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Evaluation Of Asphalt Concrete Produced By The Dryer-Drum Mixing Process

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Apostolos, John A., and Mann, Gary W.

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16. ABSTRACT

The quality of asphalt concrete produced by a dryer-drum mixing plant was investigated. A dryer-drum mixing plant was used on two State Projects in northern California during 1973. The A.C. mixture did not appear to be harmed by the simultaneous drying of the aggregate and mixing of the aggregate and asphalt. However, indications exist that unconsumed burner fuel may have contaminated the asphalt and softened it.

This dryer-drum mixing equipment produced an A.C. mixture of a uniformity that matches the mean capability of conventional plants. Both the asphalt content and the aggregate gradation remained with reasonable limits of the sought values.

Relative compactions obtained on one project were less than that desired.

An air pollution control device (water-scrubber) was necessary in addition to the cyclone dust collector supplied with the plant in order to meet emission requirements.

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Asphalt content, aggregate gradation, aggregate drying, bituminous mixing plant, bituminous pavement, continuous mixing plant, dryer-drum mixing

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An air pollution control device (water-scrubber) was necessary in addition to the cyclone dust collector supplied with the plant in order to meet emission requirements.

The A.C. pavement appears to be providing satisfactory service at this time with no rutting or major defects in evidence. Further coring and inspection will be continued.

A brief study was made on a second plant operating in El Dorado National Forest for the U.S. Forest Service. This plant used both propane and diesel fuel. No contamination of the asphalt was evident from either fuel. The A.C. mix temperature for this plant was approximately 40°F higher than that for the plant used on the State projects.

17. KEY WORDS

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November 1974

FHWA No. F-8-19
TL No. 633125

Mr. R. J. Datel
Chief Engineer

Dear Sir:

I have reviewed and now submit for your information this interim research project report titled:

EVALUATION OF ASPHALT CONCRETE

PRODUCED BY THE DRYER-DRUM MIXING PROCESS

Study made by..........................Pavement Section

Under the Supervision of................George B. Sherman and John B. Skog

Principal Investigator..................Robert N. Doty

Co-Investigator.........................Gary W. Mann

Report Prepared by......................John A. Apostolos and Gary W. Mann

Very truly yours,

JOHN L. BEATON
Chief Engineer, Transportation Laboratory

Attachment

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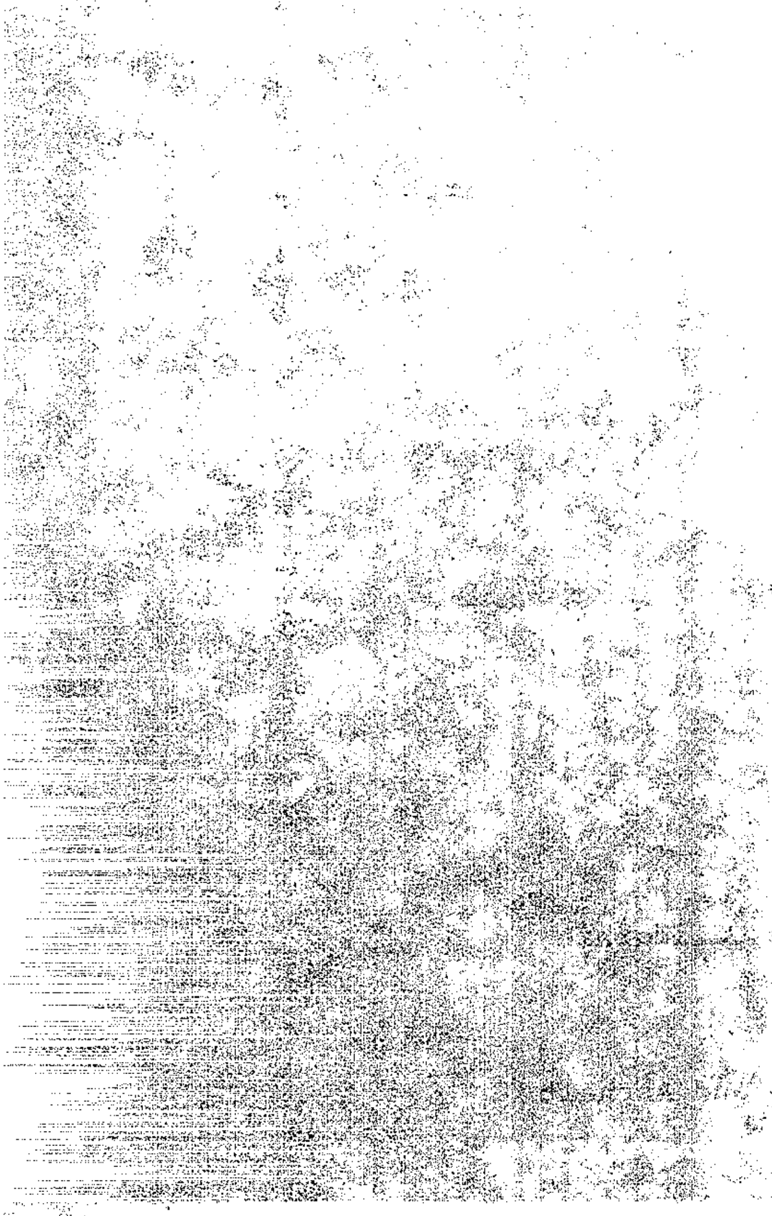


