separates aggregates into four sizes and rejects oversize.
Supply bins store ample supply of aggregate for continuous high-capacity operation.
Gates strike off column of aggregate after weigh-hopper compartments have been filled.
Weigh-hopper with five individual compartments simultaneously measures out all sizes of aggregate, including mineral filler.
Jacketed asphalt weigh-bucket measures out correct amount of asphalt for each batch.
Exclusive Dyna-Mix pugmill achieves thorough mixing faster than any other pugmill made.
Negative slope of bin walls minimizes arching.
Grizzly protects dryer from oversize and foreign material.
Belt feeder has adjustable, graduated gates. Wide angle of contact between sand and belt minimizes bridging.
Reciprocating feeder for coarse aggregates has adjustable, graduated gates.
Integral reciprocating feeder maintains uniform continuous flow of aggregate to dryer drum. Chute replaces feeder on some models.
Roto-elevator discharges into boot of hot elevator. High discharge eliminates need for pit.
Fan develops controlled gas and air flow for dryer combustion system and dust collector.
Collected fines fed by screw conveyor to boot of hot elevator.
Oversize pugmill discharge gate allows faster discharge and eliminates segregation.
Optional mineral filler feeding and measuring system stores material at ground level.

IV. Asphalt Plants

A. General

There are two types of stationary plants, the continuous mix (Figure 17) and the weigh-batch (Figure 18). These plants are manufactured and sold by various companies. These companies produce different models of their plants with varying production capacities to meet the requirements of any construction project. Both plants are identical up to the hot bins containing the aggregates that have been screened into separate bins according to sieve sizes.

In the continuous mix plant, the aggregates from the different bins are fed through calibrated gates to an apron conveyer in the proportion desired. The proportioned material is then carried by an enclosed bucket elevator to an apron conveyer from where it enters the twin pug continuous mixer. As the material enters the mixer, asphalt is applied continuously from spraying nozzles to the moving aggregates. Conveyers carrying the aggregate, as well as the asphalt pump, are driven by the same power units so that, theoretically, variations in engine speed do not affect the accuracy of the proportioning. The aggregate and asphalt are mixed while being forced to travel the length of the pug mill mixer and the resulting mixture is discharged into waiting trucks.

In the weigh-batch plant, the aggregates are drawn from the bins into the weighbox in the respective amounts required. The asphalt is weighed into the asphalt bucket. The weighbox and the asphalt bucket are suspended from separate scale beams and the weights as they are loaded are indicated on separate telltale dials. The aggregate is dropped from the bottom of the weighbox into the mixer located directly below it. After mixing the aggregates dry for a few seconds, the asphalt is added and the two raw materials then mixed for not less than 30 seconds. The discharge gate at the bottom of the mixer is then opened and the mixture falls into a truck.

B. <u>Component Parts of the Weigh-Batch Plant</u>

According to Item 340.4 of the Texas Highway Department 1962 Standard Specifications, either the weigh-batch or continuous mix plant may be used to produce asphaltic concrete if they meet the requirements of the specifications.

This course will refer only to the weigh-batch plant since it was approximately 10 years ago when the last continuous mix plant operated in this District. First, the component parts of the weigh-batch plant, as well as their functions, will be described. After the description of each part, the specification item number and the specification requirement for that particular part of the plant will be included.

1. <u>Cold Aggregate Bin and Proportion Device under Item 340.4</u>

Each aggregate is separated by bins; these bins are usually charged by a crane with a clamshell bucket. Gates that can be accurately set and secured should be located beneath the bins to insure a uniform flow of aggregate to the feeders. There are several types of feeders, including the continuous belt, reciprocating plate, vibratory and gravity flow types. Generally, the reciprocating plate or vibratory feeders are in more common use in this area. When the gates are set at the correct opening for each aggregate, the feeders should deliver the aggregates to the conveyer belt in their proper proportions. The conveyer belt then delivers the aggregate to either a bucket or belt conveyer which transfers the aggregate to the dryer.

The aggregate bin shall have at least four compartments of sufficient size to store the amount of aggregate required to keep the plant in continuous operation. The bin shall be designed to prevent overflow of material of one bin to that of another bin. The proportioning device shall provide a uniform and continuous flow of aggregate in the desired proportion to the dryer. Each aggregate shall be proportioned in a separate compartment.

2. <u>Dryer under Item 340.6</u>

The proportioned aggregate is delivered by the cold aggregate elevator to the upper end of the dryer. The dryer is a revolving cylinder, usually from three to nine feet in diameter and from 20 to 40 feet long, in which aggregate is dried and heated by an oil and gas burner. The cylinder is equipped with longitudinal cups or channels, called flights, which lift the aggregate and drop it in veils through the burner flame and hot gasses. The slope of the cylinder, its speed, diameter and the arrangement and number of flights control the length of time required for the aggregate to pass through the dryer. The dryer performs two functions in removing moisture from the aggregate:

(1) The heat of the dryer vaporizes the moisture

(2) The vapor is drawn off by the draft

There are two basic types of oil burners used in dryers. One uses steam for atomizing the fuel oil: the other uses low-pressure air. There are also low and high-pressure gas burners.

The dryer shall be of the type that continually agitates the aggregate during heating and in which the temperature can be controlled in order that aggregates will not be injured in the necessary drying and heating operations. The burner, or combination of burners, and type of fuel used shall be such that no residue from the fuel shall adhere to the heated aggregate. A recording thermometer shall be provided which will record the temperature of the aggregate when it leaves the dryer. The dryer shall be of sufficient size to keep the plant in continuous operation.

3. Dust Collector under Item 340.4

Dust collectors are installed in asphalt plants to reduce dust nuisance and to recover a portion of the usable fines that would otherwise be lost to the atmosphere. A dust-collector duct is connected to the high end of the aggregate dryer at the cold-aggregate entrance to the dryer. The dust-collector fan, or fans, furnishes the draft that draws the flame and hot gases through the dryer. Dust particles from the dryer and other parts of the plant are carried through a series of ducts which enter the circular dust collector tangentially near the top. The current of air then goes into a whirling movement and the heavier dust particles are separated by centrifugal force and fall to the bottom of the dust collector. The finer dust may remain in suspension and be carried out the exhaust stack with the air. The collected fines are withdrawn from the bottom by means of a screw conveyer and returned to the aggregate flow from the dryer at the bottom of the hot aggregate elevator. Item 340.4 requires that plants be equipped with satisfactory dust collectors.

4. Screening and Proportioning under Item 340.4

Screens on the modern asphalt plant are generally of the horizontal vibrating types. The screens are located above the hot-aggregate storage bins. The function of the screens is to accurately separate the aggregate into specified sizes and deposit them into the correct bins. The screens are attached to frames forming as many as four decks of varying widths and lengths, depending on the size of the plant. The hot aggregate from the dryer is lifted by an enclosed bucket elevator and deposited on the top deck of the screens. Screens with the largest openings are attached to the frame forming the first deck. Any aggregate larger than the opening in the top screen is rejected by the screens and goes into the reject chute. The other screens are attached to the remaining frames under the top screen frame in the order of their respective sizes, the finest screen being on the bottom. The type of asphalt that is to be produced will govern the opening size of the screens that will be used over the different bins. For each particular type of asphalt mixture, there is a bin tolerance which gives the allowable variation for each of the bin sieve sizes.

The screening capacity and size of the bins shall be sufficient to screen and store the amount of aggregate required to properly operate the plant and keep the plant in continuous operation at full capacity. Provisions shall be made to enable inspection forces to have easy and safe access to the proper location on the mixing plant where representative samples may be taken from the hot bins for testing. The aggregate shall be separated into at least four bins when producing Type "A," Type "B," and Type "C" mixtures, at least three bins when producing Type"D" mixtures and at least two bins when producing Type "E" and Type "F." If mineral filler is needed, an additional bin shall be provided. Only the bin gradation tolerance requirement for Type "D" mixtures will be listed, since this is the type to be discussed in the plant production.

Type "D" (FINE GRADED SURFACE COURSE):

Bin No. 1 - will contain aggregates of which 90 to 100 per cent by weight will pass the No. 10 sieve.

Bin No. 2 - will contain aggregates of which at least 85 per cent by weight will be of such size as to pass the 1/4-inch sieve and be retained on the No. 10 sieve.

Bin No. 3 - will contain aggregates of which at least 85 per cent by weight will be of such size as to pass the 1/2-inch sieve and be retained on the No. 4 sieve.

5. Aggregate with Box and Batching Scales under Item 340.4

The aggregate weight box and batching scale are located below the hot-aggregate bins. The aggregate weighbox is suspended from the scale beam. The scale is provided with weight-graduated dial and a pointer or telltale indicater which indicates the weight of the aggregate as it enters the weighbox.

The aggregate is drawn separately from the bins and allowed to fall into the weighbox. The weight of the aggregate from each bin is predetermined and the weight accumulated on the weight graduated dial until each bin has contributed its portion to the total aggregate in the weighbox.

The aggregate weighbox and batching scales shall be of sufficient capacity to hold and weigh a complete batch of aggregate. The weighbox and scales shall conform to the requirements of the Item, "Weighing and Measuring Equipment."

6. <u>The Asphalt Material Bucket and Scales under Item 340.6</u>

The asphalt bucket is attached to the scale beam and is gnerally located outside and adjacent to the aggregate weighbox. The scale is provided with a pointer or telltale indicator which indicates the weight of the asphalt on a weight-graduated dial as it enters the bucket. The hot asphalt is pumped to the asphalt weigh bucket from the storage tank, or tanks, and the weight of asphalt introduced into the weigh bucket is controlled by a cutoff valve. The asphalt is heated by the circulation of steam or hot oil in pipe lines which extend through the storage tanks.

The asphaltic material bucket and scales shall be of sufficient capacity to hold and weigh the necessary asphaltic material for one batch. If the material is measured by weight, the bucket and scales shall conform to the requirements of the Item, "Weighing and Measuring Equipment."

7. <u>Mixer under Item 340.4</u>

Located below the aggregate weighbox opening is the enclosed and lined mixer compartment. Housed in the mixer compartment are the liquid asphalt slotted spray bar which furnishes the asphalt from the asphalt weigh bucket and the twin rotating shaft pug mill mixers equipped with paddle shanks and paddle tips. When mixing the aggregate and asphalt, the shafts turn in opposite directions, which causes the material to float upward between the two shafts. When the aggregate is dumped into the mixer, it is dry mixed for at least five seconds to uniformly distribute the various sizes throughout the batch before the asphalt is added. Then, the asphalt is added to the aggregate and they are mixed for a minimum of 30 seconds, or longer, depending on the time required to produce a homogeneous mixture. Located at the bottom of the mixer, is a discharge gate through which the mixed material can be delivered to trucks for transportation to the construction project.

The mixer shall be of the pugmill type and shall have a capacity of not less than 2,000 pounds in a single batch. The number of blades and the position of same shall be such as to give a uniform and complete circulation of the batch in the mixer. The mixer shall be equipped with an approved spray bar that will distribute the asphaltic material quickly and uniformly throughout the mixer. Any mixer that has a tendency to segregate the mineral aggregate or fails to secure a thorough and uniform mixing with the asphaltic material shall not be used. This shall be determined by mixing the standard batch for the required time, then dumping the mixture and taking samples from its different parts. This will be tested by the extraction test and must show that the batch is uniform throughout. All mixers shall be provided with an automatic time lock that will lock the discharge doors of the mixer for the required mixing period. The dump door, or doors, and the shaft seals of the mixer shall be tight enough to prevent the spilling of aggregate or mixture from the pugmill.

In the charging of the weighbox and in the charging of the mixer from the weighbox, such methods or devices shall be used as are necessary to secure a uniform asphaltic mixture. In introducing the batch into the mixer, all mineral aggregate shall be introduced first; shall be mixed thoroughly for a period of five to twenty seconds, as directed, to uniformly distribute the various sizes throughout the batch before the asphaltic material is added; the asphaltic material shall then be added and the mixing continued for a total mixing period of not less than 30 seconds. This mixing period may be increased, if, in the opinion of the Engineer, the mixture is not uniform.

V. <u>Plant Inspection Checklist</u>

The method of handling the materials and the general requirements for equipment used at the plant are covered very well in the specifications; however, the Plant Inspector should devote enough time inspecting the parts of the plant as they are set up to be sure they meet the specifications. Listed below are parts of the plant that the Inspector should check as the plant is being set up and, also, check periodically when the plant is in operation:

1. Check cold aggregate bins to see that no holes are in the bins that would allow aggregate intermingling. See that gate openings at the bottom of the bins are adjustable and that they can be accurately set and secured.

2. Check asphalt storage tanks as they arrive at the plant to be sure they are empty. If the tank contains asphalt, submit a sample to Austin for test before using, unless positive identification of material can be obtained from the Resident Engineer in charge of the project on which the storage tank was last used. If the asphalt is from the same producer and the type and grade are the same as that which is to be used on the project, allow it to be used upon verification from the Resident Engineer in charge of the previous project.

   All lines through asphalt storage tanks that are used to circulate hot oil or steam for the purpose of heating the stored asphalt are to be free of leaks.

3. Require all temperature indicators to be installed and check for accuracy.

4. Check screens and frames to see that they are in good condition and that no torn places exist in the screens. See that various sections are properly placed over bins; that bins are in good condition; and that no overflow can occur from one bin to another. See that each bin is equipped with an overflow pipe.

5. Check discharge gates on hot bins and weighbox to see that they close properly and that there is no leakage after being closed.

6. Check all weighing devices to see that they are functioning properly. Make calibration with standard weights. If necessary, require the service of a trained scale man.

7. Check pugmill mixing paddles to see that they are complete and in place; properly set; and not unduly worn.
8. Check discharge gate at pugmill mixer to see that there is no leakage when it is closed.

VI. Starting the Plant

A. General

The plant and roadway inspection personnel should be complete prior to the completion of the plant setup. By the time the plant is set up and ready to operate, the plant inspector should have made a thorough inspection of the equipment for compliance with the specification requirements. If the plant meets the requirements of the specifications, it can be started and the hot bins filled to determine the per cent by weight of the material from each hot bin that will be used to make the aggregate portion of the batch. In order to plant-produce the aggregates to the hot bins according to the combined grading used in designing the laboratory mixes, it is necessary to proportion each aggregate from a separate cold aggregate storage bin to the feeders.

B. Cold Feed Proportioning

Assume that the cold-aggregate bins have been filled and that each of the proposed aggregates has been placed in a separate bin. Then, the bin gate for each aggregate should be set at a predetermined height that would deliver the aggregates in the desired proportions to the feeders. This height is determined from past experience, manufacturer's calibration chart, or from actual calibration of gate openings.

Most manufacturers furnish approximate calibrations for gate openings of their equipment. When these are available, they are helpful in making the initial gate setting; however, the most accurate method of setting the gates is to make calibration charts for each gate, using the aggregate to be employed in the mix.

Assume that the gates are to be calibrated. The gate is set at some increment, usually about 25 per cent of the total opening or less, and the feeder is started. When the feeder is running normally, material is measured for a known time interval into a tared container and weighed. The moisture content of the material is determined and the total wet weight of the material is converted to dry weight. The operation is repeated for as many gate openings as the plant inspector feels is necessary.

The calibration chart for each aggregate should show the gate opening (in inches or square inches) plotted as the horizontal ordinate and the dry pounds per minute or dry tons per hour, according to the units preferred, delivered by the feeder as a vertical ordinate.

C. Hot Bin Sieve Analysis

After all cold-aggregate bin gates have been calibrated, the bins should be refilled. The cold feed gates can then be set to deliver the aggregates to the feeders in the desired percentages to produce a total volume which will accomodate a normal operation of the plant.

The plant is started and the hot bins filled. Then, three aggregate samples of equal volume are taken from each bin. The samples should come from the approximate bottom, middle and top levels of the material in the bin as it falls into the weigh hopper from the operator-controlled gate opening located at the bottom of each bin. The three samples from each bin are then combined and thoroughly mixed to form a composite sample of that bin. The composite bin sample from each separate bin is then quartered or run through a sample splitter, to obtain a representative portion of specified (Bulletin C-14) weight, from which the sieve analyses will be run. The results of the sieve analyses are used to determine the initial per cent by weight that each bin will furnish of its sieve sizes to the total weight of the asphaltic concrete batch.

Listed in the following table for each of the three hot bins (specified for Type "D" Asphaltic Concrete) are assumed sample weights used to determine the sieve analyses.

HOT BIN SIEVE ANALYSES

SIEVE SIZES	Bin No. 1		Bin No. 2		Bin No. 3	
	Weight in grams retained on sieves	Percent of sample retained on sieves	Weight in grams retained on sieves	Percent of sample retained on sieves	Weight in grams retained on sieves	Percent of sample retained on sieves
+ 1/2"	0.0	0.0	0.0	0.0	0.0	0.0
1/2"- 3/8"	0.0	0.0	0.0	0.0	21.5	1.3
3/8"- No. 4	0.0	0.0	111.0	9.6	1448.0	85.2
4 - 10	26.0	2.2	949.0	82.0	193.0	11.4
10 - 40	218.3	18.4	76.0	6.6	20.5	1.2
40 - 80	531.6	44.8	5.0	0.4	2.5	0.1
80 - 200	302.6	25.5	8.0	0.7	5.0	0.3
Pass 200	108.0	9.1	8.0	0.7	9.0	0.5
Total	1186.5	100.0	1157.0	100.0	1699.5	100.0

The per cent by weight of the sieve sizes in each bin shown above is calculated as follows:

$$\text{Per cent passing larger and retained on smaller sieve} = \text{Weight retained} \times \frac{1}{\text{Total weight of sample}} \times 100$$

D. Determination of Bin Percentages and Bin Weights

Based on the density and stability curves representing the average test values of the design mixtures, an asphalt content of 5.8% by weight will be selected to start the plant. The weight of the aggregate will obviously be 100%, minus 5.8% or 94.2%. To obtain an initial design hot bin grading analysis, each of the sieve sizes of the design grading will furnish 94.2% to the total mixture:

Sieve sizes	Grading analysis of design combined total aggregate per cent by weight				Design hot bin grading analysis per cent by weight	
+ 1/2"	0.0	x	.942	=	0.0	
1/2" - 3/8"	3.0	x	.942	=	2.8	
3/8" - No. 4	34.5	x	.942	=	32.5	
4 - 10	27.5	x	.942	=	25.9	61.2 Total + 10
10 - 40	7.6	x	.942	=	7.2	
40 - 80	15.1	x	.942	=	14.2	
80 - 200	9.0	x	.942	=	8.5	
Pass 200	3.3	x	.942	=	3.1	
	100.0				94.2	
			Asphalt		5.8	
					100.0	

The per cent by weight that each bin will furnish has, in this case, been determined by trial and error, and these percentages are as follows: Bin 1 - 32%; Bin 2 - 25%; and Bin 3 - 37.2%. To determine the grading analysis contributed by Bins 1, 2, and 3, respectively, it is necessary to multiply their grading analysis percentages by that per cent of the total aggregate which is to be contributed from each bin as follows:

*(1) Grading analysis (per cent by weight)
**(2) Per cent to be taken from bin
***(3) Grading analysis (per cent by weight) contributed from bin to the total mixture

Bin No. 1

Sieve Sizes	*(1)		**(2)		***(3)
+ 1/2"	0.0	x	.32	=	0.0
1/2" - 3/8"	0.0	x	.32	=	0.0
3/8" - No. 4	0.0	x	.32	=	0.0
4 - 10	2.2	x	.32	=	0.7
10 - 40	18.4	x	.32	=	5.9
40 - 80	44.8	x	.32	=	14.3
80 - 200	25.5	x	.32	=	8.2
Pass 200	9.1	x	.32	=	2.9
	100.0				32.0

Bin No. 2

Sieve Sizes	*(1)		**(2)		***(3)
+ 1/2"	0.0	x	.25	=	0.0
1/2" - 3/8"	0.0	x	.25	=	0.0
3/8" - No. 4	9.6	x	.25	=	2.4
4 - 10	82.0	x	.25	=	20.5
10 - 40	6.6	x	.25	=	1.7
40 - 80	0.4	x	.25	=	0.1
80 - 200	0.7	x	.25	=	0.2
Pass 200	0.7	x	.25	=	0.1
	100.0				25.0

Bin No. 3

Sieve Sizes	*(1)		**(2)		***(3)
+ 1/2"	0.0	x	.372	=	0.0
1/2" - 3/8"	1.3	x	.372	=	0.5
3/8" - No. 4	85.2	x	.372	=	31.7
4 - 10	11.4	x	.372	=	4.2
10 - 40	1.2	x	.372	=	0.5
40 - 80	0.1	x	.372	=	0.0
80 - 200	0.3	x	.372	=	0.1
Pass 200	0.5	x	.372	=	0.2
	100.0				37.2

Combining the various sizes furnished from the three bins, we have a combined analysis as follows:

*(1) Combined Analysis
**(2) Initial Selected Design

Sieve Sizes	Bin #1		Bin #2		Bin #3		*(1)		**(2)	
+1/2"	0.0	+	0.0	+	0.0	=	0.0		0.0	
1/2"-3/8"	0.0	+	0.0	+	0.5	=	0.5		2.8	
3/8"- 4	0.0	+	2.4	+	31.7	=	34.1		32.5	
4 -10	0.7	+	20.5	+	4.2	=	25.4	60.0 Total + 10	25.9	61.2 Total + 10
10 -40	5.9	+	1.7	+	0.5	=	8.1		7.2	
40 -80	14.3	+	0.1	+	0.0	=	14.4		14.2	
80 -200	8.2	+	0.2	+	0.1	=	8.5		8.5	
Pass 200	2.9	+	0.1	+	0.2	=	3.2		3.1	
	32.0		25.0		37.2		94.2		94.2	
Asphalt							5.8		5.8	
							100.0		100.0	

The combined bin analysis meets the specified master grading requirements (Item 340.3 - Paving Mixtures) and, since the variations (Item 340.3 - Tolerances) from the selected design are well within acceptable limits, the calculated combination of bins is satisfactory.

Assuming that the plant will produce a 4,000 batch, the batch weights are as follows:

Bin No. 1	=	32.0%	x	4,000	=	1,280 Lbs.
Bin No. 2	=	25.0%	x	4,000	=	1,000 Lbs.
Bin No. 3	=	37.2%	x	4,000	=	1,488 Lbs.
Asphalt	=	5.8%	x	4,000	=	232 Lbs.
					Total	4,000 Lbs.

E. Inital Plant Operation and Adjustment for Maximum Production

After the bin weights have been determined, the plant can begin producing asphaltic concrete; however, the maximum production rate, commonly expressed in tons per hour, that can be expected from any plant when producing an asphaltic concrete mixture within the specifications, depends on the efficiency of the drier and the plant screening unit. The greatest quantity of aggregate that can be dried and heated to produce a mixture having a temperature within a specified range, is governed by the size of the drier, method of heating and moisture content of the aggregate. The maximum quantity of aggregate that can be produced in each bin, according to specified sieve size tolerances, is dependent on the amount of material available from the drier, type of aggregate, effective screening area dnd the most applicable screen combination.

All asphalt plants carry a maximum manufacturer's rating in tons per hour; however, some combinations of aggregates will not always allow a plant to produce asphaltic concrete at the manufacturer's rated capacity. The potential maximum production can only be established when the required tests results indicate that the component parts of the plant have reached peak efficiency and are operating within the limits of the specifications. It is recommended when starting asphaltic concrete production that the plant should be put into operation at approximately 50% of the manufacturer's maximum rated capacity. To increase the plant production to the maximum, it is recommended that it be done gradually and be controlled by sieve analysis tests from each hot bin. During the transition to maximum production, it is also recommended that sieve analysis be made of the aggregate in each bin for approximately every hour of plant operation. The sieve analyses results obtained from the aggregate in the hot bins during the first day of operation should determine whether the plant screens will produce the aggregate according to the specified bin tolerances or indicate screen size changes that must be made.

