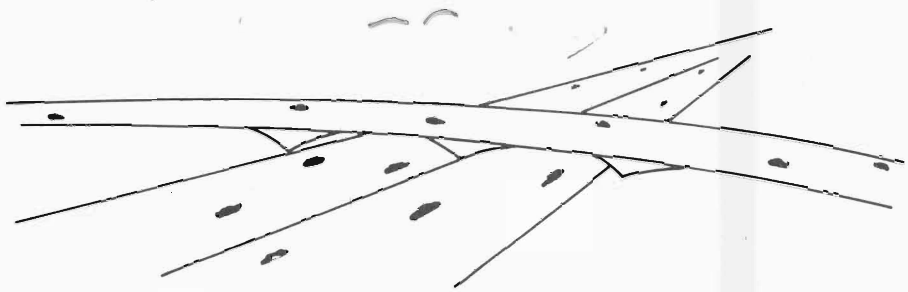

DEPARTMENTAL RESEARCH

Report Number SS 15.8

THE DRYER-DRUM-MIXER PROCESS FOR PRODUCING ASPHALT CONCRETE

TEXAS HIGHWAY DEPARTMENT

THE DRYER-DRUM-MIXER PROCESS
FOR PRODUCING
ASPHALT CONCRETE

by

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District 18

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ABSTRACT

The dryer-drum-mixer process, adequately controlled, can be used to produce a uniformly graded, well-coated asphaltic concrete with good workability. Transporting, placing, and compacting can be accomplished with standard equipment. The completed mix is comparable to similar mixes produced by a conventional process.

COMMENTS

A new asphaltic concrete product is being promoted with the development of the dryer-drum-mixer process. This new product is mixed and placed at temperatures between 200° F and 250° F with varying percents of moisture. The workability is controlled by the moisture content. The physical properties of this mix are between hot mix asphaltic concrete and hot mix cold laid asphaltic concrete. Sufficient quanities of this type of mix have been placed to insure that a uniformly mixed product can be produced with good workability. Since hot mix asphaltic concrete and hot mix cold laid concrete have been used for many years with satisfactory service, a product with properties between these two known products should give satisfactory service.

The equipment manfacturers promoting the dryer-drum-mixer process for the production of asphaltic concrete are claiming many advantages when comparing this process to the conventional process controlled by the standard specifications. These two processes are not comparable since many of the requirements specified in the standard specifications must be waived in order to permit the use of the dryer-drum-mixer process. The conventional process (batch mix or continuous mix) can operate just as efficient as the dryer-drum-mixer process without the hot aggregate screening and proportioning requirements. A low temperature mix with moisture can be produced by the conventional process. By waiving these requirements, the conventional process can be modified and compared equally to the dryer-drum-mixer process.

Uniformly graded stockpiles, non-segregating handling procedures, and accurately proportioning methods are requirements which have never been fully accomplished. Rigid stockpile requirements may increase the cost of the mineral aggregate more than the savings obtained by eliminating the hot aggregate screening and proportioning equipment. Asphalt measured by a fluidometer controlled by belt scales is not as accurate as asphalt measured by the batch on beam scales.

The use of the dryer-drum-mixer process is a judgment decision which must be made during the design stage. The intended use of the product will be the deciding factor. If gradation and asphalt tolerance can be extended without affecting the serviceability of the product, then the savings in equipment cost necessary for separating and accurately proportioning the mineral aggregate and the asphalt is justified. If moisture does not affect the durability of the product, then the savings in fuel required to remove the moisture is justified.

SUMMARY

The data presented in this report is based upon evaluation tests sampled from 40,000 tons of asphalt stabilized base produced by the Shearer's Dryer-Drum-Mixer Process. This test data was supplemented by plant control data and observations made during production.

The mix produced was a fine graded base course with 0% retained on the one-half inch sieve, 45% retained on the number ten sieve, and with 5.2% asphalt. The mineral aggregate was produced by blending a pit run sand and gravel with a processed river gravel.

A uniformly graded, well-coated asphalt stabilized base was produced with the completed mix temperatures varying from 200° F to 300° F. The moisture content in these mixes varied from 0.0% at 300° F to 1.5% at 200° F. No problems were noted with mixing, storing, transporting, placing, or compacting while operating within this temperature range. Uncoated aggregate was obtained at a final mixing temperature below 200° F. No mix was produced at temperatures above 300° F.