ACKNOWLEDGEMENT

The researchers wish to express their appreciation to the following personnel of the Transportation Laboratory: Mr. Kenneth Iwasaki, who joined them in their field studies and who was instrumental in performing the multitude of highly specialized tests required on the field samples, Messrs. Thomas Scrimsher, James A. Cechetini, and Glenn R. Kemp, who added their invaluable expertise in the areas of mix design, asphalt concrete compaction, and asphalt sampling and testing.

The researchers further wish to thank Mr. Charles McKee and Mr. John Pickrell, Resident Engineers on the California State projects, Mr. Ewing Colvin, and Mr. Leonard Stern of the U. S. Forest Service (Iron Mountain project), the O'Hair Construction Company, and the R. D. Watson Construction Company for their assistance and cooperation in obtaining the field samples, and Mr. Leigh Spickelmire of the Transportation Construction Department for reviewing the draft.

This work was performed as part of a research project conducted in cooperation with the U. S. Department of Transportation, Federal Highway Administration under item F-8-19. The contents of this report reflect the views of the Transportation Laboratory which is responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the State of California or the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

INTRODUCTION

The conventional method of producing asphalt concrete involves heating and drying processed aggregate in a dryer-drum, segregating it by size using hot screens and bins, then recombining and introducing the graded aggregate into a pug-mill where it is mixed with a measured quantity of pre-heated asphalt. A recent innovation designed to streamline the production process and cut down on the necessary plant hardware and associated costs is the dryer-drum mixing method. This method involves attaining the final gradation of aggregate by means of electronically controlled feed belts, each metering out a proportionate quantity from pre-graded cold hoppers, i.e., cold feed control. The combined aggregate is then introduced to the dryer-drum mixer together with the pre-heated asphalt, where the aggregate is dried, heated and mixed with the asphalt simultaneously. The hot mix exiting the dryer-drum mixer is elevated and stored in a surge silo ready for transport to the paving operation.

By eliminating the need for hot bins, hot screens, and the pug-mill, the cost of producing asphalt concrete should decrease. Any such cost reductions should be beneficial to both the producer and the user of asphalt concrete. Manufacturers of these plants claim that this process permits mixing at lower temperatures than with conventional methods, resulting in the use of less fuel. The moisture retained in the final mixture (a reported 2 to 3 percent) supposedly provides the lubrication required to achieve satisfactory compaction of the A.C. mix even with these lower temperatures.

