3463

EFFECT OF BAGHOUSE FINES ON COMPACTION OF BITUMINOUS CONCRETE

by

G. W. Maupin, Jr.
Research Scientist

(The opinions, findings, and conclusions expressed in this report are those of the author and not necessarily those of the sponsoring agencies.)

Virginia Highway and Transportation Research Council
(A Cooperative Organization Sponsored Jointly by the Virginia Department of Highways & Transportation and the University of Virginia)

Charlottesville, Virginia

May 1981
VHTRC 81-R49

3464

BITUMINOUS RESEARCH ADVISORY COMMITTEE

R. L. ALWOOD, Chairman, District Materials Engineer, VDH&T

A. D. BARNHART, District Materials Engineer, VDH&T

P. F. CECCHINI, District Engineer, VDH&T

J. L. CORLEY, Assistant District Engineer — Construction, VDH&T

W. R. DAVIDSON, Assistant Maintenance Engineer, VDH&T

W. A. DENNISON, District Materials Engineer, VDH&T

C. E. ECHOLS, Asst. Prof. of Civil Engineering, U. Va.

R. V. FIELDING, Materials Engineer, VDH&T

C. S. HUGHES III, Highway Research Senior Scientist, VH&TRC

A. B. JOHNSON, Assistant Construction Engineer, VDH&T

J. T. LOVE, Materials Engineer, Materials Division, VDH&T

H. E. MARSHALL, District Engineer, FHWA

C. G. MCALLISTER, Chief Chemist, Materials Division, VDH&T

R. S. THOMAS, Bituminous Engineer — Maintenance Div., VDH&T

R. D. WALKER, Chairman, Dept. of Civil Engineering, VPI & SU

SUMMARY

Four bituminous mixes were tested in the laboratory to determine the effect of variations in the concentration of baghouse fines on the density and tenderness of bituminous mixes. On the basis of results indicating that the gradation of baghouse fines is the best indicator of potential problems, a procedure was recommended for checking the gradation if problems are encountered with compaction, stability, or abnormal variations in density.

3466

EFFECT OF BAGHOUSE FINES ON COMPACTION OF BITUMINOUS CONCRETE

by

G. W. Maupin, Jr.
Research Scientist

INTRODUCTION

To avoid violating air quality standards, all hot mix asphalt plants must have systems for collecting the dust generated in the manufacturing process. Many plants have used wet scrubbers to remove this dust with water; however, "baghouses" are becoming the most widely used means of handling it. With a wet scrubber system, the dust becomes sludge that is wasted. With the baghouse, the dust is collected and some portion usually is fed back into the bituminous mixture. The dust, or "fines", can affect the stiffness of the mixture, which in turn, influences the compaction of the mixture during construction. Because of recent problems in achieving the desired density and with tenderness of the mixture during rolling, the influence of baghouse fines was investigated.

PURPOSE AND SCOPE

The purpose of the investigation was to determine the effect of variations in the concentration of baghouse fines on the density and tenderness of bituminous concrete. The investigation was limited to a laboratory study of mixes from four asphalt plants that use baghouse dust collectors.

MATERIALS

Table 1 lists the sources and blends of aggregate for each mix. AC-20 asphalt cement was used in all mixes.

3463

Table 1

Sources and Blends of Materials

Mix	Mix Producer	Blend	Source
1	Short Paving Co.	75% S-5 Blend Granite	Lone Star, Jack Quarry
		25% Concrete Sand	Lone Star, Puddledock Farm
2	Newton Asphalt Co.	40% 7/16" Traprock	Vulcan Materials, Manassas
		35% #20 Traprock	Vulcan Materials, Manassas
		25% Concrete Sand	Buffalo Sand & Gravel Camp Springs, Maryland
3	Warren Bros.	85% Crushed Stone	Richmond Crushed Stone, Chesterfield
		15% Concrete Sand	Lone Star, Willis Road
4	Sam Finley, Inc.	50% #8	Occoquan Quarry
		35% #10	Occoquan Quarry
		15% Sand	Unknown

PROCEDURE

Mix Designs

With the aggregates and baghouse fines obtained from the four asphalt plants, mixes incorporating various percentages of baghouse fines were prepared in the laboratory along with a reference mix containing 3% fines, the amount typically returned to the mix in the plant, to represent the mix normally produced at the plant.[1] Tables 2-5 list the quantities of baghouse fines used in the mixes and the resultant S-5 gradations for each variation. The gradation for each baghouse obtained by a combination of sieve and hydrometer analysis is plotted in Figure 1.

Usually, the baghouse material is fed by a screw auger onto the hot aggregate elevator, transported to the screen system, and deposited in the fine aggregate bin. The largest variations in the concentration of this material in a mix probably occur in a stop-and-start operation where the ratio of the fines from the drier to the fines from the baghouse dust collector can vary considerably.

Table 2

Gradation and Asphalt Content of Mix #1

Sieve	Job Mix Target	Job Mix Range	0% Baghouse Dust	3% Baghouse Dust	7% Baghouse Dust	10% Baghouse Dust
1/2	100.0	-	100.0	100.0	100.0	100.0
1/4	73.0	-	73.0	73.0	73.0	73.0
4	63.0	58.0 - 68.0	62.5	63.1	63.4	63.9
30	27.0	23.0 - 31.0	25.4	27.1	29.3	31.0
200	6.5	5.0 - 8.0	5.7	6.6	7.6	8.4
A.C.	5.4	-	5.4	5.4	5.4	5.4

Fine hot bin = -1/4" material

Table 3

Gradation and Asphalt Content of Mix #2

Sieve	Job Mix Target	Job Mix Range	0% Baghouse Dust	3% Baghouse Dust	5% Baghouse Dust	6% Baghouse Dust
1/2	100.0	-	100.0	100.0	100.0	100.0
4	63.0	58.0 - 68.0	63.1	63.1	63.1	63.1
8	46.4	-	46.4	46.4	46.4	46.4
30	23.0	19.0 - 27.0	21.4	23.1	24.1	24.7
200	4.0	2.5 - 5.5	1.6	4.0	5.6	6.4
A.C.	5.4	-	5.4	5.4	5.4	5.4

Fine hot bin = -1/8" material (used -#8 for lab study)