Efficient operating conditions for this fine graded mix were established with the completed mix leaving the drum at a temperature between 220° F and 240° F with approximately one percent moisture. Plant production was limited by the field placement equipment to a rate of 250 tons per hour. All field operations were completed with standard equipment. The average field density was 94.0% of the actual theoretical density. The laboratory test data, as well as the

physical appearance of the completed mix indicates that this mix is comparable to the mixes produced by a conventional mixing process.

Some fluctuation in the asphalt content was experienced due to mechanical problems with the asphalt delivery pump and the aggregate belt scales. To insure that the aggregate-asphalt ratio remains constant, accurate calibrations of these feed controls, frequently checked, are essential.

THE DRYER-DRUM-MIXER PROCESS
FOR
ASPHALTIC CONCRETE

The dryer-drum-mixer process used to produce asphaltic concrete is a continuous operation controlled exclusively by the cold feeds, mineral aggregates, asphalt, and combustion fuel. The mineral aggregates and the asphalt enter the drum simultaneously with the hot combustion gases. As these combined materials flow through the drum, the mineral aggregates are partially dried, mixed with the asphalt, and heated to a specified temperature. The completed mix exits onto an elevator and is carried to a surge silo where it is then ready for delivery to a project.

The uniformity of the completed product depends upon the uniformity of the cold feeds. Uniformly graded stockpiles, non-segregating handling procedures, and accurate proportioning methods are essential. The ratio of the total mineral aggregate and the asphalt must remain constant. A constant temperature gradient must be maintained throughout the drum.

There are several manufacturing companies producing asphaltic concrete mixing equipment which utilizes the dryer-drum-mixing process. The major differences in these various mixers are the method of adding asphalt to the mixer and the use of additives to aid in the mixing and coating process. This report describes the Shearer's Dryer-Drum-Mixer Process. No additives, other than those required in the completed mix, were used in this process.

The mineral aggregates were proportioned volumetrically through separate bins with adjustable gate openings onto variable speed conveyor belts. These aggregates were collected on a central conveyor belt and the total flow of material was measured electronically with a belt scale. The belt scale operates from a load cell located under one section of the central conveyor feed belt. A variable capacity asphalt pump, controlled electronically by the belt scale, established the rate of asphalt delivered to the drum. A thermostatic sensor, located on the exit end of the dryer, controlled the combustion fuel feed. A master control was used to regulate the total feed rate after the individual feed proportions were established.

Air pollution was controlled by passing the stack gases through a wet scrubber before exiting into the atmosphere. The amount of emission to the atmosphere varied with the production rate and the amount of moisture permitted in the completed mix.

EVALUATION OF COMPLETED MIX

To evaluate the quality of the completed mix, thirty eight samples were taken independent of the normal plant control samples. The results obtained are shown in Tables I, II, and III. Table I shows gradation, asphalt content, moisture content, laboratory density and stability. Table II shows the physical changes in the asphalt resulting from the drying, mixing, and placing process. Other data, such as, sampling point, mixing temperature and exhaust temperature are given. The average compacted in place density is shown in Table III.

Figure I shows the normal operating conditions used for the producing and placing of this mix. A good quality mix was obtained with the completed mix leaving the dryer-drum at temperatures between 200° F and 300° F. Uncoated aggregates were obtained at temperatures below 200° F. The moisture content varied from 0% for mixes at 300° F to 1.5% for mixes at 200° F. Comparative stripping tests indicated that the asphaltic coating on the mineral aggregate was equal to mixes produced by the conventional HMAC mixers. The most economical operating conditions were established with the completed mix leaving the drum at a temperature of 225° F and 1.0% moisture.

Initially, the asphalt was added to the cold aggregate immediately before entering the dryer-drum-mixer. To reduce the amount of fine aggregate loss through the exhaust and to reduce the time the asphalt was exposed to the flame, the asphalt was added through a pipe located ten feet inside the dryer-drum-mixer. A comparison of the asphalt penetration values before and after making this change are shown in Table IV. Samples No. 27 through 38 were taken after making this change.

Samples No. 1 through 17,27,28, and 29 were taken during normal operating conditions. Samples No. 18 through 26 and Samples No. 30 through 38 were taken during two different test periods while the plant was producing mix at temperatures between 250° F and 300° F, with low moisture contents.