An additional benefit of the dryer-drum mixing process is the reported reduction in the amount of dust emitted from the dryer exhaust and hot bins as compared to conventional plants[1,2].

Because of the potential benefits of this new method, it is of importance to evaluate the asphalt concrete produced by the dryer-drum and determine its performance in the field. Accordingly, this research effort was designed to answer the following questions:

1) Is the mixture being harmed by the exposure of the asphalt to the conditions within the dryer-drum mixer;

2) Will the plant equipment produce a consistently uniform product;

3) Will the combination of lower mix temperatures and higher moisture contents present any construction or performance problems;

4) Is the mix produced durable under field conditions.

CONCLUSIONS

At this stage of the study, the following general conclusions can be drawn about the observed dryer-drum mixing method of asphalt concrete production:

1. The A.C. mixture tested did not appear to be harmed by the exposure of the asphalt in the dryer-drum mixer. However, unconsumed burner fuel (diesel) apparently contaminated the asphalt and softened it, or "cut" it back, excessively. Thus, burner efficiency may be critical to the production of a quality mix.

2. The dryer-drum mixing plant produced A.C. mixture of a uniformity that matches the mean capability of conventional plants. Both the asphalt content and the aggregate gradation variation remained within reasonable limits.

3. Relative compactions obtained were marginal to substandard. This low compaction could be attributed to one or more of the following three factors: (a) improper operation of the vibratory roller, (b) lower than conventional mix temperatures, and (c) lack of the extra remaining moisture anticipated in the dryer-drum process.

4. An air pollution control device was necessary in addition to the cyclone dust collector on the one plant tested to date. The water-scrubber added to the stack was effective, but necessitated the development of a settling pond for the effluent.

5. The A.C. pavement appears to be providing generally satisfactory service at this time with no rutting or major defects in evidence.

IMPLEMENTATION

It is recommended that the following be implemented:

1. Permit the use of dryer-drum mixing plants on additional projects, provided they comply with air pollution standards.

2. Require a mix temperature above 250°F, to aid compactive effort, except where adequate compaction at a lower temperature can be demonstrated.

DISCUSSION

Sampling and Testing

In order to evaluate the asphalt concrete produced by the dryer-drum mixing process, the State of California approved its use, on an experimental basis, on two contracts at the request of O'Hair Construction Company. These were contract Nos. 02-104404 (in Siskiyou County near the community of Macdoel) and No. 02-104304 (in Shasta/Lassen Counties between the communities of Susanville and Old Station). It was intended that a "control" section using conventionally produced A.C. would be included as a part of each study but the remoteness of these test areas precluded this.

An additional project, contracted by the U. S. Government, was also observed during this study at the request of the U. S. Forest Service. This last project was under construction by the R. D. Watson Construction Company at Iron Mountain Road, in El Dorado National Forest, California, for the U. S. Forest Service.

The observation and testing procedure for the two State projects consisted of the following:

1. Measuring and photographing emissions of the stack exhaust.

2. Sampling aggregate prior to mixing and then testing for gradation and moisture content.

3. Sampling asphalt prior to mixing and then testing for penetration, absolute viscosity, and other characteristics.

4. Sampling A.C. mix at the plant and at the street, then subjecting these samples to the following procedures:

    a. Extraction and grading of the aggregate.

    b. Abson recovery of the asphalt and testing the residue as in (3) above.

    c. Heating and compacting the A.C. mix to obtain relative compaction data.

5. Determining the density of the A.C. mat after final rolling, by nuclear gage measurements.

6. Periodically obtaining cores of the pavement and determining their in-situ density, then subjecting them to the test procedures outlined in step 4, and

7. Periodically conducting visual inspections of the roadway to ascertain its condition.

The test methods used are listed in Appendix B.