3470

Table 4

Gradation and Asphalt Content of Mix #3

Sieve	Job Mix Target	Job Mix Range	0% Baghouse Dust	3% Baghouse Dust	5% Baghouse Dust	6% Baghouse Dust
1/2	100.0	-	100.0	100.0	100.0	100.0
1/4	72.0	-	71.9	71.9	71.9	71.9
4	62.0	57.0 - 67.0	61.8	62.2	62.5	62.7
30	27.0	23.0 - 31.0	25.3	27.3	28.6	29.2
200	6.5	5.0 - 8.0	5.0	6.4	7.2	7.7
A.C.	5.6	-	5.6	5.6	5.6	5.6

Fine hot bin = -1/4" material

Table 5

Gradation and Asphalt Content of Mix #4

Sieve	Job Mix Target	Job Mix Range	0% Baghouse Dust	3% Baghouse Dust	4% Baghouse Dust	5% Baghouse Dust
1/2	100.0	-	100.0	100.0	100.0	100.0
4	59.0	54.0 - 64.0	57.7	57.7	57.7	57.7
30	20.0	16.0 - 24.0	17.4	19.5	20.2	20.9
200	5.0	3.5 - 6.5	2.5	5.0	5.8	6.6
A.C.	5.9	-	5.9	5.9	5.9	5.9

Fine hot bin = -#4 material

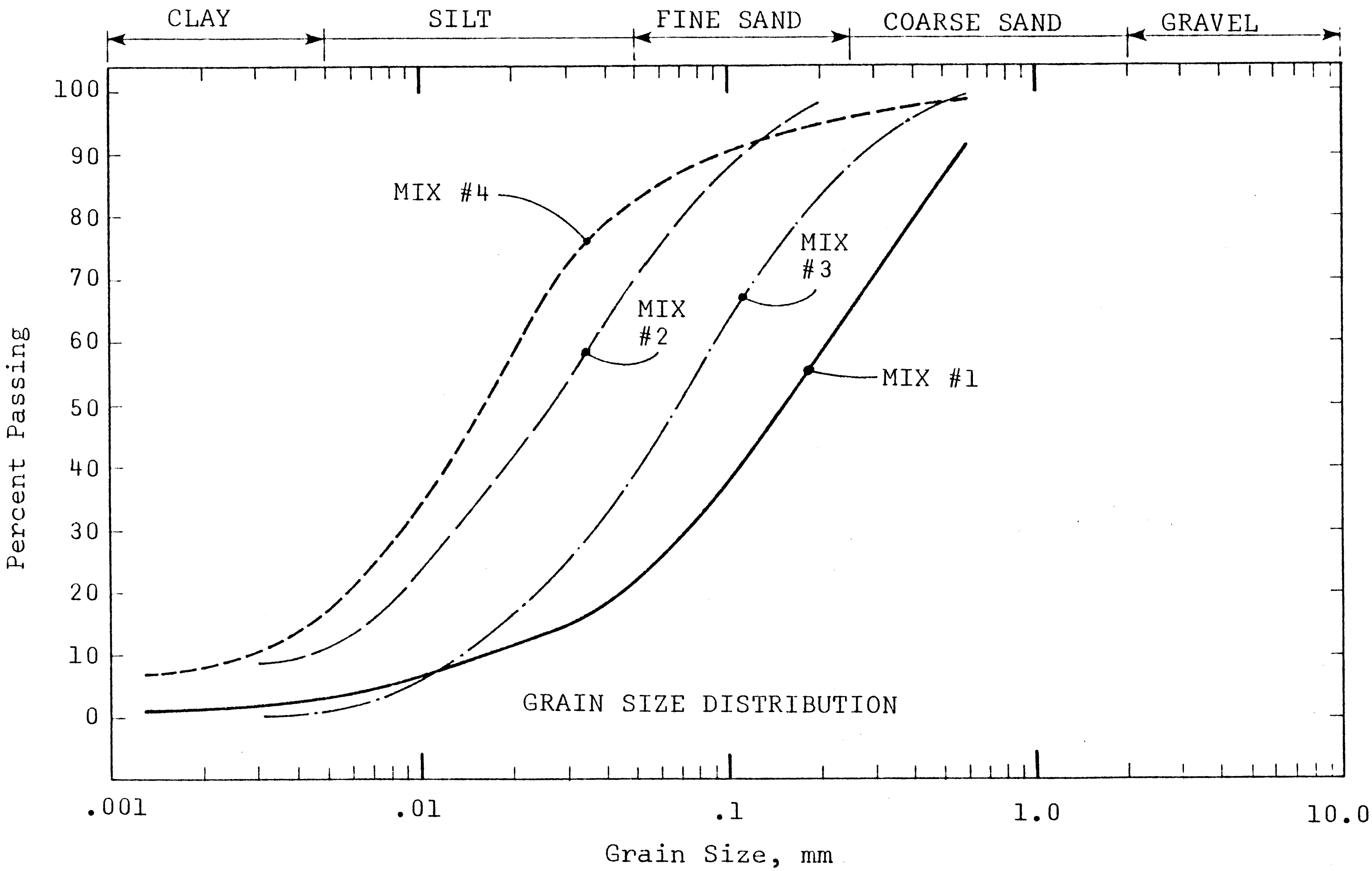


Figure 1. Gradations of baghouse fines.

In the laboratory, the aggregate was sieved and recombined to yield the desired blend. Baghouse fines were substituted for the same size material as that contained in the hot bin to simulate the variations in production. Laboratory studies of baghouse fines often substitute these fines for only the -#200 natural aggregate; however, this procedure would result in variations in the gradation quite different from those in plant production because the fine hot bin contains aggregate larger than the #200 sieve.

The aggregate from each plant was combined with 3% baghouse fines to yield the job mix. The quantities of baghouse fines for medium high and high levels were selected to remain within or reasonably close to the job mix gradation.

Specimen Fabrication

All specimens, 4.0 inches in diameter x 2.5 inches high, were compacted with a California kneading compactor, which is described in ASTM test method D1561. The compactive effort was equivalent to 50/50 blows with a Marshall compaction hammer.

Testing

Density and voids were measured and stability tests were performed according to ASTM test method D1559.

There is no standard test method to measure the potential tenderness of a bituminous mixture. Various methods have been used, including penetration measurements. Usually the depth of penetration or the time to penetrate to a standard depth under a controlled load is used to measure tenderness.

Penetration tests were performed on the compacted mix in this study in an attempt to measure the potential effect of baghouse fines on mix tenderness during construction. Four penetration tests were performed on each specimen as it cooled and while still in the mold. The time was recorded for a 0.25-in. diameter rod loaded with a 16.0-lb. weight to penetrate 0.25 in. below the surface of the mix. Individual readings were usually obtained at 10°-20°F intervals beginning at 180°F. An attempt was made to avoid placing the rod on a large aggregate particle.