As shown in Table I, a gradual gradation change in the mineral aggregate occurred during the production of this mix. The pit run sand and gravel used in this mix gradually changed to a finer gradation. This change was observed during production and the control design was adjusted to allow for the change. Non-uniformity of the cold bin feeds contributed to some gradation variations, however, most of the variations were caused by the gradation changes in the pit-run sand and gravel.

The original design for this mix specified 5.8% asphalt. In order to maintain workability and stability, the asphalt content was reduced to 5.2%. This reduction was necessary to allow for moisture retained in the compacted mix (approximately 0.5%) and to correct for gradation changes in the mineral aggregates. Considerable fluctuation in the asphalt content was encountered. This fluctuation was due to malfunctions of the belt scale and the asphalt pump.

The data presented in Table II clearly shows that asphaltic concrete can be produced by the dryer-drum-mixer process without severely affecting the physical properties of the asphalt. Only two test samples show a change by this process to be greater than the change that occurred by the thin film oven test. The data also indicated that the place of adding the asphalt will affect the properties of the asphalt in the completed mix.

Table III shows that adequate compaction was obtained by three different compacting procedures. The average field density was 94.0% of the actual theoretical density.

FLOW DIAGRAM FOR ASPHALTIC CONCRETE

BY

DRYER-DRUM-MIXER PROCESS

AND

PLACEMENT

Loop 12
Dallas, Texas

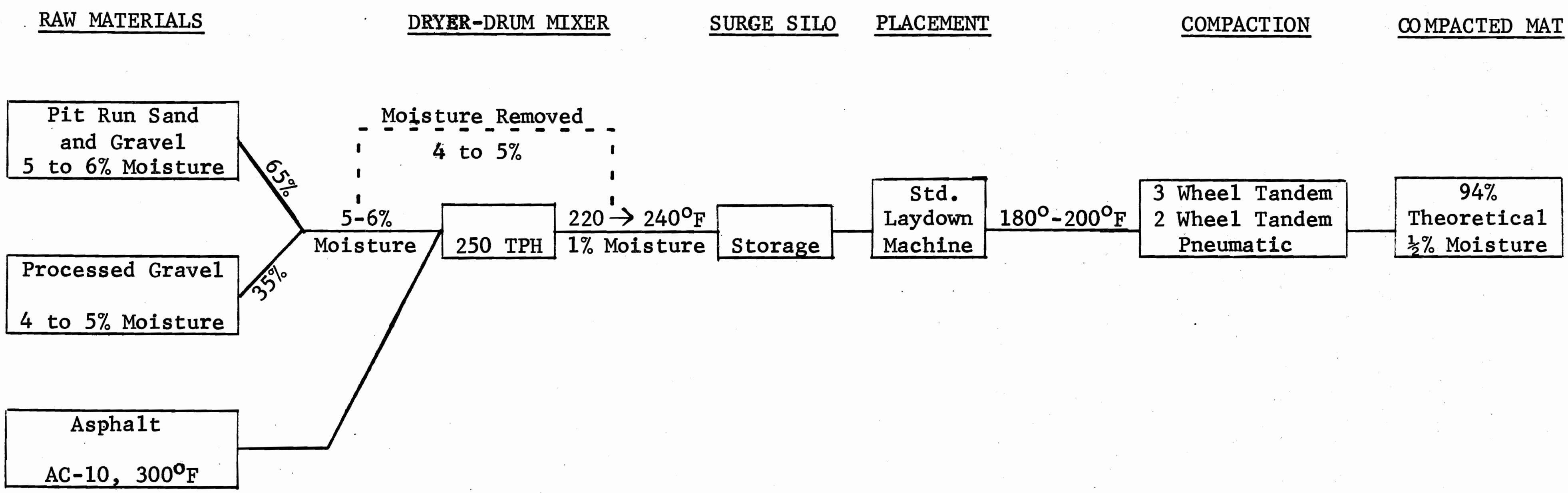

Figure I

QUALITY CONTROL DATA

Sample	Place	Mix Temp. (°F)	Flame Temp. °F (Exhaust)	Gradation (Extractions)								Molded Specimens	
				+1/2	+10	10-40	40-80	80-200	-200	Asphalt	Moist.	Density	Stability
1	Mixer	225	465	2.0	33.7	22.6	26.7	8.0	2.6	6.4	--	--	--
2	Mixer	225	445	2.3	35.7	21.9	27.2	6.8	2.4	6.0	--	--	--
3	Mixer	250	460	1.5	36.0	21.7	25.2	7.4	2.8	6.1	--	--	--
4	Mixer	230	390	0.7	43.6	18.7	22.8	6.6	2.5	5.6	--	--	--
5	Mixer	255	365	1.2	35.0	20.3	28.4	8.1	2.2	5.5	--	--	--
6	Mixer	225	400	2.5	47.0	18.0	21.7	5.6	2.4	5.3	--	--	--