Projects

Macdoel - Route 97

The first project, in Macdoel, California, consisted of overlaying 12.4 lane miles of old, cracked asphalt concrete, using a dense graded California Type B* 3/4" maximum mix. An AR2000 paving grade asphalt was used. The average thickness of the overlay was 0.2 ft. for a total of 25,000+ tons. As the A.C. was manufactured by a brand new dryer-drum mixing plant, it was expected that the initial "bugs" inherent in any new plant would be ironed out by the contractor while on this project. The modified plant would then be evaluated again on the larger Susanville-Old Station project. For a description of the plant operation, see Appendix A.

The major difficulties encountered with the equipment on the Macdoel contract involved adjustments of the burner, the location of the asphalt discharge nozzle within the drum, the size and shape of the internal baffles in the drum, and some problems with the conveyor-belt motors. Most of these adjustments, which were made in an attempt to clean up the "stack" emissions, had been finalized by the end of the first project.

Paving commenced during late August, 1973 and ended on September 1, 1973. For a description of the paving equipment used, see Appendix C. Observation and sampling was conducted from August 27 through August 30, 1973. The plant was operating at the rate of approximately 350 tons per hour during this sampling period. A total of 7 sample sets were obtained and tested. Each set included aggregate, asphalt, and A.C. at the plant and A.C. at the street. Ambient and sample temperatures were recorded, and the density of the pavement after final rolling was measured in the vicinity of the "street" samples of A.C. As each sample was taken it was carefully sealed for later determination of moisture content. A small quantity of dry ice was placed within the A.C. sample containers several minutes prior to filling each container. This was done in order to provide a more inert carbon dioxide (CO_2) rich mixture in the sample cans. It was hoped this would prevent any oxidation of the asphalt in the mix from the time of sampling until the sample was tested in the laboratory. It was also expected that the remaining small pieces of dry ice in the sample containers would sublimate immediately upon contact with the hot A.C. mixture and that the CO_2 gas would permeate the voids and further expel at least some of the remaining oxygen. In practice, however, the dry ice sublimated slowly, raising the pressure to the point of distending the plastic lids of some sample cans and

*California Standard Specifications - January, 1973.

popping the metal lids off other cans with some force. This difficulty was corrected by incizing small openings in the plastic tops and sealing them after the pressure was balanced, while for the metal-lid cans, the remaining dry ice was removed prior to filling with the A.C. sample.

The problems encountered in obtaining, keeping, and using the dry ice were considerable. As the samples were taken back to the laboratory and tested within a short period of time, the benefit was probably slight. Using dry ice was discontinued with future sampling. Photos of the total operation, including photos of stack emissions (Figure 1), were taken at various times.