Immediately after the penetration tests were performed, the specimens were extracted from the molds for later testing in indirect tension. After the specimens had cured for 24 hours, indirect tensile tests were performed at room temperature (72°F) at a deformation rate of 2.0 inches per minute. The tensile strength was calculated as

$$S_t = \frac{P_{max}}{t} \cdot \frac{S_{10}}{10,000} ,$$

where

S_t = indirect tensile strength in psi;
P_{max} = maximum load in lb.;
t = specimen thickness in in.; and
S_{10} = correction factor for flattening.

Table 6 lists the numbers of specimens for the tests.

Table 6

Numbers of Specimens for Tests

	Amount of Baghouse Dust			
	0%	Normal (3%)	Medium High	High
Number of Marshall Specimens	8	8	8	8
Number of Specimens for Penetration and Indirect Tensile Tests	4	4	4	4

RESULTS

Voids and Stability

Figure 2 illustrates the influence of the quantity of baghouse fines on the magnitude of total air voids in the mixes. Mix #2 was influenced the most and mix #1 the least. The slopes of the curves indicated that the void content of mix #2, and possibly that of mix #4, would be affected significantly by variations in the quantity of baghouse fines fed to the hot elevator at the hot mix plants. Variations in the amount of baghouse fines fed into mixes #2 and #4 might result in larger than normal variations of in-place density. An examination of Figure 1 reveals that the gradations of the baghouse fines for mixes #2 and #4 are finer than those for mixes #1 and #3.

3474

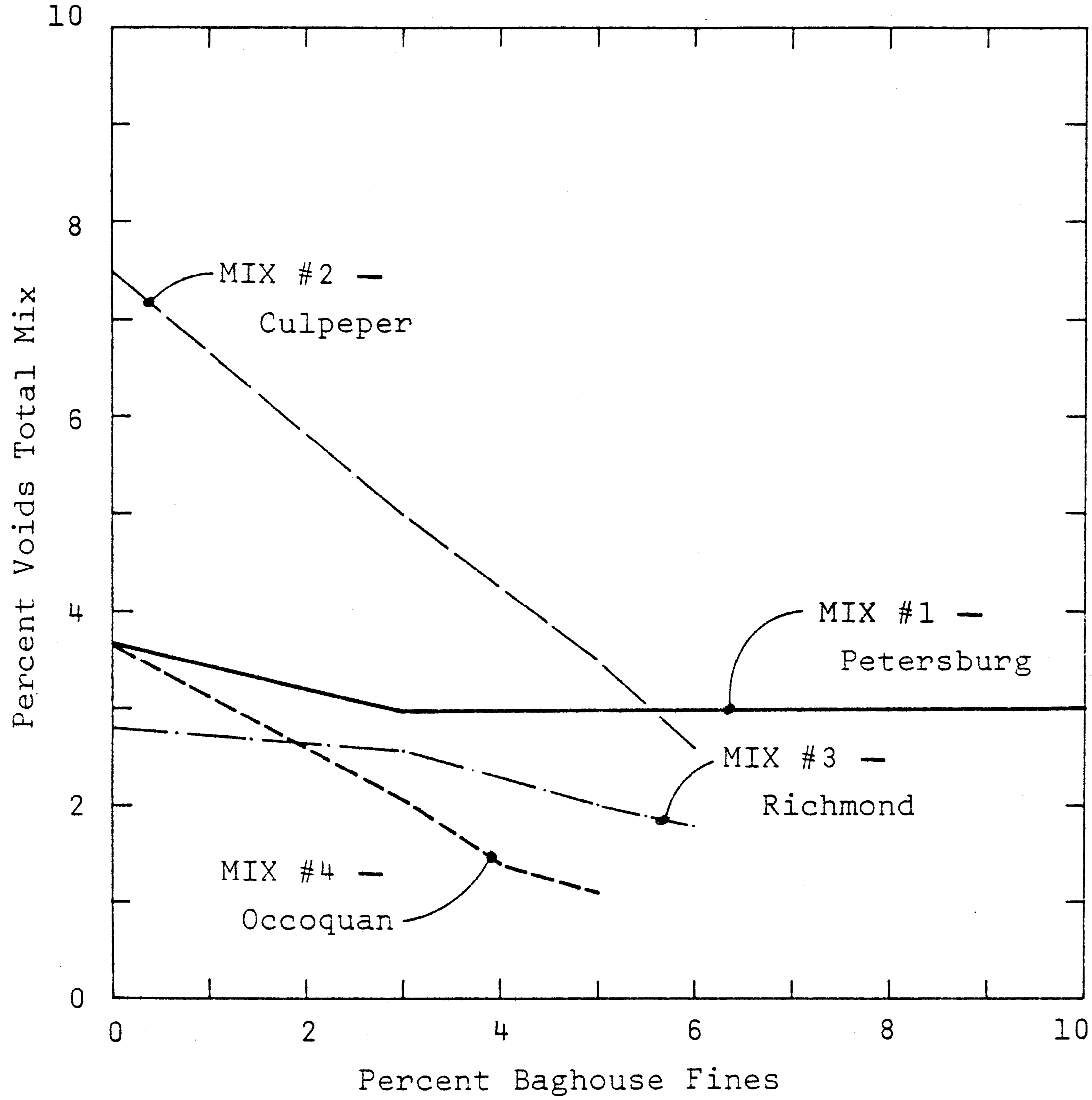


Figure 2. Voids total mix vs. percentage of baghouse fines.

Similar trends for stability are illustrated in Figure 3. The effect of changes in the quantity of baghouse fines was greatest for mix #2 and least for mix #1. Mix #2 had a much lower stability than the other mixes; however, as the void contents of the mixes approached equality at high percentages of baghouse fines, the stabilities also tended to become equal.

In summary, the influence of the quantity of baghouse fines on stability appeared to be reflected in the corresponding influence of baghouse fines on the void contents, and the variations in void content appeared to be related to the gradation of the baghouse fines.

Indirect Tensile Strength

Figure 4 illustrates the effect of baghouse fines on the indirect tensile strength. A dust acting as an asphalt extender is suspended in the asphalt cement and increases the binder stiffness from which most of the tensile strength is developed.(2) If baghouse fines act as an asphalt extender, it is expected that the tensile strength would increase as the quantity of baghouse fines increases. The baghouse fines appeared to act primarily as an asphalt extender in mixes #2 and #3, as is reflected in the increase in tensile strength as the amount of baghouse fines increased.

