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It also refers to field practice and behavior of asphaltic mixtures containing bag house dust.

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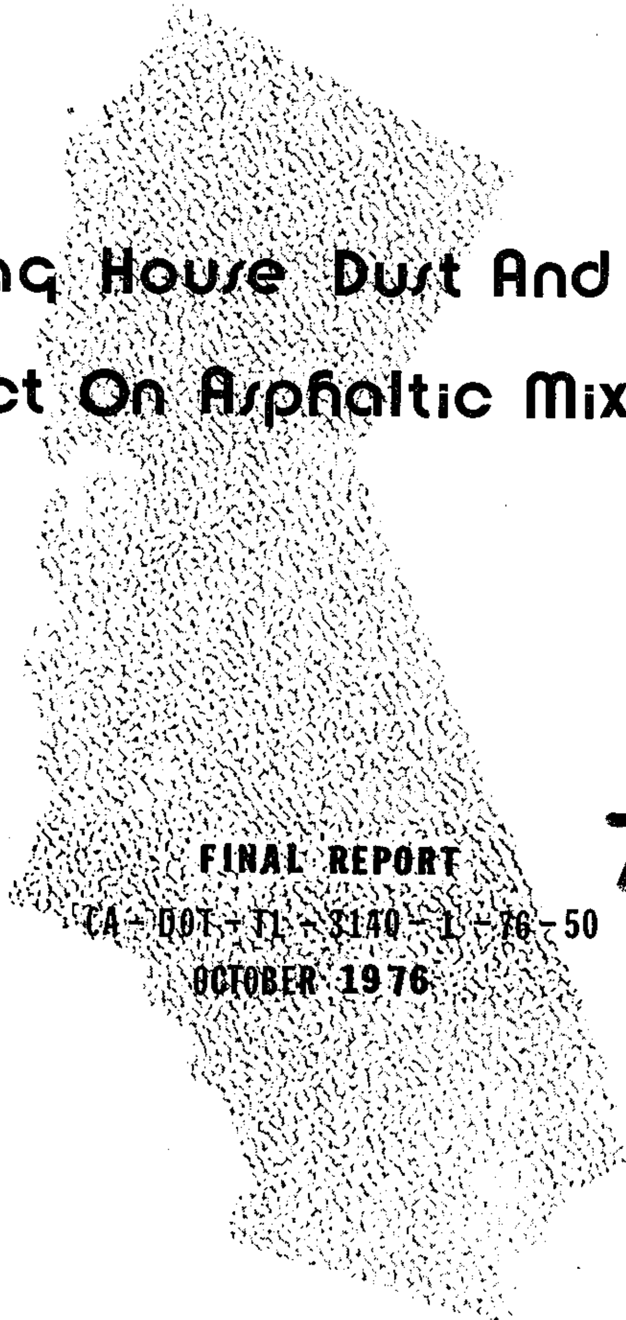
TRANSPORTATION LABORATORY

RESEARCH REPORT



Bag House Dust And Its Effect On Asphaltic Mixtures

76-50

FINAL REPORT

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CALIFORNIA DEPARTMENT OF TRANSPORTATION

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STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION
DIVISION OF STRUCTURES & ENGINEERING SERVICES
OFFICE OF TRANSPORTATION LABORATORY

October 1976

TL No. 643140

Mr. C. E. Forbes
Chief Engineer

Dear Sir:

I have approved and now submit for your information this final research project report titled:

BAG HOUSE DUST AND ITS
EFFECT ON ASPHALTIC MIXTURES

Study made by . . . . Roadbed & Concrete Branch

Under the Supervision of . . . . John B. Skog and Donald L. Spellman

Principal Investigator . . . . Robert N. Doty

Co-Investigator . . . . Thomas Scrimsher

Report Prepared by . . . . Thomas Scrimsher

Very truly yours,

GEORGE A. HILL
Chief, Office of Transportation Laboratory

Attachment

TS:lrb

ACKNOWLEDGEMENTS

We wish to gratefully acknowledge the cooperation received from personnel in Caltrans District 04 - San Francisco, Caltrans District 07 - Los Angeles, and the City and County of Los Angeles. Personnel in these units, under the direction of Mr. Stan Bruzza, Mr. Bob D'Allo, Mr. G. Snelling, and Mr. N. Lillich, respectively, supplied the samples for this study.

The Laboratory work was very ably handled by Mr. Kenneth Iwasaki, with assistance from various personnel in the Bituminous Mix Group of the Roadbed and Concrete Branch.

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INTRODUCTION

During the processing of mineral aggregates for use in asphalt concrete, dust size particles are generated, mostly from drying operations. In and around large metropolitan areas, the use of bag houses as an effective means of minimizing air pollution associated with this production of hot asphaltic mixtures is rapidly becoming commonplace. The disposal of dust collected by this system, however, has created a problem. It was proposed to reintroduce this material into the mix as an inert filler. This dust is exceedingly fine - in most cases finer than that permitted by California's current specification for filler dust (1). Because excessive amounts of very fine material such as filler dust have been known to cause an AC mixture to become "critical" (very sensitive to a slight increase in asphalt), field personnel have been apprehensive about permitting the return of the bag house dust to the mixtures. The Contractor argues, however, that the dust is part of the natural aggregate and, thus, that he should be permitted to use it in the mixture, as a disposal problem will occur if the bag house dust cannot be returned to the mix. Testing was therefore needed to determine the effect of various amounts of different bag house dust on asphalt concrete.

CONCLUSIONS

The following conclusions have been formulated based upon the results of this study:

1. The surface area of bag house dust will generally range between 800 and 1200 sq ft/lb.

2. Use of limited amounts of bag house dust will have no significant adverse affect on Caltrans' Types A and B asphalt concrete under the following conditions:

a. If the aggregate contains no more than 2.0% bag house dust (when the surface area of the dust does not exceed 1200 sq ft/lb, as determined by Test Method No. Calif. 340).

b. If the total amount of passing No. 200, including bag house dust, does not exceed limits in the January 1975 Standard Specifications for Types A and B asphalt concrete.

c. If the optimum asphalt content determined in the Laboratory (Test Method No. Calif. 367) is not exceeded.

RECOMMENTATIONS AND IMPLEMENTATION

1. It is recommended that asphalt concrete plants equipped with bag houses be permitted to add as much as 2.0% bag house dust, by dry wt of aggregate, to the asphalt concrete when the following conditions are met:

a. The dust is added by accurate measurement.

b. The dust is placed into either the weigh box or pug mill to assure uniformity of distribution within the mix.

c. The dust is submitted along with the other mineral aggregate from the bins for AC design. (An amount equivalent to that to be added by the Contractor should be used for mix design purposes.)

2. Prior to the addition of bag house dust to any asphalt concrete at the plant, laboratory testing of the mix including bag house dust should be completed.

3. The surface area requirement should be eliminated for filler dusts in order to permit consideration of bag house dust as a filler. When the passing No. 200 fraction of an aggregate grading is "0", then an amount of filler (bag house dust etc.) equivalent to a maximum of 3.0% may be permitted.

DISCUSSION

A. General

Bag houses are typically large metal rectangular enclosures (see Figures 1 and 2) that house two or three hundred cloth bags. Each bag is approximately 8 inches in diameter and 6 to 10 feet long. Dirty air moving through the enclosure is filtered as it moves among and through the walls of the suspended bags with the dust collecting on the bag fabric. The bags are cleaned by air pulses which remove the dust and permit it to fall to the bottom of the bag house from where it is transported from the bag house to a plant or storage silo. Although there are many manufacturers of bag houses, the principles of operation are essentially the same.

The use of bag houses is rapidly becoming commonplace, especially in large metropolitan areas. Also, discussions with plant operators have revealed that approximately 1.5 to 2.0% of the aggregate processed is collected as dust in the bag house. As a consequence, finding methods of disposing of the collected dust is becoming a problem unless it can be used in the mix. Most all owners of "bag houses" are now returning the dust to the mix; however, their methods of returning it, such as the location of the return and the quantity returned, vary considerably.