7	Silo	195	370	2.2	40.2	18.4	25.2	7.7	3.3	5.2	--	--	--
8	Silo	200	450	5.3	44.7	20.2	19.9	6.9	3.0	5.3	--	--	--
9	Silo	210	400	4.0	45.0	18.3	22.1	6.6	2.8	5.2	--	--	--
10	Silo	237	540	1.1	36.4	21.0	25.5	7.9	3.1	6.1	--	--	--
11	Mixer	190	400	1.9	48.2	15.9	20.7	7.7	2.5	5.0	1.6	--	--
12	Silo	199	400	2.5	50.4	13.7	19.9	7.9	3.0	5.1	1.6	--	--
13	Rdwy.	170	---	4.1	48.2	14.9	21.1	7.6	2.9	5.3	1.3	--	--
14	Silo	190	---	5.2	47.3	16.0	21.6	7.4	2.6	5.1	--	--	--
15	Mixer	240	400	1.9	44.3	16.8	22.5	8.3	2.8	5.3	0.6	94.7	31

Table I

QUALITY CONTROL DATA

Sample	Place	Mix Temp. (°F)	Flame Temp. °F (Exhaust)	Gradation (Extractions)								Molded Specimens	
				+1/2	+10	10-40	40-80	80-200	-200	Asphalt	Moist.	Density	Stability
16	Silo	240	---	5.0	46.8	16.6	21.6	7.5	2.6	4.9	0.5	94.8	34
17	Rdwy.	190	---	1.9	41.3	18.2	24.5	8.0	2.5	5.5	0.0	95.5	34
18	Mixer	285	450	3.4	47.0	16.1	22.2	7.9	2.6	4.2	1.1	94.7	34
19	Silo	285	---	2.6	48.4	15.4	21.2	7.8	3.0	4.2	0.1	94.8	34
20	Rdwy.	265	---	2.8	46.8	15.5	22.4	8.4	2.8	4.1	0.1	94.6	34
21	Mixer	285	430	1.9	41.5	18.5	25.1	8.1	2.5	4.3	0.2	93.4	33
22	Silo	285	---	0.2	37.8	20.6	26.3	8.4	2.5	4.4	0.1	94.7	34
23	Rdwy.	255	---	2.1	41.9	18.7	24.7	8.0	2.6	4.1	0.0	93.8	32
24	Mixer	285	420	1.9	43.7	18.5	24.2	7.4	2.2	4.0	0.0	94.2	31
25	Silo	280	---	1.8	46.1	17.5	22.5	7.7	2.4	3.8	0.1	94.5	33
26	Rdwy.	250	---	3.7	40.6	19.3	25.0	7.7	3.1	4.3	0.0	93.9	30
27	Mixer	215	265	1.1	45.2	13.3	27.7	9.8	2.8	4.2	0.1	--	--
28	Silo	205	---	0.6	41.8	13.8	25.1	11.6	3.3	4.4	0.1	--	--
29	Rdwy.	190	---	1.4	49.9	11.6	21.6	10.2	2.9	3.8	0.1	--	--
30	Mixer	280	355	0.0	44.3	9.0	26.2	12.8	3.2	4.5	0.0	--	--

QUALITY CONTROL DATA

Sample	Place	Mix Temp. (°F)	Flame Temp. °F (Exhaust)	Gradation (Extractions)								Molded Specimens	
				+1/2	+10	10-40	40-80	80-200	-200	Asphalt	Moist.	Density	Stability
31	Silo	270	---	0.1	49.0	8.1	22.7	12.3	3.4	4.5	0.0	--	--
32	Rdwy.	260	---	0.3	46.2	7.8	24.4	13.8	3.4	4.4	0.0	--	--
33	Mixer	270	355	0.9	46.6	8.1	24.8	13.8	3.4	4.4	0.0	--	--
34	Silo	270	---	0.6	48.9	7.8	23.9	11.7	3.5	4.2	0.0	--	--
35	Rdwy.	265	---	0.8	51.4	7.6	22.7	11.0	3.1	4.2	0.0	--	--
36	Mixer	280	360	0.4	46.2	8.5	25.2	12.1	3.2	4.8	0.0	--	--
37	Silo	270	---	1.7	34.2	10.1	32.3	14.2	3.7	5.5	0.0	--	--
38	Rdwy.	255	---	1.9	49.1	7.7	22.3	13.2	3.3	4.4	0.0	--	--