To start production, the cold aggregate bin gates should be set at a predetermined height (preferably from bin calibration charts) that will allow the feeders to proportion the aggregates according to the design combination and in the quantity to begin the plant operation at approximately 50% capacity. As an illustration, assume that the maximum production of the plant is 150 tons per hour; therefore, 50% of the maximum production would amount to 75 tons per hour. The combined weight of the aggregate contained in the 75 tons per hour of asphaltic concrete must be contributed from the four aggregates according to their design combination; therefore, each aggregate bin gate must be set to deliver its hourly required weight portion of the combined total aggregate to the feeder for processing through the plant and into the hot bins. The weight contributed by the aggregate and asphalt in tons per hour to the asphaltic concrete to be produced at the rate of 75 tons per hour is illustrated as follows: the design combination of the aggregate by weight contained 12% limestone, 25% oyster shell, 35% gravel screenings and 28% local sand. The asphaltic concrete mixture was selected from the design data to contain 5.8% asphalt by weight and 94.2% aggregate by weight.

The per cent by weight that each aggregate from the design combination will furnish is calculated as follows:

*(1) Aggregate
**(2) Per cent by weight of design combination
***(3) Total per cent of aggregate by weight in mixture
****(4) Per cent by weight furnished by each aggregate

*(1)	**(2)		***(3)		****(4)
Limestone	12	x	94.2	=	11.3
Oyster Shell	25	x	94.2	=	23.5
Gravel Screenings	35	x	94.2	=	33.0
Local Sand	28	x	94.2	=	26.4
	100	x	94.2	=	94.2
				Asphalt	5.8
				Total	100.0

The per cent by weight that each aggregate and the asphalt must furnish to 75 tons of asphaltic concrete is calculated as follows:

*(1) Aggregate
**(2) Per cent by weight furnished by each aggregate
***(3) Tons of asphaltic concrete
****(4) Tons of each aggregate in asphaltic concrete

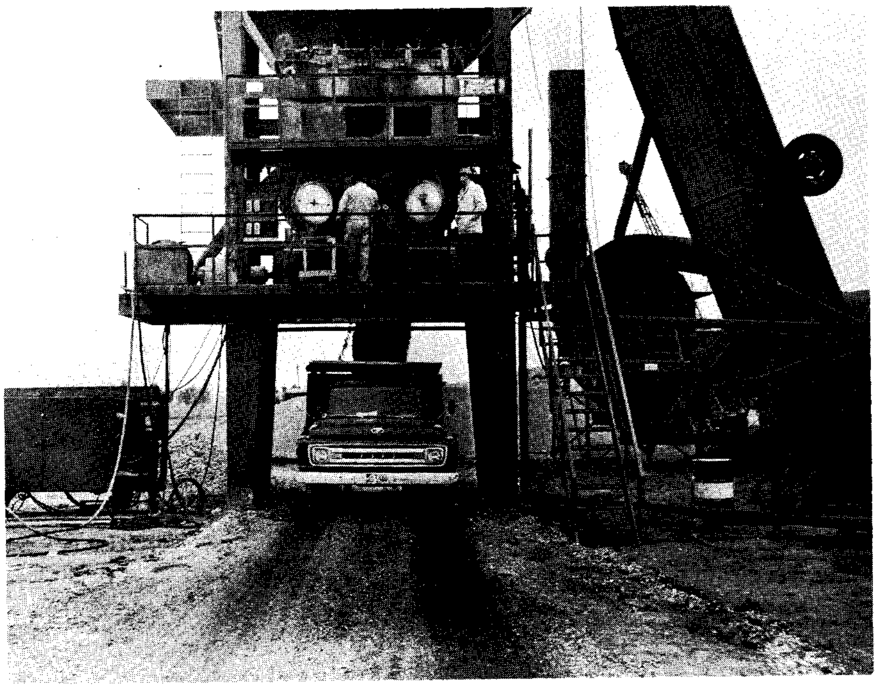
*(1)	**(2)		***(3)		****(4)
Limestone	11.3	x	75	=	8.475
Oyster Shell	23.5	x	75	=	17.625
Gravel Screenings	33.0	x	75	=	24.750
Local Sand	26.4	x	75	=	19.800
Total Aggregate	94.2	x	75	=	70.650
Asphalt	5.8	x	75	=	4.350
Total	100.0				75.000

To produce the aggregate portion of the asphaltic concrete at the rate of 75 tons per hour, according to design combinations, each aggregate must furnish its weight in tons per hour from the cold aggregate bin to the feeder as follows: Limestone, 8.475 tons; Oyster shell, 17.625 tons; gravel screenings, 24.750 tons; and local sand, 19.800 tons. Then, 4.350 tons of asphalt and 70.650 tons of aggregate per hour must be blended in the plant pugmill mixer to produce the asphaltic concrete mixture at the rate of 75 tons per hour.

To produce a 4,000-pound batch of asphaltic concrete at a uniform rate of 75 tons per hour requires the asphalt and aggregate to enter the pugmill, be thoroughly blended and finally discharged into a haul truck within a time interval of 1.6 minutes.

With the plant in operation, the cold feeders will then make the preliminary proportioning of the aggregates by depositing them on a moving conveyor located below the feeders. The aggregate

The total asphaltic concrete mixture (4,000 pounds) is then thoroughly mixed for at least 30 seconds, or longer, to obtain uniform blending of the asphaltic material with the aggregate. During the mixing time that the batch is required to remain in the pugmill mixer, the operator should begin weighing the materials required for another 4,000-pound batch. When the batch that is being mixed in the pugmill has been blended to the required uniformity, it can be dumped into a haul truck for transportation to the project.



Then the aggregates and asphalt that have been weighed for the batch to follow are dumped into the pugmill mixer for processing. The weighing and mixing sequence used to obtain the completed mixture then becomes a routine plant operation with the quantity of production being controlled by truck transportation from the plant to the roadway and placement of the material on the road.

During the first day of plant operation, a representative sample of the asphaltic concrete from the first load produced should be taken. This sample is to be used in molding a laboratory test specimen from which a preliminary density test result can be obtained to verify that the mixture will produce a density within a specified range. An experienced plant inspector can generally tell by visual inspection whether the mixture will produce an acceptable density when tested. Thus, he is able to accept it for use on the roadway until the density results are determined from the three specimens required to be molded and tested daily. When the plant inspector has had little or no previous experience, it may be advisable to produce one batch in the plant pugmill on the day before roadway placement begins to obtain samples for testing to prove mixture density acceptance.

When at least two truck loads of asphaltic concrete have been produced by the plant, hot bin sampling of the aggregates should begin. An extreme effort should be made to obtain a representative sample of the aggregate in each bin. Samples should be secured by passing a shovel or pan quickly through the stream of material as it flows from each bin into the weigh hopper. The daily road report requires each set of sieve analysis to be identified by a roadway station number within the limits of the area over which the load of asphaltic concrete representing the sieve analysis is placed.

The roadway inspector is notified by a note as each sieve analysis is taken. This note states the sieve analysis number, time of sampling, temperature of asphaltic concrete, and truck number of asphaltic concrete represented by the sieve analysis. The note is given to the truck driver for delivery to the roadway inspector who completes the information by adding the roadway station number. The roadway inspector returns the completed information for all sieve analysis tests that have been run during the day to the plant inspector who uses it to prepare his daily laboratory report.

The assumed hot bin sieve analyses tests results for the first day of plant operation will be illustrated on seven sheets of Form 544, "Asphaltic Concrete Screen and Sieve Analysis Work Sheet." The information shown on Form 544 is as follows:

1. The percentages by weight of the total aggregate according to sieve sizes contained in each hot bin.
2. The per cent by weight that each bin will contribute of its aggregate to the total aggregate in the mixture.
3. The percentages of the aggregate by weight according to sieve sizes that each bin will furnish to the total aggregate in the mixture.
4. The percentages of the total aggregate by weight according to sieve sizes furnished from all bins to make up the total aggregate in the mixture.

Item 340.4 of the Standard Specifications requires the hot aggregate bins to contain the aggregates in the following sizes when producing Type "D" (Fine Graded Surface Course):

Bin No. 1 - Will contain aggregates of which 90 to 100 per cent by weight will pass the No. 10 sieve.

Bin No. 2 - Will contain aggregates of which at least 85 per cent by weight will be of such size as to pass the 1/4" sieve and be retained on the No. 10 sieve.

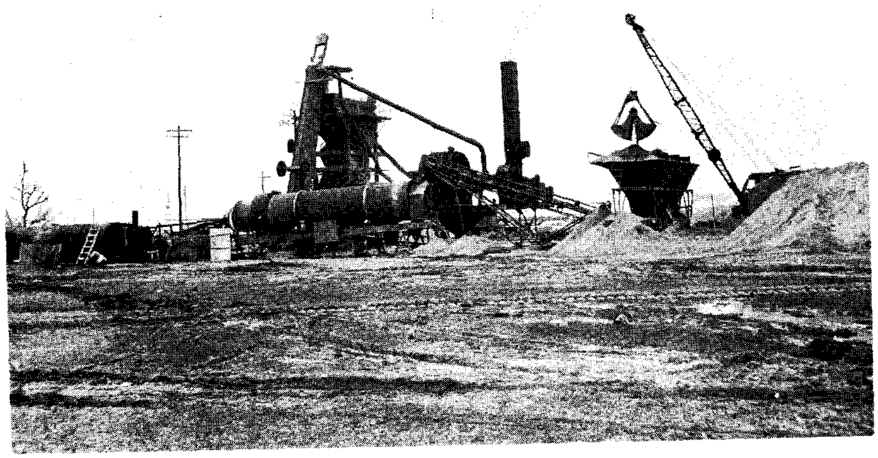
Bin No. 3 - Will contain aggregates of which at least 85 per cent by weight will be of such size as to pass the 1/2" sieve and be retained on the No. 4 sieve.

The aggregate sieve analyses results for the first and second test recorded on Form 544 (see Hot Bin Sieve Analysis) show the aggregate sizes in the respective bins to be well within the specified requirements. Based on these two tests, it would be recommended that the production of the plant be increased 10%. This would increase the production to 60% (90 tons per hour) of the manufacturer's maximum 150 tons per hour for the plant. The aggregate cold feed unit would then be required to increase its aggregate portion from 70.650 tons per hour to 84.780 tons per hour. The aggregate sieve analyses results for the third and fourth tests recorded on Form 544 show the aggregate sizes in the respective bins to be within the specifications. Based on these two tests, it would also be recommended that the production of the plant be increased an additional 10%. To effect this change, the aggregate cold feed unit must be adjusted to increase its aggregate portion from 84.780 tons per hour to 98.910 tons per hour. With the aggregate portion increased to this amount, the plant would be producing at 70% (105 tons per hour) of its 150 tons per hour maximum rated capacity.

Bulletin C-14 specifies that a minimum of three specimens (one set) be molded from the asphaltic concrete produced for each day of plant operation to be used in testing it for density and stability. The bulletin also requires an extraction test of the asphaltic concrete to be performed in conjunction with the density and stability tests. A sieve analysis of the aggregate in each hot bin should be made at the same time that the asphaltic concrete mixture is obtained for density, stability and extraction testing. Simultaneous sampling of the hot bin aggregates and asphaltic concrete mixture to be used in the above-mentioned tests is necessary in order to correlate their test results. As an illustration, assume that a sample of the asphaltic concrete for testing is to be taken from the haul truck at the same time that the hot aggregate bin samples are obtained for their fifth sieve analysis. To obtain a sample of the asphaltic concrete, it is suggested that small amounts of the material be taken from different locations in the truck to be combined by blending to form the composite sample. The small samples should consist of representative portions of non-segregated material obtained from the interior of a batch after removing some of the material from its natural sloping edges. The combined weight of the small samples should produce a composite asphaltic concrete sample of at least five thousand grams. Three specimens can then be molded from a portion of the asphaltic concrete sample to obtain density and stability tests results as described in Tests 4 and 5 of Bulletin C-14. Shown on Form 545, page 83, are assumed values illustrating the calculations required in determining the density of the individual specimens, and finally, the average density of the three specimens. An average density of 97% is considered to be optimum according to Item 340.1 of the Standard Specifications. After the densities have been calculated, the three specimens are packed according to Test No. 6 in Bulletin C-14 and shipped to the Austin Laboratory for stability testing. Listed on Form CX-101, page 84, is an illustration of the information required to accompany the specimen submission to the Austin Laboratory. To obtain prompt average stability test results for each set of specimens, they should be reported to the District Office by teletype from the Austin Laboratory. In order to obtain test results by teletype, it must be requested as illustrated on Form CX-101, page 84. Three CX-101 forms are required to be submitted with each set of three specimens. One is placed inside the can, one in a standard laboratory envelope wired to the outside of the can and a third by mail to the State Highway Engineer directed to the attention of D-9. Using another portion of the asphaltic concrete sample, an extraction test must be performed. The method of procedure to be used in performing the extraction is outlined in Test No. 7 of Bulletin C-14. Shown on Form 546, page 85, are assumed values illustrating the calculations necessary to obtain the extraction results. The plant-produced mixture sieve analysis and asphalt content when tested by extraction, must agree with those of the designated plant design mixture within the specified tolerances of Specification Item 340.3(2). A comparison of the sieve analysis and asphalt content from the extraction test results shown on Form 546, page 85, with those of the selected plant design mixture on page 6 confirms the mixture to be within the specified tolerances. Referring to the fifth hot aggregate bin sieve analysis, the assumed results indicate that the plant screens are now processing the maximum amount of material that can be expected of them. This is evident by observing the percentage of increase in the amount of aggregate retained on one of the sieve sizes in both the two and three bins. These sieve size increases have occurred on the 10-40 in the two bin and the 4-10 in the three bin. The 10-40 sieve size aggregate is predominately one-bin material; therefore, overriding of this size aggregate into the two bin is occurring. The 4-10 sieve size aggregate is predominately two-bin material; therefore, overriding of this size aggregate into the three bin is also occurring. This overriding of the aggregate is a typical example of what can be expected from plant screens as they approach or become overloaded with material. This condition occurred after the plant production had been increased from 90 to 105 tons per hour.

The percentage of the total aggregate shown in Bin No. 1 to be passing the No. 10 sieve is well within the 90 to 100 per cent specified to pass that sieve. The percentage of the total aggregate shown in Bin No. 2 to be passing the 1/4" sieve and retained on the No. 10 sieve is 85% which is the minimum required by the specification. The sum of the percentage of the total aggregate shown in Bin No. 3 to be retained on the 3/8" and 1/2" sieves is 85%; this, also is the minimum required by the specifications. Referring Sieve Analyses 6 and 7, the assumed results show the aggregates according to sieve sizes in Bins 2 and 3 are being produced slightly above the minimum requirement for each bin. The fifth, sixth and seventh sieve analyses results have proven that the screen combination being used in the plant should not be expected to process the aggregate for a total production of asphaltic concrete exceeding 105 tons per hour. If the Contractor insists on higher production, the hot bin screens over the first and second bins must be changed. At the end of the day, or at least during the following morning, all records required to be used in making the daily reports should have been checked. This information is given to the plant inspector who uses it to fill out Form 404, "Daily Field Laboratory Report, page 86; the required number of these daily reports, according to the type of project, are submitted to the District Office weekly for proper distribution. Listed on Form 404 is the information obtained from the forms illustrating the tests that were performed and the other information which must always be available when making this report.

The description of the first day of plant operation is not intended to mislead anyone into thinking that plant production of asphaltic concrete is easily controlled. Experienced contractors' plant personnel would be capable of making prior adjustments to the plant which would make the operation function as smoothly as it has been described. Some combinations of aggregates will require the most experienced contractors' personnel to make adjustments in the plant during the first few days of operation. The tests which are required by the specifications will determine very early whether immediate adjustments to the plant must be made. When tests prove that adjustments are necessary, have the plant foreman make them immediately. The goal that should be set by all concerned is to have the plant operate as it was described during the first day of operation and it can be done.



Texas Highway Department
Form No. 544

TEXAS HIGHWAY DEPARTMENT
ASPHALTIC CONCRETE SCREEN AND SIEVE ANALYSIS
WORK SHEET

Date 1-1-64 Stencil No. --- Design No. D1-1-5.8

Time 8:00 A.M. Type "D" Station No. 7+50

Spec. Item 340---010 Proj. No. C 1-1-1

Size	Bin No. 1 Total %	(a) x 32.0 %	Bin No. 2 Total %	(b) x 25.0%	Bin No. 3 Total %	(c) x 37.2 %	Bin No. 4 Total %	(d) x %	Combined Analysis % (a+b+c+d)
+1"									
1" — 3/4"									
3/4" — 1/2"									
+5/8"									
5/8" — 1/2"									
+1/2"									
1/2" — 3/8"					1.0	0.4			0.4
3/8" — 1/4"			4.3						
+3/8"									
1/4" — 4			4.9	2.3	84.7	31.5			33.8
4 — 10	2.0	0.6	82.6	20.7	12.2	4.5			25.8
10 — 40	18.8	6.0	7.0	1.7	1.5	0.6			8.3
40 — 80	43.9	14.1	0.2	0.1	0.1	0.0			14.2
80 — 200	26.7	8.5	0.4	0.1	0.2	0.1			8.7
Pass 200	8.6	2.8	0.6	0.1	0.3	0.1			3.0
Total	100.0 %	32.0 %	100.0 %	25.0 %	100.0 %	37.2 %	100.0 %	%	94.2 %

60.0 Total + 10

Asphaltic Binder = OA 90 = 5.8 %

Total = 100.0 %

I. SIZER
Inspector

Hot Bin Sieve Analysis No. 1

Texas Highway Department
Form No. 544

TEXAS HIGHWAY DEPARTMENT
ASPHALTIC CONCRETE SCREEN AND SIEVE ANALYSIS
WORK SHEET

Date 1-1-64 Stencil No. --- Design No. D 1-1-5.8

Time 9:15 Type "D" Station No. 16+00

Spec. Item 340---0 Proj. No. C 1-1-1

Size	Bin No. 1 Total %	x (a) 32.0 %	Bin No. 2 Total %	x (b) 25.0 %	Bin No. 3 Total %	x (c) 37.2 %	Bin No. 4 Total %	x (d) %	Combined Analysis % (a+b+c+d)
+1"									
1" – 3/4"									
3/4" – 1/2"									
+5/8"									
5/8" – 1/2"									
+1/2"									
1/2" – 3/8"					0.3	0.1			0.1
3/8" – 1/4"			1.0						
+3/8"									
1/4" – 4			1.0	0.5	85.7	31.9			32.4
4 – 10	2.2	0.7	87.8	22.0	13.2	4.9			27.6
10 – 40	15.0	4.8	8.0	2.0	0.6	0.2			7.0
40 – 80	43.4	13.9	0.6	0.1	0.0	0.0			14.0
80 – 200	29.4	9.4	0.7	0.2	0.1	0.0			9.6
Pass 200	10.0	3.2	0.9	0.2	0.1	0.1			3.5
Total	100.0 %	32.0 %	100.0 %	25.0 %	100.0 %	37.2 %	100.0 %	%	94.2 %

60.1

Asphaltic Binder = OA 90 = 5.8 %

Total = 100.0 %

I. SIZER
Inspector

No. 2

Texas Highway Department
Form No. 544

TEXAS HIGHWAY DEPARTMENT
ASPHALTIC CONCRETE SCREEN AND SIEVE ANALYSIS
WORK SHEET

Date 1-1-64 Stencil No. --- Design No. D 1-1-5.8

Time 10:30 Type "D" Station No. 23+10

Spec. Item 340---- Proj. No. C 1-1-1

Size	Bin No. 1 Total %	(a) x 32.0 %	Bin No. 2 Total %	(b) x 25.0 %	Bin No. 3 Total %	(c) x 37.2 %	Bin No. 4 Total %	(d) x %	Combined Analysis % (a+b+c+d)
+1"									
1" — 3/4"									
3/4" — 1/2"									
+5/8"									
5/8" — 1/2"									
+1/2"									
1/2" — 3/8"					0.9	0.3			0.3
3/8" — 1/4"			2.9						
+3/8"									
1/4" — 4			3.1	1.5	86.1	32.0			33.5
4 — 10	1.8	0.6	84.8	21.2	10.2	3.8			25.6
10 — 40	16.6	5.3	8.0	2.0	2.0	0.7			8.0
40 — 80	45.0	14.4	0.3	0.1	0.2	0.1			14.6
80 — 200	27.8	8.9	0.4	0.1	0.2	0.1			9.1
Pass 200	8.8	2.8	0.5	0.1	0.4	0.2			3.1
Total	100.0 %	32.0 %	100.0 %	25.0 %	100.0 %	37.2 %	100.0 %	%	94.2 %

59.4

Asphaltic Binder = OA 90 = 5.8 %

Total = 100.0 %

I. SIZER
Inspector

No. 3

Texas Highway Department
Form No. 544

TEXAS HIGHWAY DEPARTMENT
ASPHALTIC CONCRETE SCREEN AND SIEVE ANALYSIS
WORK SHEET

Date 1-1-64 Stencil No. --- Design No. D 1-1-5.8

Time 11:40 Type "D" Station No. 30+25

Spec. Item 340---- Proj. No. C 1-1-1

Size	Bin No. 1 Total %	(a) x 32.0 %	Bin No. 2 Total %	(b) x 25.0 %	Bin No. 3 Total %	(c) x 37.2 %	Bin No. 4 Total %	(d) x %	Combined Analysis % (a+b+c+d)
+1"									
1" — 3/4"									
3/4" — 1/2"									
+5/8"									
5/8" — 1/2"									
+1/2"									
1/2" — 3/8"					1.3	0.5			0.5
3/8" — 1/4"			4.5						
+3/8"									
1/4" — 4			5.1	2.4	85.0	31.6			34.0
4 — 10	1.0	0.3	82.8	20.7	10.8	4.0			25.0
10 — 40	16.9	5.4	6.2	1.5	2.2	0.8			7.7
40 — 80	45.6	14.6	0.3	0.1	0.2	0.1			14.8
80 — 200	25.9	8.3	0.4	0.1	0.2	0.1			8.5
Pass 200	10.6	3.4	0.7	0.2	0.3	0.1			3.7
Total	100.0 %	32.0 %	100.0 %	25.0 %	100.0 %	37.2 %	100.0 %	%	94.2 %

59.5

Asphaltic Binder = OA 90 = 5.8 %

Total = 100.0 %

I. SIZER
Inspector

No. 4

TEXAS HIGHWAY DEPARTMENT
ASPHALTIC CONCRETE SCREEN AND SIEVE ANALYSIS
WORK SHEET

Date 1-1-64 Stencil No. --- Design No. D 1-1-5.8

Time 1:00 P.M. Type "D" Station No. 41+00

Spec. Item 340---- Proj. No. C 1-1-1

Size	Bin No. 1 Total %	x (a) 32.0 %	Bin No. 2 Total %	x (b) 25.0 %	Bin No. 3 Total %	x (c) 37.2 %	Bin No. 4 Total %	x (d) %	Combined Analysis % (a+b+c+d)
+1"									
1" — 3/4"									
3/4" — 1/2"									
+5/8"									
5/8" — 1/2"									
+1/2"									
1/2" — 3/8"					0.5	0.2			0.2
3/8" — 1/4"			1.6						
+3/8"									
1/4" — 4			2.5	1.0	84.5	31.4			32.4
4 — 10	1.9	0.6	82.5	20.6	12.6	4.7			25.9
10 — 40	17.9	5.7	10.0	2.5	1.6	0.6			8.8
40 — 80	44.3	14.2	0.6	0.2	0.1	0.0			14.4
80 — 200	26.9	8.6	1.1	0.3	0.3	0.1			9.0
Pass 200	9.0	2.9	1.7	0.4	0.4	0.2			3.5
Total	100.0 %	32.0 %	100.0 %	25.0 %	100.0 %	37.2 %	100.0 %	%	94.2 %