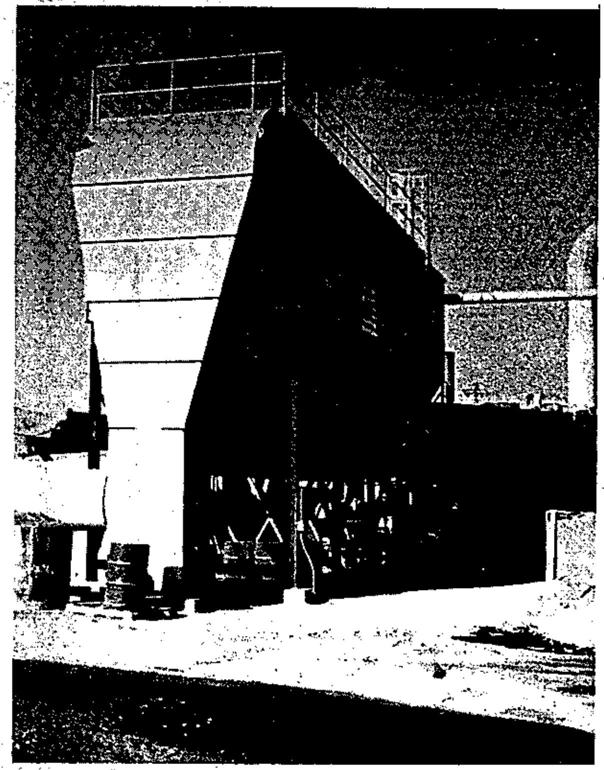

FIGURE 1

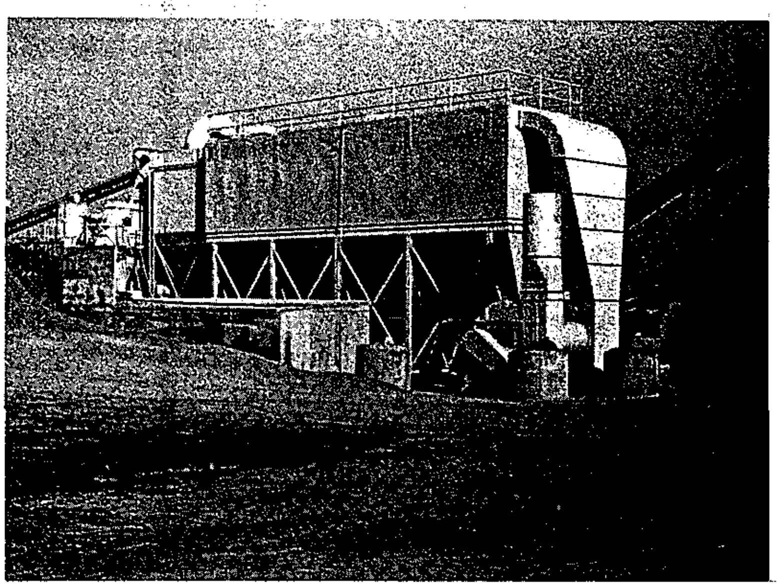

FIGURE 2
TYPICAL HOT-PLANT BAG-HOUSE

In January 1974, a telephone survey of the City of Los Angeles, the County of Los Angeles, and Districts 03 and 04 of the Department of Transportation revealed the following:

The City of Los Angeles owns and operates two plants of their own and controls all operations very accurately. Mr. George Snelling, Staff Engineer of the Bureau of Structural Maintenance of the City of Los Angeles, stated that bag house dust was being put back into the mixture as a requirement. Approximately 1.0 to 1.5% was being returned to the mixture using a screw conveyor system. It was returned directly to the weigh hopper. He stated that the City of Los Angeles did not permit the dust to be introduced at the hot elevator and that commercial plants in the general area were also processing their bag house dust in a similar manner.

Mr. Lillich, Materials Engineer of Los Angeles County, commented that the County was returning about 2.0% dust and in the same manner as indicated by the City of Los Angeles (a screw metering system to place the dust into the weigh hopper).

Mr. Stan Bruzza of Caltrans District 04 in San Francisco commented that bag house dust in his area was not as closely monitored. Amounts ranging from 1.0 to 2.5% were being returned to the mix and more frequently than not at the hot elevator. As a result, on some projects "fat" spots were appearing in the roadway, apparently caused by excess dust in an occasional batch. In the Sacramento area (District 03), introducing bag house dust back into the "hot" elevator has also produced mixtures similar to those encountered in District 04.

Although the original intent of this study was to measure the effect of all the filler dusts submitted on asphalt concrete containing both rounded and angular aggregates with both 3/4" and 1/2" maximum size aggregate, the cost became prohibitive. Therefore, only six samples (Table 1) of bag house dust were tested using only the 1/2" maximum size aggregate. However, both the rounded and angular aggregate were included. AR 2000 and AR 4000 paving grade asphalts from both Douglas Oil and the Golden Bear Oil Company were used for the study. The dusts selected for study included samples of the finest and coarsest gradings from those submitted.

Information received from some projects in the San Francisco Bay Area and around Sacramento indicated that the surface flushing and instability that were occurring may have been caused by excessive amounts of bag house dust. In each case, investigation revealed that the dust was being returned to the "hot" elevator of the plant. This method of introducing bag house dust back into the aggregate apparently was causing inconsistencies in the mix. On the other hand, no problems involving flushing or instability were being reported when the dust was being metered into the mix at the pug mill. Thus, it was decided that this study would include a determination of the effect on optimum asphalt content when bag house dust was added to a "dust-free" mixture. However, the results of this testing (Table 2) indicated that the difference in asphalt demand due to bag house dust was not significant when 2% dust was added so the asphalt content used to subsequently study the effect of bag house dust was confined to the optimum asphalt content for a mix <u>without</u> bag house dust. In other words, no adjustment in asphalt content was made to compensate for the addition of the dust. In reality, this is what actually is taking place during production at the present time.

TABLE 1

BAGHOUSE DUST ANALYSIS

DIST.	SAMPLE NUMBER	SOURCE	GRADING T.M.CALIF. 202 WASH -30	WASH -200	DRY -200	DRY/WASH RATIO	SP. GR. T.M.CALIF. 208	SURF. AREA T.M.CALIF. 340
07 *	74-1092	Sully-Miller, So. Gate	100	95.4	91.4	96%	2.67	930
	74-1095	Sully-Miller, So. Gate	100	95.2	85.2	90%	2.65	890
	74-1093	Sully-Miller, Long Beach	100	96.4	81.5	93%	2.63	950
	74-1094	Industrial - Los Angeles	100	95.4	50.9	53%	2.70	980
	74-1096	Industrial - Wilmington	100	93.6	92.0	98%	2.69	780
	74-1097	Sully-Miller, Torrance	100	100	49.3	49%	2.62	1130
	74-1098	Vernon - Gardena	100	98.1	96.3	98%	2.68	840
	74-1099	Sully-Miller, Inglewood	96	85.0	81.3	96%	2.62	720
*	74-1100	Sully-Miller, El Monte	100	91.9	58.8	64%	2.69	1035
	73-1820	Oro Grande- American Cement Corp.	100	100	63	63%	2.87	1000
	74-1202	Oro Grande - Riverside Cement Co.	100	99.9	99.2	99%	2.83	940
04 *	74-1177	Lowrie Paving Co.- Hot Plant, So. San Francisco	100	87.9	86.2	98%	2.67	450
*	74-1178	Basalt Rock Co., A. C. Plant McNears Point San Rafael	100	94.0	73.1	78%	2.62	1180
*	74-1179	Industrial Asphalt Co. Pleasanton	99.7	89.5	88.1	99%	2.69	850
	74-1180	Basalt Rock Co. AC Plant #1 Napa	99.9	97.6	97.1	99%	2.73	705
	74-1181	Gallagher & Burke AC Plant, Oakland	100	99.9	82.7	83%	2.67	1120
	74-1200	Walnut Creek	100	96.6	88.1	91%	2.78	780
	74-1201	Lake Herman (Vallejo)	100	38.3	32.7	85%	2.73	230
		*Sources used in this study.						

TABLE 2

BAGHOUSE DUST STUDY

(1/2 MAX MEDIUM)

SERIES	AGGREGATE	% PASSING #200		ASPHALT		% REC.
		NATURAL	BAGHOUSE DUST*	AR GR.	SOURCE	
5A	Round	4.0	0	2000	Golden Bear	4.5-4.8
5B	Round	4.0	0	4000	Golden Bear	4.8-5.1
6A	Angular	4.0	0	2000	Golden Bear	5.5-5.8
6B	Angular	4.0	0	4000	Golden Bear	5.7-6.0
7A	Round	6.0	0	2000	Golden Bear	4.5-4.8
7B	Round	6.0	0	4000	Golden Bear	4.8-5.1
7C	Round	6.0	0	2000	Douglas	4.5-4.8
7D	Round	6.0	0	4000	Douglas	4.8-5.1
8A	Angular	6.0	0	2000	Golden Bear	5.3-5.6
8B	Angular	6.0	0	4000	Golden Bear	5.5-5.8
8C	Angular	6.0	0	4000	Douglas	5.5-5.8
9A	Angular	4.0	2.0	2000	Golden Bear	5.5-5.8
9B	Round	4.0	2.0	2000	Golden Bear	4.4-4.7
9C	Angular	4.0	2.0	4000	Douglas	5.5-5.8
9D	Round	4.0	2.0	4000	Douglas	4.6-4.9

* TEST NO 74-1178, SURFACE AREA = 1180

B. Analysis of Test Data

Dust Analysis

The six samples of dust selected for this study varied somewhat in the chemical and physical makeup (Table 3). All the samples, however, contained 20 to 40% quartz and 10 to 25% plagioclase. The specific gravities of the dusts ranged from 2.62 to 2.69. The fineness, as defined by Test Method No. Calif. 340, ranged from 450 to 1180 square feet per pound.

Stabilometer Value

The stabilometer value used was determined per Test Method No. Calif. 366. Stability, as used here, is the ability to resist plastic deformation under a vertical load. The California stabilometer test is performed on a test specimen compacted with a Kneading Compactor (Test Method No. Calif. 304). The specimen is heated to 140°F prior to testing to minimize the effect of cohesion on the resistance to deformation exhibited by the mix. Thus, the stabilometer value is primarily a measure of the inter-particle friction of the aggregate. This measure of frictional resistance can be influenced by the amount of asphalt used in the mix, the particle shape of the aggregate, the aggregate gradation and, in many instances, by the fineness of the passing No. 200 fraction of the aggregate. In this study, the fineness of this fraction (-#200) was the prime variable under consideration.

Previous experience with both the fineness of the passing No. 200 fraction and the amount used in the mixture, relative to the maximum size aggregate, has indicated that either or both may affect the stabilometer values and/or the asphalt demand for an otherwise well-designed mixture.