COMPARISON TEST RESULTS

OF

ASPHALT AFTER DRYER-DRUM MIXING

Sample No.	1	2	3	4	5	6	7	8	9
Penetration at 77°F, 100g., 55 sec.									
Asphalt	97	97	97	92	92	92	91	90	93
Extracted Asphalt	64	58	64	60	57	62	**37	**29	43
Ductility, 77°F, 5 cm/m., cm									
Asphalt (After thin film oven test)	141+	141+	141+	141+	141+	141+	141+	141+	141+
Extracted Asphalt	141+	141+	141+	141+	141+	141+	135	31	141+
Viscosity at 140°F, Stokes									
Asphalt	934	934	934	913	913	913	884	836	828
Asphalt (After thin film oven test)	1795	1795	1795	1631	1631	1631	1865	2008	2067
Extracted Asphalt	1421	1559	1886	1897	2115	1710	**8757	** 22305	2281
Asphaltic Concrete Place Sampled *	Mixer	Mixer	Mixer	Mixer	Mixer	Mixer	Silo	Silo	Silo
Temperature, °F	240	250	250	230	230	245	195	200	210
% Moisture in Asphaltic Concrete	---	---	---	---	---	---	---	---	---

* Silo samples taken from truck immediately after loading from silo.
** No. 7 & 8 extracted asphalt is not consistent with other test data.

Table II

COMPARISON TEST RESULTS

OF

ASPHALT AFTER DRYER-DRUM-MIXING

Sample No.	10	11	12	13	14	15	16	17	18
Penetration at 77°F, 100g., 55 sec.									
Asphalt	93	92	92	92	92	95	95	95	96
Extracted Asphalt	66	54	59	48	57	52	59	53	59
Ductility, 77°F, 5 cm/m., cm									
Asphalt (after thin film oven test)	141+	141+	141+	141+	141+	141+	141+	141+	141+
Extracted Asphalt	141+	141+	141+	141+	141+	141+	141+	141+	141+
Viscosity at 140°F, Stokes									
Asphalt	828	884	884	884	884	883	883	883	780
Asphalt (after thin film oven test)	2067	2024	2024	2024	2024	2050	2050	2050	1962
Extracted Asphalt	1460	1953	1855	2755	1820	2587	1445	1682	1748
Asphaltic Concrete Place Sampled	Silo	Mixer	Silo	Rdwy.	Silo	Mixer	Silo	Rdwy.	Mixer
Temperature, °F	237	190	199	170	190	240	240	190	285
% Moisture in Asphaltic Concrete	---	1.64	1.6	1.25	---	0.6	0.5	0.0	1.1

* Silo samples taken from truck immediately after loading from silo.

COMPARISON TEST RESULTS

OF

ASPHALT AFTER DRYER-DRUM-MIXING

Sample No.	19	20	21	22	23	24	25	26	*** Average
Penetration at 77°F, 100g., 55 sec.									
Asphalt	96	96	97	97	97	97	97	97	95
Extracted Asphalt	64	54	60	65	56	**71	57	60	58
Ductility, 77°F, 5 cm/m., cm									
Asphalt (after thin film oven test)	141+	141+	141+	141+	141+	141+	141+	141+	141+
Extracted Asphalt	141+	141+	141+	141+	141+	141+	141+	141+	141+
Viscosity at 140°F, Stokes									
Asphalt	780	780	842	842	842	842	842	842	867
Asphalt (after thin film oven test)	1962	1962	1994	1994	1994	1994	1994	1994	1935
Extracted Asphalt	1362	1738	1471	1299	1671	**836	1597	1216	1762
Asphaltic Concrete Place Sampled	Silo	Rdwy.	Mixer	Silo	Rdwy.	Mixer	Silo	Rdwy.	---
Temperature, °F	285	265	285	285	255	285	280	250	
% Moisture in Asphaltic Concrete	0.1	0.1	0.15	0.1	0.0	0.0	0.1	0.0	---

* Silo samples taken from truck immediately after loading from silo.
** Sample No. 24 - Viscosity and penetration is not consistent with other test data.
*** Sample No. 7,8 & 24 not used in average.