58.5
Total + 10

Asphaltic Binder = OA 90 = 5.8 %

Total = 100.0 %

I. SIZER
Inspector

No. 5
Density & Extraction Tests

Texas Highway Department
Form No. 544

TEXAS HIGHWAY DEPARTMENT
ASPHALTIC CONCRETE SCREEN AND SIEVE ANALYSIS
WORK SHEET

Date 1-1-64 Stencil No. --- Design No. D 1-1-5.8

Time 2:30 Type "D" Station No. 52+60

Spec. Item 340----- Proj. No. C 1-1-1

Size	Bin No. 1 Total %	x 32.0 % (a)	Bin No. 2 Total %	x 25.0 % (b)	Bin No. 3 Total %	x 37.2 % (c)	Bin No. 4 Total %	x % (d)	Combined Analysis % (a+b+c+d)
+1"									
1" – 3/4"									
3/4" – 1/2"									
+5/8"									
5/8" – 1/2"									
+1/2"									
1/2" – 3/8"					0.2	0.1			0.1
3/8" – 1/4"			0.2						
+3/8"									
1/4" – 4			2.2	0.6	86.3	32.1			32.7
4 – 10	1.3	0.4	83.0	20.8	12.9	4.8			26.0
10 – 40	17.3	5.5	12.1	3.0	0.3	0.1			8.6
40 – 80	45.3	14.5	0.8	0.2	0.1	0.0			14.7
80 – 200	25.6	8.2	0.8	0.2	0.1	0.1			8.5
Pass 200	10.5	3.4	0.9	0.2	0.1	0.0			3.6
Total	100.0 %	32.0 %	100.0 %	25.0 %	100.0 %	37.2%	100.0 %	%	94.2 %

58.8

Asphaltic Binder = OA 90 = 5.8 %

Total = 100.0 %

I. SIZER
Inspector

No. 6

TEXAS HIGHWAY DEPARTMENT
ASPHALTIC CONCRETE SCREEN AND SIEVE ANALYSIS
WORK SHEET

Date 1-1-64 Stencil No. --- Design No. D 1-1-5.8

Time 3:40 Type "D" Station No. 62+10

Spec. Item 340---- Proj. No. C 1-1-1

Size	Bin No. 1 Total %	(a) x 32.0 %	Bin No. 2 Total %	(b) x 25.0 %	Bin No. 3 Total %	(c) x 37.2 %	Bin No. 4 Total %	(d) x %	Combined Analysis % (a+b+c+d)
+1"									
1" – 3/4"									
3/4" – 1/2"									
+5/8"									
5/8" – 1/2"									
+1/2"									
1/2" – 3/8"					1.1	0.4			0.4
3/8" – 1/4"			2.0						
+3/8"									
1/4" – 4			2.8	1.2	85.6	31.8			33.0
4 – 10	2.7	0.9	82.9	20.7	12.3	4.6			26.2
10 – 40	14.3	4.6	11.2	2.8	0.3	0.1			7.5
40 – 80	43.3	13.9	0.3	0.1	0.1	0.0			14.0
80 – 200	28.3	9.0	0.3	0.1	0.2	0.1			9.2
Pass 200	11.4	3.6	0.5	0.1	0.4	0.2			3.9
Total	100.0 %	32.0 %	100.0 %	25.0 %	100.0 %	37.2 %	100.0 %	%	94.2%

59.6

Asphaltic Binder = OA 90 = 5.8%

Total = 100.0 %

I. SIZER
Inspector

No. 7

Texas Highway Department
Form No. 545

TEXAS HIGHWAY DEPARTMENT
ASPHALTIC CONCRETE DATA SHEET ON MOLDED SPECIMENS AND ROAD SAMPLES

$$\text{Actual Specific Gravity} = \frac{A}{D}$$

$$* \text{ Density of Specimen (\%)} = \frac{100\, G_a}{G_t}$$

Where:

G_a = Actual Specific Gravity of Specimen

A = Weight of Specimen in Air

B = Weight of Specimen + Paraffin in Air

C = Weight of Specimen + Paraffin in Water

G_p = Specific Gravity of Paraffin

G_t = Theoretical Specific Gravity of Specimen

$D = B - C - \left(\frac{B-A}{G_p}\right)$ = Actual Volume of Specimen

$$G_t = \frac{100}{\frac{94.2}{**2.607} + \frac{5.8}{**1.008}} = \frac{100}{36.133 + 5.754} = \frac{100}{41.887} = \underline{\underline{2.387}}$$

Date 1-1-64 Stencil No. --- Design No. D 1-1-5.8

Spec. Item 340---- Type "D" Station No. 41+00

Proj. No. C 1-1-1

DATA AND CALCULATIONS G_t = 2.387 G_p = 0.90

		Laboratory Specimens			Road Samples		
Spec. No.		1	2	3			
Spec. Height		2.00	1.97	1.94			
Actual Specific Gravity of Spec.	A	953.0 gm.	955.0 gm.	953.0 gm.	gm.	gm.	gm.
	B	1003.2 gm.	1003.6 gm.	1007.4 gm.	gm.	gm.	gm.
	C	534.5 gm.	537.6 gm.	536.2 gm.	gm.	gm.	gm.
	B–C	468.7	466.0	471.2			
	$\frac{B-A}{G_p}$	55.8	54.0	60.4			
	D	412.9 cc	412.0 cc	410.8 cc	cc	cc	cc
	G_a	2.308	2.318	2.320			
	*	96.7	97.1	97.2			

	Laboratory Specimens	Road Samples
Average Actual Specific Gravity	2.315	
Average Density (%)	97.0	

** Refer to page 17.

KEN MOLDER
Inspector

FORM CX-101

IDENTIFICATION SLIP FOR ASPHALTIC CONCRETE

~~Dist.~~ or Res. Engr. B.I.G. HURRY

Address Peaceful Valley, Texas

Sampler's Name Ken Molder

Sampler's Title Inspector II

Contractor Blackie Roads, Inc.

Aggr. Producer Limestone Crackers, Inc.-Stone, Texas; Shell-Hulls, Inc.-Feud Bay, Texas. Gravel Screenings-Little Rocks, Inc.-Pebbles, Texas. ~~Location~~ Sand-Local-Rube Pit

Asphalt Producer Cole Black Asphalt Co.

Type OA-90

Sampled from Plant
(Design Specimen, Car, Truck, Plant, Road)

Station No. ---

Identification Marks

Material HOT MIX ASPHALTIC CONCRETE

Control No.	Sect. No.	Job No.	Str. No.
1	1	1	---

Federal Proj. No.	County	Hwy. No.
---	Alpha	1

Dist. No.	I.P.E. No.	Req. No.	Date Sampled
1	---	---	1-1-64

Specification Item No. 340---

Stencil No. --- Type "D"

	Sample 1	Sample 2	Sample 3	Average
Binder (% by Wt.)	5.8	5.8	5.8	5.8
Theo. Sp. Gr.	2.387	2.387	2.387	2.387
Actual Sp. Gr.	2.308	2.318	2.320	2.315
Density (%)	96.7	97.1	97.2	97.0

Remarks: PLEASE TELETYPE AVERAGE STABILITY TEST RESULT.

Texas Highway Department
Form No. 546

TEXAS HIGHWAY DEPARTMENT
ASPHALTIC CONCRETE EXTRACTION TEST
WORK SHEET

Date 1-1-64 Stencil No. --- Design No. D 1-1-5.8

Time 1:00 Type "D" Station No. 41+00

Spec. Item 340---- Proj. No. C 1-1-1

Sample	= 1800.0	gm. (X)	Total Solvent	= 1790.0	ml. (B)
Residue	= 1674.7	gm. (A)	Dish + Ash (100 ml.)	= 106.0	gm.
Orig. Filter	= 32.0	gm.	Dish	= 105.0	gm.
Final Filter	= 33.2	gm.	Ash (100 ml.)	= 1.0	gm. (C)
Pass 200-Mesh	= 1.2	gm. (D)			

SIEVE ANALYSIS

Size	Grams	Per Cent
~~XXXXXXXX~~		
~~XXXXXXXX~~		
~~XXXXXXXX~~		
~~XXXXXXXX~~		
~~XXXXXXXX~~		
~~XXXXXXXX~~		
1/2" — 3/8"	2.0	0.1
~~XXXXXXXX~~		
~~XXXXXXXX~~		
3/8"-4 ~~XXXXXXXX~~	574.2	31.9
4 - 10 ~~XXXXXXXX~~	459.0	25.5
10 — 40	160.2	8.9
40 — 80	262.6	14.6
80 — 200	167.4	9.3
Pass 200	49.3+1.2+17.9=68.4	3.8
Total Loss	106.2	5.9
Total		100.0

57.5 Total + 10

Total Loss (%) = $\frac{100\,(X-A-D)-BC}{X}$ = $\frac{100\,(1800.0-1674.7-1.2) - 1790 \times 1.0}{1800}$ =

$\frac{100\,(124.1) - 1790}{1800} = \frac{12410 - 1790}{1800} = \frac{10620}{1800} =$ 5.9%

Resid. Bit. (%) = Total Loss (%) — Moisture (%) — Hydrocarbon Vol. (%)

		Per Cent
Total Aggregate	=	94.1
Moisture	=	0.0
Hydrocarbon Volatiles	=	0.0
Residual Bitumen	=	5.9
Total		100.0

WILL SPINNER
Inspector

Texas Highway Department
Form No. 404

TEXAS HIGHWAY DEPARTMENT
FIELD LABORATORY REPORT FOR ASPHALTIC CONCRETE

County: Alpha — Project No.: C 1-1-1 — Control: 1-1-1 — Date: 1-1-64

Location of Plant: Boon Docks — Type of Plant: Weigh-Batch — Contractor: Blackie Roads, Inc.

Specs. Item No.: 340--- — Stencil No.: --- — Type: "D"

Combined Bin Analysis / Extractions

Size	Des. No. D-1 Analysis	1	2	3	4	5	6	7	8	Extractions 5		
½"-3/8"	2.8	0.4	0.1	0.3	0.5	0.2	0.1	0.4		0.1		
3/8"-4	32.5	33.8	32.4	33.5	34.0	32.4	32.7	33.0		31.9		
1/2"—1/4"												
4 — 10	25.9	25.8	27.6	25.6	25.0	25.9	26.0	26.2		25.5		
+10	61.2	60.0	60.1	59.4	59.5	58.5	58.8	59.6		57.5		
10 — 40	7.2	8.3	7.0	8.0	7.7	8.8	8.6	7.5		8.9		
40 — 80	14.2	14.2	14.0	14.6	14.8	14.4	14.7	14.0		14.6		
80 — 200	8.5	8.7	9.6	9.1	8.5	9.0	8.5	9.2		9.3		
Pass 200	3.1	3.0	3.5	3.1	3.7	3.5	3.6	3.9		3.8		
Asphalt	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8		5.9		
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0		100.0		

	Time	Sta. No.	Lane Rt.	Lane Lt.	Mix. Temp.	Lab. Density	% Stability
1	8:00	7+50	x	x	325		
2	9:15	16+00	x	x	335		
3	10:30	23+10	x	x	320		
4	11:40	30+25	x	x	325		
5	1:00	41+00	x	x	340	97.0	34.0
6	2:30	52+60	x	x	345		
7	3:40	62+10	x	x	345		
8							

SUMMARY

	Sq. Yd	Tons
Prev. Report	0	0
This Report	19,200	720
To Date	19,200	720

Avg. Rate to Date: 75.0 lbs./sq. yd.

% Complete: 2.4

Days Run

Course	Station to Station	Lane	Sq. Yd.	Tons
Levelup	0+00 - 72+00	Rt & Lt	19,200	720

Source of Aggregates	Size	Bulk Sp. Gr.
Limestone-Stone, Tex.	½ - 4	2.753
Shell-Fued Bay, Tex.	3/8 - 40	2.550
G. Scrngs-Pebbles, Tex.	3/8 - 10	2.571
Sand-Local-Rube Pit	- 10	2.647

Asphalt:

Type: OA 90

Producer: Cole Black Asphalt Co.

Sp. Gr. (77°F.): 1.008

Weather: Fair

Min. Temp.: 60

Max. Temp.: 85

Aggregate used: 678.240 Tons

Asphalt used: 41.760 Tons

DUDE DAILEY
Inspector

No. 1

VII. Plant Adjustments That May Be Required

1. Changing Hot Bin Aggregate Screens

The bin aggregate sieve size requirements for the various types of mixtures produced are listed under screening and proportioning of Item 340.4 of the Standard Specifications. Plant screens must be changed when they fail to produce the aggregate into the respective bins according to their specified sizes. The correct acceptable combination of screens must be selected by obtaining test results from various combinations of the screens in an actual plant screening operation. The production of asphaltic concrete should be postponed until test results indicate the correct combination of plant screens has been determined.

2. Balancing the Hot Aggregate Bins

Certain conditions will always occur in plant production of hot mix asphaltic concrete that will require bin batch weight adjustments. The amount of aggregate produced in the individual bins will vary at times, and this condition will require adjustments to be made. This is normal, and the plant inspector should make compensating bin batch weight changes when practicable to keep the bins balanced and eliminate overflowing of their materials. Changes in the bin batch weight percents will effect a change in the per cent by weight of the sieve sizes of the aggregate in the plant mixture. The allowable sieve size changes of the aggregate are governed by the designated grading of the proposed plant mixture. The applicable sieve size tolerance deviation from those of a designated mixture are specified in Item 340.3(1) of the Standard Specifications. It may become necessary to designate an alternate proposed plant mixture if the bin batch weight changes fail to produce a mixture within the specified tolerances after aggregate bin balancing has been accomplished. The aggregate grading or asphalt content of a designated plant mixture may be changed, within specified limits, in order to obtain more uniform control of plant materials. When changes are made in a designated mixture, they must produce an alternate mixture that will conform to the applicable requirements of Item 340.3(1). It is recommended that the plant inspector make adjustments that will be beneficial to production provided they do not violate the specification requirements. It is not intended to imply that frequent adjustments should be made in plant operation to compensate for temporary malfunctioning of the component parts of a plant.

As an illustration, assume that during the second day of plant operation the three bin begins to produce more aggregate than it did on the first day. Assume that this additional volume of material being produced into the three bin begins to cause a continual overflowing of the aggregate through the bin overflow pipes onto the ground. To stop this overflow of aggregate from the three bin, assume that an additional 2% by weight must be added to the weight that it is now furnishing to the batch. With the three bin producing more aggregate, it can generally be expected for the production of the two bin to decrease because most of the material in both bins are furnished from the coarse aggregates. Based on this assumption, the 2% added to the batch weights in the third bin will be subtracted from the batch weight previously furnished by the two bin. This interchanging of equal percents of the batch weights between the two and three bins will result in a total aggregate batch weight identical to the one which was being used before the bin changes were made. The new percents that each bin would now furnish of its sieve sizes to the aggregate portion of the batch would be as follows: Bin No. 1 - 32.0%; Bin No. 2 - 23.0%; and Bin No. 3 - 39.2%. The sum of these percents would amount to 94.2% of the total weight of the batch. The remaining percent of the total weight of the batch would be 5.8% and will be furnished by the asphalt. The weight of the aggregate and asphalt portions in the total mixture are identical to those used during the first day of operation. The 2% increase in the batch weight portion of the three bin would result in a mixture containing coarser size aggregates. Gradual interchanging of bin batch weights between bins is recommended when bin balancing is necessary.

VIII. Plant Inspection Personnel and Their Duties

A. General

The minimum number of personnel should include a plant inspector and three assistants. One assistant should be stationed at the truck scales, if that type of scale is required by the specifications, to observe the weighing of the hot mix asphaltic concrete in each truck and to issue a ticket showing the net weight being hauled by the truck. If the specifications allow the hot mix asphaltic concrete to be weighed by the plant batch scales only, then the above-mentioned assistant should be stationed at that location where he can observe the weighing of each batch and issue a ticket for the net load being hauled by each truck.

The other two assistants should be used in the plant laboratory to make hot bin aggregate sieve analyses, sand equivalent tests, asphaltic concrete extraction tests, and mold hot mix asphaltic concrete specimens of the plant-mixed material from which density and stability are determined.

The plant inspector should supervise and help, if necessary, in performing the specified tests required in the field laboratory. During plant operation, he should make frequent daily observations of the operation of the different units of the plant to be sure that they are functioning properly. When necessary, he should make adjustments in the composition of the mixture within the specification limits, if he thinks it advisable in order to produce a mixture having more desirable qualities. He will specify the temperature of the mixture, within the specification limits, as it is dumped from the pugmill. He will control the volume of the plant production, when necessary, to meet specification requirements. He should keep a daily record of material received and prepare the daily plant report. He should work in close cooperation with the roadway inspectors to produce a mixture, within the specification limits, which, when placed on the roadway, will produce a mat having the desired texture and adequate density.

IX. Plant Sampling and Testing

The daily test requirements and the minimum number of each of these tests required when producing hot mix asphaltic concrete from a weigh batch plant are listed on page 46 of Bulletin C-14 as follows:

1. Make a minimum of four combined sieve analyses
2. Make a minimum of one extraction test
3. Make a minimum of one set of molded specimens for density and stability.

More than the minimum testing is usually required during the first few days of operation in getting the plant off to the right start; however, when all the necessary adjustments have been made and the plant is operating satisfactorily, the minimum number of tests required is adequate.

X. Description of Equipment used to Place Level-up and Paver Courses

A. Asphalt Distributor

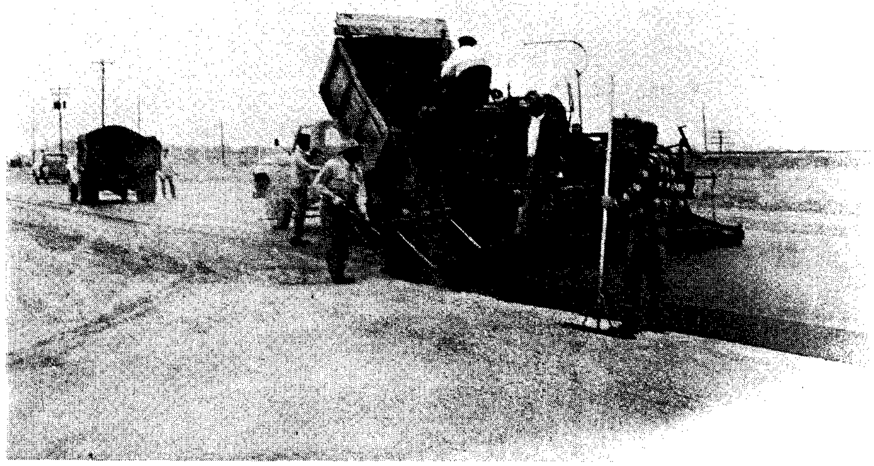
The asphalt distributor consists of a pneumatic-tired truck, or truck-drawn trailer, on which is mounted an insulated tank to hold the liquid asphalt which is to be applied to the roadway surface. The tank is equipped with a heating system, usually oil burning, which is used to heat the liquid asphalt. Direct heat from the heating system is applied to the asphalt from the flue passing through the insulated tank. A thermometer is installed in the tank to determine the temperature of the asphalt.

ASPHALT DISTRIBUTOR

The distributor is equipped with a power-driven pump capable of pumping liquid asphalt, under pressure, through a system of pipes, to a transverse roadway spraybar containing spraying nozzles from which the asphalt can be applied to the roadway surface. The spraybar is located at the rear end of the tank and behind the rear wheels of the truck. To control the application of asphalt, the pump is set to deliver the asphalt to the spraybar nozzles at the desired rate. To apply the asphalt from the spraybar nozzles to the roadway surface at a given rate of application per square yard, the truck must be driven at a calculated speed over the area to be sprayed. A connection to the tank is furnished for attaching a hose for single or multiple nozzle outlet to be used when hand spraying becomes necessary.

B. Haul Trucks

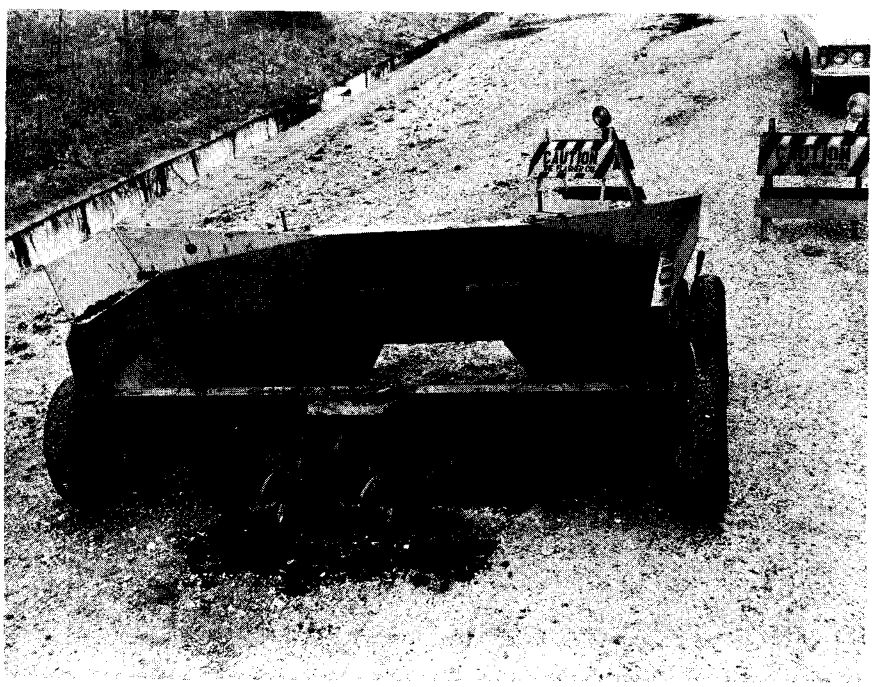
Haul trucks are dump trucks used to transport the asphaltic mixture from the plant to the roadway where the asphaltic concrete course is to be placed.