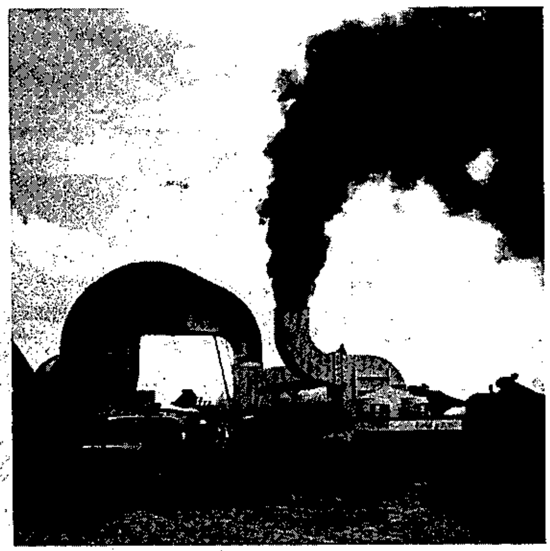


Figure 1

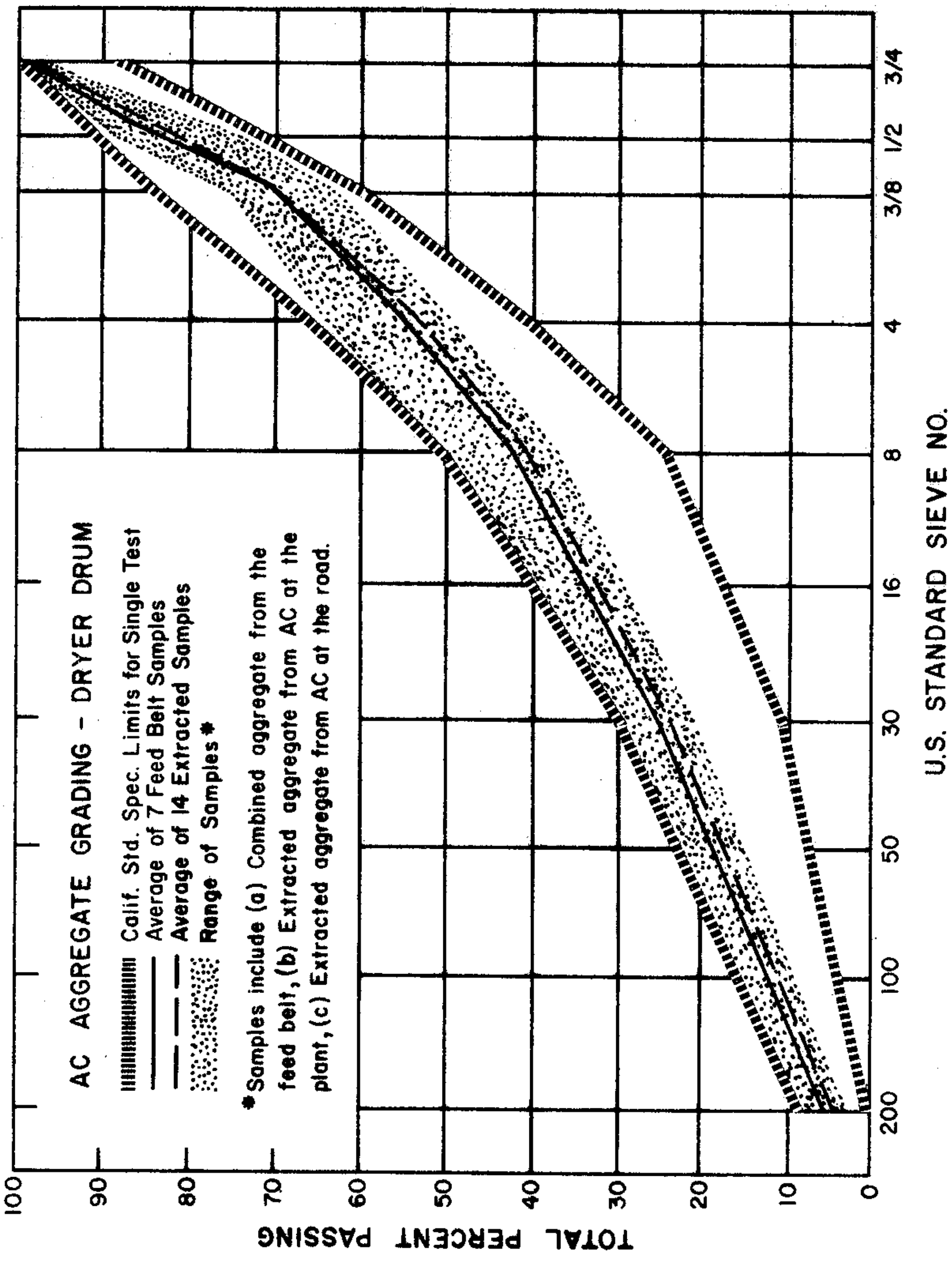
Dryer-Drum Mixing Plant During
First Week of Operation

Core samples were obtained from the pavement in the vicinity of each "street" A.C. sample location after approximately two weeks of traffic. These cores were tested in the same manner as the A.C. samples taken during construction.