TABLE 3

ANALYSIS OF VARIOUS BAGHOUSE DUSTS

MINERALS PRESENT AND PERCENT OF EACH

74-1092

15-20%	Quartz
20%	Degraded biotite
15%	Plagioclase Microcline
10%	Amphibole
10%	Chlorite
5-10%	Vermiculite
5%	Magnetite, Iron Oxide
< 5%	Muscovite
Trace	Calcite
5%	Others

74-1099

20%	Quartz
20-25%	Plagioclase Microcline
15%	Degraded biotite
10%	Amphibole
10%	Chlorite
Trace	Calcite
5%	Mixed layer mineral probably biotite-chlorite
< 5%	Muscovite
5%	Iron Oxide
5%	Others

74-1100

20%	Degraded biotit
20%	Quartz
20-25%	Plagioclase Microcline
10%	Amphibole
10%	Chlorite
7%	Iron Oxide
< 5%	Muscovite
< 5%	Calcite
5%	Zeolite (probable)

74-1177

40%	Quartz
20%	Plagioclase
5-10%	Chlorite
5%	Amphibole
5%	Mica
5%	Calcite
< 5%	Iron Oxide
5%	Serpentine (probable)
5%	others
5%	Amorphous?

74-1178

15%	Quartz
15%	Plagioclase
10%	Mica
5-10%	Chlorite
5-10%	Calcite
< 5%	Amphibole
5%	Vermiculite
5%	Iron Oxide
5%	Others
25-30%	Amorphous?

74-1179

25%	Quartz
10-15%	Plagioclase
5-10%	Chlorite
5%	Mica
5%	Amphibole
< 5%	Calcite
< 5%	Serpemtome
5-10%	Iron Oxide
5%	Mixed layer Mineral
5%	Others
15-20%	Amorphous?

Generally, but not in all instances, extremely fine material added to an asphaltic mixture as a filler to correct a deficiency in the aggregate gradation has required a reduction in the asphalt content to prevent a loss of stability or a bleeding pavement. Although the surface area in the overall gradation increases with the addition of filler, the filler is so fine that it combines with and acts like the asphalt binder and increases the volume of "asphalt" in the mix. In many cases, the amount of asphalt used must be reduced to maintain the integrity of the mix. A maximum specification for fineness, as defined by Test Method No. Calif. 340, is designated in California's 1975 Standard Specifications to minimize the adverse effect of filler material. Bag house dust, however, is generally much finer than the specified limits for filler dust. When a quantity equivalent to 2.0% by weight was added to gradations that were designed with and without sufficient minus No. 200, very little effect on stability was noted until the total minus No. 200 reached 8.0% (with relationship to the 1/2" max. size gradation, Table 4). There were indications, with both angular aggregate and rounded aggregate, that immersion compression values began to drop with an increase in the resilient modulus (Table 5). This reflection, however, appears to be associated with asphalt source and thus is not considered a significant observation relative to the behavior of bag house dust.

Also, as was expected, stabilometer values in general were lower for the rounded aggregate than for the angular aggregate (Table 5 B-G and 6 B-E). This is a reflection of the interparticle friction which is reduced with rounded particles. In several instances, however, it was noted that the stabilometer value slightly increased when 2.0% bag house dust was added. This phenomena was attributed to a slight influence of cohesion. As stated earlier, cohesion is minimized in the stabilometer

TABLE 4

AGGREGATE PROPERTIES

SAMPLE NUMBER	AGGREGATE SHAPE	K_c	K_f	K_m	MOD. CKE. ABSORP.	SE	SP.GR. "C"	SP. GR. "F"	SA −200	GRADING (% PASSING)								
										1/2	3/8	4	8	16	30	50	100	200
74-1062	ROUNDED	1.0	1.0	1.0	0.3	85	2.62	2.71	290	100	90	65	47	35	25	14	6	4
74-1187	ANGULAR	1.1	1.0	1.0	0.2	76	2.75	2.75	400	100	87	59	45	35	25	13	7	4

TABLE 5A

BAGHOUSE DUST STUDY
ANGULAR AGGREGATE

1/2" B MED. GRADING

SERIES	PERCENT-200 DUST NO	DUST %	NAT. %	TOT. %	ASPHALT GRADE	ASPHALT SOURCE	ASPHALT %	STAB.	SP. GR.	COHES.	RESIL. MODULUS PSI x 10^5	IMMER. COMP. RATIO	SURF ABRAS. (GRAMS) RUBBER 100°F	SURF ABRAS. (GRAMS) STEEL 40°F
$6A_1$	1	2	4	6	AR-4000	Douglas	5.5	41/40	2.40/2.40	359/237	2.38/2.33	73	0.2	35.6
$6A_2$	2	2	4	6	AR-4000	Douglas	5.5	42/43	2.36/2.39	382/342	2.26/2.93	88	0.1	36.5
$6A_3$	3	2	4	6	AR-4000	Douglas	5.5	39/42	2.38/2.40	376/337	2.30/2.51	70	0.2	32.9
$6A_4$	4	2	4	6	AR-4000	Douglas	5.5	36/37	2.43/2.39	335/339	2.78/2.55	71	0.0	31.9
$6A_5$	5	2	4	6	AR-4000	Douglas	5.5	39/41	2.41/2.40	342/397	2.25/2.99	80	0.2	32.8
$6A_6$	6	2	4	6	AR-4000	Douglas	5.5	43/44	2.40/2.39	288/311	2.23/2.35	106	0.1	32.6
$6F_1$	1	2	4	6	AR-4000	Golden Bear	5.5	40/40	2.42/2.40	483/351	8.79/8.04	50	0.5	53.2
$6F_2$	2	2	4	6	AR-4000	Golden Bear	5.5	41/40	2.43/2.43	382/393	8.69/7.48	42	0.0	49.4
$6F_3$	3	2	4	6	AR-4000	Golden Bear	5.5	38/41	2.42/2.43	293/478	8.22/8.92	41	0.0	42.9
$6F_4$	4	2	4	5	AR-4000	Golden Bear	5.5	38/36	2.39/2.39	284/225	7.33/7.52	37	0.4	50.0
$6F_5$	5	2	4	6	AR-4000	Golden Bear	5.5	39/39	2.40/2.41	322/404	7.67/6.97	42	0.0	50.5
$6F_6$	6	2	4	6	AR-4000	Golden Bear	5.5	37/41	2.43/2.41	370/284	7.93/8.22	30	0.7	56.5

TABLE 5A (cont'd)

BAGHOUSE DUST STUDY

ANGULAR AGGREGATE

1/2" B MED. GRADING

SERIES	PERCENT-200				ASPHALT			STAB.	SP. GR.	COHES.	RESIL. MODULUS	IMMER. COMP.	SURF ABRAS. (GRAMS)	
	DUST		NAT.	TOT.										
	NO	%	%	%	GRADE	SOURCE	%				PSI x 10^5	RATIO	RUBBER 100°F	STEEL 40°F
$6D_1$	1	2	4	6	AR-2000	Douglas	5.3	39/35	2.39/2.40	261/340	1.86/1.78	77	0.3	26.0
$6D_2$	2	2	4	6	AR-2000	Douglas	5.3	43/40	2.44/2.44	296/361	1.64/1.38	81	0.2	23.9
$6D_3$	3	2	4	6	AR-2000	Douglas	5.3	40/38	2.40/2.40	280/223	1.45/1.49	84	0.0	26.3
$6D_4$	4	2	4	6	AR-2000	Douglas	5.3	43/40	2.42/2.42	209/248	1.37/1.34	68	0.2	20.2
$6D_5$	5	2	4	6	AR-2000	Douglas	5.3	41/41	2.42/2.42	250/260	1.58/1.51	78	0.1	29.9
$6D_6$	6	2	4	6	AR-2000	Douglas	5.3	40/37	2.40/2.41	230/373	1.63/1.50	93	1.1	29.7
$6E_1$	1	2	4	6	AR-2000	Golden Bear	5.3	36/37	2.43/2.43	407/365	6.77/6.17	54	0.6	41.9
$6E_2$	2	2	4	6	AR-2000	Golden Bear	5.3	38/40	2.41/2.44	290/334	5.31/6.08	68	0.0	46.3
$6E_3$	3	2	4	6	AR-2000	Golden Bear	5.3	40/38	2.42/2.42	287/327	5.32/5.43	54	0.6	47.4
$6E_4$	4	2	4	6	AR-2000	Golden Bear	5.3	40/39	2.41/2.41	241/232	4.79/4.77	67	1.1	49.8
$6E_5$	5	2	4	6	AR-2000	Golden Bear	5.3	39/37	2.42/2.42	264/318	5.15/5.14	44	0.2	49.8
$6E_6$	6	2	4	6	AR-2000	Golden Bear	5.3	40/33	2.40/2.43	303/352	5.07/5.68	38	1.1	48.2

TABLE 5B

BAGHOUSE DUST STUDY

ANGULAR AGGREGATE (TEICHERT-PERKINS)