HAUL TRUCKS

C. <u>Windrow Evener</u>

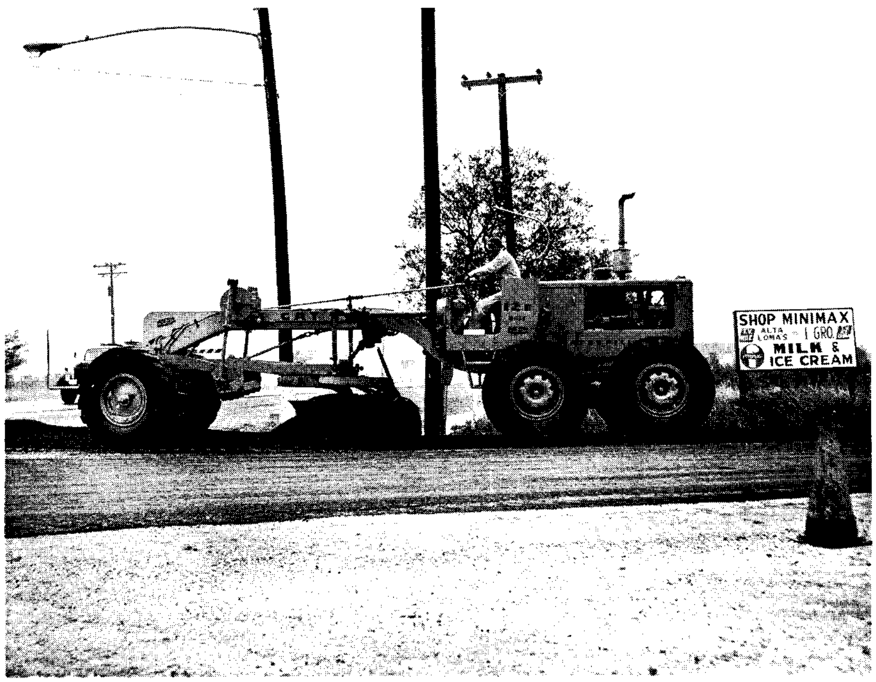
The windrow evener, usually made of metal, is a hopper-type box which can be attached to,and towed by, trucks and is used for windrowing material. It is constructed wider at the top into which the material is dumped from the haul truck and tapers to a narrower opening at the bottom of the box. The narrow opening rests on the surface of the roadway on which the material is to be windrowed from the box as it is towed by the truck. In the rear, beginning at the bottom of the box and extending upward, is an adjustable gate, used to control the height and width of the windrow, by which the quantity of material is controlled.



WINDROW EVENER

D. The Motor Grader

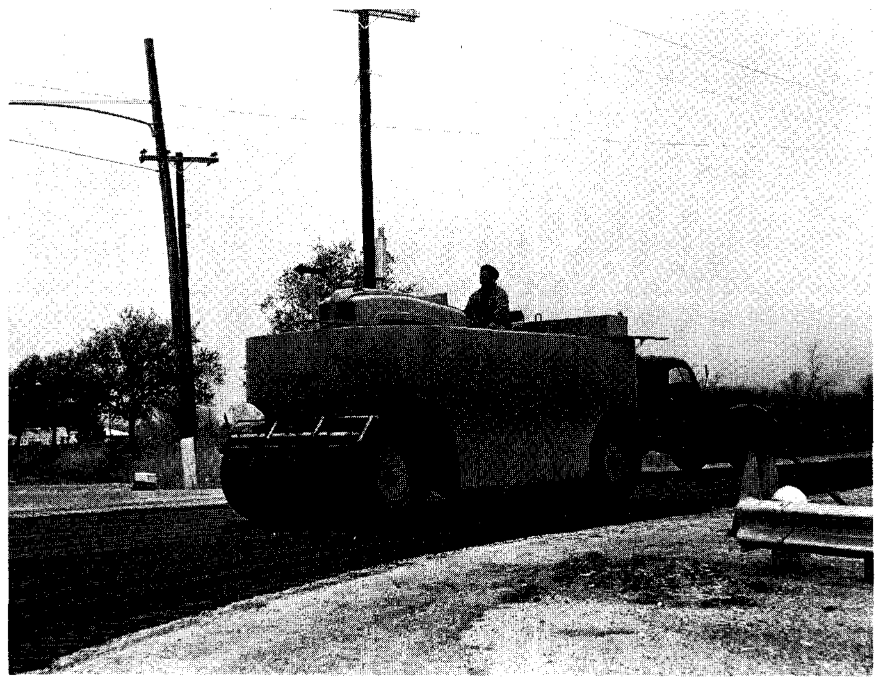
The motor grader is a pneumatic-tired self-propelled unit with a wheelbase at least 16' in length. It is equipped with a power-operated suspended blade, usually 12' or more in length. The motor grader with its blade and long wheelbase allows uniform spreading of materials and close section tolerance finishing possible when operated by a skilled operator.



MOTOR GRADER

E. Self-Propelled Pneumatic Rollers

Self-propelled tandem pneumatic tire rollers are available in weights ranging from three tons to thirty-five tons. Ballast can be added to the rollers to increase the weights. These rollers consist of pneumatic tires mounted on wheels on a front and rear axle. The front rolling wheels, which are the steering wheels and the rear rolling wheels vary in number according to roller type.



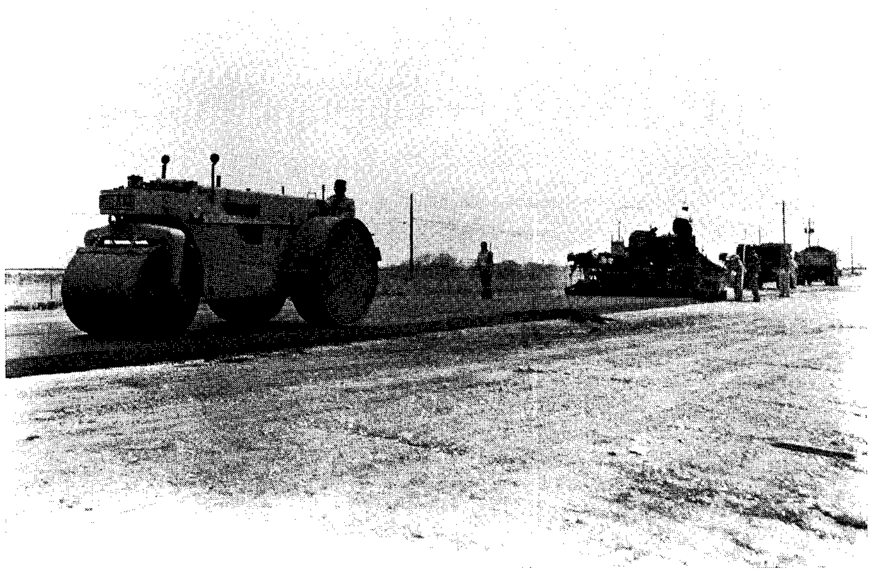
SELF-PROPELLED PENUMATIC ROLLER

The pneumatic tire roller wheels on the rear axle are positioned in such manner that the rear group of tires will cover the entire gap between the adjacent tires of the forward group during rolling operations. A pneumatic roller is used to produce a higher density in the asphaltic concrete course than is generally possible to obtain from the steel wheel rollers.

F. Steel Wheel Rollers

Steel wheel rollers are of two basic types - three-wheel and tandem.

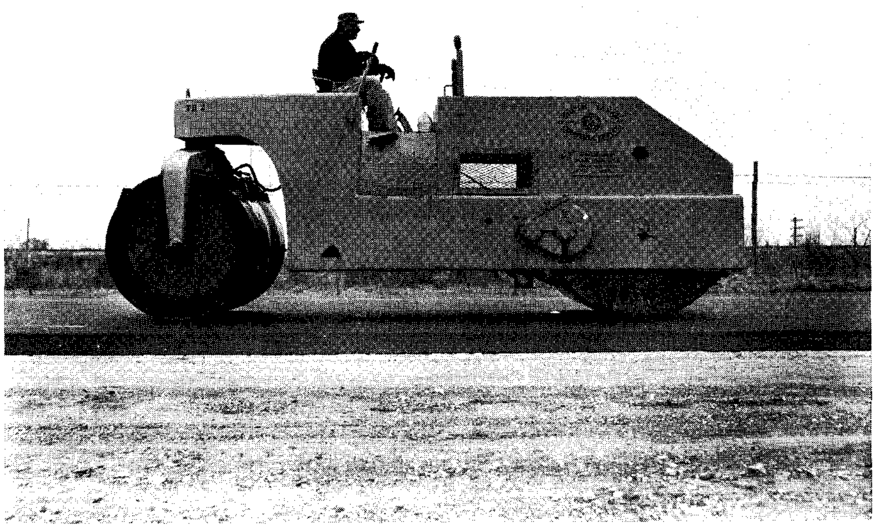
1. Three-wheel rollers are available in weights ranging from five tons to twenty tons. Some have wheels to which ballast can be added to increase the weight. The three-wheel roller is equipped with two rear rolling wheels on the same axle and a single front rolling wheel which is used to steer the roller. The two rear rolling wheels which are used as drive wheels are usually sixty inches to seventy inches in diameter by twenty to twenty-four inches wide. The front rolling wheel, or the steering wheel, is of smaller diameter but wider. The three-wheel roller is used to obtain the initial roller compaction of the asphaltic concrete directly behind the paver.



THREE-WHEEL-ROLLER

2. Two-axle tandem rollers are available in weights ranging from three tons to twenty tons or more. Many are equipped with wheels to which ballast can be added to increase the weight. The two-axle tandem roller is equipped with a single front rolling wheel and a single rear rolling wheel. The rear rolling wheel, which is used as the drive wheel, is usually about sixty inches in diameter by fifty-four inches wide. The front rolling wheel, or steering wheel, is smaller in diameter but equal in width to the rear rolling wheel. The two-axle tandem roller is used as a finishing roller to eliminate roller marks and irregularities left by other rollers.

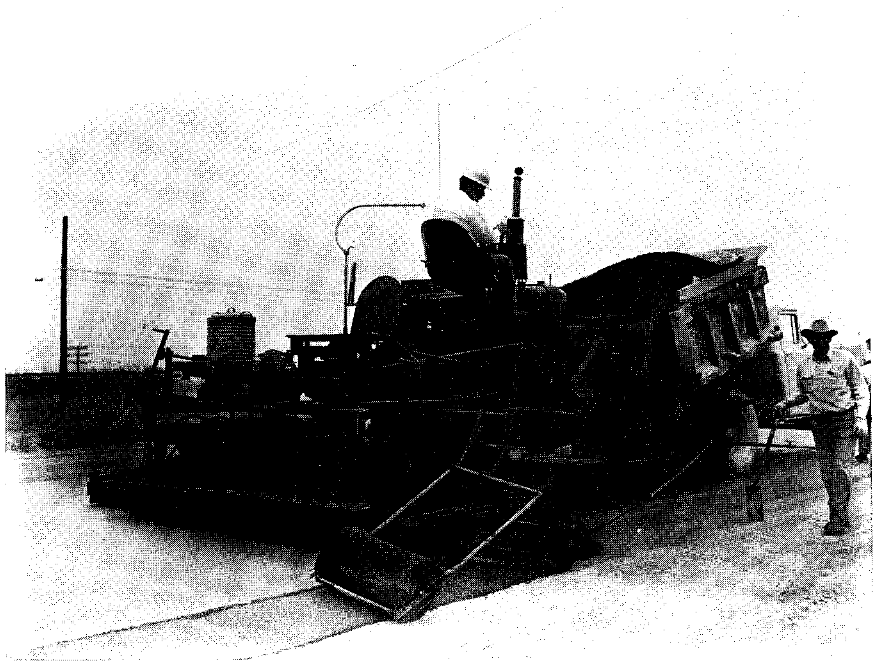
The wheels of all steel rollers used to compact asphaltic concrete mixtures must be kept thoroughly moistened with water to prevent adhesion of the mixture to the roller wheels; therefore, all rollers must be equipped with a water compartment and means of furnishing water to the rolling wheels.



TWO-AXLE TANDEM ROLLER

G. Asphalt Paver

Asphalt pavers that are capable of producing satisfactory surfaces can be obtained from many manufacturers of this type of equipment. Essentially, all pavers are similar in design and consist of a tractor and a screed unit. The self-propelled tractor unit pushes the truck, carries the hopper, and pulls the screed unit. The tractor unit is usually propelled by crawler-type tracks; however, there are pavers that are propelled by pneumatic tires mounted on wheels. The hopper mounted on the tractor unit is equipped with two slat conveyors which move the mix that is dumped from the truck through adjustable gates to the spreading screws. The spreading screws, which are attached to the rear of the tractor unit, are used to spread the mix in front of the screed.



ASPHALT PAVER

The screed unit is towed by means of long leveling arms which extend forward from the screed unit and are attached to a pivot point near the front of the tractor unit. This allows the screed to float on the mix as it is spread. The screed unit strikes off and imparts an initial compaction by the use of attached tamps or vibrators. (Some pavers are equipped with tamps - others with vibrating screeds.) As the tractor pulls the screed into the mix, the path of the bottom of the screed is parallel to the direction of the pull. The screed will maintain this level, in most cases, until the depth adjustment controls mounted on the screed unit are changed. Generally, screeds are either eight feet or ten feet in width; however, surfaces may be placed in wider widths by adding screed unit extensions which are standard accessories available with all pavers. The screed unit is mechanically constructed to allow the screed to be set to conform to most transverse sections used in modern roadway construction. Screed units are also equipped with fuel heaters which can be used to heat the screed when it becomes necessary.

All of the above-described equipment must meet the specification requirements; therefore, each piece of equipment must be approved for use on the project.

XI. Hot Mix Asphaltic Concrete Motor Grader Level-Up Course

A. General

A level-up course is primarily used to improve the riding quality of bases and pavements. The level-up course is used to correct any irregularities that have developed in the longitudinal grade line and transverse section. A motor grader, with its adjustable blade and at least 16' wheelbase, will spread and finish material to a close longitudinal grade line tolerance. A skilled operator using this type motor grader, with ample material, should be able to produce a satisfactory level-up course.

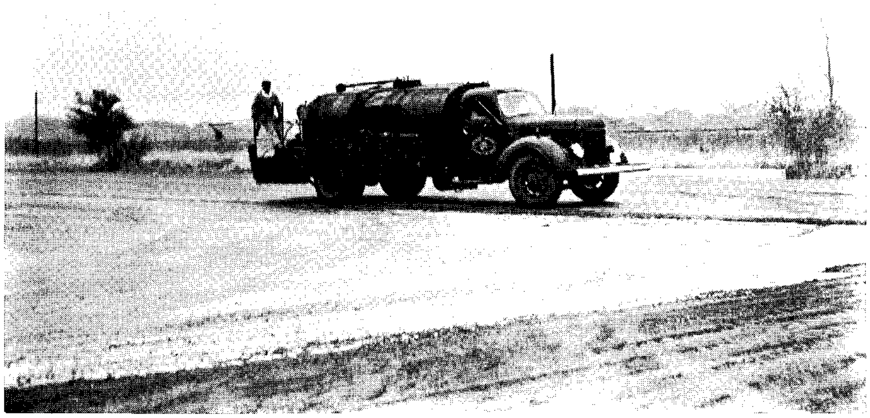
The condition of the surface to be leveled up determines the amount of material required to produce the desired course. The minimum amount of level-up course (3/8" maximum sieve size aggregate) that a motor grader operator should be expected to place satisfactorily is about 50 pounds per square yard. The maximum amount placed per course should not exceed 100 pounds per square yard. A level-up course requiring over 100 pounds per square yard should be placed in two courses.

B. Weather Factors Controlling Placement

The quality of a level-up course is greatly affected by the seasons of the year, and it is especially difficult to obtain satisfactory results during the winter months. "Construction Methods" under Item 340.6 of the Standard Specifications gives the Engineer wide latitude for controlling the placement of asphaltic mixtures when weather conditions are not suitable. The air temperature requirement in Specification Item 340.6 governing the placement of a level-up course should be strictly enforced. It is recommended that placement be postponed during any day that wind velocities are high. Wind action causes the mixture to lose its heat and this results in improper bonding. Material that has become too cold is very susceptible to raveling under traffic. Placement of a level-up course should never be allowed when weather conditions will have an adverse effect on the course.

C. Preparation of Base and Rate of Tack Coat Application

If necessary, the surface on which the level-up is to be placed should be thoroughly cleaned by brooming or other methods. If needed, a stringline should be set to control the width and alignment of the tack coat and level-up course. Tack coats are required to insure a bond between the existing surface and level-up course and may be applied either by asphalt distributor spraybar or handspray attachment.



TACK COAT APPLIED BY HAND SPRAY

A tack coat application rate in excess of 0.05 of a gallon per square yard is very seldom required. These light applications make uniform covering of the surface area impossible. Acceptable coverage must finally be obtained by rolling the applied tack coat with a pneumatic-tired roller, or other equipment, to distribute it more uniformly over the surface. The rate of tack coat application should be governed by the per cent of asphalt that is to be used in the asphaltic concrete mixture to be placed. Generally, a tack coat should not exceed 0.03 of a gallon per square yard when placing mixtures containing 5.5 per cent asphalt or higher.
Prime coats of MC-1 cutback asphalt are applied on flexible bases in order to waterproof them and bond their surface material.
Cement-stabilized bases are cured and their surfaces preserved by the application of either RC-2 or MC-1 cutback asphalts.
In most cases, there is sufficient residual asphalt left on the surface of both types of bases by the cutback asphalt to provide a bond between the base and the following course. If additional tack coat is necessary, the application rate should be reduced to compensate for the existing residual asphalt already on the base.

D. <u>Control and Utilization of Traffic</u>

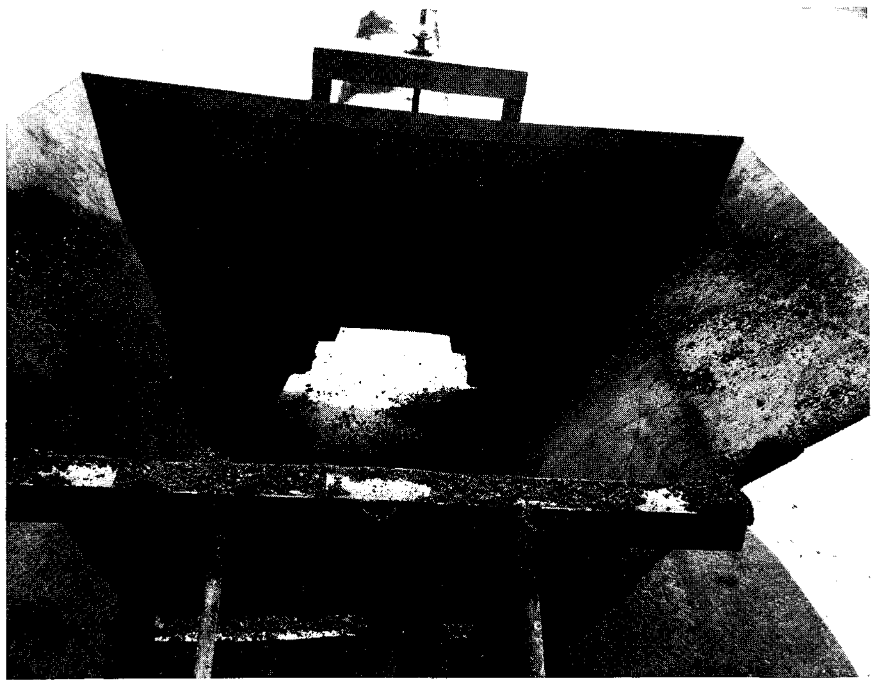
Assume that an existing concrete pavement under traffic is to be leveled up with asphaltic concrete. Traffic should not be allowed to use any section of pavement where the equipment is actually placing the course but must be detoured on the shoulders. Immediately after the level-up has been completed on each section, traffic movement should be allowed on the course. The additional rolling provided by traffic can be very beneficial in obtaining additional compaction. The safety of the public and convenience of traffic must be taken into consideration constantly. Item 7, "Legal Relations and Responsibilities to the Public," of the Standard Specifications sets out the procedure that must be enforced.

E. Windrowing of Material Prior to Motor Grader Placement of a Course

Before any asphaltic concrete can be placed on the pavement, the tack coat must be applied at its chosen rate of application per square yard. Tack coat could be applied to an estimated length of roadway that would accommodate the total plant production of one day's operation; however, there will always be some traffic using the tack-coated surface during construction. This procedure can become very dangerous. The safety of traffic should always be considered, so it is recommended that the tack coat be applied over shorter sections as needed.

When the surface which is to receive the level-up course has been satisfactorily prepared, the plant can begin producing asphaltic concrete. The trucks will transport the mixture from the plant to the road where it will be used to level up the pavement. The material must be placed in a windrow of uniform distribution before the motor grader equipment begins placement of the course. The most successful method of uniformly distributing the material in a windrow at the required rate per square yard is by the use of a windrow evener. The material may be windrowed at any desired position longitudinally along the pavement which will furnish the best working conditions.

The windrow evener is positioned on the pavement at the beginning of the proposed level-up course and as each truck arrives, it is attached to the windrow evener and the material dumped into it.



WINDROW EVENER POSITIONED

The windrow evener is then pulled longitudinally along the pavement by the truck and the material is windrowed from the adjustable gate opening in the back. The adjustable gate in the windrow evener must be adjusted by trial and error to deliver the windrowed material in the specified quantity. A constant check must be made to be certain that the required amount of material is being placed. The trucks must pull the windrow evener in a straight line in order to obtain a straight windrow, which is very important to a motor grader operator, as it makes the material easier to work and allows better control of the spreading operation. If the windrow is not placed reasonably straight, the operator will lose valuable time in shifting it into a workable position. Any unnecessary movement of the windrow will cause the material to lose heat which results in poor cohesion of the material particles after placement.

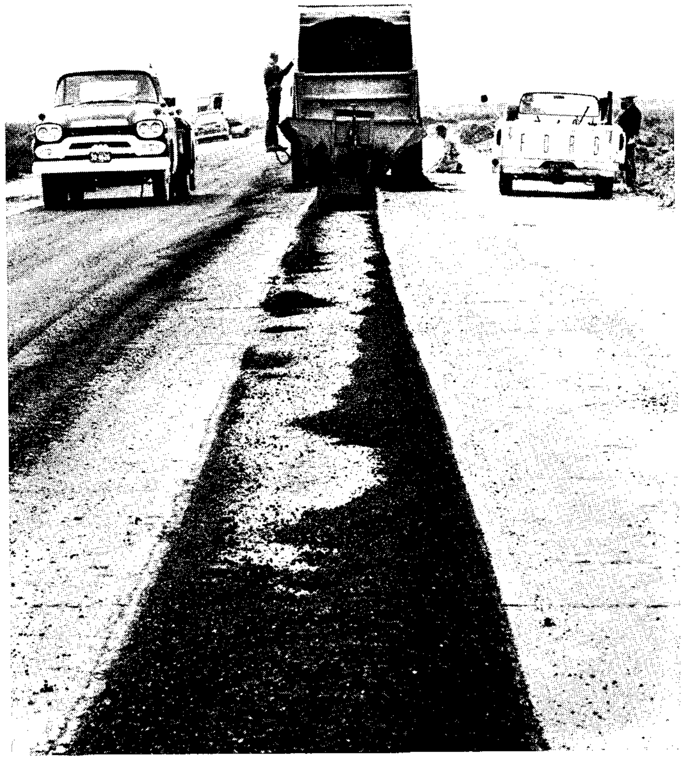
F. Coordinating Windrowing of Material with Motor Grader Placement

The seasons of the year will determine the amount of material that can be windrowed before placement must begin. During summer application, it is recommended that a section never exceeds 1,000 feet in length; during winter placement, section length should be varied to obtain the best results possible. The section length may be varied at any time to meet unforeseen construction conditions.

As an illustration, the length of land (section of roadway) is chosen to be leveled up by the motor grader equipment. The placing of the course should begin immediately after the required amount of material has been windrowed. Windrowing of the material for the next land should be continued as the motor grader equipment places the course on the preceding land.

It is impossible to specify the distance over which the material should be windrowed before its placement is halted. That can only be determined by the skill of the operator and the time it requires him to place a land course. Generally, it is best to allow windrowing for a length of only one land ahead of the land on which the course is being placed.

It is recommended that the windrow be omitted for a short distance between motor grader lands.