The results of the aggregate gradation tests indicated that the aggregate combination obtained by the multi-hopper/conveyor-belt system was reasonably uniform and within the California Standard Specification limits. Figure 2 indicates the range of gradation evident in the aggregate and A.C. samples. The exhibited bias towards the upper limits of the gradation curve was attributed to the characteristic grading of the stockpile used for each cold feed hopper rather than to any fault of the system.

Figure 2

MACDOEL - 3/4" MAX.



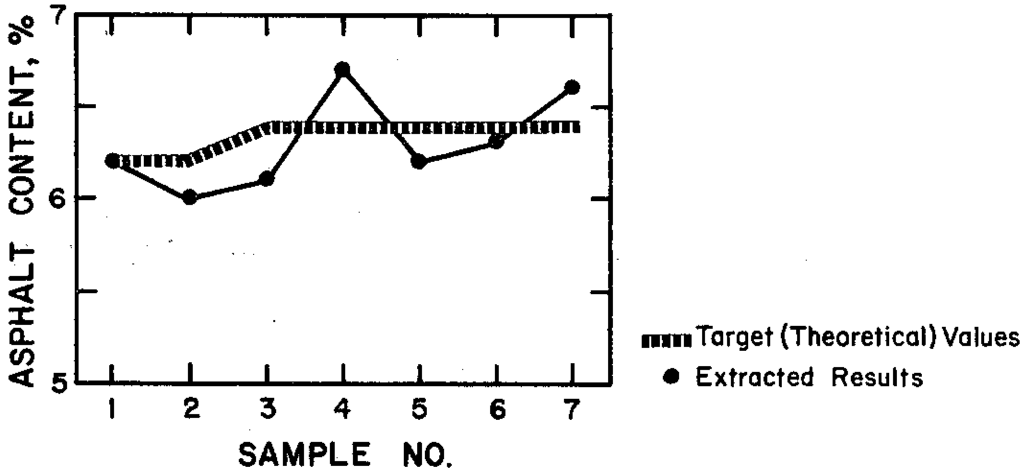
The production system was designed to continuously sense the weight of aggregate on the conveyor-belt and automatically adjust the rate of asphalt delivery in order to produce a constant ratio of aggregate-to-bitumen. Provisions existed to compensate for aggregate moisture. This moisture was determined by the plant inspector one or more times daily, and the correction made via the electronic controls. The results of the tests, shown in Figure 3 and Table 1, indicated that the asphalt content of the A.C. mix varied somewhat from the target value. However, since the contractor was still in the process of adjusting various parameters when these samples were taken, evaluation of the test results beyond reporting was not deemed proper, and further analysis was reserved for the results of the second project.

Table 2 shows that penetration tests on the original asphalt gave an average value of 87. Asphalt obtained from the A.C. samples by the Abson Recovery method yielded average penetrations of 121 and 125 from the plant and street samples, respectively. Under conventional production methods, loss of volatile fractions and/or oxidation of the asphalt would provide Abson recovery residues of approximately 30-40 percent harder than the original, i.e., have a penetration value around 60. The fact that the recovered asphalt was not harder, but in the range of 40 percent softer than the original, even though "exposed" to the burner in the dryer-drum mixer, indicated that the asphalt was probably being contaminated by unconsumed burner fuel (diesel oil). The absolute viscosity results (Table 3) show that the recovered asphalt was softer than would be expected from a pug-mill (simulated by the rolling thin film procedure). These low viscosities caused the A.C. mix to be slow-setting during the rolling operation, which was at lower temperatures than conventionally produced A.C., but no harmful effects were apparent when observing the finished mat. Asphalt recovered from the core samples 12 days after placing had an average penetration of 93, exhibiting the characteristic hardening of this material with time. However, due to the short period of time between placing and coring, this amount of hardening can only be attributed to additional volatiles evaporating and not solely to oxidation. This would further indicate the presence of diesel in the final A.C. mixture.