SUMMARY SHEET

% BH DUST (SA^* = 450)	TOTAL % PASS #200	ASPHALT			STAB.	COHES.	SP. GR.	RESIL. MODULUS PSI x 10^5	IMMER. COMP. RATIO	SURF. ABRAS. (GRAMS)	
		SOURCE	GRADE	%						RUBBER 100°F	STEEL 40°F
0	4	Douglas	AR-2000	5.5	39	150	2.39	1.02	70	0.0	17.7
0	6	Douglas	AR-2000	5.3	40	273	2.40	1.77	50	0.2	23.5
2	6	Douglas	AR-2000	5.3	42	228	2.42	1.36	68	0.2	20.2
0	4	Golden Bear	AR-2000	5.5	40	148	2.40	4.07	51	0.4	42.4
0	6	Golden Bear	AR-2000	5.3	39	343	2.41	5.72	44	0.6	45.4
2	6	Golden Bear	AR-2000	5.3	40	236	2.41	4.78	67	1.1	49.8
0	4	Douglas	AR-4000	5.7	43	230	2.42	1.70	49	0.2	30.9
0	6	Douglas	AR-4000	5.5	38	365	2.40	2.45	79	0.4	26.8
2	6	Douglas	AR-4000	5.5	36	337	2.41	2.67	71	0.0	31.9
0	4	Golden Bear	AR-4000	5.7	40	216	2.38	6.90	34	0.2	66.8
0	6	Golden Bear	AR-4000	5.5	36	445	2.41	8.05	43	0.6	54.0
2	6	Golden Bear	AR-4000	5.5	37	255	2.39	7.42	37	0.4	50.0

*SA= surface area determined as per Test Method No. Calif 340-B

TABLE 5C

BAGHOUSE DUST STUDY

ANGULAR AGGREGATE (TEICHERT-PERKINS)

SUMMARY SHEET

% BH DUST (SA = 720)	TOTAL % PASS #200	ASPHALT			STAB.	COHES.	SP. GR.	RESIL. MODULUS PSI x 10^5	IMMER. COMP. RATIO	SURF. ABRAS. (GRAMS)	
		SOURCE	GRADE	%						RUBBER 100°F	STEEL 40°F
0	4	Douglas	AR-2000	5.5	39	150	2.39	1.02	70	0.0	17.7
0	6	Douglas	AR-2000	5.3	40	273	2.40	1.77	50	0.2	23.5
2	6	Douglas	AR-2000	5.3	42	328	2.44	1.51	81	0.2	23.9
0	4	Golden Bear	AR-2000	5.5	40	148	2.40	4.07	51	0.4	42.4
0	6	Golden Bear	AR-2000	5.3	39	343	2.41	5.72	44	0.6	45.4
2	6	Golden Bear	AR-2000	5.3	39	312	2.42	5.70	68	0.0	46.3
0	4	Douglas	AR-4000	5.7	43	230	2.42	1.70	49	0.2	30.9
0	6	Douglas	AR-4000	5.5	38	365	2.40	2.45	79	0.4	26.8
2	6	Douglas	AR-4000	5.5	42	362	2.38	2.60	88	0.1	36.5
0	4	Golden Bear	AR-4000	5.7	40	216	2.38	6.90	34	0.2	66.8
0	6	Golden Bear	AR-4000	5.3	36	445	2.41	8.05	43	0.6	54.0
2	6	Golden Bear	AR-4000	5.3	40	388	2.43	8.09	42	0.0	49.4

TABLE 5D

BAGHOUSE DUST STUDY

ANGULAR AGGREGATE (TEICHERT-PERKINS)

SUMMARY SHEET

% BH DUST (SA = 850)	TOTAL % PASS #200	ASPHALT			STAB.	COHES.	SP. GR.	RESIL. MODULUS PSI x 10^5	IMMER. COMP. RATIO	SURF. ABRAS. (GRAMS)	
		SOURCE	GRADE	%						RUBBER 100°F	STEEL 40°F
0	4	Douglas	AR-2000	5.5	39	150	2.39	1.02	70	0.0	17.7
0	6	Douglas	AR-2000	5.3	40	273	2.40	1.77	50	0.2	23.5
2	6	Douglas	AR-2000	5.3	38	302	2.40	1.57	93	1.1	29.2
0	4	Golden Bear	AR-2000	5.5	40	148	2.40	4.07	51	0.4	42.4
0	6	Golden Bear	AR-2000	5.3	39	343	2.41	5.72	44	0.6	45.4
2	6	Golden Bear	AR-2000	5.3	36	328	2.42	5.39	38	1.1	48.2
0	4	Douglas	AR-4000	5.7	43	230	2.42	1.70	49	0.2	30.9
0	6	Douglas	AR-4000	5.5	38	365	2.40	2.45	79	0.4	26.8
2	6	Douglas	AR-4000	5.5	44	300	2.40	2.29	106	0.1	32.6
0	4	Golden Bear	AR-4000	5.7	40	216	2.38	6.90	34	0.2	66.8
0	6	Golden Bear	AR-4000	5.5	36	445	2.41	8.05	43	0.6	54.0
2	6	Golden Bear	AR-4000	5.5	39	327	2.42	8.08	30	0.7	56.5

TABLE 5E

BAGHOUSE DUST STUDY

ANGULAR AGGREGATE (TEICHERT-PERKINS)

SUMMARY SHEET

% BH DUST (SA = 930)	TOTAL % PASS #200	ASPHALT			STAB.	COHES.	SP. GR.	RESIL. MODULUS PSI x 10^5	IMMER. COMP. RATIO	SURF. ABRAS. (GRAMS)	
		SOURCE	GRADE	%						RUBBER 100°F	STEEL 40°F
0	4	Douglas	AR-2000	5.5	39	150	2.39	1.02	70	0.0	17.7
0	6	Douglas	AR-2000	5.3	40	273	2.40	1.77	50	0.2	23.5
2	6	Douglas	AR-2000	5.3	37	300	2.40	1.82	77	0.3	26.0
0	4	Golden Bear	AR-2000	5.5	40	148	2.40	4.07	51	0.4	42.4
0	6	Golden Bear	AR-2000	5.3	39	343	2.41	5.72	44	0.6	45.4
2	6	Golden Bear	AR-2000	5.3	36	387	2.43	6.47	54	0.6	41.9
0	4	Douglas	AR-4000	5.7	43	230	2.42	1.70	49	0.2	30.9
0	6	Douglas	AR-4000	5.5	38	365	2.40	2.45	79	0.4	26.8
2	6	Douglas	AR-4000	5.5	40	298	2.40	2.36	73	0.2	35.6
0	4	Golden Bear	AR-4000	5.7	40	216	2.38	6.90	34	0.2	66.8
9	6	Golden Bear	AR-4000	5.5	36	445	2.41	8.05	43	0.6	54.0
2	6	Golden Bear	AR-4000	5.5	40	417	2.41	8.42	50	0.5	53.2

TABLE 5F

BAGHOUSE DUST STUDY

ANGULAR AGGREGATE (TEICHERT-PERKINS)

SUMMARY SHEET

% BH DUST (SA = 1035)	TOTAL % PASS #200	ASPHALT			STAB.	COHES.	SP. GR.	RESIL. MODULUS PSI x 10^5	IMMER. COMP. RATIO	SURF. ABRAS. (GRAMS)	
		SOURCE	GRADE	%						RUBBER 100°F	STEEL 40°F
0	4	Douglas	AR-2000	5.5	39	150	2.39	1.02	70	0.0	17.7
0	6	Douglas	AR-2000	5.3	40	273	2.40	1.77	50	0.2	23.5
2	6	Douglas	AR-2000	5.3	39	252	2.40	1.47	84	0.0	26.3
0	4	Golden Bear	AR-2000	5.5	40	148	2.40	4.07	51	0.4	42.4
0	6	Golden Bear	AR-2000	5.3	39	343	2.41	5.72	44	0.6	45.4
2	6	Golden Bear	AR-2000	5.3	39	305	2.42	5.38	54	0.6	47.4
0	4	Douglas	AR-4000	5.7	43	230	2.42	1.70	49	0.2	30.9
0	6	Douglas	AR-4000	5.5	38	365	2.40	2.45	79	0.4	26.8
2	6	Douglas	AR-4000	5.5	40	356	2.39	2.41	70	0.2	32.9
0	4	Golden Bear	AR-4000	5.7	40	216	2.38	6.90	34	0.2	66.8
0	6	Golden Bear	AR-4000	5.5	36	445	2.41	8.05	43	0.6	54.0
2	6	Golden Bear	AR-4000	5.5	40	385	2.42	8.57	41	0.0	42.9

TABLE 5G

BAGHOUSE DUST STUDY

ANGULAR AGGREGATE (TEICHERT-PERKINS)

SUMMARY SHEET

% BH DUST (SA = 1180)	TOTAL % PASS #200	ASPHALT			STAB.	COHES.	SP. GR.	RESIL. MODULUS PSI x 10^5	IMMER. COMP. RATIO	SURF. ABRAS. (GRAMS)	
		SOURCE	GRADE	%						RUBBER 100°F	STEEL 40°F
0	4	Douglas	AR-2000	5.5	39	150	2.39	1.02	70	0.0	17.7
0	6	Douglas	AR-2000	5.3	40	273	2.40	1.77	50	0.2	23.5
2	6	Douglas	AR-2000	5.3	41	255	2.42	1.55	78	0.1	29.9
0	4	Golden Bear	AR-2000	5.5	40	148	2.40	4.07	51	0.4	42.4
0	6	Golden Bear	AR-2000	5.3	39	343	2.41	5.72	44	0.6	45.4
2	6	Golden Bear	AR-2000	5.3	38	291	2.42	5.28	44	0.2	49.8
0	4	Douglas	AR-4000	5.7	43	230	2.42	1.70	49	0.2	30.9
0	6	Douglas	AR-4000	5.5	38	365	2.40	2.45	79	0.4	26.8
2	6	Douglas	AR-4000	5.5	40	370	2.40	2.63	80	0.2	32.8
0	4	Golden Bear	AR-4000	5.7	40	216	2.38	6.90	34	0.2	66.8
0	6	Golden Bear	AR-4000	5.5	36	445	2.41	8.05	43	0.6	54.0
2	6	Golden Bear	AR-4000	5.5	39	363	2.40	7.32	42	0.0	50.5