SPACE OMITTED BETWEEN LANDS

To obtain this gap in the windrow, the windrow evener is simply moved forward and no material is placed. The space should be of sufficient length to allow the motor grader equipment to operate efficiently without running over the windrowed material in the adjoining land. Generally, sufficient working space between lands can be obtained by omitting a length of windrow equivalent to that furnished by one truckload of material. If this working space is not provided for, it will result in equipment movement over the windrow, which results in compaction of the material. This can result in an inferior joint between lands. Prior to the motor grader equipment placing the course on an adjoining land, the previously omitted material must be placed in the gap at its beginning. This is accomplished by dumping the material directly from the truck into this gap. The material is then windrowed by the motor grader in the omitted space. This completes the windrowed material in the next land on which the course is to be placed and also furnishes a hot load of material at the joint between lands. From this hot load of material, it is possible to obtain better cohesion between the materials forming the joint.

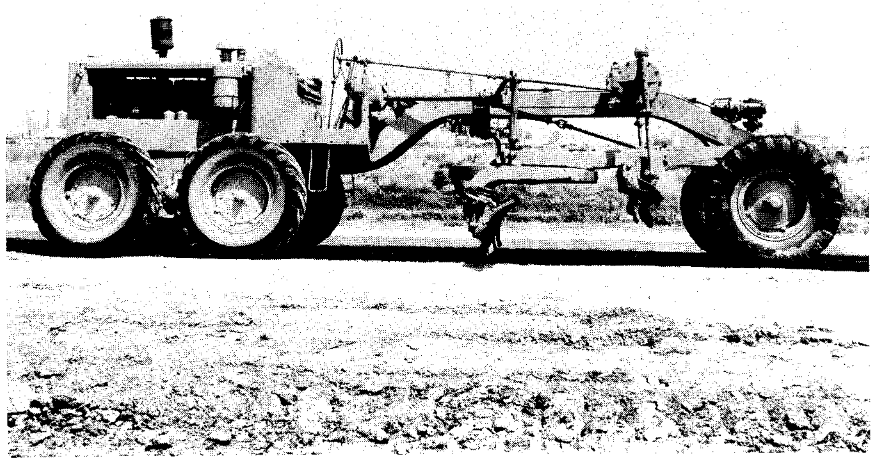
The above-described method of procedure can result in almost continuous windrowing of material and satisfactory placement of the course.

G. Description of Working Positions of the Motor Grader Blade

The standard specifications require the motor grader to be a self-propelled power unit. Its wheelbase must be not less than 16' in length and the attached power-operated blade cannot be less than 12' in length.

When placing a level-up course, the blade attached to a motor grader is normally identified in two positions. One is called a square-blade; the other an angled-blade. The square-blade can occupy only one position. The angled-blade may occupy many positions. At both of the positions, the blade may be raised or lowered vertically to control the depth of the material placed.

The following description of angled and square-blade positions will be less confusing if it is assumed that the forward movement of the motor grader is due north. Assume also that the length of the blade is 12'. The 12' length of the blade must be positioned due east and west to be called a square-blade. This puts the 12' length of the blade perpendicular to the wheelbase length of the motor grader.



SQUARE BLADE POSITION

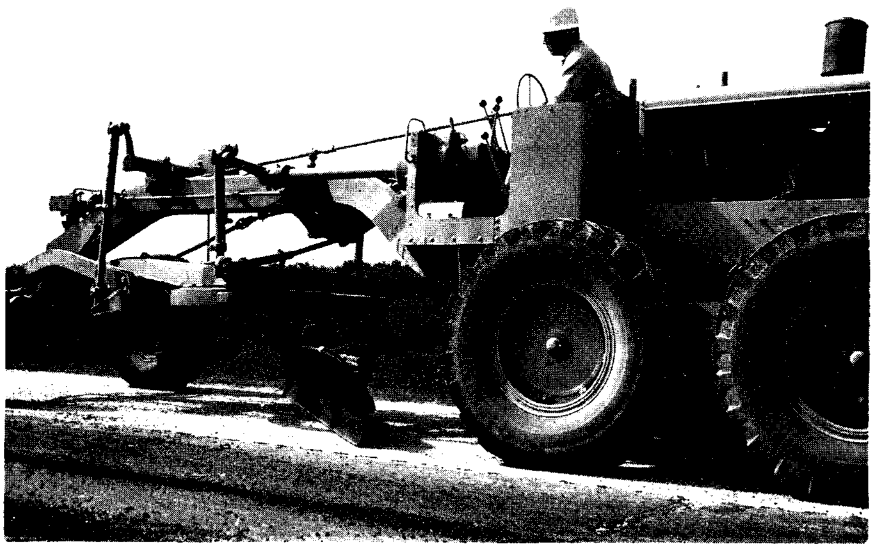
At the square-blade position, the material can be moved longitudinally along the pavement. This type of blading is used to spread and drift material into depressions which have occurred in the pavement surface. Each extremity of a square-blade is referred to as the end.

To describe the angled blade, it is best to start with the blade in a square-blade position. As previously described, the 12' length of the square-blade is in due east and west position. To spread material from west to east while traveling north, the left end of the blade must be set pointing in a northwesterly direction. Beginning with a square-blade position, the left end of the blade must be angled forward in the direction of the left front wheel.

ANGLE-BLADE POSITION
TO SPREAD MATERIAL TO RIGHT

This automatically angles the right end of the blade in the direction of the right rear wheels. This position of the blade allows spreading of the material to the right (east side) and also windrows any extra material on that side. The left end of the blade in this position is known as the toe. The right end is known as the heel.

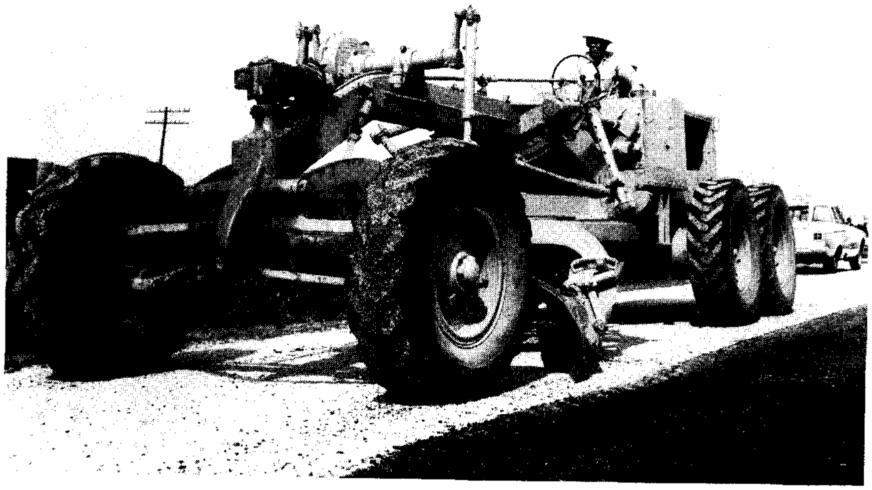
To spread material from east to west while traveling north, the right end of the blade must be set pointing in a northeasterly direction. Beginning with the square-blade position, the right end of the blade must be angled forward in the direction of the right front wheel.



ANGLE BLADE POSITION
TO SPREAD MATERIAL TO LEFT

This automatically angles the left end of the blade in the direction of the left rear wheels. This position of the blade allows spreading of the material to the left (west side) and also windrows any extra material on that side. The right end of the blade in this position is known as the toe. The left end is known as the heel.

In most cases, the toe and the heel of a blade are visible to the operator at all times. There are positions at which the blade may be set from which the heel of the blade is not visible to the operator. This is known as blading with a blind heel.



BLIND HEEL POSITION

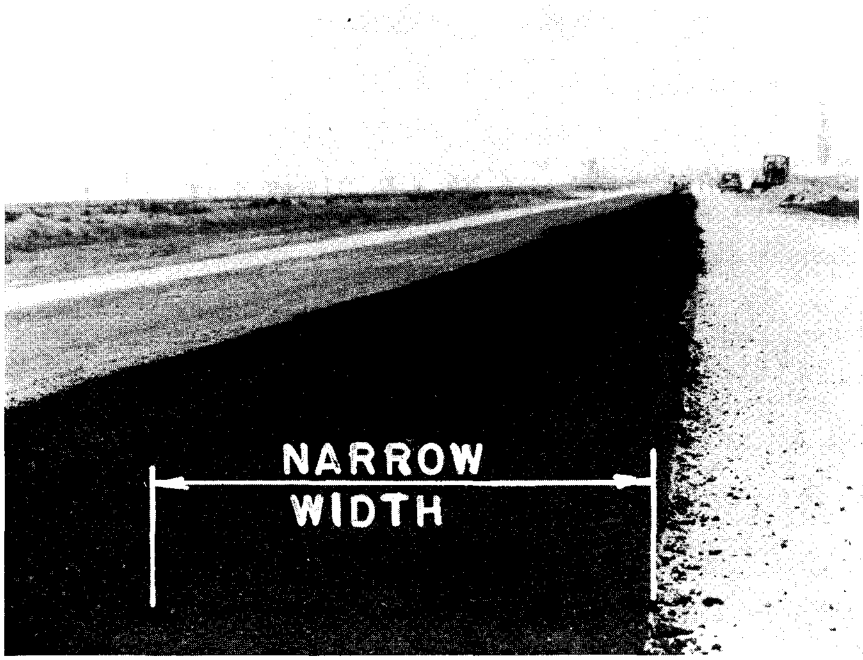
In this position, the heel is between the rear wheels of the motor grader and directly below the operator. This position allows narrow lateral spreading and windrowing of excess material between the rear wheels of the motor grader directly below the operator.

This type of blading is generally used to move a windrow of material after it has been placed parallel to a stringline or the edge of an existing pavement. The blind-heel type of blading is used to obtain straight longitudinal edges for the level-up course when moving the windrow from the edges.

MOVING WINDROW FROM EDGE
WITH BLIND HEEL POSITION

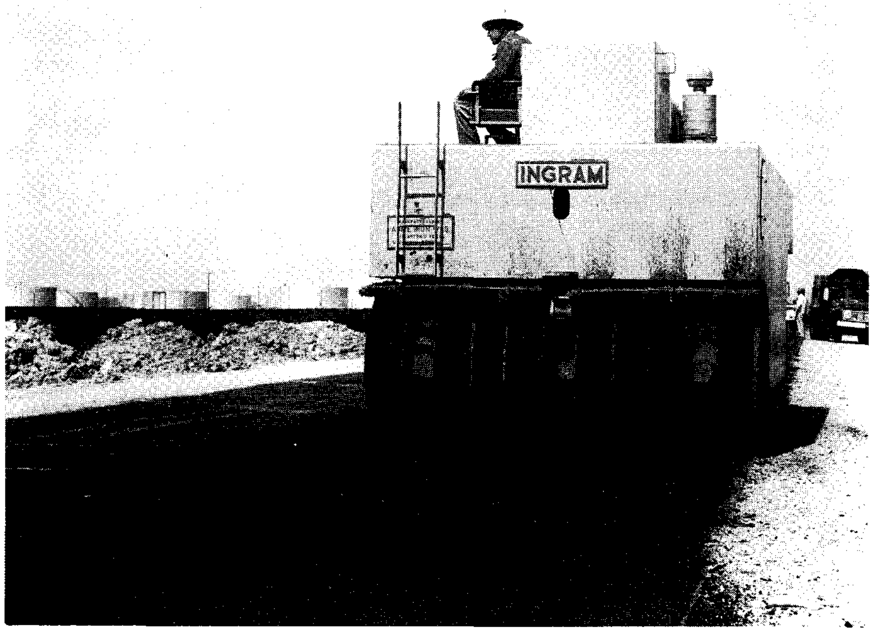
When moving the windrow from the edges using this type of blading, it is necessary to stop all rolling operations.

Rolling operations must be suspended at this time, because the motor grader has spread only a very narrow width of material during the blind heel pass; therefore, the roller could not roll without lapping over the edges, which is not desirable.



NARROW WIDTH SPREAD
BY BLIND-HEEL PASS

An extra pass with the motor grader must be made in order to spread a greater width of material before rolling can begin.



EXTRA PASS AFTER BLIND HEEL PASS
PROVIDES SUFFICIENT WIDTH FOR ROLLER

During the extra pass, the angle of the blade is changed from the blind heel position to a more normal angled position before spreading the windrow in the direction of the centerline of the road. Most operators dislike operating a blind heel, because it requires the extra blading operation to obtain the rolling width; however, it is recommended that the initial windrow placed at each edge, during leveling-up operation, be spread away from it by the blind heel method.

The speed at which a motor grader is operated during the spreading of the material can affect the quality of the course. A motor grader operated above its maximum second-gear speed can cause corrugations in the level-up course. It is also possible to cause corrugations from a motor grader traveling in first or second gear, if it is not in good operating condition. It is recommended that the second gear speed of the motor grader be the maximum at which the course can be placed. Operating information pertaining to motor graders may be obtained from their respective dealers in pamphlet form.

H. Motor Grader Placement of Level-Up Course

Assume that a level-up course will be applied to an existing concrete pavement 24' in width. The proposed level-up will be applied to the pavement at the rate of 75 pounds per square yard of its surface area. Assuming that 720 tons of asphaltic concrete will be the maximum amount that can be produced by the plant during an eight-hour day, it would be possible to place 7200 linear feet of level-up course during one day.

With the plant capable of producing the estimated 720 tons of material for the eight-hour period, the average hourly rate would amount to 90 tons per hour. District 12 of the Texas Highway Department requires, by special provision, that two motor graders be used to place a level-up course when the production of the plant exceeds 50 tons of asphaltic concrete per hour. In this case, the plant will average 90 tons per hour; therefore, two motor graders will be required.

Texas Highway Department
Form 187

56079-660-50m

DAILY ROAD REPORT—ASPHALT

Alpha County. State Control No. 1 Sec. 1 Job 1 F. A. P. No.

Type Tack Coat RC2 Contractor Black Roads, Inc. Date 1-1-64

MATERIALS—RECEIVED

R. R. CAR NO.	MATERIAL	NET WT.	LAB. REP.	AMOUNT	R. R. CAR NO.	MATERIAL	NET WT.	LAB. REP.	AMOUNT
Truck	RC2		64-10-C	4000 Gal.					

ASPHALT APPLICATION

GENERAL								ASPHALT					
REF. NO.	CRSE. NO.	DIST. NO.	LENGTH STA.	to STA.	LENGTH FT.	WIDTH FT.	AREA S. Y.	R. R. CAR NO.	GALS. START	GALS. END	NET GALS.	TEMP. ° F.	GALS./ S. Y.
1	1	1	0+00	16+00	1600	24'	4267		900	780	120	160	.028
2	1	1	16+00	32+00	1600	24'	4267		780	665	115	155	.027
3	1	1	32+00	48+00	1600	24'	4267		665	555	110	155	.026
4	1	1	48+00	64+00	1600	24'	4267		555	430	125	150	.029
5	1	1	64+00	80+00	1600	24'	4267		430	310	120	150	.028
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AGGREGATE

Source of Aggregate 1st Course
Source of Aggregate 2nd Course
Source of Aggregate 3rd Course
Rate Aggregate Applied 1st Course
Rate Aggregate Applied 2nd Course
Rate Aggregate Applied 3rd Course

ASPHALT

Source of Asphalt 1st Application Cold Black Asphalt Co.,
Source of Asphalt 2nd Application Sun Down, Texas
Source of Asphalt 3rd Application
Time Work Began:
Time of Last Application:
Time Work Finished:
Reasons for Time Loss:

SUMMARY OF DAYS WORK

	ASPHALT GALLONS	ASPHALT SQ. YDS.	BLADING HOURS	ROLLING HOURS
1ST COURSE				
PREV. REPORT	0	0		
THIS REPORT	590	21335		
TO DATE	590	21335		
AV. RATE	.028 gals. per. S. Y.			
2ND COURSE				
PREV. REPORT				
THIS REPORT				
TO DATE				
AV. RATE	gals. per. S. Y.			
3RD COURSE				
PREV. REPORT				
THIS REPORT				
TO DATE				
AV. RATE	gals. per. S. Y.			
TOTALS				

Remarks:

Instructions: Make three copies, one for File D-6, one for Dist. Engr., and one for Res. Engr. To be prepared daily and submitted at least once each week.

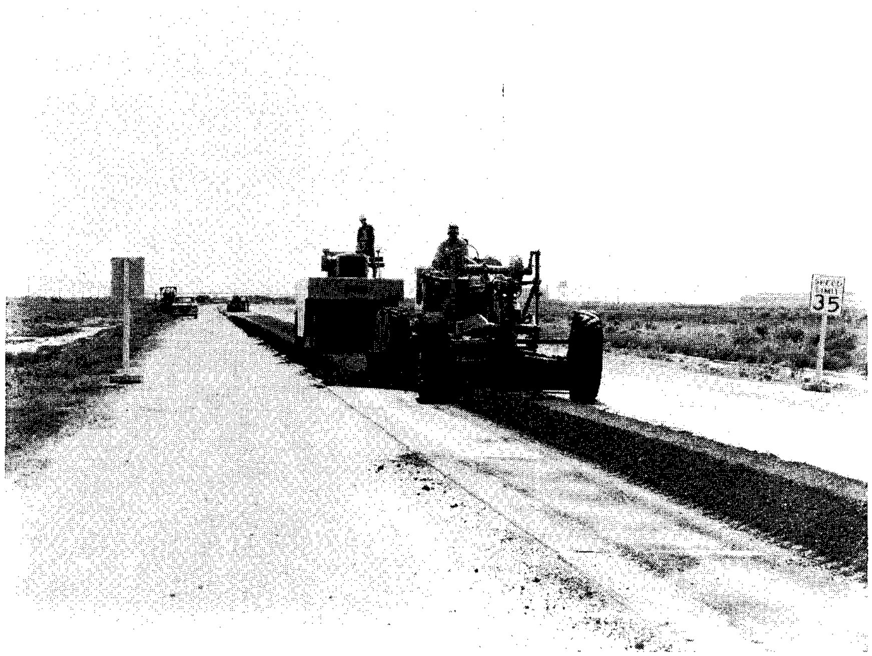
Speck Face
Inspector

Report No. 1

The asphalt content of the mixture to be placed will be 5.7% of the weight of the total mixture. The temperature selected for the asphaltic concrete mixture is 340°F as it is dumped from the plant pugmill into the haul trucks. The allowable range of mixture temperatures and the tolerance allowed for a specified mixture temperature are listed in Item 340.5 of the Standard Specifications. Each truck will transport 10 tons of asphaltic concrete from the plant to the roadway. Placing the material at the rate of 75 pounds per square yard, each truckload would produce a windrow 100' in length. If it is assumed that the motor graders will start placing the course in land lengths of 800', eight truck loads, or 80 tons, of material per land will be required. Prior to placing the asphaltic concrete on the roadway, the concrete pavement must be thoroughly cleaned. Placing a stringline for tack coat application alignment control will not be necessary. The edge of the existing concrete pavement will be more accurate than a stringline. The intended rate of application will be 0.03 gallon per square yard of pavement surface. The chosen length of surface to which it will be applied is 1,600 linear feet. Additional tack coat application will be applied on sections as needed. The lengths of application rate and temperature of RC-2 applied for the day are shown on Form 187, page 120. The recommended temperature range between which RC-2 tack coat should be applied is listed in Item 300.3 of the Standard Specifications.

In this case, the material will be windrowed by a windrow evener along the centerline at the existing 24' pavement. This will be referred to as the original windrow. After the material has been windrowed longitudinally along an 800' land, a length of windrow equivalent to the length that would be furnished by one truckload will be omitted from the first space in the second land. A truck moves the empty windrow evener over this space and continues windrowing material on the second land. Placing of the level-up course by the motor graders and windrowing of the material now becomes a dual operation.

The leveling-up of a surface is accomplished by multiple lateral blade lift spreading of the material from the original windrow. The material may be required to be bladed from edge to edge across the pavement as many as four times before satisfactory leveling-up is accomplished. The pneumatic roller should follow the motor grader as each lateral lift is spread with exception to the final lift.



PNEUMATIC ROLLER
FOLLOWING MOTOR GRADER

The final lift generally requires compaction by the steel-wheel rollers only; however, use of the pneumatics is not prohibited. As pointed out previously, the only place the rollers will not be able to follow the motor grader on each lift is when the initial windrow on the respective edges is being moved by a blind-heel blade. An extra pass will be required to spread the narrow width of material wider before rolling can continue. Each lift should be thoroughly rolled to allow the operator to place the material in the next lift where it is most needed. During lateral spreading, the equipment wheels must be kept off windrows and non-uniformly spread material.

Spreading of the first land is described in detail as follows: The first motor grader operator blades approximately half of the material from the original windrow and starts spreading a light lift over the pavement in a transverse direction. In addition to the material spread, the first operator leaves a windrow for the second operator who then finishes spreading the light lift of material across the pavement and places his excess material in a windrow at the outside edge and within the limits of the pavement. During the spreading of the material, the pneumatic roller, or rollers, should follow each grader, when possible, and compact the material being spread.

<u>Care must be taken by all equipment operators of motor graders and rollers to keep their equipment wheels off windrows and non-uniformly distributed material.</u> With the spreading operation being rotated by the operators, the windrowed material previously placed on the edge of the pavement is spread in another small lift back across the road in the direction of the centerline with the pneumatic

roller following the graders (with the exception of the first blind heel pass). There should be some material left from that half of the road and it is added to the remaining original windrow at the center of the road. From this windrow, the first light lift of material is spread and compacted from the center across the remaining half of the pavement as previously described for the other half. The excess material left after this operation is placed in a windrow at the outside edge and within the limits of the pavement.

The windrow of material from this edge is bladed back across the pavement to the opposite edge. The pneumatic roller should follow the graders to this edge and then be removed. Generally, at this stage, there is still a small windrow of material left which should be square-bladed back across the pavement and feather-edged to the opposite edge of the pavement. Square-blading is very helpful in the placing of material in low places in the course. During the square-blading of the material, the grader is followed by the steel-wheel roller, or rollers, to obtain a smoother surface texture. This type surface is important in level-ups, since it helps to control raveling of the course.

After the first land is completed by the motor grader operators, the second should begin immediately if enough material for a land has been placed on the road. Before the blading operation can be started however, the material in the space that was omitted to allow for the turning movement of equipment working the first land, must be placed. This material is dumped directly from the truck into the space and windrowed by the motor graders to match the windrow placed by the windrow evener. A space equivalent to one load is omitted at the beginning of the third land to allow for the turning of equipment while placing the second land. Then, material is placed on the third land by the windrow evener while the motor graders repeat the operation described above on the second land. In placing adjoining lands, it becomes necessary to make a transverse joint between them. Generally, the best joint is obtained by featheredging the material in each land across their common transverse joint during their respective placement. The joint is completed during the placing of the latter land, and the motor grader crossing the joint to featheredge material into the other land should spread or cut material as required to obtain a suitable joint. Good transverse joints between all lands can be constructed by this method with the motor grader when operated by a skilled operator. The described method of placing level-up should be satisfactory to follow until the level-up course is completed.

The quality of the level-up is almost entirely dependent on the ability of the motor grader operators and, generally, after the first two lands have been completed, the Inspector should know whether a change of operators is necessary.

XII. Asphalt Concrete Finishing Machine Course

A. General

The asphalt finishing machine, sometimes referred to as a paver, is used to place single or multiple asphaltic concrete courses. The asphalt paver is used to place either hot or cold asphaltic concrete mixtures on various types of bases and pavements. Due to the more workable quality of a heated mixture, the paver is primarily used to place hot mix asphaltic concrete mixes.

The total depth of each paver course should be governed by the maximum-size aggregate contained in the mixture to be placed. To obtain the best results for any course, its final compacted depth should be at least twice the size of the mixture's maximum aggregate.