Penetration Tests

The variation in penetration test results was very large; therefore, the bands of results including all concentrations of baghouse fines are shown in Figures 5-8 instead of in individual curves for each concentration. The purpose of the penetration tests was to determine the potential for tenderness during construction. In relative terms, the mixes with lower curves (i.e., fast penetration) would have a greater potential to be tender than the mixes with high plots (i.e., slow penetration). The degree of the spread of results as the concentration of baghouse fines is varied is indicative of the change in mix stability and tenderness. A narrow spread is preferred because it indicates only a small tendency for the stability to change.

The effect of changes in the concentration of baghouse fines on penetration is pronounced in mixes #4 and #2 and somewhat apparent in mix #3. There is no indicated influence of penetration for mix #1. It appears the finer graded baghouse material influences the penetration and potential tenderness more than the coarser-graded material.

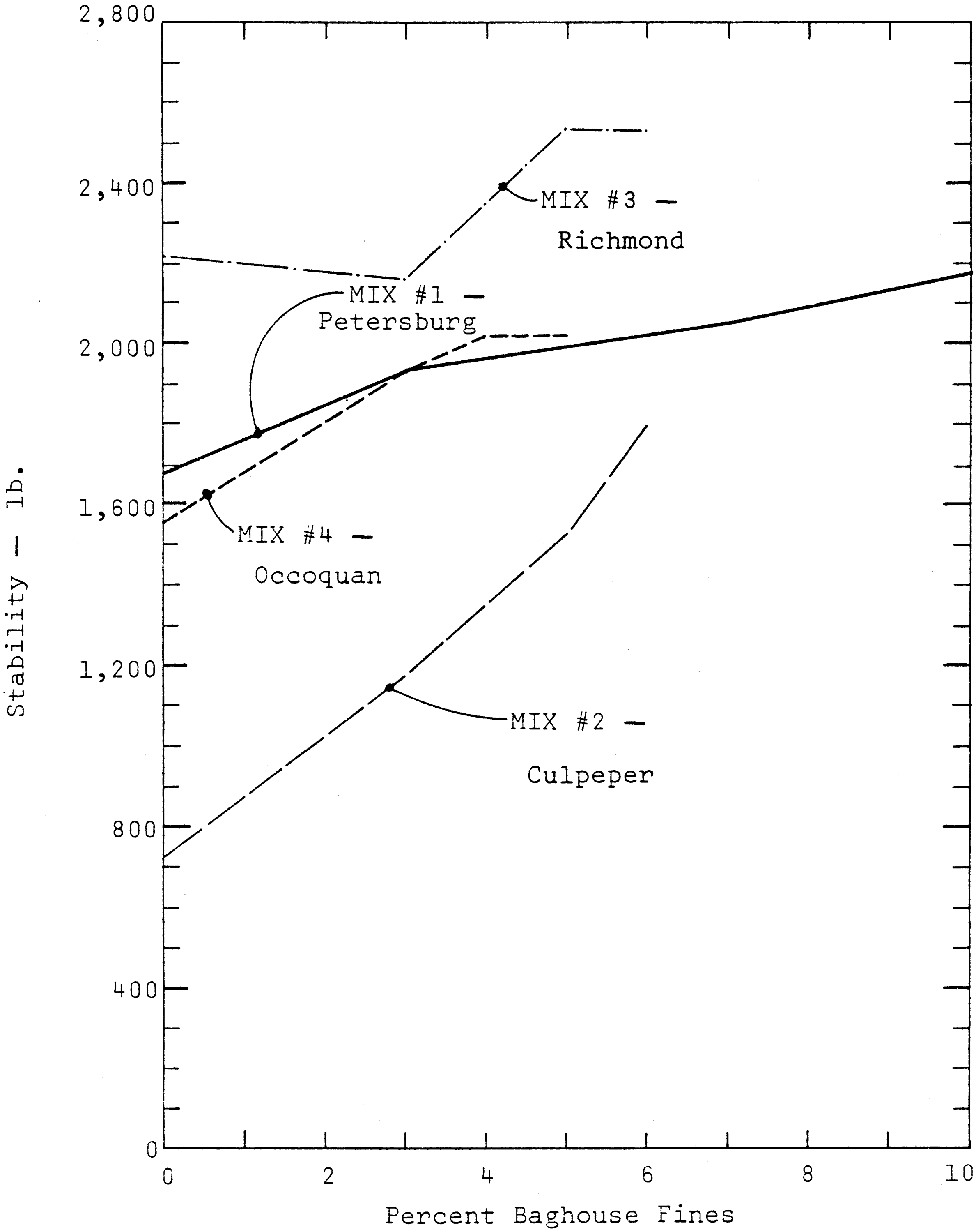


Figure 3. Stability vs. percentage of baghouse fines.