COMPARISON TEST RESULTS

OF

ASPHALT AFTER DRYER-DRUM-MIXING

Sample No.	27	28	29	30	31	32	* 33	34	35
Penetration at 77°F, 100g., 55 sec.									
Asphalt	90	90	90	87	87	87	87	87	87
Extracted Asphalt	62	67	54	56	66	79	*90	60	52
Ductility, 77°F, 5 cm/m., cm									
Asphalt (after thin film oven test)	141+	141+	141+	141+	141+	141+	141+	141+	141+
Extracted Asphalt	141+	141+	141+	141+	141+	141+	141+	141+	141+
Viscosity at 140°F, Stokes									
Asphalt	935	935	935	946	946	946	946	946	946
Asphalt (after thin film oven test)	2283	2283	2283	2373	2373	2373	2373	2373	2373
Extracted Asphalt	1112	1290	1982	1996	1327	1110	*1014	1508	2000
Asphaltic Concrete Place Sampled *	Mixer	Silo	Rdwy.	Mixer	Silo	Rdwy.	Mixer	Silo	Rdwy.
Temperature, °F	215	205	190	280	270	260	270	270	265
% Moisture	.08	.08	.08	.03	.02	.02	.03	.02	.01

* Silo samples - Taken from truck immediately after loading from silo.
** Sample No. 33 - Do not use in average.

COMPARISON TEST RESULTS

OF

ASPHALT AFTER DRYER-DRUM-MIXING

Sample No.	36	37	38	Avg.					
Penetration at 77°F, 100g., 55 sec.									
Asphalt	87	87	87	88					
Extracted Asphalt	55	55	53	54					
Ductility, 77°F, 5 cm/m., cm									
Asphalt (after thin film oven test)	141+	141+	141+	141+					
Extracted Asphalt	141+	141+	141+	141+					
Viscosity at 140°F, Stokes									
Asphalt	946	946	946	943					
Asphalt (after thin film oven test)	2373	2373	2373	2350					
Extracted Asphalt	1938	1941	2071	1662					
Asphaltic Concrete Place Sampled	Mixer	Silo	Rdwy.						
Temperature, °F	280	270	255						
Moisture (% by Wt.)	.04	.02	.02						

Average of Samples 27-38

AVERAGE FIELD DENSITIES

Core Samples

Type of Equipment and Rolling Sequence	Average Density (% of Theoretical)
I. Sequence One	
A. Pneumatic	94.0%
B. Two Wheel Tandem (22 cores)	
C. Three Wheel Tandem	
II. Sequence Two	
A. Three Wheel Tandem	
B. Two Wheel Tandem (5 cores)	94.5%
C. Pneumatic	
III. Sequence Three	
A. Vibratory (12 cores)	93.4%

Table III

AVERAGE PENETRATION TEST VALUES

1. Asphalt Enters Mixer with the Aggregate (23 tests)

Place of Sampling				* Total Loss In Penetration
	Extracted Asphalt			
Storage Tank	Mixer	Silo	Roadway	
95	59	59	54	41

2. Asphalt Enters Mixer Through Pipe Extended Ten Feet Inside the Mixer (8 tests)

Place of Sampling				* Total Loss In Penetration
	Extracted Asphalt			
Storage Tank	Mixer	Silo	Roadway	
88	58	--	53	35

* Total Loss in penetration is based upon samples taken from roadway.

Table IV

CONCLUSIONS

Based upon the test results and observations made during the mixing and placing of asphaltic concrete produced by the dryer-drum-mixer process, the following conclusions were made:

(1) The dryer-drum-mixer process, adequately controlled, can be used to produce a uniformly graded, well-coated asphaltic concrete with good workability.

(2) Storing, transporting, placing, and compacting can be accomplished with standard equipment.

(3) Uniformly graded stockpiles, non-segregating handling methods, and accurate proportioning are essential.

(4) Moisture affects the workability and stability of the completed mix (information concerning durability is not available).

(5) The changes in the physical properties of the asphalt are less than the changes occurring during the thin film oven test.

(6) The accuracy of a variable capacity asphalt pump is questionable. A variable capacity fluidometer receiving asphalt from a constant line pressure is more reliable.