TABLE 6A

BAGHOUSE DUST STUDY

ROUND AGGREGATE

1/2" B MED. GRADING

SERIES	PERCENT-200				ASPHALT			STAB.	SP. GR.	COHES.	RESIL. MODULUS	IMMER. COMP.	SURF ABRAS. (GRAMS)	
	DUST		NAT.	TOT.										
	NO	%	%	%	GRADE	SOURCE	%				PSI x 10^5	RATIO	RUBBER 100°F	STEEL 40°F
$4A_2$	2	2	4	6	AR-4000	Douglas	4.8	37/36	2.36/2.36	274/254	2.91/2.57	51	0.8	47.4
$4A_3$	3	2	4	6	AR-4000	Douglas	4.8	38/39	2.36/2.34	235/255	3.14/3.13	58	0.8	50.2
$4A_4$	4	2	4	6	AR-4000	Douglas	4.8	37/37	2.37/2.37	232/174	3.65/2.99	67	1.5	54.5
$4A_5$	5	2	4	6	AR-4000	Douglas	4.8	41/40	2.36/2.36	261/277	4.83/3.71	62	0.5	47.0
$4B_2$	2	2	4	6	AR-4000	Golden Bear	4.8	29/28	2.31/2.33	274/255	6.96/7.73	26	0.4	62.1
$4B_3$	3	2	4	6	AR-4000	Golden Bear	4.8	34/33	2.37/2.36	319/247	6.84/6.38	22	1.5	72.6
$4B_4$	4	2	4	6	AR-4000	Golden Bear	4.8	35/33	2.39/2.38	225/245	6.96/6.39	22	1.0	59.5
$4B_5$	5	2	4	6	AR-4000	Golden Bear	4.8	36/34	2.39/2.37	306/232	5.715/6.68	40	1.6	61.2
$5A_2$	2	2	4	6	AR-2000	Douglas	4.5	41/38	2.35/2.35	137/108	1.57/1.87	48	1.3	45.2
$5A_3$	3	2	4	6	AR-2000	Douglas	4.5	35/35	2.37/2.34	226/179	1.57/1.63	50	1.0	40.1
$5A_4$	4	2	4	6	AR-2000	Douglas	4.5	38/37	2.36/2.36	116/135	2.11/2.09	51	0.8	44.2
$5A_5$	5	2	4	6	AR-2000	Douglas	4.5	38/39	2.37/2.39	229/270	2.40/2.57	60	0.6	41.6
$5B_2$	2	2	4	6	AR-2000	Golden Bear	4.5	37/34	2.38/2.36	117/161	5.95/6.50	39	1.1	72.4
$5B_3$	3	2	4	6	AR-2000	Golden Bear	4.5	37/40	2.37/2.36	188/149	6.36/7.41	22	2.2	67.7
$5B_4$	4	2	4	6	AR-2000	Golden Bear	4.5	41/39	2.36/2.36	116/132	6.34/7.04	33	1.4	79.8
$5B_5$	5	2	4	6	AR-2000	Golden Bear	4.5	36/40	2.38/2.37	235/229	8.33/7.42	34	2.0	66.4

TABLE 6B

BAGHOUSE DUST STUDY

ROUND AGGREGATE (MADISON SAND & GRAVEL)

SUMMARY SHEET

% BH DUST (SA = 450)	TOTAL % PASS #200	ASPHALT			STAB.	COHES.	SP. GR.	RESIL. MODULUS PSI x 10^5	IMMER. COMP. RATIO	SURF. ABRAS. (GRAMS)	
		SOURCE	GRADE	%						RUBBER 100°F	STEEL 40°F
0	4	Douglas	AR-2000	4.5	36	114	2.36	1.75	56	0.2	45.0
0	6	Douglas	AR-2000	4.5	33	100	2.36	1.47	62	0.7	34.1
2	6	Douglas	AR-2000	4.5	38	126	2.36	2.10	51	0.8	44.2
0	4	Golden Bear	AR-2000	4.5	33	107	2.37	7.92	23	0.6	68.4
0	6	Golden Bear	AR-2000	4.5	33	133	2.37	5.26	25	0.8	60.2
2	6	Golden Bear	AR-2000	4.5	40	124	2.36	6.69	33	1.4	79.8
0	4	Douglas	AR-4000	4.8	35	136	2.34	2.69	52	0.4	44.4
0	6	Douglas	AR-4000	4.8	36	173	2.37	2.20	65	0.3	34.2
2	6	Douglas	AR-4000	4.8	37	203	2.37	3.32	67	1.5	54.5
0	4	Golden Bear	AR-4000	4.8	30	185	2.36	5.26	20	0.3	64.7
0	6	Golden Bear	AR-4000	4.8	36	146	2.36	8.26	17	0.2	56.4
2	6	Golden Bear	AR-4000	4.8	34	235	2.38	6.69	22	1.0	59.5

TABLE 6C

BAGHOUSE DUST STUDY

ROUND AGGREGATE (MADISON SAND & GRAVEL)

SUMMARY SHEET

% BH DUST (SA = 720)	TOTAL % PASS #200	ASPHALT			STAB.	COHES.	SP. GR.	RESIL. MODULUS PSI x 10^5	IMMER. COMP. RATIO	SURF. ABRAS. (GRAMS)	
		SOURCE	GRADE	%						RUBBER 100°F	STEEL 40°F
0	4	Douglas	AR-2000	4.5	36	114	2.36	1.75	56	0.2	45.0
0	6	Douglas	AR-2000	4.5	33	100	2.36	1.47	62	0.7	34.1
2	6	Douglas	AR-2000	4.5	40	122	2.35	1.72	48	1.3	45.2
0	4	Golden Bear	AR-2000	4.5	33	107	2.37	7.92	23	0.6	68.4
0	6	Golden Bear	AR-2000	4.5	33	133	2.37	5.26	25	0.8	60.2
2	6	Golden Bear	AR-2000	4.5	36	139	2.37	6.25	39	1.1	72.4
0	4	Douglas	AR-4000	4.8	35	136	2.34	2.69	52	0.4	44.4
0	6	Douglas	AR-4000	4.8	36	173	2.37	2.20	65	0.3	34.2
2	6	Douglas	AR-4000	4.8	37	264	2.36	2.74	51	0.8	47.4
0	4	Golden Bear	AR-4000	4.8	30	185	2.36	5.26	20	0.3	64.7
0	6	Golden Bear	AR-4000	4.8	36	146	2.36	8.26	17	0.2	56.4
2	6	Golden Bear	AR-4000	4.8	29	265	2.32	7.35	26	0.4	62.1

TABLE 6D

BAGHOUSE DUST STUDY

ROUND AGGREGATE (MADISON SAND & GRAVEL)

SUMMARY SHEET

% BH DUST (SA = 1037)	TOTAL % PASS #200	ASPHALT			STAB.	COHES.	SP. GR.	RESIL. MODULUS PSI x 10^5	IMMER. COMP. RATIO	SURF. ABRAS. (GRAMS)	
		SOURCE	GRADE	%						RUBBER 100°F	STEEL 40°F
0	4	Douglas	AR-2000	4.5	36	114	2.36	1.75	56	0.2	45.0
0	6	Douglas	AR-2000	4.5	33	100	2.36	1.47	62	0.7	34.1
2	6	Douglas	AR-2000	4.5	35	202	2.36	1.60	50	1.0	40.1
0	4	Golden Bear	AR-2000	4.5	33	107	2.37	7.92	23	0.6	68.4
0	6	Golden Bear	AR-2000	4.5	33	133	2.37	5.26	25	0.8	60.2
2	6	Golden Bear	AR-2000	4.5	39	165	2.37	6.88	22	2.2	67.7
0	4	Douglas	AR-4000	4.8	35	136	2.34	2.69	52	0.4	44.4
0	6	Douglas	AR-4000	4.8	36	173	2.37	2.20	65	0.3	34.2
2	6	Douglas	AR-4000	4.8	39	245	2.35	3.14	58	0.8	50.2
0	4	Golden Bear	AR-4000	4.8	30	185	2.36	5.26	20	0.3	64.7
0	6	Golden Bear	AR-4000	4.8	36	146	2.36	8.26	17	0.2	56.4
2	6	Golden Bear	AR-4000	4.8	34	283	2.36	6.61	22	1.5	72.6

TABLE 6E

BAGHOUSE DUST STUDY

ROUND AGGREGATE (MADISON SAND & GRAVEL)

SUMMARY SHEET

% BH DUST (SA =1180)	TOTAL % PASS #200	ASPHALT			STAB.	COHES.	SP. GR.	RESIL. MODULUS PSI x 10^5	IMMER, COMP. RATIO	SURF. ABRAS. (GRAMS)	
		SOURCE	GRADE	%						RUBBER 100°F	STEEL 40°F
0	4	Douglas	AR-2000	4.5	36	114	2.36	1.75	56	0.2	45.0
0	6	Douglas	AR-2000	4.5	33	100	2.36	1.47	62	0.7	34.1
2	6	Douglas	AR-2000	4.5	39	250	2.38	2.48	60	0.6	41.6
0	4	Golden Bear	AR-2000	4.5	33	107	2.37	7.92	23	0.6	68.4
0	6	Golden Bear	AR-2000	4.5	33	133	2.37	5.26	25	0.8	60.2
2	6	Golden Bear	AR-2000	4.5	38	232	2.38	7.97	34	2.0	66.4
0	4	Douglas	AR-4000	4.8	35	136	2.34	2.69	52	0.4	44.4
0	6	Douglas	AR-4000	4.8	36	173	2.37	2.20	65	0.3	34.2
2	6	Douglas	AR-4000	4.8	40	269	2.36	3.88	62	0.5	47.0
0	4	Golden Bear	AR-4000	4.8	30	185	2.36	5.26	20	0.3	64.7
0	6	Golden Bear	AR-4000	4.8	36	146	2.36	8.26	17	0.2	56.4
2	6	Golden Bear	AR-4000	4.8	35	269	2.38	6.20	40	1.6	61.2

test by testing at 140°F; however, it is not completely eliminated. Thus, factors influencing cohesion will also reflect slightly in the stabilometer test and will be most evident in materials of a rounded nature.