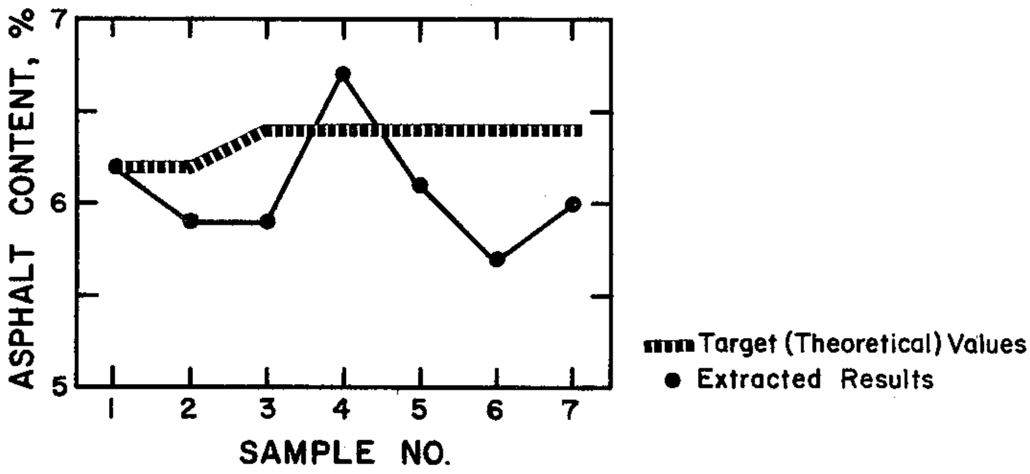
It has been claimed that the moisture content of the aggregate protects the asphalt from the burner temperatures and provides a more ductile A.C. mix[3]. However, this could not be evaluated because the stockpile moisture remained constant, at a relatively dry 4 to 4.5 percent by weight during the entire period of this project. This resulted in A.C. mix moisture contents of 0.8 to 1.4 percent even though up to 3 percent was permitted by the contract specifications.

Figure 3

ASPHALT CONTENT VARIATION
MACDOEL



3A- Asphalt content of AC sampled at the plant



3B-Asphalt content of AC sampled at the street

TABLE 1

ASPHALT CONTENT

(Reported as % of dry aggregate weight)

MACDOEL

Sample No.	Target Value	From Truck At Plant	From Street During Paving	From Core After 12 Days
1	6.2	6.2	6.2	5.7
2	6.2	6.0	5.9	6.0
3	6.4	6.1	5.9	6.3
4	6.4	6.7	6.7	6.5
5	6.4	6.2	6.1	5.9
6	6.4	6.3	5.7	6.2
7	6.4	6.6	6.0	6.3
Standard Error		0.26	0.32	0.28

TABLE 2

ASPHALT PENETRATION

MACDOEL

Sample No.	Original Asphalt From Tank	Abson Recovery Residues From Truck At Plant	From Street During Paving	From Core After 12 Days
1	90	139	140	112
2	--	116	110	101
3	86	116	112	95
4	85	108	130	95
5	--	110	150	77
6	86	132	116	86
7	86	126	116	87
Average	87	121	125	93
Standard Error	2.0	11.6	15.4	11.4
Penetration Retained		139%	144%	107%

TABLE 3

ABSOLUTE VISCOSITY OF ASPHALT (140°F)

MACDOEL

Sample No.	Rolling Thin Film Residue From Original Asphalt	Abson Recovery Residues From Truck At Plant	 From Street During Paving	 From Core After 12 Days
1	1920	746	738	877
2	--	801	893	946
3	1994	818	856	1012
4	2045	897	713	1045
5	--	838	655	1418
6	1877	692	808	1350
7	1822	754	816	1133
Average	1932	792	783	1112
Standard Error	89	68	84	203

Visual inspection of the A.C. mix indicated that the aggregate was properly coated with asphalt. A little uncoated material was in evidence after paving but this small amount was mostly due to the crushing of occasional soft aggregate particles by the rollers.