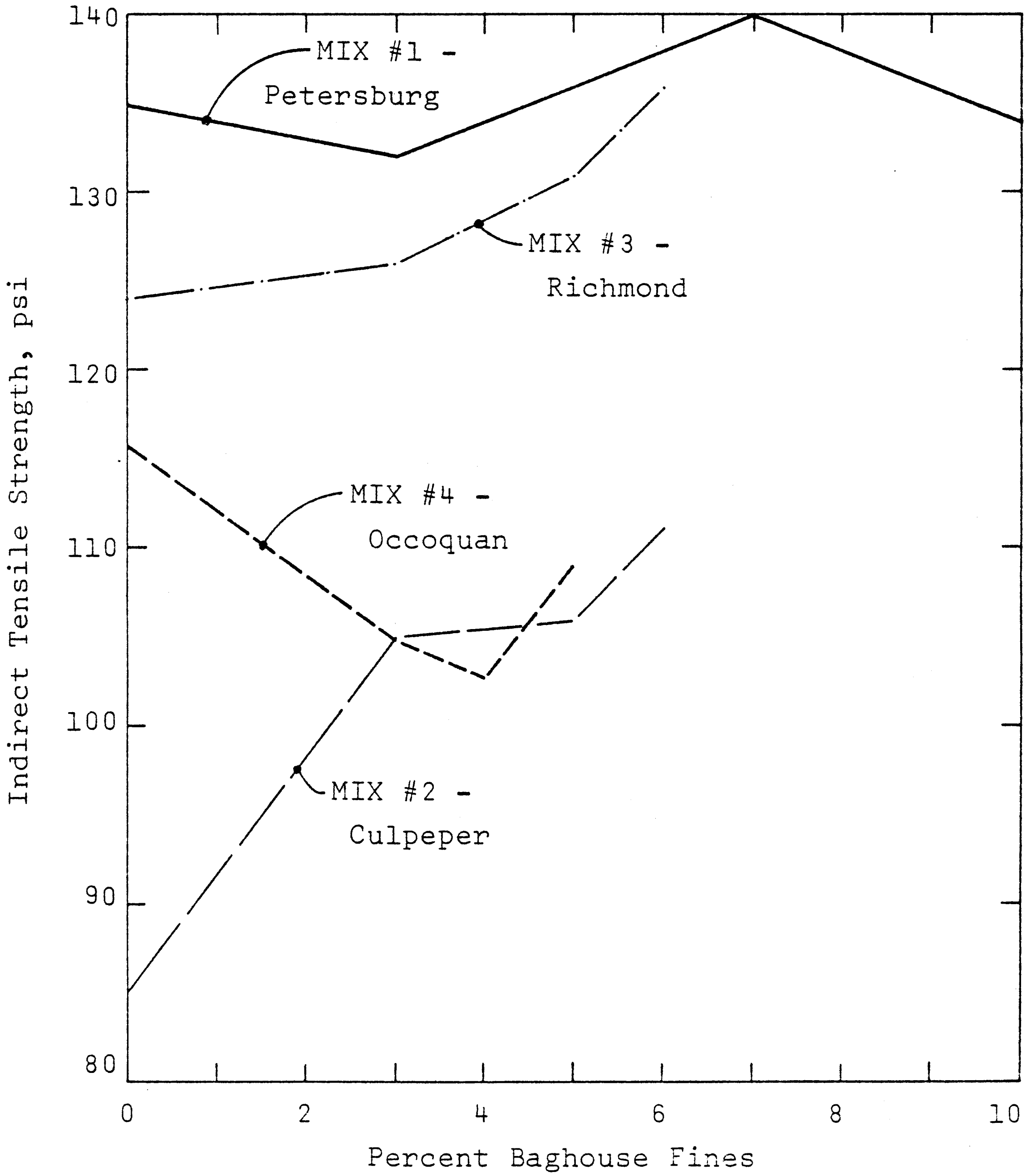


Figure 4. Indirect tensile strength vs. percentage of baghouse fines.

3478

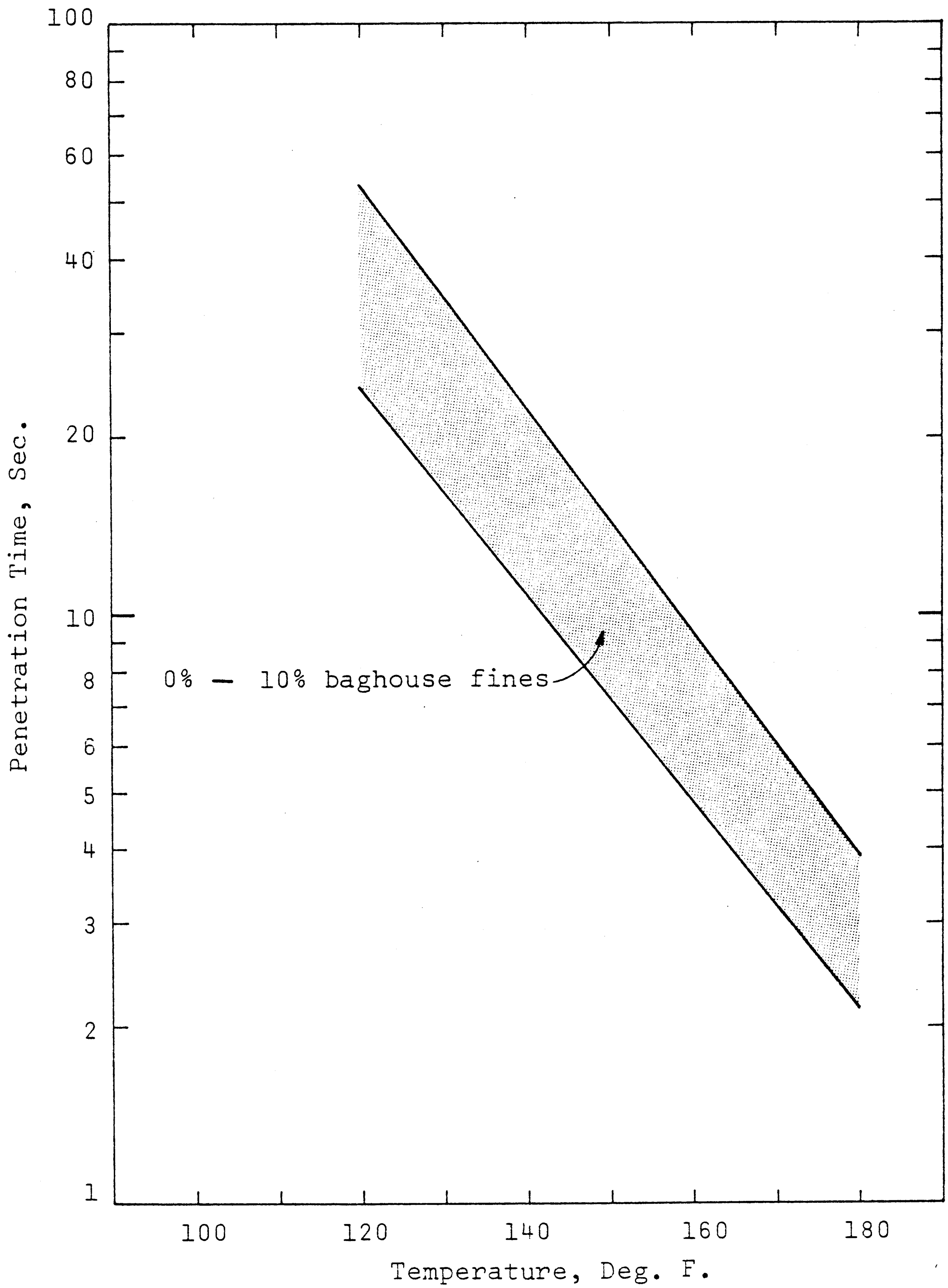


Figure 5. Time to penetrate ¼ in. vs. mix temperature for mix #1.