In summary, it appears that with the addition of 2.0% dust very little effect on stability will be noticed, if the total passing No. 200, including the dust, is kept within the tolerances provided for the various aggregate gradings listed in the 1975 California Standard Specifications (Tables 7 and 8).

Cohesiometer Value

The cohesiometer value reflects, to some degree, a measure of the tensile strength of an asphaltic mixture. While a value has never been agreed upon for classifying an asphaltic mixture as good or poor relative to roadway performance, it is generally agreed that values of 50 or less indicate a friable mixture, highly susceptible to surface raveling. However, for most any gradation utilizing paving grades of asphalt (AR 2000 to AR 16000), cohesion values of 100 to 300 are easily obtainable in the laboratory after 15 hours of curing at 140°F.

Cohesion is influenced by the viscosity of asphalt, the amount of asphalt, the aggregate total surface area (a function of gradation), test temperature, and rate of loading. In this study, the objective was to measure the influence of the addition of 2.0% bag house dust of varying fineness. It appeared that the addition of the dust to the mixes being tested had no detrimental effect on cohesion; in fact, the cohesion was improved in most cases with the finer dust (Figures 3, 4, 5, and 6). This tends to substantiate the theory previously discussed that extremely fine materials tend to combine with the asphalt, increase its volume and apparent viscosity and thus act somewhat as an asphalt extender.

TABLE 7

BAGHOUSE DUST STUDY

ANGULAR AGGREGATE (TEICHERT-PERKINS)

PERCENT PASSING # 200			ASPHALT			STAB.	COHES.	SP. GR.
NAT. FINES	BH DUST (SA=450)	TOTAL	SOURCE	GRADE	%			
5	0	5	Douglas	AR-4000	5.3	36	245	2.44
0	2	2	Douglas	AR-4000	5.3	36	824	2.40
0	3	3	"	"	"	40	290	2.41
0	4	4	"	"	"	39	270	2.41
1	2	3	Douglas	AR-4000	5.3	34	330	2.43
1	3	4	"	"	"	45	420	2.43
1	4	5	"	"	"	38	495	2.46
2	2	4	Douglas	AR-4000	5.3	34	170	2.37
2	3	5	"	"	"	40	365	2.44
2	4	6	"	"	"	41	473	2.44
3	2	5	Douglas	AR-4000	5.3	42	254	2.41
3	3	6	"	"	"	40	373	2.42
3	4	7	"	"	"	38	470	2.46
4	2	6	Douglas	AR-4000	5.3	37	355	2.45
4	3	7	"	"	"	33	380	2.46
4	4	8	"	"	"	33	355	2.42
5	2	7	Douglas	AR-4000	5.3	34	483	2.45
5	3	8	"	"	"	35	505	2.47
5	4	9	"	"	"	35	462	2.45
6	2	8	Douglas	AR-4000	5.3	33	390	2.45
6	3	9	"	"	"	31	539	2.45
6	4	10	"	"	"	24	480	2.47
7	2	9	Douglas	AR-4000	5.3	31	432	2.44
7	3	10	"	"	"	29	510	2.43
7	4	11	"	"	"	27	495	2.46
8	2	10	Douglas	AR-4000	5.3	34	440	2.43
8	3	11	"	"	"	25	503	2.47
8	4	12	"	"	"	23	355	2.46

TABLE 8

BAGHOUSE DUST STUDY

ANGULAR AGGREGATE (TEICHERT-PERKINS)

PERCENT PASSING # 200			ASPHALT			STAB.	COHES.	SP. GR.
NAT. FINES	BH DUST (SA=1180)	TOTAL	SOURCE	GRADE	%			
5	0	5	Douglas	AR-4000	5.3	36	245	2.44
0	2	2	Douglas	AR-4000	5.3	37	280	2.43
0	3	3	"	"	"	42	310	2.39
0	4	4	"	"	"	40	180	2.41
1	2	3	Douglas	AR-4000	5.3	39	310	2.42
1	3	4	"	"	"	40	390	2.42
1	4	5	"	"	"	45	370	2.41
2	2	4	Douglas	AR-4000	5.3	35	345	2.43
2	3	5	"	"	"	37	460	2.42
2	4	6	"	"	"	38	370	2.42
3	2	5	Douglas	AR-4000	5.3	45	370	2.41
3	3	6	"	"	"	40	464	2.42
3	4	7	"	"	"	43	536	2.43
4	2	6	Douglas	AR-4000	5.3	34	405	2.41
4	3	7	"	"	"	39	355	2.42
4	4	8	"	"	"	33	380	2.43
5	2	7	Douglas	AR-4000	5.3	37	513	2.44
5	3	8	"	"	"	32	435	2.43
5	4	9	"	"	"	28	380	2.46
6	2	8	Douglas	AR-4000	5.3	26	592	2.46
6	3	9	"	"	"	23	634	2.47
6	4	10	"	"	"	23	570	2.47
7	2	9	Douglas	AR-4000	5.3	27	576	2.46
7	3	10	"	"	"	18	584	2.49
7	4	11	"	"	"	15	534	2.49
8	2	10	Douglas	AR-4000	5.3	26	486	2.48
8	3	11	"	"	"	27	427	2.47
8	4	12	"	"	"	25	560	2.48