B. Asphalt Finishing Machine

The most commonly used pavers are Barber-Green, Blaw-Knox, and Cedarapids. Each paver consists of a tractor unit and a screed unit, and the general function of both of these units has been previously described on page 102. Each paver is equipped to deliver an initial compaction to the mixture as the course is being placed. This initial compaction is accomplished by the use of a screed unit with attached tamper or a vibrating screed. At the present time, Barber-Greene and Blaw-Knox pavers are equipped with tamps and the Cedarapids is equipped with a vibrating screed. Motive power for the Barber-Greene and Cedarapids is furnished by their respective tractor units through crawler tracks. The tractor unit of the Blaw-Knox paver furnishes motive power through pneumatic-tired wheels. Any of the above-mentioned pavers are capable of placing a satisfactory asphaltic concrete course when they are functioning properly.

The Inspector's and Contractor's personnel involved in the paving operation should be thoroughly familiar with the basic design, construction and principles of asphalt pavers. Such knowledge of the paver will enable those responsible for the quality of the work to recognize when the paver is functioning at its best. Operators paver manuals for all makes of asphalt pavers are available from the manufacturer or their sales representatives. These manuals describe in detail the component parts of the paver and their function. An operators manual for the specific paver being used on the project should be kept on hand at all times to be used as a reference. The manual should be thoroughly studied by both the Inspector's and the Contractor's personnel in order to enable them to tell when adjustments or repairs to a paver are necessary. Adjustments or repairs to a paver should not be neglected when it is evident that they are needed, <u>even if the paving operation has to be stopped</u>.

C. <u>Checking the Finishing Machine Prior to Use</u>

The paver should be thoroughly checked by a skilled mechanic to be sure that all of its parts are in good repair and functioning properly before being brought to the project. However, after the paver is received on the project, the Inspector should check the condition of those parts of the paver which are most essential in producing a satisfactory course. These parts include the screed unit, compaction unit (either tamp or vibrator), and the unit furnishing movement to the paver, such as tracks or pneumatic-tired wheels. Any adjustments or replacement of parts needed, should be made before the paver is used on the project. The frame of a paver should be very carefully checked to be sure that it has not been bent, because a paver with a bent frame can seriously affect the course being placed. The Inspector does not have to be a mechanic to check a paver, but he should have an operators manual for the particular paver he is checking to use as a reference.

D. Lengthening of the Finishing Machine Screed

The basic length (transverse) of the screed on all modern pavers is ten feet. Factory screed extensions in various lengths are available for pavers, which will allow their basic screeds to be lengthened to at least 14 feet. It is recommended, when practicable, that all necessary lengthening of a paver screed be made with screed extensions of equal length on both ends of the basic screed. Extending the screed length of a paver in this manner will keep the machine in better balance. When extensions are added to a screed, they should be checked with a straightedge to make sure they are parallel with the basic screed.

E. Screed Crown Adjustments

The screed units of the previously-mentioned pavers provide mechanical crown adjustments located in the center of their basic 10' transverse length. With reference to the ends of the transverse length of a screed, positive or negative crown height may be put in the screed at its center by the attached screw adjusting arrangements. The crown height which is possible to be put in these paver screeds varies from 3/4" negative to 3" positive. The width (longitudinal length) of these paver screeds is normally 20 to 24 inches, depending on the individual paver. The leading edge of the screed nearest to the material spreading augers is referred to as the toe, and the trailing edge at the rear of the paver is referred to as the heel. The previously-mentioned pavers are equipped with screed crown adjustments that allow independent setting of crown in the toe and heel. Screed crowns of equal height may be set at both points, or they may be varied.

Blaw-Knox and Cedarapids pavers are equipped with two visual screed crown height indicators; one will reflect the crown height contained in the toe of the screed and the other, the height contained in the heel. When a crown is to be set in the screed of either a Blaw-Knox or Cedarapids paver, the required height must be adjusted in the toe and heel of the screed by their respective adjusting screws. The Barber-Greene paver is equipped with one visual screed crown height indicator which is intended to reflect identical crown heights contained in both the toe and heel of the screed. On the Barber-Greene paver, the individual crown height adjusting screws controlling both the toe and heel of the screed are equipped with a sprocket and chain which will allow the toe and heel of the screed to be adjusted simultaneously. However, the chain connecting the toe and heel crown adjusting screws on the Barber-Greene paver can be disconnected to allow individual crown setting in the toe and heel of the screed.

The crown height indicators furnished on all pavers can very seldom be relied upon to indicate the correct amount of crown contained in a screed, particularly if the paver has been used considerably. It is recommended that as crown is being set in the toe or heel of a screed, that its amount be verified by the use of a stringline and a measuring device. This method requires a stringline to be tightly drawn across the transverse length of the screed surface. To set crown in the toe of a screed, the stringline should be located along the leading edge of the screed and the toe crown adjusting screw would be adjusted to furnish the desired crown. The amount of crown may then be verified by measurement from the stringline to the screed. Crown can also be put in the heel of the screed in the same manner. The amount of crown specified on the typical section in the plans should be set in the heel of the screed and a slightly greater crown set in the toe of the screed. When the screed toe crown is slightly greater than the heel crown, it will cause the material to funnel under the screed which generally gives a smoother and more uniform mat. As a rule of thumb, the toe screed crown is usually set from 1/16th of an inch to 1/8th of an inch higher than the crown which is to be set in the heel of the screed.

It is customary to require the three-wheel roller to cover the course from one edge to the other by successive passes moving laterally the width of the rear bull wheels with each pass. As the roller moves across the course in these small lateral laps, portions of the center of the course are rolled more than the rest of the pavement. This occurs because one rear (bull) wheel finally begins to roll in the track of the other. The extra rolling in the center of a pavement course can cause more compression (decreased mat thickness) of the material at this point than the normal rolling will cause to the other portions of the course. The material in the center can become compressed to a point that will result in a course having an inverted crown. If a course develops an unintentional inverted crown, whether it be from rolling or any other source, it must be corrected. This condition can be corrected by adjusting additional crown into the screed to allow extra material to be placed at this point. When crown in excess of the specified amount occurs in the center of the pavement course being placed, it also must be corrected by making the necessary screed crown adjustments. The crown required in a screed to obtain the specified finished crown in the pavement must be determined by trial during the paving operation.

F. <u>Operating Speeds of the Finishing Machine</u>

The possible minimum and maximum operating speed ranges of the above-mentioned pavers vary when compared to each other. The minimum speed range of the respective pavers varies from ten to sixteen feet per minute and their maximum speed range varies from 102 to 273 feet per minute.

The best results would be obtained if the paver could place the asphaltic concrete material in a continuous operation during each working day. Continuous placement of a course by a paver for long daily periods of time is practically impossible, due to various uncontrollable delays which will occur; therefore, intermittent daily placing of a course can be expected. The paver should be operated at a speed, which would most consistently keep it in operation. The maximum rate of speed in feet per minute that a paver can be operated depends on the condition of the paver, type of mixture being placed, and results obtained after the course has been placed.

G. <u>Sequence of Single Finishing Machine Course Placement</u>

It is recommended, when practicable, that the total width of the proposed roadway (which may consist of two or more paver course widths) be completed in section lengths based on the normal daily asphaltic concrete production of the plant. As an illustration, assume that a 24' width asphalt concrete surface is to be placed on a roadway in two 12' widths by a paver. The length of the first 12' width placed by the paver would contain the total amount of asphaltic concrete produced by the plant for that days operation. The next days production of asphaltic concrete by the plant would be placed by the paver on the remaining unpaved 12' lane adjacent to the previously paved portion of the 24' roadway.

If more than two paver course widths are necessary, then an additional day is required for each extra paver width course placed. Variation in daily plant production and deviation from the proposed rate of asphaltic concrete application in the individual lanes will not allow exactly equal lengths to be placed each day. However, the method of controlling the length of adjacent paver lane courses by the normal daily production of the plant usually results in satisfactory full-width completion of the asphaltic concrete course.

It is especially important to complete full widths, as described, when the road is used by traffic during construction; also, traffic movement over an exposed vertical edge bevels the face and makes the matching of the adjacent course to the beveled face difficult.

H. Sequence of Multiple Finishing Machine Course Placements

It is recommended, when practicable, that each full width course be placed over the entire length of the project prior to placement of the following course. It is also recommended that the same method of placement be used for each layer of multiple-course placement as was previously described for single-course placement. When the road is used by traffic during construction, the movement of traffic over the individual courses can be helpful in adding density to them. This added density to each course by traffic can result in less settlement in the final course after completion of the project.

I. Mixture Temperature Control

The best quality hot-mix asphaltic concrete paver courses, like all surfaces containing asphalt products, are obtained when they are placed during warm weather. However, Item 340.5 of the Standard Specifications allows a mixture temperature range which enables satisfactory courses to be placed during all seasons of the year. A mixture temperature is selected within the specified temperature range of Item 340.5; however, if necessary, the selected temperature may be changed at any time within the specified range. During production, the mixture temperature should be checked constantly to be sure that it does not vary from the selected temperature by more than 25°F as specified in Item 340.5. The mixture temperature should be hot enough to obtain the best possible surface texture when the course is placed by the paver and the maximum density in the course after rolling operations have been completed. The air temperature and weather conditions governing the placement of hot mixes outlined in Item 340.6 of the Standard Specifications should be strictly enforced.

J. Preparation of Base and Rate of Tack Coat Application

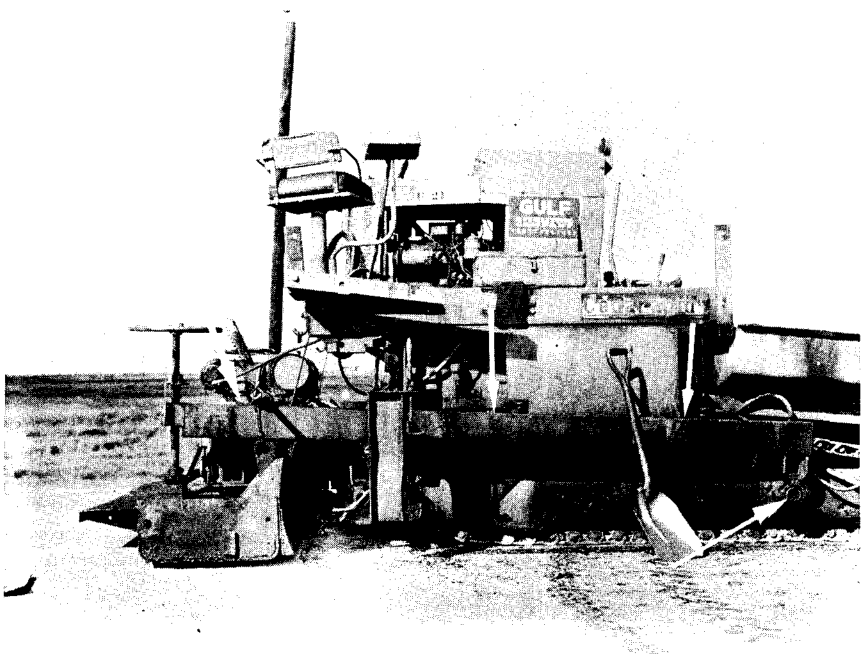
The surface on which any course is to be placed should be thoroughly cleaned by brooming or other methods. If needed, a stringline should be set to control the alignment of tack coat and the paver course. Tack coat method of application, rate per square yard, and other methods described in the level-up chapter on page 105 is also recommended for paver courses.

K. Control of Traffic

The usual width of a modern highway traffic lane is 12' and all pavers are capable of placing an asphalt course of this width in one operation. When a lane course is being placed by a paver, traffic using that lane must be detoured around the freshly-placed course in certain areas of the work in progress. This detour area would include any portion of the asphalt course placed that had not received the final rolling operation. When a paver is placing a lane course on one lane of a two-lane highway, two-lane traffic movement within the working area can be accomplished by use of the other lane and a shoulder. If the shoulder will not allow safe passage for one lane of traffic, controlled one-lane movement of the two-lane traffic using the road must be enforced. When two lanes of traffic are required to use one lane, flagmen must be used to safely control the traffic movement. Placement of lane courses on roads having three lanes or more should not require traffic to be restricted to the use of one lane. The safety of the public and convenience of traffic must be taken into consideration constantly. Item 7, "Legal Relations and Responsibilities to the Public," of the Standard Specifications sets out the procedure that must be enforced.

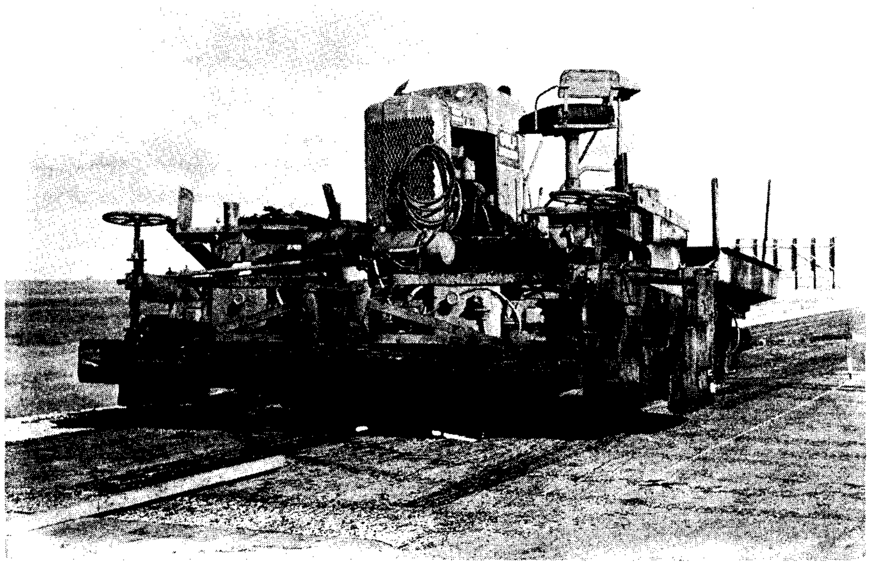
L. <u>Operation of the Asphalt Finishing Machine Screed</u>

As previously described, the typical asphalt paver consists of two main units, the tractor unit and the screed unit. The tractor unit provides motive power to the paver through crawlers or rubber-tired wheels. The tractor unit also furnishes the additional power necessary to operate the paver. The screed unit, which controls the placement of the pavement mat, is attached to the tractor unit by two long screed arms that pivot well forward on the tractor unit.



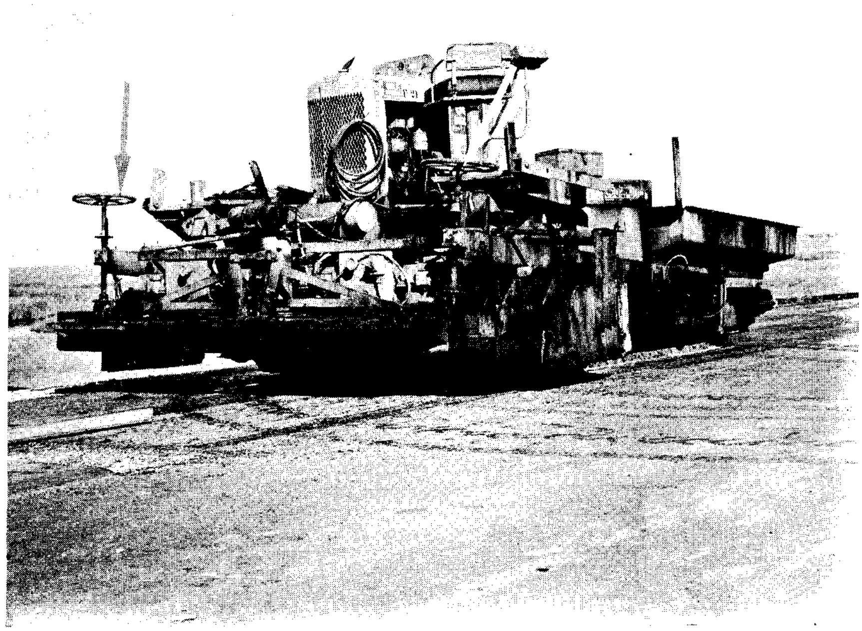
<u>SHOWING SCREED ARM AND PIVOT ATTACHMENT</u>

This type of attachment of the leveling arms to the tractor unit allows the screed unit to be raised or lowered vertically, within certain limits. The screed unit may be raised hydraulically and locked in a vertical position to allow the paver to be transported or moved under its own power from one location to another.



SHOWING SCREED RAISED AND LOCKED IN VERTICAL POSITION

The screed unit should never be locked in any vertical position while it is being used to lay the pavement mat, but should be free to ride along on the surface of the mat at the thickness governed by the screed height adjusting mechanism. The screed height adjusting mechanism is located on each end of the basic screed.

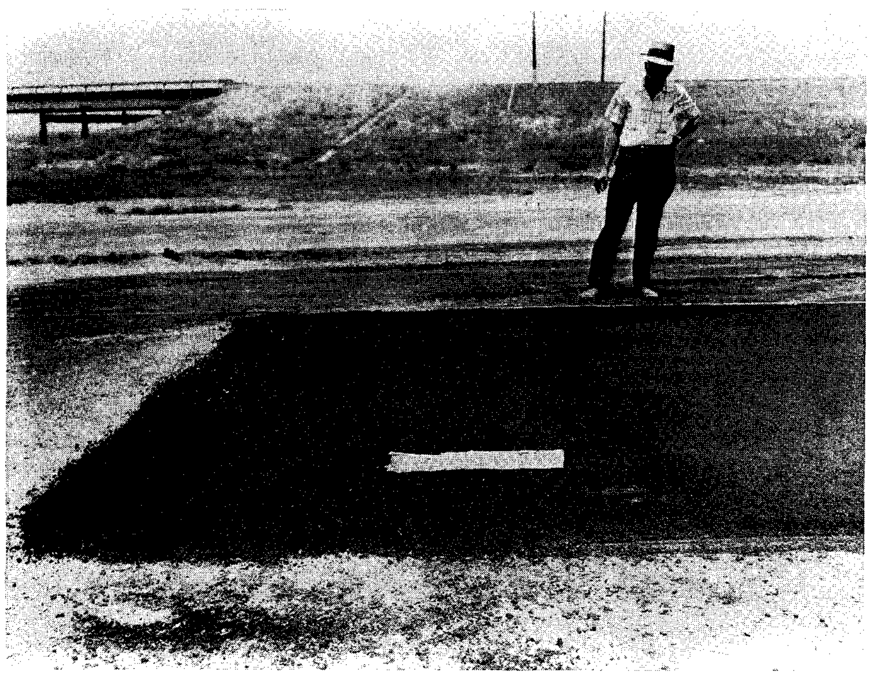


SHOWING SCREED HEIGHT ADJUSTING MECHANISM

These manually operated mechanisms control the thickness of the mat by tilting the toe of the screed up or down, thus allowing more or less material to pass under the screed for greater or lesser course thickness. If the thickness of a pavement mat is to be changed by manually operating either of the screeds' mechanical height controls, it should be done gradually if existing conditions will permit. Gradual mat thickness adjustments will result in a better riding surface; however, conditions will be encountered that will require the mat thickness to be changed abruptly.

M. <u>Description of Transverse Joints and Their Construction</u>

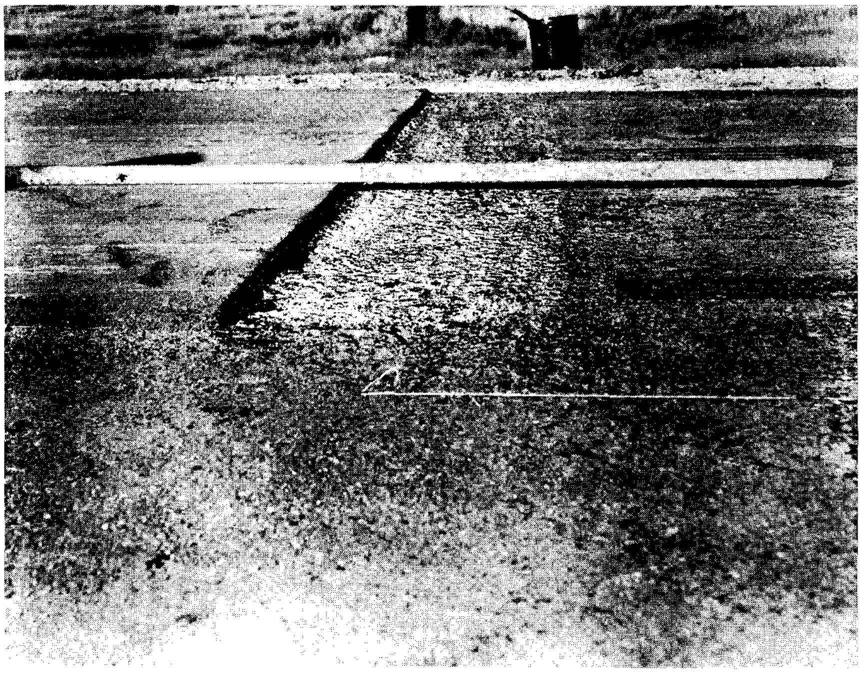
There are two types of transverse joints used in paver-placed asphaltic concrete pavement, the tapered joint and the butt joint (vertical face joint). A tapered joint is used mainly at the beginning or ending of the project; however, existing features inside the limits of the project may also require its use at other places. To make a tapered joint, the thickness of the mat should be zero at the existing surface and increase in thickness to the desired thickness within the chosen transition distance.



SHOWING TAPERED JOINT

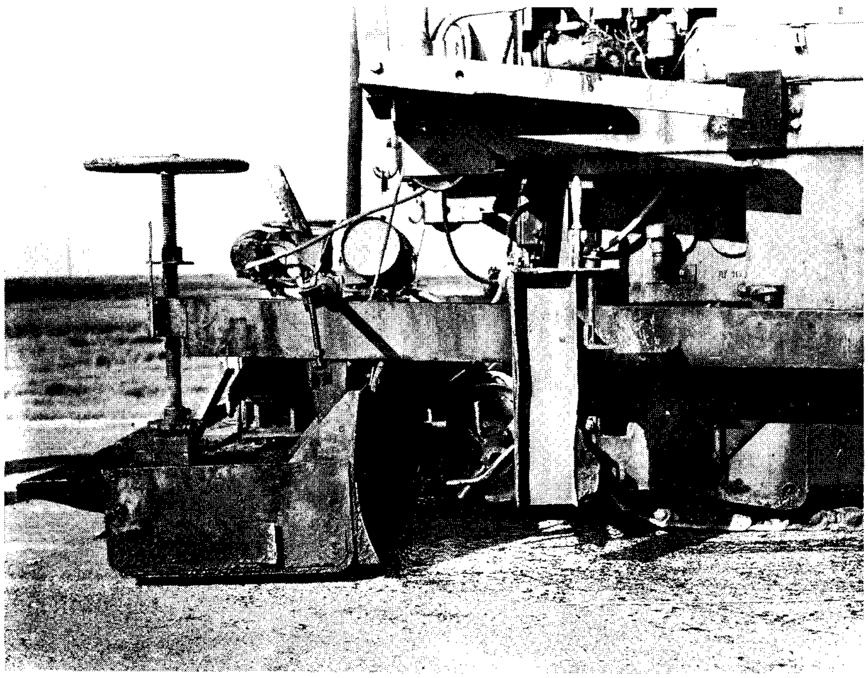
This is accomplished by placing the screed directly on the surface of the existing pavement and gradually adjusting the height controls of the screed as the tractor unit tows it onto the material which has been spread in front of the leading edge of the screed by the augers. When the desired mat thickness has been obtained, the height controls should be left at this position and adjusted only when necessary to control the mat thickness as placement of material continues. To make a tapered joint at the end of a course transition, the thickness of the mat being placed should be decreased in thickness within the chosen transition distance to zero at the existing surface. This is accomplished gradually by adjusting the height controls of the screed down to a featheredge against the existing surface. Permanent transitions from existing surfaces to a finished mat thickness resulting from tapered joints should be of sufficient length to furnish satisfactory pavement riding qualities.