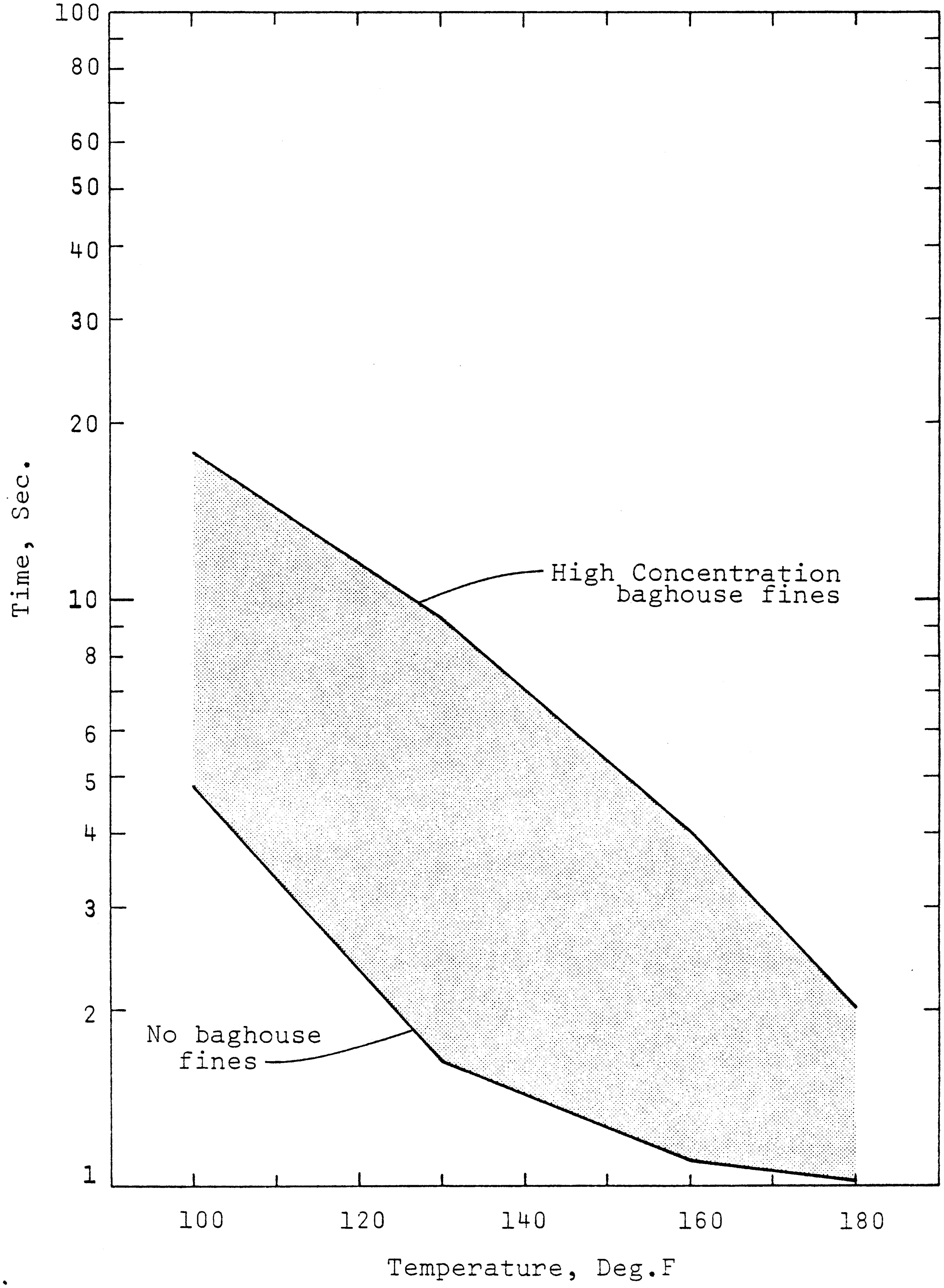


Figure 6. Time to penetrate ¼ in. vs. mix temperature for mix #2.