6.0% #200 = 4% NATURAL + 2% BAGHOUSE DUST

ANGULAR AGGREGATE

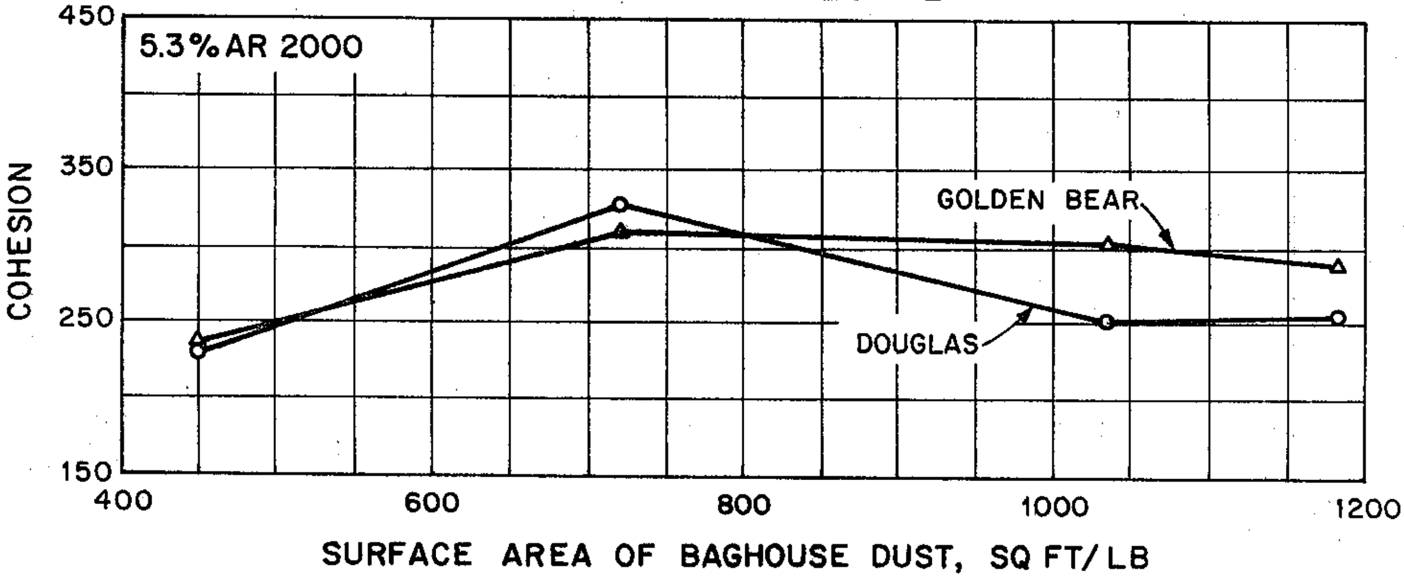

FIGURE 3

ROUNDED AGGREGATE

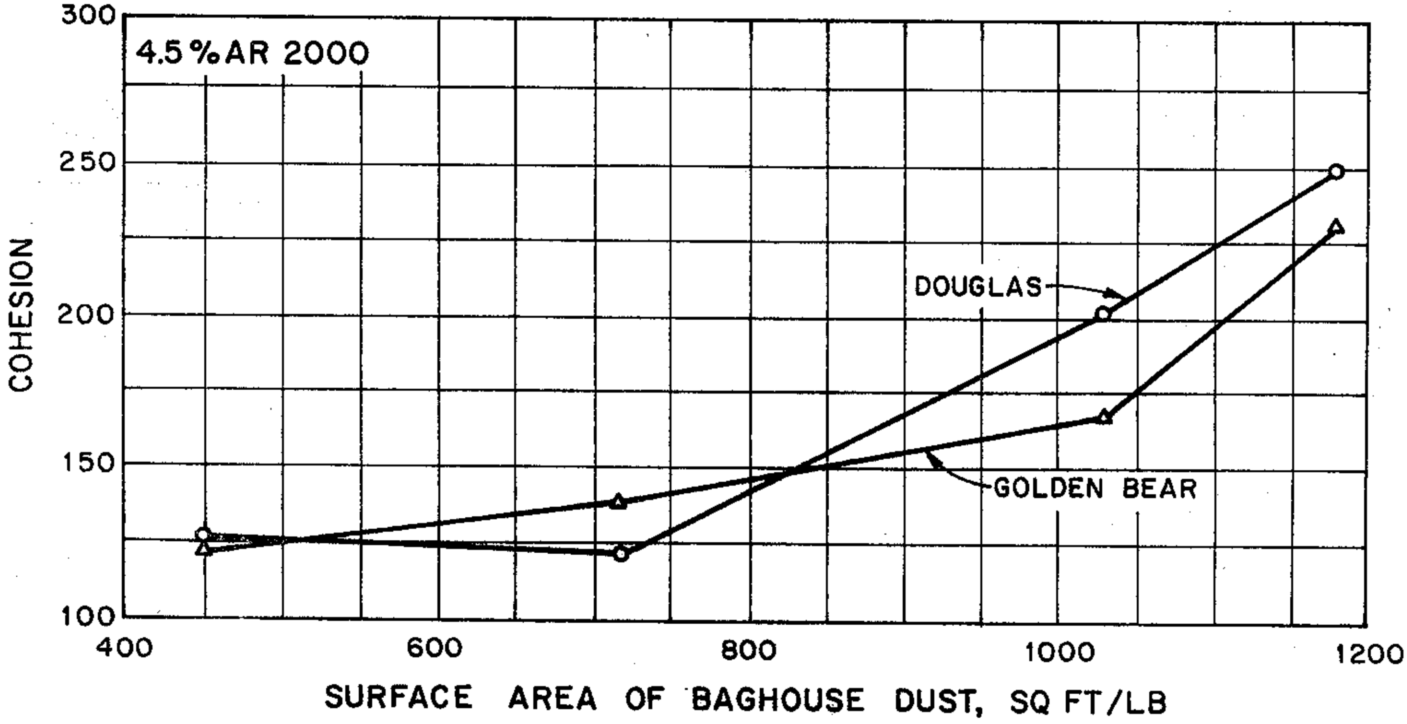

FIGURE 4

6.0% #200 = 4% NATURAL + 2% BAGHOUSE DUST

ANGULAR AGGREGATE

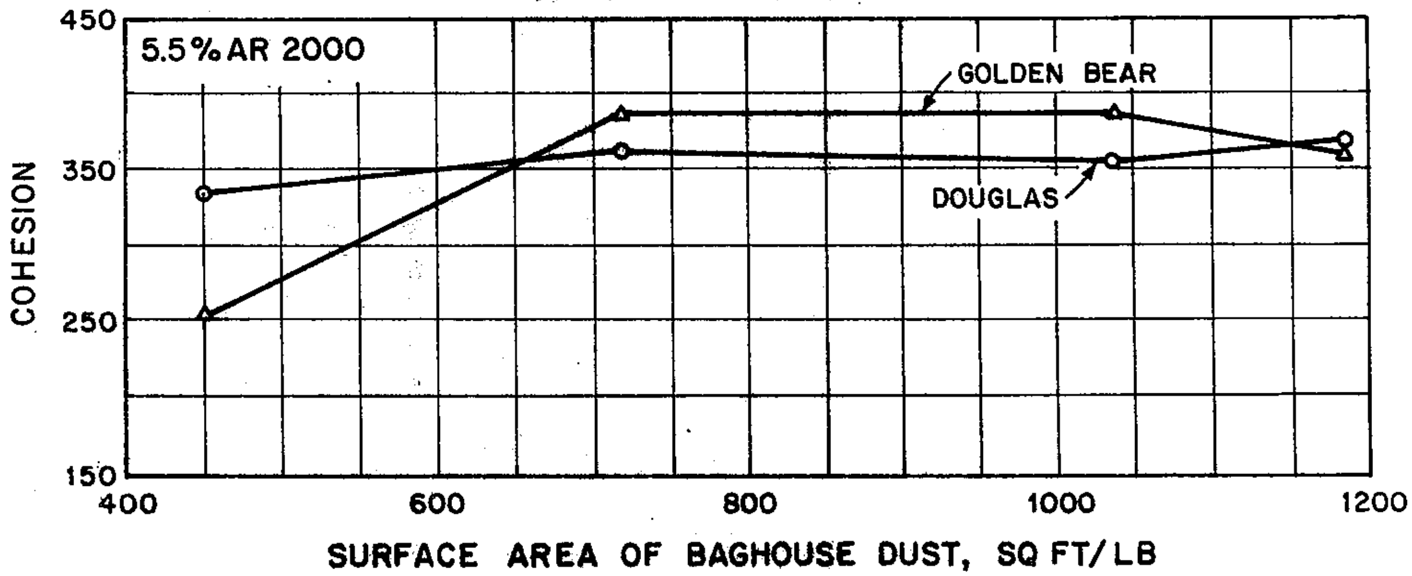

FIGURE 5

ROUNDED AGGREGATE

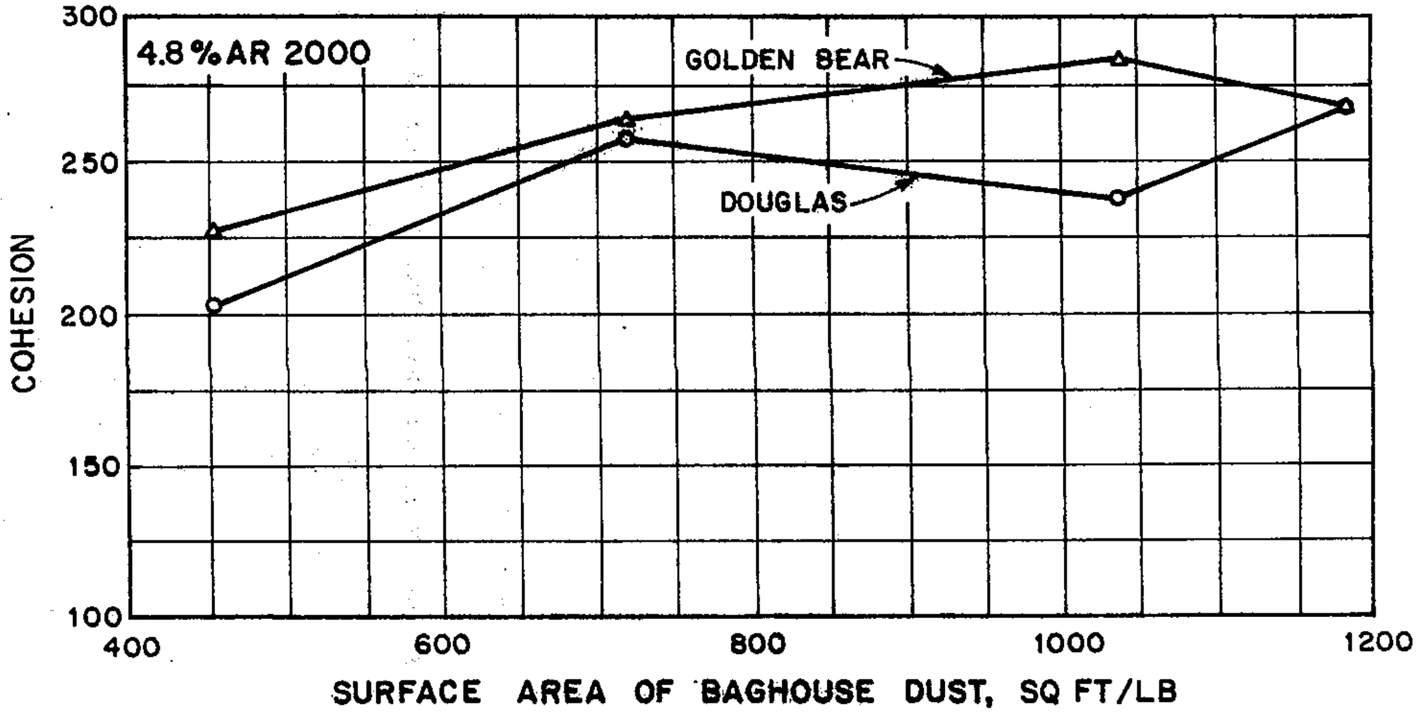

FIGURE 6

In summary, the additon of 2.0% bag house dust with a given asphalt content is beneficial from the standpoint of cohesion.