The butt joint is used at adjoining vertical faces. This type joint is more commonly used than the tapered joint when asphaltic concrete is placed with a paver.



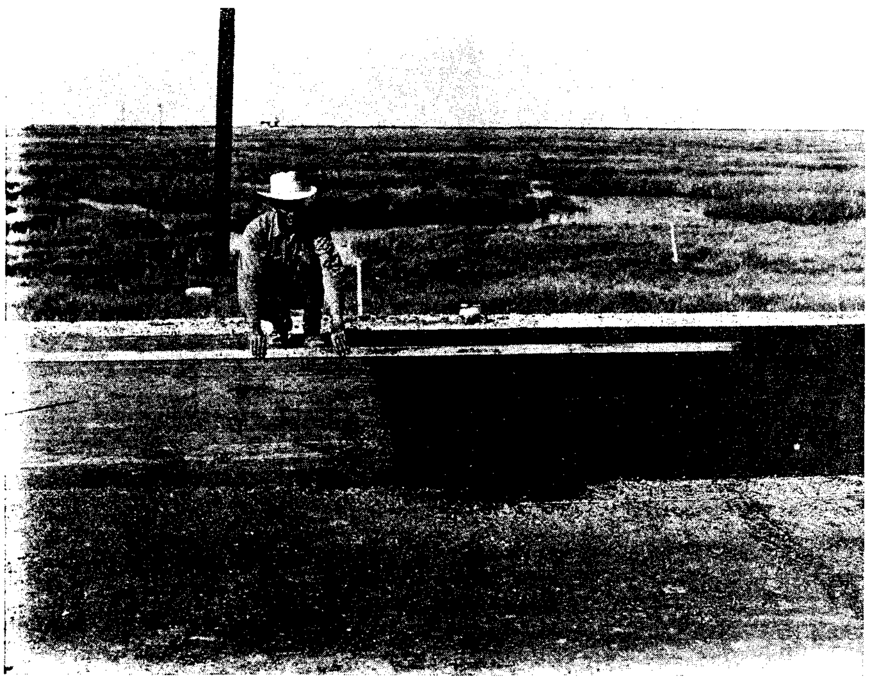
SHOWING BUTT JOINT

In making a butt joint, the paver must be positioned so that the full weight of the screed rests on the existing surface with the leading edge of the screed aligned with the transverse vertical edge of the existing surface.



SHOWING SCREED ALIGNED WITH VERTICAL EDGE OF JOINT

With the screed in this position, its height controls are adjusted to elevate the leading edge of the screed to obtain a mat surface slightly higher than the surface of the existing pavement at the joint in an amount that will furnish a satisfactory riding surface across the joint after final compaction by the rollers. The height at which the leading edge of the screed has to be set varies at each joint. However, a skilled screedman is capable of setting the screed height controls to produce a satisfactory joint which will require very little correction, if any. To make a butt joint with the screed height controls set at their selected height, the paver tows the screed onto the material which has been spread in front of the leading edge of the screed by the augers. After the mat has been placed adjacent to the existing pavement, the joint should be straightedged and any corrections which are necessary should be made by handworking with lutes or rakes prior to rolling.



STRAIGHTEDGING THE JOINT

The joint should be checked with a straightedge before and after the rolling operations to show any irregularities outside specified tolerance which will require correction before the joint is accepted.

The most difficult butt joint construction occurs when the paver is required to pull the screed onto a vertical face joint in the existing pavement while placing a mat. This requires the screed height controls to be adjusted to obtain greater mat height as the tractor unit starts up on the existing vertical joint and then lower the mat height by adjusting the screed height controls as the tractor unit begins traveling entirely on the surface of the existing pavement. Construction of a butt joint in this manner should be avoided unless existing circumstances will not allow it to be made as previously described.

Construction of at least one butt joint is required to connect the mat to be placed with an existing mat at the beginning of each day; however, delays during daily placement of a mat can require a butt joint to be made in order to continue the paving operation later in the day. The use of the butt joint is not restricted to single course mat placements, since it can also be used in multiple course placements against any existing fixed vertical contour.

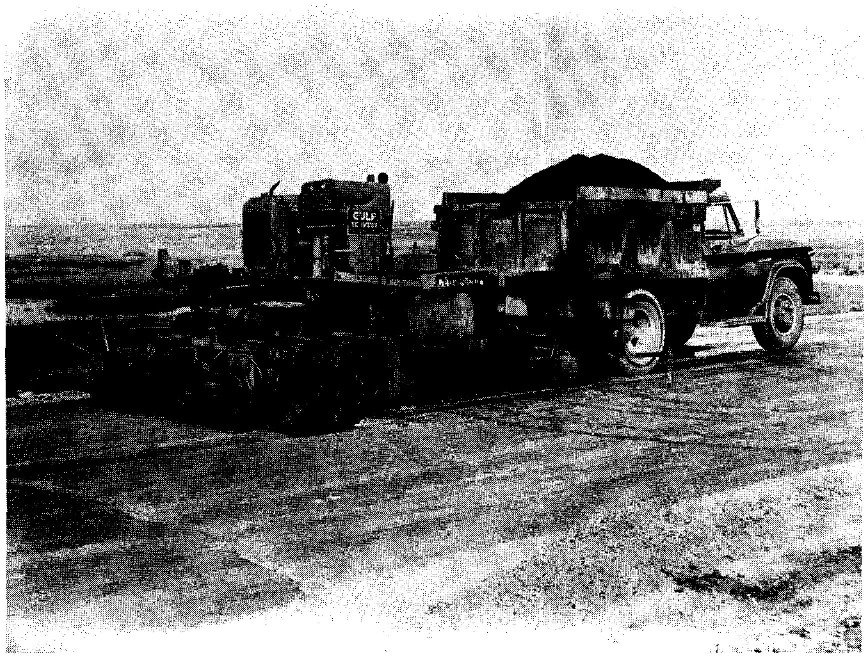
N. Description of the Paver Operation

The paver is positioned on the surface to be paved and its alignment control attachment set to allow the operator to correctly steer the paver along an established guideline.

ALIGNMENT CONTROL SHOWING INDICATOR

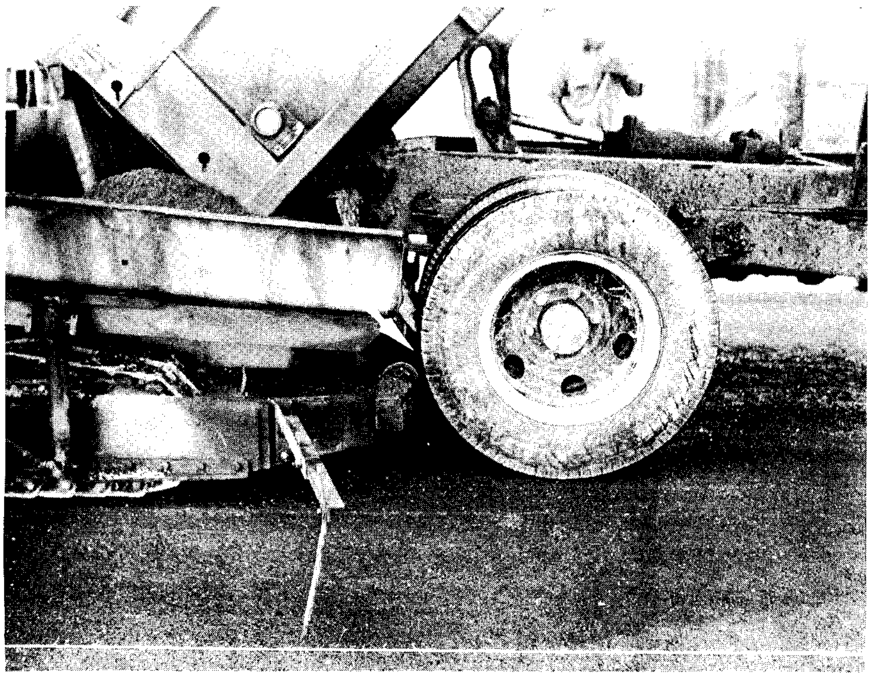
The screed is placed on the surface to be paved and positioned to produce an acceptable height pavement mat at the beginning of the project. It is always advisable to heat the screed with the attached oil-burning heater at the beginning of a days operation, or at any time after the paver has been delayed long enough to allow the screed to become cold. Heating a cold screed prior to placing the material is helpful in preventing the mixture from adhering to it.

The material is delivered from the plant to the paver in trucks. The first truck to arrive backs up until its rear wheels contact the truck rollers mounted on the front end of the paver and begins dumping its material into the paver hopper.



TRUCK READY TO DUMP

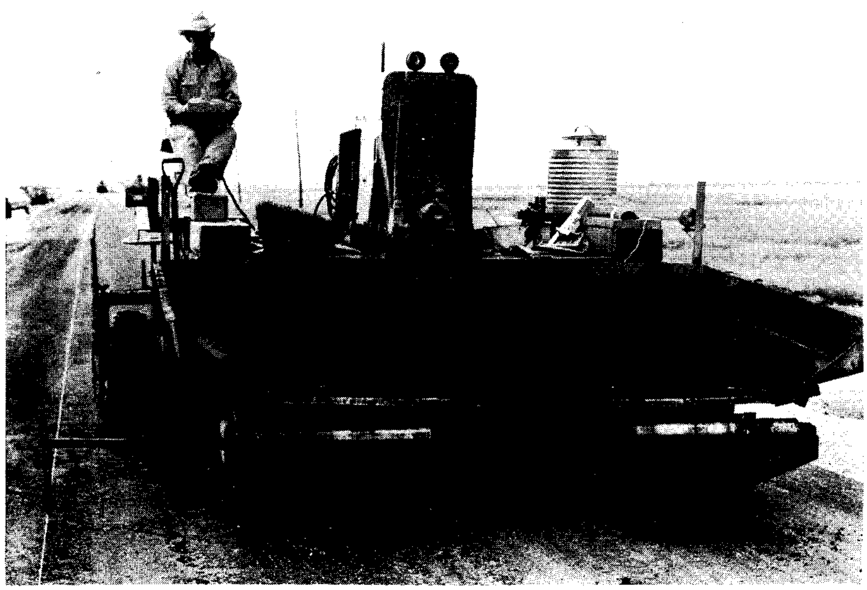
It is not unusual for the volume of material hauled by modern-day trucks to exceed the volume of the paver hopper; therefore, before a truck can completely unload into the hopper, the excess volume contained in the truck over the volume that the hopper can hold must be placed in the mat on the road by the paver as it pushes the truck along. The truck should be pushed entirely by the paver as it unloads and the driver should steer his truck parallel to the proposed alignment of the course to allow the paver operator to maintain proper control of the paver. A truck driver, while unloading material into the hopper, should apply his brakes just firmly enough to maintain rear truck wheel contact with the paver's truck rollers.



REAR TRUCK WHEEL IN CONTACT WITH PAVER TRUCK ROLLERS

This will eliminate unnecessary bumping of the paver and the possibility of spilling part of the load on the area in front of the paver. A portion of the material as it is placed into the hopper by the first truck must be placed on the surface to be paved between the tractor unit and the transverse length of the leading edge of the screed by the paver's bar feeders and spreading augers prior to the beginning of the mat placement by the paver. For the best paving results, the height of the material across the transverse length of the screed should be kept approximately at the top of the auger shaft as the mat is being placed. When the material is spread across the leading edge of the screed, the operator can start placing the mat, making the required type transverse joint. As the paver tractor unit pulls the screed onto the material, the screedman will adjust the screed height by means of the manually-operated screed mechanism to force enough material under the screed which will furnish an acceptable mat height after the final rolling operation.

When the first truck is unloaded and moved from the paver, another truck should be placed in front of the paver to start dumping its load in the hopper. As a rule, the trucks should not back into the paver but should be engaged by the paver as it moves along. Backing a truck up to a motionless paver, unless the driver is careful, can result in jolting the paver backwards, which will cause the back edge of the screed to dig into the pavement mat already placed. When this happens, it can make handworking with lutes necessary to eliminate the screed mark and hand finishing never can be made to blend with a screed-placed surface. When placement by the paver is delayed during the day, some material should be kept in front of the screed and in the hopper from the previous truck so the paver can begin placing the mat as it engages the next truck.



SHOWING MATERIAL KEPT IN HOPPER FROM PREVIOUS TRUCK

Any delay in placement of the mat which causes the mix remaining in the paver to lose enough of its heat to seriously affect the texture and compaction of the mat will necessitate making a transverse joint at this time. When a transverse butt joint must be made in a mat under any condition, it is general practice to cut the mat joint to a vertical face before the paving operation begins again.

To begin paving again, the bottom of the screed must be placed on the top of the mat with its leading edge parallel to the butt joints. Spread the mix across the full width of the screed as previously described and continue placement of the mat.

O. <u>Assumed Construction Conditions and Methods of Operation</u>

A one-paver course of hot-mix asphaltic concrete at a proposed average rate of 125 pounds per square yard of the previously-described level-up surface area will be assumed. This 24' width course will be placed by the paver in two 12' widths. Traffic movement is to be allowed through the project, but controlled movement by detouring will be provided, when necessary, within the limits of the roadway. One 12'lane allows traffic to travel in a northerly direction and the other allows travel in a southerly direction. The 100' stations making up the project length, begin at the south end of the project and increase numerically in a northerly direction to the end of the project. The plant is located at the beginning of the project (south end) and each 12' course will be placed from south to north. With this method of course placement, the east lane will be placed with the movement of traffic and the west lane will be placed against the movement of traffic.

Assume that the Inspector has checked the most important parts of the paver and found them satisfactory to begin the paving operation. As previously mentioned, the asphalt roadway surface will be placed in two 12' course widths. The basic width of the screed on the paver to be used is ten feet; therefore, it must be extended to a width of twelve feet. The screed will be widened by adding a one-foot (factory furnished) screed extension to each end of its 10' width.

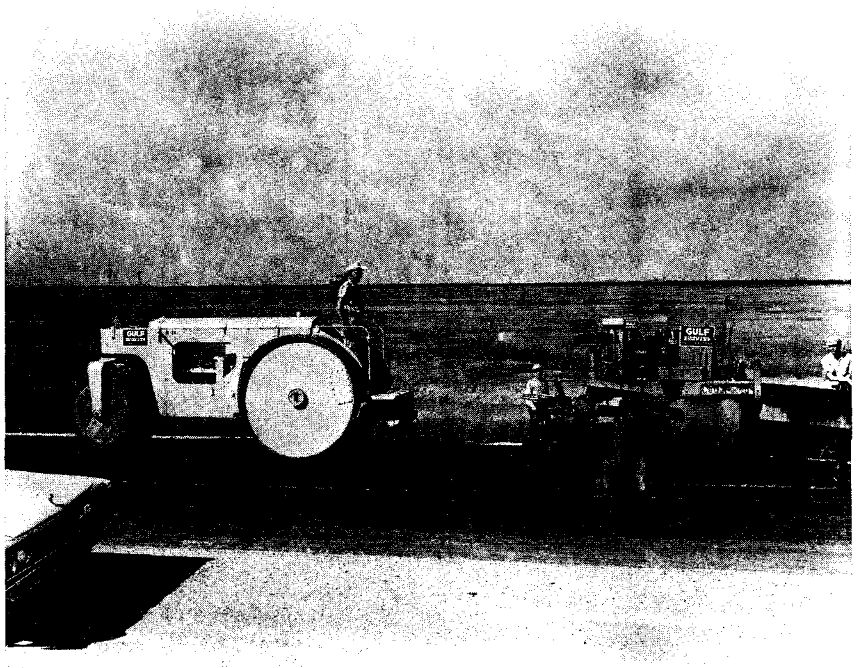
After the extensions have been added, an initial trial crown must be set in the screed before starting the placement of the course. As pointed out previously, in order to produce a specified crown in the finished surface of a course, after the final rolling operation, the initial crown setting may have to be adjusted. Assume that the proposed finished crown slopes from the center of the 24' width course to its edges at the rate of 1/8th of an inch per foot. As recommended previously, the crown will be set slightly higher in the toe of the screed than that height which will be set in the heel. For this sloping type of surface, 1/8th of an inch crown in height will be set in the toe of the screed and 1/16th of an inch crown will be put in the heel of the screed. The pavement crown height will be checked by a stringline with reference to the edges of the mat before and after the rolling operations. If the desired final crown is not being obtained, appropriate adjustments to the screed will be made.

To begin the paving operation, the 12' west lane (south-bound) of the existing 24' level-up course will receive the first asphaltic concrete paver course. The portion of the level-up to be covered by the 12' paver course will be cleaned by brooming, if necessary, prior to the application of the RC-2 tack coat. It was previously recommended that RC-2 tack coat rate of application be limited to a maximum of 0.03 of a gallon per square yard when the mixture to be placed contained 5.5% asphalt by weight or more. The tack coat will be applied over short sections, as needed, during each day of operation to provide for the safety of traffic movement. The paving mixture to be placed will contain 5.8% asphalt by weight and the tack coat is to be applied between the limits of 0.02 and 0.03 of a gallon per square yard. The plant will be assumed to operate for eight hours each day at an average production rate of 90 tons of asphaltic concrete per hour. Ninety tons per hour production by the plant gives a daily production of 720 tons of asphaltic concrete (eight-hour period). If the 12' width course is placed at an average rate of 125 pounds per square yard, the paver course will cover 8,640 linear feet during the days operation. Assume that the tack coat has been applied to a 12' width of approximately half this 8,640 feet, to begin the paving operation. Tack coat will be applied to the other half of the 8,640 feet when it is needed.

Asphaltic concrete for this project will be placed during the summer months. At this time of year, a course placed with a mixture having a temperature of approximately 300°F will usually give the best results, except where wire mesh is used in the pavement. This degree of mixture heat will generally furnish satisfactory surface texture when placed by the paver and also permit immediate rolling of the course, which is extremely important. Wind and air temperature generally governs the temperature to which the mixture must be heated to obtain the best results. Assume that the plant will start production of the asphaltic concrete at a chosen temperature of 300°F; however, mixture temperature deviation from this temperature within the specified range will be accepted.

In conjunction with paver placement of the mat, it will be rolled in sequence by a ten-ton steel three-wheel roller, a Type "B" self-propelled pneumatic-tired roller ballast, loaded to weigh 12.5 tons, and a ten-ton steel two-wheel tandem roller. Two-way movement by each roller along the mat will be required while performing the rolling operation across its transverse width. Turning around of the rollers to perform one-way rolling operation is not permitted. The three-wheel roller should be operated with its drive wheels forward in the direction of the paving operation. Rolling by this method with the drive wheels of the three-wheel roller forward will result in less pushing of the uncompacted mat. The pneumatic and tandem rollers will be operated with their drive wheels forward in the direction of the paving operation; however, if desired, both of these rollers may be operated with their drive wheels in either position when they follow the three-wheel roller.

All rollers will be operated at a rate of speed slow enough to eliminate any pushing of the mat, which results from fast rolling speeds. The initial rolling of the mat by the three-wheel roller will follow paver placement as closely as possible; however, if cracking or shoving occurs in the mat, the roller operator will stop the rolling operation to allow the mat to cool to a point that satisfactory rolling can be accomplished.



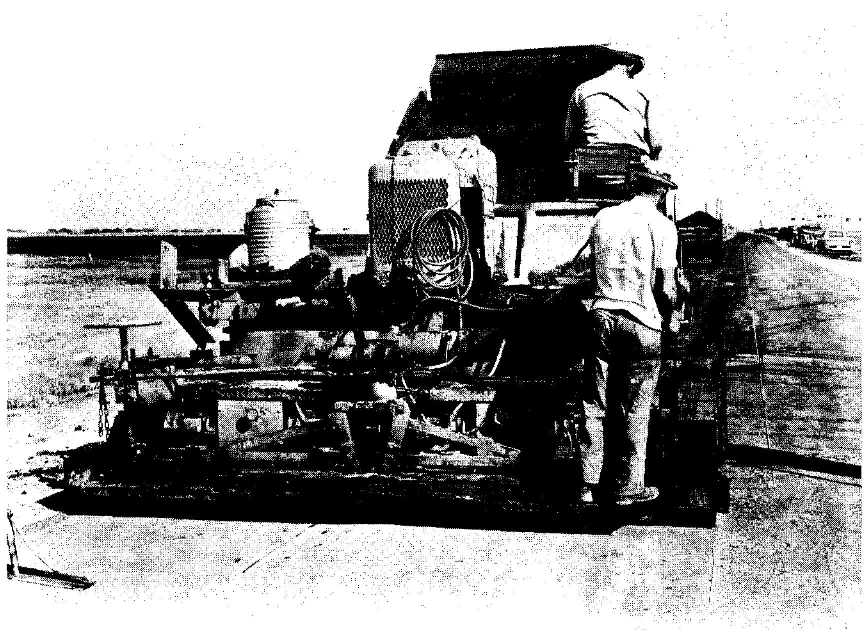
SHOWING THREE-WHEEL ROLLER FOLLOWING PAVER PLACEMENT

It is common practice to roll the mat from its low outside edge inward toward the high side, since this method of rolling practically eliminates the tendency of the heated mixture to move toward the low side of the mat.

P. Description of a Paver-placed Course

The paver is positioned at the beginning of the project (south end) on the 12' west lane and the screed is heated by the attached oil-burning heater to prevent the mixture from adhering to it when placement of the mat begins. The heat will be applied to the screed until the mixture will maintain the screed heat. The screed is placed on the existing surface with its leading edge slightly elevated to begin a tapered joint from zero height at the beginning of the transverse joint to a proposed compacted 1-1/4th-inch mat thickness over a 25' transition length.

To aid the operator in steering the paver along a guideline, a guidebar is provided which can be attached to the paver on either side at the hopper end. The guideline used by the operator to place the mat in this case will be a stringline along the centerline of the existing concrete pavement on which the level-up course has been placed.



SHOWING STRINGLINE

Placing the course on the west lane in a northerly direction and using the centerline of the pavement as a guideline will require the paver to be operated from the right side; however, all pavers are built to permit operation from either side.