3460

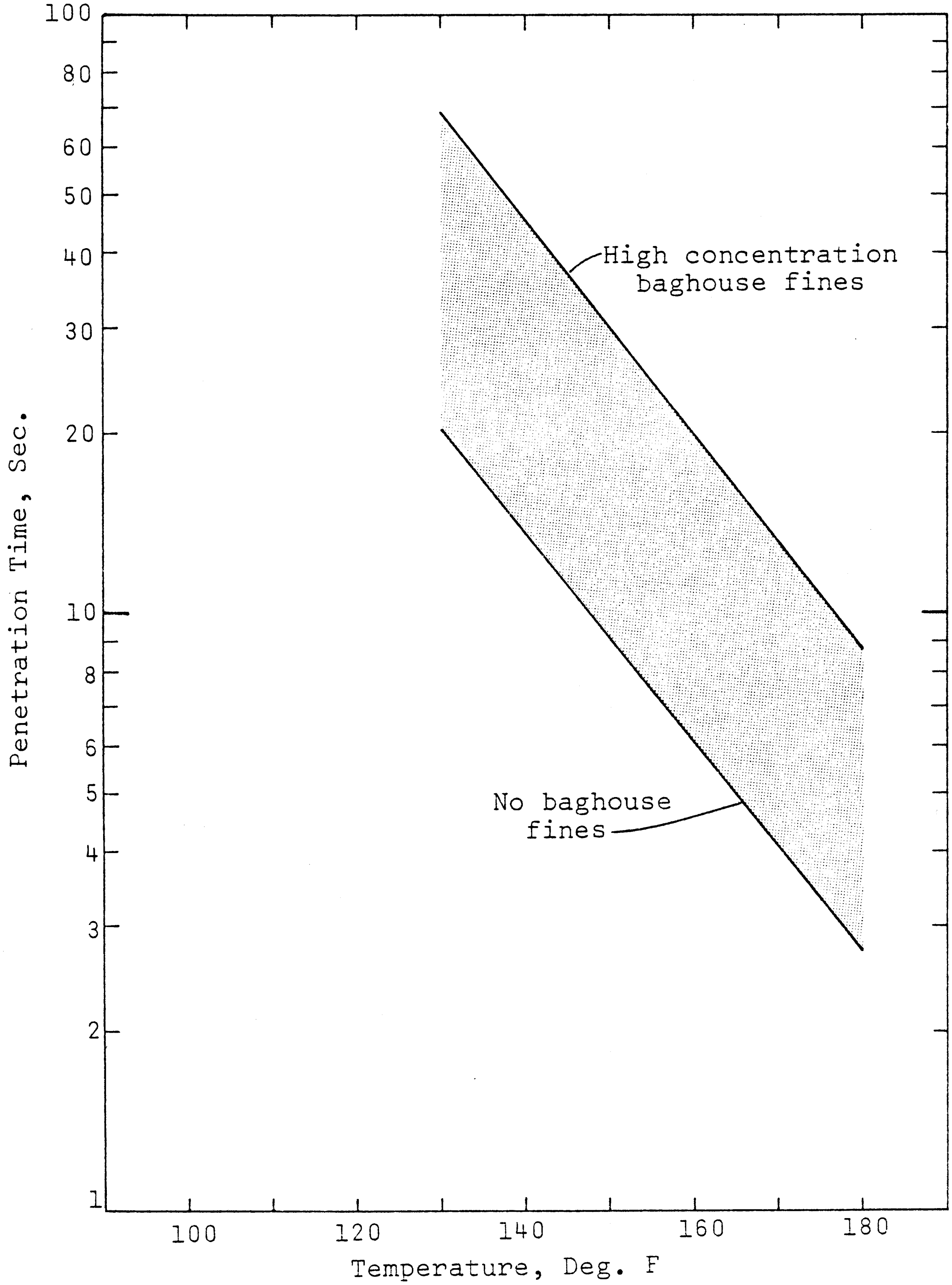


Figure 7. Time to penetrate ¼ in. vs. mix temperature for mix #3.

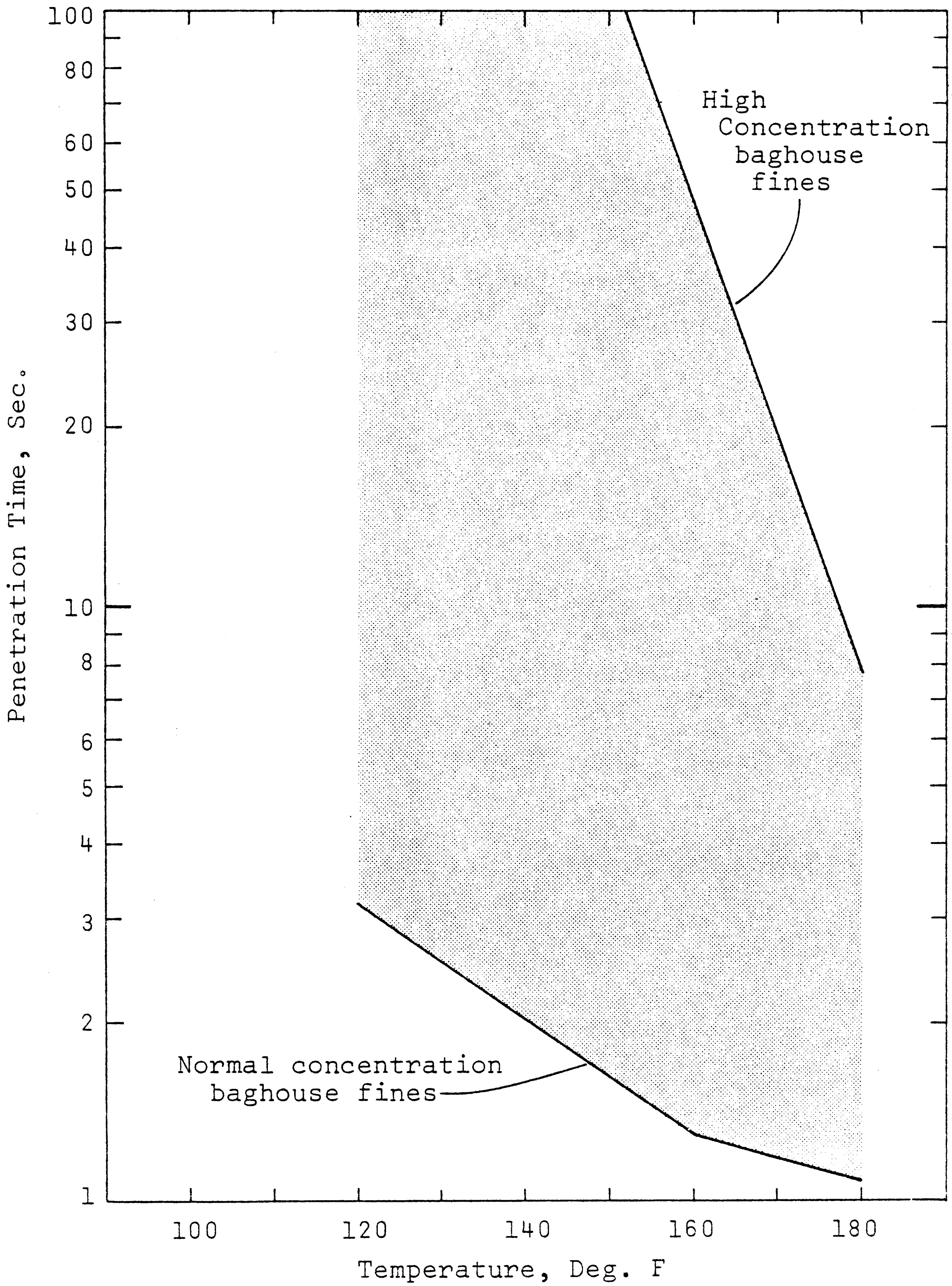


Figure 8. Time to penetrate ¼ in. vs. mix temperature for mix #4.

Mixes #1 and #3 had relatively slow rates of penetration at all percentages of baghouse fines, which indicated a stable mix. Also the spread of results for different percentages was relatively narrow, which indicated little influence of the quantity of baghouse fines on tenderness. Mix #2 had a fast rate of penetration and a wide spread of results, which indicated potential tenderness problems. Mix #4 exhibited a fast penetration at the normal percentage of baghouse fines (3%), but a slower penetration with increasing amounts (4% to 5%). There might be a tenderness problem that could be corrected by adding baghouse fines.