Optimum Asphalt Content

The optimum asphalt content for an asphaltic mixture is determined in accordance with Test Method No. Calif. 367. The method involves considerations of stabilometer value, void content, and visual observation for surface flushing of a laboratory-compacted test specimen using the kneading compactor.

Due to the limited availability of personnel and funds, only a limited number of test "sets" were prepared (Table 2) and only the finer size dust samples were used, with 2.0% added to a gradation consisting of 4.0% natural -200 material.

As was expected, the optimum asphalt content was significantly less for the rounded aggregate (1.0%) than the angular, and there was also a slight difference between grades of asphalt. (The AR-2000 required about 0.3% less asphalt than the AR-4000.) However, there appeared to be no significant change in asphalt "demand" between gradations consisting of 4.0% or 6.0% -200 natural or a combination of 4.0% natural -200 and 2.0% bag house dust. Because the gradation did not appear to affect the optimum asphalt content greatly (Figure 7), an average of 4.8% and 5.7% asphalt (by dry weight of the aggregate) was used with the rounded aggregate and the angular aggregate, respectively. Accuracy at a plant is generally accepted to be within ± 0.2% of the desired asphalt percentage. Thus, the influence of bag house dust on asphalt demand appeared to be within normal plant variation.

OPTIMUM ASPHALT RECOMMENDATIONS

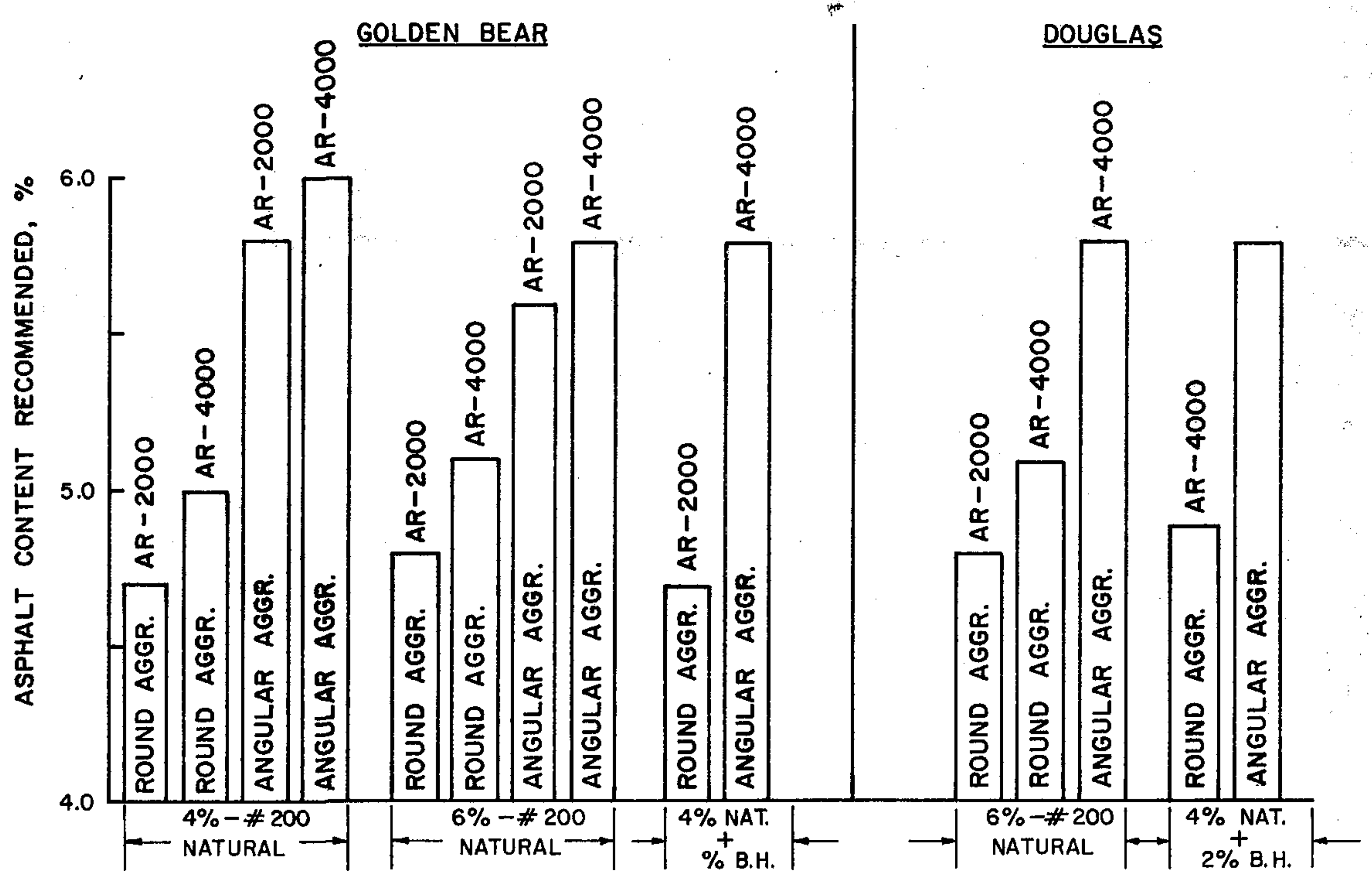

FIGURE 7

Specific Gravity

The addition of 2.0% bag house dust, regardless of fineness, had no significant effect on the specific gravity of the asphalt concrete. However, the addition of 4.0% dust did increase the density and thus the specific gravity. (An increase in cohesion and decrease in stability were also noted.) Due to the fact that the addition of 4.0% dust increased the amount passing the #200 sieve to 8.0%, which exceeded grading limits for this gradation, only token testing was completed. Reducing the amount of passing #200 natural material sufficiently to permit the use of 4.0% bag house dust was not considered to be a practical way to increase the use of bag house dust.

Surface Abrasion Test

The surface abrasion test (Test Method No. Calif. 360) involves bouncing small rubber or steel balls on the surface of a compacted test specimen (compacted with a double plunger and static load) to measure surface abrasion. High surface abrasion loss is a condition indicative of mixtures with film stripping tendencies, deficiencies in asphalt, or, in the case of mixtures subjected to tire chains, a possible lack of compaction. Mixtures tested with rubber balls have been given a tentative maximum loss of 15 grams and for those abraded with steel balls, a maximum loss of 35 grams has been set. The addition of bag house dust did not significantly affect the abrasion loss; however, the asphalt source did show a significant effect (see Tables 5 and 6).

The Resilient Modulus (M_R)

This is a relatively new test and is still under study. Its values are yet to be related to field performance; however, it is expected that a correlation with fatigue, and thus durability, may soon be established. This modulus is a measure of the capacity of the material to absorb energy without being permanently deformed. As was noted with the surface abrasion test, the amount and fineness of the bag house dust did not significantly affect the resilient modulus of the asphalt concrete. The grade and source of asphalt did, however, influence this characteristic (see Tables 5 and 6).

The Immersion Compression Test

Although not a test commonly used in California, the Immersion Compression test was included for general information. ASTM Test Procedure Nos. D-1074 and D-1075 were followed. Test results indicate that the addition of 2.0% bag house dust had little or no influence; however, the values dropped considerably when 4.0% dust was used.

C. Summary

There appears to be very little effect on an asphaltic mixture if 2.0% bag house dust is added to an asphalt concrete mix providing the maximum amount passing the No. 200 sieve, including the added bag house dust, does not exceed the limits established in the 1975 Standard Specifications.

Limited funds prohibited extensive additional testing; however, there were indications that the addition of 4.0% bag house dust may adversely influence some of the properties of an asphaltic mixture. It appears from field information that this much dust is generally not accumulated in the normal operation of asphalt concrete plants. Field reports of occasional problems such as flushing, bleeding and instability in conjunction with the test results reported herein justify the following conclusions regarding the use of bag house dust:

1. No more than 2.0% bag house dust should be added to an asphalt concrete mixture containing 1.0% or more -200 material.

2. The addition of no more than 3.0% bag house dust should be permitted if the -200 fraction of the aggregate before addition is equal to "0".

3. Under no circumstances should the use of bag house dust be permitted if the final gradation, including the dust, would exceed the limits on the passing No. 200 sieve.

4. A method of uniformly and accurately adding the dust should be used at the plant. Adding the dust at the hot elevator should not be permitted.

The ultimate decision on the permissible amount of dust to use will necessarily have to be based upon the results of tests with the aggregate in question. Very little effect was noted due to the addition of 2.0% dust with any of the aggregate or asphalt combinations studied. These combinations represent only a small percentage of the asphalts and aggregates used in state work. With the addition of 4.0% some problems related to stability and other properties were noticed (erratic test results). It would appear that, as a rule of thumb, the addition of 2.0% bag house dust may be considered safe in most cases; however, a design verification in the Lab with the proposed dust should be performed.

Although some bag house dusts may be utilized without apparently damaging the mix, the amount used should be closely monitored. As indicated by the lab work reported herein, the addition of dust equivalent to 4.0% begins to have an adverse effect on the mixture; thus, adding dust indiscriminately may result in quantities exceeding 4.0% occasionally and will most likely cause problems. The practice of adding the dust at the hot elevator results in variable amounts entering the mix. This sometimes results in poor roadway performance; thus, this construction practice should be avoided.

REFERENCES

1. Standard Specifications, State of California Department of Transportation, January 1975.