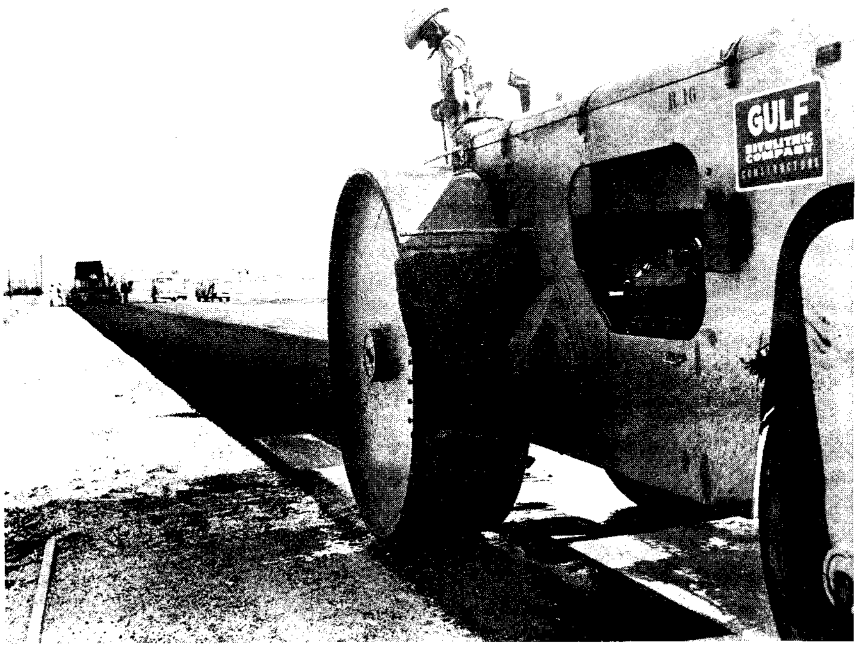
The first truckload of material received from the plant is backed up to the paver until it makes rear wheel tire contact with the truck rollers located on the hopper end of the paver. After the truck rear wheel tires contact the paver truck rollers, the driver applies the truck brakes only firmly enough to maintain contact between the truck and the paver. The truck endgate is then released and the truck bed raised hydraulically by the driver to dump the material into the paver hopper with the truck driver still applying the brakes firmly enough to maintain truck and paver contact. The operator then begins moving material from the hopper with the bar feeders to the augers for spreading in front of the leading edge of the screed. When the material has been spread by the augers across the surface between the tractor unit and the leading edge of the screed to at least auger shaft height, the operator starts the paver in motion, pushing the unloading truck with the truckdriver applying the truck brakes only firmly enough to maintain truck and paver contact. The paver is operated at a very low rate of speed to allow the screed man to maintain better control of the screed as he varies the mat thickness from zero at the beginning of the transverse joint to the desired thickness within the chosen transition length. When the transition to the desired mat thickness has been made, the paver is stopped until all necessary straightedging and handworking of the surface within the limits of the transition has been completed.

The paver then continues placement of the mat and its operating speed is adjusted to place the mat as continuously as possible. As previously stated, the plant produces the mixture at an average rate of 90 tons per hour; therefore, if the mat is placed at an average rate of 125 pounds per square yard, the calculated rate of speed required for the paver, based on plant production and rate of roadway application, would amount to 18 feet per minute. The paver will be operated as close to this rate of speed as possible; however, speed adjustments will be made as necessary.

As placement of the mat continues during the day, the Inspector checks the average rate of application of asphaltic concrete placed in pounds per square yard by calculations based on the total weight of material contained in every five truckloads placed. The Inspector also checks the days over-all average rate of application each time a five-load average is computed. This will be calculated from the summation of the total amount of asphaltic concrete which has been placed up to that time during the day. Variations from the proposed 125-pound per square yard rate of application are not unusual; however, gradual screed adjustments should be made to place the mixture within five pounds per square yard of the proposed 125 pounds per square yard application rate. Gradual adjustment of the screed to obtain the desired daily average rate of application of material is especially recommended, since it will produce a more satisfactory riding surface in the finished pavement. The over-all average rate of application, based on the total amount of material placed should be kept slightly below the specified 125 pounds. The reason for this procedure is to stay within plan quantities and to accumulate a material reserve which can be used in the event extra material is needed anywhere within the project limits.

Q. Description of Rolling Operation

The three-wheel rolling operation on the 25' transition surface will begin immediately after the handwork with lutes has been completed. The three-wheel roller operator backs the roller up to the transverse joint with the two bull wheels (drive wheels) forward (north) in the direction of the paving operation. The edge of the bull wheel is aligned with the outside edge (west edge) of the 12' wide mat to begin the rolling operation.

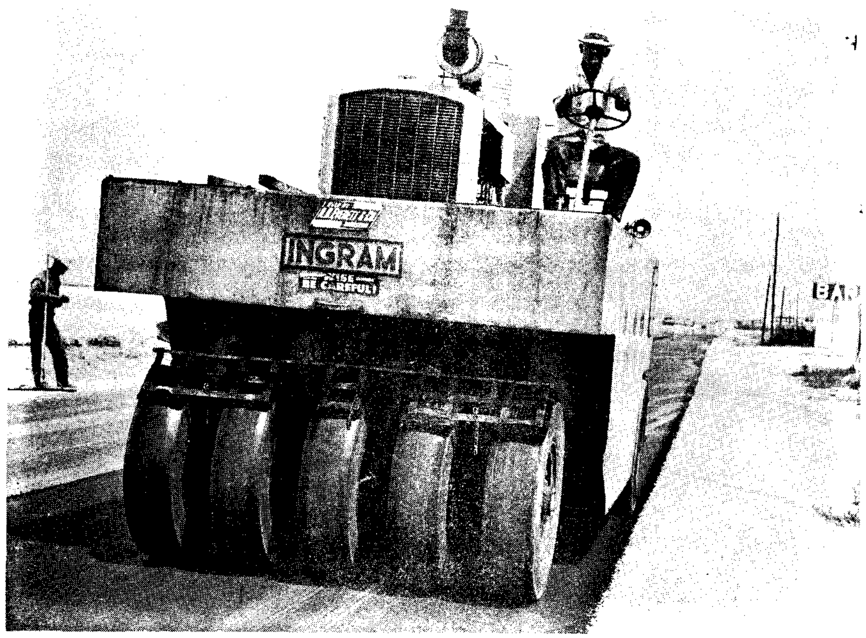


SHOWING BULL WHEEL ALIGNED WITH OUTSIDE EDGE OF PAVEMENT

The operator keeps the edge of the bull wheel aligned with the outside edge of the mat transition as he rolls along it. After completion of the first longitudinal rolling pass (north) by the roller along the edge of the transition, the operator reverses his direction of travel and steers the roller forward (south) longitudinally and angles it inward to align the edge of the bull wheel parallel and slightly lapped onto the imprint made by the initial rolling pass. This lateral movement (west to east) by the roller at the respective ends continues in conjunction with the alternating longitudinal backward and forward rolling passes until coverage by the roller's bull wheels is completed. After the three-wheel rolling operation has been completed, the operator moves the roller back to the outside edge (west edge) of the mat. He then backs the roller up to the north end of the previously rolled 25' mat transition.

The edge of the bull wheel is again aligned with the outside edge (west edge) of the unrolled mat ahead. From this location, the operator continues the roller operation as he steers the roller backward (north) rolling along the mat's west edge up to approximately ten feet of the paver, where he gradually brings the roller to a stop. The starting or stopping of all rollers on the mat should be done gradually to eliminate unnecessary displacement of the mat at these locations. As pointed out previously, the operator reverses his direction of travel at the end of each roller pass, and as he starts back, the roller is angled slightly inward to align the edge of the bull wheel parallel and slightly lapped onto the imprint made by the previous roller pass. As the roller reverses direction of travel, it is not immediately angled inward to a new position; rather, it is allowed to roll along the previous path for a short distance before it is gradually angled to move laterally. This method of lateral movement by the roller at the end of each pass continues with the alternating backward and forward rolling passes until coverage of this section by the roller's bull wheels is completed.

After completion of the compaction of the section by the three-wheel roller, the operator moves it to the west side at the north end of this section and begins the rolling operation on the next section, using the same procedure. The pneumatic roller will then begin rolling the mat in the section that has been rolled by the three-wheel roller. The pneumatic roller operator backs the roller up to the transverse joint with the drive wheels forward (north) in the direction of the paving. The edge of the drive wheel tire is aligned with the outside edge (west edge) of the 12' wide mat to begin the rolling operation.



SHOWING PNEUMATIC ROLLER

The operator then steers the roller backwards (north) and keeps the edge of the drive wheel tire aligned with the outside (west) edge of the mat. The pneumatic roller operator stops his roller slightly south of the stop made by the three-wheel roller operator at the end of the section. This eliminates unnecessary concentrated compaction resulting from stopping two rollers at identical places on the mat. The rolling continues by the same method described for the three-wheel rolling operation; however, the pneumatic roller moves laterally only enough for each tire to slightly lap onto the imprint of its previous rolling pass. After the three-wheel and pneumatic rollers complete their rolling operation on any section of a mat, very little additional roller compaction can be obtained.

The pneumatic rolling operation on the mat in each section will be followed by the tandem rolling operation. The tandem roller operator backs the roller up to the transverse joint with the drive wheels forward (north) in the direction of the paving. The edge of the drive wheel is aligned with the outside edge (west edge) of the 12' wide mat to begin the rolling operation. The operator steers the roller backward (north) and keeps the edge of the drive wheel aligned with the outside edge of the mat.

THREE-WHEEL TANDEM ROLLER ALIGNED WITH PAVEMENT EDGE

The operator stops his roller slightly south of the stop made by the pneumatic roller to also eliminate stopping two rollers at identical places on the mat. The rolling continues by the same method described for the three-wheel roller; however, the tandem roller moves laterally only enough for its two rolling wheels to lap half their width onto the imprint of its previous rolling pass. The tandem roller will be used mainly as a finishing roller to eliminate any marks left in the mat by the preceeding rollers and, also, to obtain a smooth uniform surface.

Throughout the construction operation, the initial rolling of the mat by the three-wheel roller will be coordinated with paver placement as closely as possible, and the pneumatic and tandem rollers will follow in sequence.

R. Construction of Transverse Joint

When the last truckload of material produced for the day by the plant is received at the roadway and has been placed by the paver on the 12' wide west lane for the distance it covers, a transverse joint will be made to end the paving for the day. Preparatory to construction of the transverse joint, the truck will be moved from its paver-pushed position after enough of its material has been placed on the west lane to allow the remaining portion of the load to be held in the paver hopper. As the paver continues placing the mat, the remaining material in the hopper should be kept equalized over the bar feeders with hand shovels in order for each individual feeder to consistently furnish material to the respective spreading augers. Shovel portioning of the material in the hopper at this time is done to obtain the desired mat thickness and width for the maximum distance possible. When the material is used up to a point that desired mat thickness and width cannot be obtained, the paver is stopped and the screed unit raised hydraulically so that the paver can be moved from the roadway to allow the transverse joint to be constructed. The non-uniform width of mat placed by the screed is removed from the road back to a point where the desired mat thickness and full 12' width can be obtained. At this point, the mat is cut to a vertical face across its 12' width to form the transverse joint (butt joint). To protect the butt joint from being beveled by the movement of traffic over it, a temporary mat transition, approximately two feet in length will be tapered from the top of the joint to the level-up course. This mat transition will be removed before continuing the paving from the butt joint; therefore, to eliminate complete bonding of the transition mat to the level-up course and to make its removal easier, a thin film of clean sand will be spread across that portion of the level-up course on which the mat transition is to be placed. To construct the mat transition, the asphalt mixture is placed on the area with shovels after which it is handworked with lutes to the desired shape and left slightly higher than the surface of the butt joint for the purpose of obtaining a roller-compacted height equal to the surface of the butt joint. After construction of the mat transition, it will be rolled in sequence by the respective rollers as they complete their rolling operation for the day.

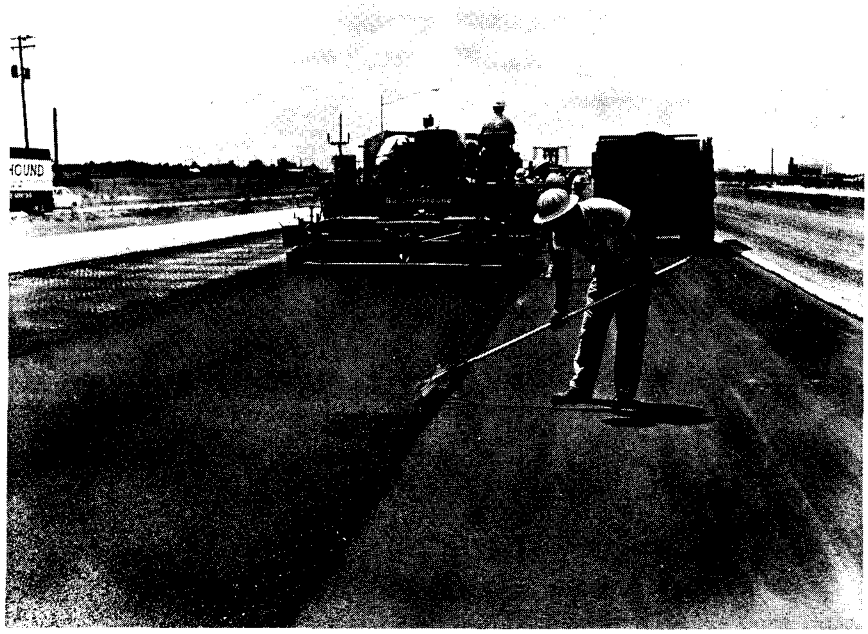
S. Placement of the Adjacent Lane

The following day, the 12' mat will be placed on the lane adjacent to the completed 12' mat on the west lane. The existing longitudinal edge of the west 12' mat (along the centerline of the proposed 24' roadway) will be used as a guideline to place the 12' mat on the east lane. Placing the mat on the east lane in a northerly direction and using the existing longitudinal edge of the west lane mat as a guideline will require the paver to be operated from the left side. The guidebar will be attached to the left side of the paver and adjusted to obtain a two-inch overlap by the screed when the operator uses it to guide the paver.

SHOWING OVERLAP OF LONGITUDINAL JOINT BY PAVER SCREED

With the guidebar set to obtain a two-inch overlap by the screed, a qualified operator should be able to guide the paver along a reasonably straight longitudinal line and obtain an overlap ranging from a minimum of one inch to a maximum of three inches. When matching a joint to a previously laid mat, a small overlap is helpful to obtain better compaction against the existing vertical face of the longitudinal joint and it is also helpful in controlling the height of the mat being placed. The height of the paver-placed mat at the joint must be high enough above the existing mat so that the additional compaction obtained from the rollers will bring the new mat down to the level of the existing mat.

The equipment is moved back to the beginning of the project (south end) to begin placing the 12' mat on the east lane. The paver is positioned on the east 12' lane at the beginning of the project and the guideline bar aligned with the existing longitudinal edge to obtain a screed lap of two inches over the longitudinal joint onto the existing mat. The material is placed into the hopper from the truck and after an adequate amount of material has been spread across the leading edge of the screed, as previously described, placing of the east 12' mat will begin. The operator moves the paver very slowly, guiding it along the longitudinal edge of the 25' transition, while the screedman adjusts the screed to obtain a mat slightly higher than the mat on which the screed is lapped. When the mat has been placed throughout the transition area, the paver will be stopped to allow paver personnel to straightedge and perform all handwork with lutes on the transition to prepare it for the rolling operation. It should be mentioned here that while placing the mat on the west land, the luteman was only required to repair any damage that might have occurred to the mat. However, when the adjoining mat is being placed, along with routine surface repair, he must lute the material off the cold mat that has been left on it by the overlapped screed. This overlapped material, which was placed there for previously described reasons, will be luted up to the hot mat's longitudinal edge, and after it has been placed in this position, the lutemen will <u>flip</u> the material onto the surface of the hot mat in such a manner that the texture and riding quality of the mat will not be affected after the rolling operations have been completed. This joint working operation by the luteman will be kept up with the paver as the mat is placed.



SHOWING LONGITUDINAL JOINT WORK

To begin the rolling operation on the transition, the three-wheel roller operator begins at the outside edge of the mat with the roller's bull wheels in the direction of the paving operation and rolls progressively inward to the longitudinal joints. After rolling the transition inward to the longitudinal joint, the three-wheel roller will begin its rolling operation on the sections to follow by rolling the longitudinal joint first. When rolling along the longitudinal joint, the operator will put one bull wheel on the cold mat and lap half of the width of the other bull wheel over the joint onto the hot mat.

ROLLING LONGITUDINAL JOINT

This initial pass by the roller along the longitudinal joint should be kept up with the progress of the screed and the remainder of the rolling of the mat width can be performed in variable length sections as the temperature and other governing factors will permit. This method of rolling the longitudinal joint will result in a better union between the two mats, because the mat being placed can be rolled at its hottest temperature by the narrow width of the bull wheel without being picked up.

After the longitudinal joint has been rolled as described above, the roller is moved back along the joint to the previously rolled section (in this particular case, the transition mat) where the roller will be positioned with one bull wheel on the outside edge and the other bull wheel over on the hot mat. Rolling of each section with the three-wheel roller will then progress as previously described from the outside edge inward to the center. Rolling sequence with the pneumatic and tandem rollers will follow the three-wheel rolling operation as previously described. The transverse joint ending the mat for the day will be constructed as previously described. Placement of the two 12' mats will be continued by the methods described until the project is completed.

XIII. Inspectors Checklist

A. Inspection of Equipment

1. At the plant make periodic inspections of:

    (1) Screens and frames: To see that they are in good condition and that material is not by-passing through "torn" places. See that various sections are properly placed over bins; that bins are in good condition; and that no overflow can occur from one bin to another.

    (2) Pugmill mixing paddles: To see that they are in place, properly set, and not unduly worn.

    (3) Weighing devices: (Asphalt scales, aggregate scales, and platform scales) to see that they are functioning properly. Make calibrations with standard weights.

    (4) Recording temperature indicators: For accuracy.

    (5) Aggregate discharge gates: To see that they close properly and to see that there is no leakage afterward.

    (6) Discharge gate at mixer: To see that there is no leakage when it is closed.

    (7) Feeding devices: For aggregate and sand, to see that they are functioning properly.

2. On the road:

    (1) Check rollers: When they arrive on the job to see that they are in proper working condition and that they are the proper type and weight.

    (2) Check distributor: For working condition, attachments, etc. Strap it, if necessary.

(3) Make periodic checks of finishing machine: To see that prime mover, conveying equipment, heating equipment, screeds, tamping bars, and vibrators are functioning properly and accurately set.

B. Routine Duties

1. At the plant (striving to produce a uniform mix).

(1) Weighing Equipment

Before starting up each morning, and at frequent intervals thereafter, check tare weights and bin weight setting on aggregate and asphalt scales. Make frequent observations of weighing operations to see that scales are not hanging up and to see that operator is weighing accurately.

Weigh empty batch trucks at least twice a day, or more frequently if necessary. Make frequent observations of platform scales (if used) to see that they are not fouled up.

See that loaded trucks are weighed accurately with proper weight allowance for empty truck. See that proper weights are recorded on tickets. Report any unusual variation from batch weights.

(2) Sieve Analysis

If your job is making sieve analysis, keep at it. When you finish one set, start on another. Make frequent tests of the fine bin. Report any unusual variation at once. You may catch a broken screen, a buckled wall in a bin, material overflowing from one bin to another, or improper feeding of the fine sand. THINK about what you are looking for.

In sampling, get representative samples. Quarter your samples carefully, recovering all fines. Shake your sieves thoroughly.

(3) Extraction tests

This test gives a check on the actual amount of asphalt going into the mix and a record of the job.

Make your calculations as soon as you complete the test. Look at the results. THINK. If the results do not check closely with the amount of asphalt which we are trying to get in the mix, report the variation at once and look for the cause. You may find an asphalt scale hanging up or a cutoff valve out of order. You may prevent some non-uniform material getting to the road.

Sample your materials carefully from the batch trucks - dig down - get a representative sample. Quarter it carefully.

(4) Laboratory specimens

These are indicative of the density which we may get on the road with the particular mix after it has been subjected to traffic. We want a dense material ultimately, but not too dense. There must be enough void space to allow the asphalt to expand under the summer heat without pushing the aggregate particles away from each other. Yet, the material must be dense enough that water will not filter into it. We make the density test, and the Austin Office makes a stability test. We are told to be cautious of material which gives a stability less than 30.

Take some pride in preparing the specimens - make them representative of what we are putting on the road. If they look unusual - too rich - too lean - or non-uniform - report this condition at once.

Sample the material carefully. Dig down into the truck - get a representative sample. Quarter it carefully. Mold the specimens carefully at the proper temperature. Place the material in the mold layers - avoid segregation. If a specimen is spoiled during molding process, throw it away and make another one.

(5) Specific gravities

Make periodic checks of the specific gravities. Your densities are computed from the specific gravity and an erroneously low specific gravity may indicate an excessively high density. This is a good job to do when you think that you have run out of something to do, but it is a test which must be run with care.

(6) Temperatures

Keep the temperatures within the range set for the particular occasion. Make frequent checks of the temperatures of asphalt and aggregate on the recording thermometers and frequent checks of the batch temperatures in the truck. Strive to hold the temperature constant - avoid sending a cold load on the road. If there is an indication of the temperature becoming too high or too low, caution the contractor's plant men. Try to avoid having to reject the loads. The contractor cannot make money on rejected loads.

(7) Aggregates, etc.

Make frequent checks of the materials to see that they are satisfactory.

(8) Condition of batch trucks

Make frequent checks of batch trucks for cleanliness. Watch out for diesel oil. When the drivers use oil to wash out their trucks, see that excess oil is swabbed out. Watch this all during the day, but especially in the early morning, around noon, and late afternoon. This oil causes unsightly spots on the road. There is no excuse for it.

(9) Visual inspection

Make a visual inspection of as many batches as possible. Watch for batches which appear to be too rich or too lean or improperly mixed. If an unusual condition is noticed, look for the cause immediately and start trying to remedy the condition as soon as possible.

Make frequent observations of the plant batch mixer operator. See that he is adding the materials in the proper sequence and proper proportions. Check the mixing time frequently. Watch out for asphalt dripping from discharge gate of mixer or for excess asphalt getting on parts of asphalt scales and causing fouling. Have such conditions remedied at once by the proper authority.

Watch out for excess asphalt around the plant yard where it can be tracked onto the job. Have this material removed or covered up.

(10) Cooperation with the road inspectors

Plant men must cooperate with the road inspection crew. The material may look good in the truck, but it may not look quite right on the road. Notes from the road are not sent in a spirit of criticism; they are sent in a spirit of continually striving to produce an excellent uniform mix at a uniform temperature - a mix which will enable the road crew to produce a proper job.

All notes should be acknowledged. If corrective action is indicated, do so and inform the road crew of your action. If not, let the road crew know what the situation is. If the road crew receives a batch so cold that the material can be picked out of the truck with the bare hands, there is no sense in telling them that the batch left the plant at 350° if the truck was on the road only five minutes. That is a case of a cold batch getting out of the plant and the proper thing to do is inform the road crew that they will not get any more cold batches and then proceed to see that they do not.

(11) Records

Keep all of your records up to date. Make computations of tests results as soon as possible. We want the records to accurately reflect what is going into the road.

2. On the Road
(Striving to get a job which the whole crew will be proud of.)

(1) Checking asphaltic concrete

Record the data from the truck ticket. Make frequent check of the temperature. See that the inspector-in-charge receives all notes and call his attention promptly to anything which appears unusual. Learn to observe what is going on. Watch each load of material as it comes in and when it is dumped. Watch the condition of the road ahead. Does it need cleaning off? Are there any places which should be patched or receive special treatment? Study the procedures for placing the material. THINK. Learn to appreciate the responsibility and problems connected with placing hot-mix asphaltic concrete.

(2) Job Inspection

Keep an eye on construction details. See that the material is spread uniformly at the proper thickness - and at the proper crown. See that rolling operations are carried out properly and that the mixture is adequately compacted to the required density. Pay particular attention to joints between spreads and between sections of the same spread, due to temporary suspension of work. See that they are properly made. Check the compacted mixture frequently for thickness and for contour. Wherever possible, make any corrections which need to be made during compaction before the mixture cools to atmospheric temperature. If the spreader causes segregated spots, or if fat or porous spots "crop up," they should be removed and replaced with acceptable material. When required, field density samples should be taken.

(3) Cooperation with the plant crew

Keep the plant crew informed about any unusual variations of the material. Acknowledge all their notes. Insist on getting a properly mixed, uniform mixture at a fairly uniform temperature, but learn to appreciate the problems which arise at the plant.