RESULTS OF OTHER STUDIES

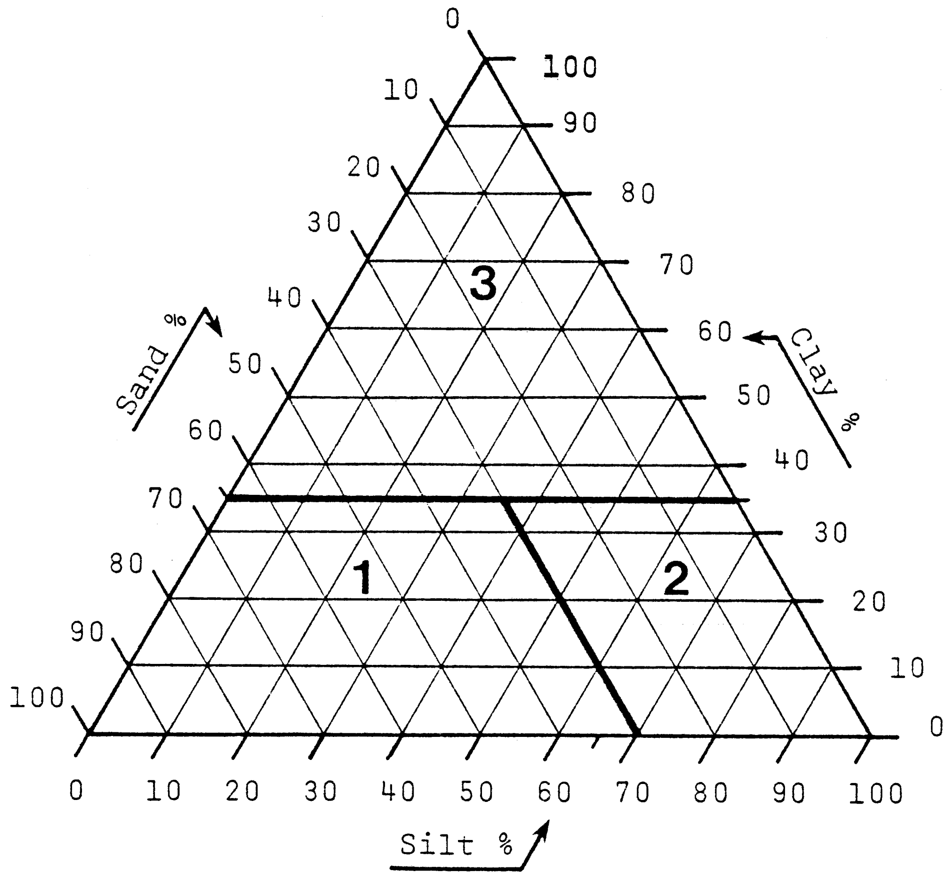
A study by the West Virginia Department of Highways determined that the quantity and gradation of baghouse dust have an influence on the properties of bituminous concrete.(2) The study recommended controlling the amount of baghouse dust in a mix on the basis of the distribution of particle sizes. A modification of the U. S. Department of Agriculture soil classification system was used to classify distribution (see Figure 9).

A recommendation was made to limit the amount of -#200 aggregate for two classifications of fines. Baghouse samples #2 and #4 of the present study would fit into one of the classifications that would decrease the amount of allowable -#200 aggregate according to the West Virginia recommendation.

An investigation by Kandhal proposed that a screening test for "percent bulk volume of fines" could be used to indicate the possible stiffening effect of fines on bituminous concrete.(3) If the bulk volume of fines was less than 50%, the concentration of fines was satisfactory; however, if it was greater than 50%, the softening point of the fines-asphalt mixture should be checked. If the increase in softening point is less than 20°F greater than that of the original asphalt, the concentration of fines is considered satisfactory. The bulk volumes of fines of mixes #2, #3, and #4 were checked and determined to be greater than the recommended 50%. The softening point was not determined because the required equipment was not available.

A study of baghouse fines by The Asphalt Institute also concluded that "the type of aggregate is not highly significant, but the fineness of the minus 200 fraction could be significant."(4)

CLASSIFICATION OF:
MECHANICAL OR
BAGHOUSE FINES FOR USE IN
BITUMINOUS CONCRETE



CLASS	SAND	SILT	CLAY
1	30-100	0- 70	0- 35
2	0- 30	35-100	0- 35
3	0- 65	0- 65	35-100
P.I. No more than 4			

Sand Sizes:	2.00-.074 mm
Silt :	.074 -.005 mm
Clay :	below .005 mm

Figure 9. Classification system for baghouse fines (Reference 2).

3484

SUMMARY AND CONCLUSIONS

Variations in the concentration of baghouse fines had an influence on the voids total mix, stability, and penetration time (used to measure tenderness) for two of the four mixes investigated. The two mixes that were influenced contained significantly finer baghouse dust than the mixes that exhibited little or no change.

The two mixes that were significantly influenced were also identified as possible problem mixes by test procedures used in two similar studies by other states.

Based on this investigation and a similar one by West Virginia, it appears that the gradation of baghouse fines is the best indicator of potential problems caused by variations in the percentage of baghouse fines in a mix.

The fines should be returned to the hot elevator in a uniform manner. Time-delay switches that synchronize the addition of baghouse fines and natural fines to the hot bins might be necessary in a start-stop operation. A bin system in which the fines are transported from the baghouse to a bin and then fed uniformly from the bin to the hot elevator can be used to improve uniformity at a moderate cost. A silo system in which fines are transported from the baghouse to a silo and transferred directly to the weigh hopper would ensure uniformity; however, this type of equipment is rather expensive.

RECOMMENDATION

If problems are encountered in the field with compaction, stability, or abnormal variations in density, the gradation of the baghouse fines should be checked. The amount of baghouse fines should possibly be decreased if it equals either the class 2 or class 3 designation in Figure 9. The following procedure should be used if baghouse fines are suspected of causing problems in a bituminous mix.

1. Obtain a sample of the fines that are returned to the hot elevator by the dust collector system.
2. Perform a hydrometer analysis on the fines according to AASHTO Test Method T88 and plot the results on a gradation chart.

3. Using the gradation plot, determine the amount (percent) of sand size (2.00 - 0.074 mm), silt size (0.074 - 0.005 mm), and clay size (below 0.005 mm) material in the sample.

4. Determine the class of the sample from the classification system chart in Figure 9.

5. If the fines fit either of the two fine classifications (classes 2 or 3), it might be necessary to decrease the amount of -200 sieve material to obtain a satisfactory mix.

3486

REFERENCES

1. Discussion with Robert L. Carroll, president of Eastern Control Systems, Inc., October 1, 1979.

2. Ward, Robert G., and John M. McDougal, "Bituminous Concrete Plant Dust Collection System— Effects of Using Recovered Dust in Paving Mix", Report No. FHWA/WV-79-003, West Virginia Department of Highways, December 1979.

3. Kandhal, Prithvi S., "Evaluation of Baghouse Fines in Bituminous Paving Mixtures", presented at 1981 Annual Meeting of the Association of Asphalt Paving Technologists, February 1981.

4. Eick, J. H., and J. F. Shook, "Effect of Baghouse Fines on Asphalt-Fines and Asphalt-Aggregate Mixtures", Draft Number 2, The Asphalt Institute, College Park, Maryland, January 23, 1978.

3488