Compaction was performed by a 16-ton vibratory roller (Figure 4), with a 10-ton static used for finishing (For Paving Equipment Used - See Appendix C). The relative compaction results averaged 95 percent (shown in Table 4), which is considered the acceptable minimum (although it is not a California State Specification).

Figure 4

The Vibratory Roller Used on Both California State Projects

The exhaust stack emitted ever-changing combinations and quantities of smoke and dust throughout the operation as the contractor tried various modifications of the plant. No measurements of the pollutants were taken, partly because of these continuing modifications and also because it was obvious that the amount of dust, etc. was excessive, except for the last two days of the operation.

TABLE 4

DENSITY OF AC (lbs/ft^3)

MACDOEL

Sample No.	From Truck At Plant (Laboratory Compaction)	From Street During Paving (Laboratory Compaction)	From Street During Paving (Nuclear Gauge)	From Core After 12 Days (Lab re-Compact)	From Core After 12 Days (Density as Rec'd.)
1	137	138	132	137	134
2	138	137	134	139	137
3	137	139	130	139	136
4	137	137	131	136	135
5	137	137	134	137	138
6	137	138	128	135	134
7	136	137	128	138	134
Average	137*	138	131	137	135
Standard Error:	0.6	0.8	2.5	1.5	1.6
Relative Compaction			95.6%		98.5%

*Value used for 100% compaction as per Calif. Test Method 304

Subsequent visual inspections have revealed that the A.C. overlay is in good condition after 10 months of traffic, some of which was chain traffic. Further coring and inspection will be accomplished at approximately 6 to 12 month intervals.

Susanville-Old Station - Route 44

The second project, between Susanville and Old Station, California, consisted of overlaying 91.2 lane miles of old, cracking A.C. with a California Type B asphalt concrete. The asphalt used was 120-150 penetration. The overlay varied in thickness, with some sections due to receive a 0.1 ft. cover, and others 0.2 ft. cover, for a total of 75,000+ tons. The A.C. was mixed using the same dryer-drum mixing plant used in the Macdoel project. The internal baffle geometry of the dryer-drum was modified somewhat prior to the plant's use on this project. Numerous relocations of the asphalt discharge nozzle were again made by the contractor during this new operation, culminating in a final location of approximately 12 ft. from the burner end of the drum.

Paving commenced on September 17, 1973 and ended on October 24, 1973. Observation and sampling were conducted from September 18, 1973 through September 21, 1973, and from October 10, 1973 through October 11, 1973. A total of 14 sample sets were obtained and tested, each test set again including aggregate, asphalt, and A.C. from the plant and A.C. from the street. All the samples were sealed to retain their native moisture for later measurements (no dry-ice was placed in the samples). Ambient and sample temperatures were recorded, and the density of the pavement after final rolling was measured in the vicinity of the "street" samples of A.C. Photos of the total operation, including stack emissions, were taken at the time of each "plant" A.C. sample. Cores were obtained from the pavement in the vicinity of each "street" sample location on January 28 and 29, 1974 and the recovered asphalt and aggregate were tested in the same manner as the A.C. samples taken during construction.

Results of the second project again indicated that the aggregate gradation obtained by the system was reasonably uniform and within specification limits. Because the mat thickness varied from 0.1 ft. to 0.2 ft. two mixtures were used for the project, a 1/2-inch maximum and a 3/4-inch maximum aggregate grading. Figures 5 and 6 indicate the range of gradation measured. Part of the variation was due to adjustments by the contractor when apparently attempting to use a maximum amount of natural fines for economic reasons.

In order to better evaluate the system's ability to provide the correct proportion of asphalt in the A.C. mix, it was necessary to perform control extractions on laboratory-mixed A.C. specimens having the same aggregate and asphalt used on the job. This was done to compare the amount of extracted asphalt from these control specimens to their known original content, and then apply the derived correction factor to the values obtained from the field

Figure 5

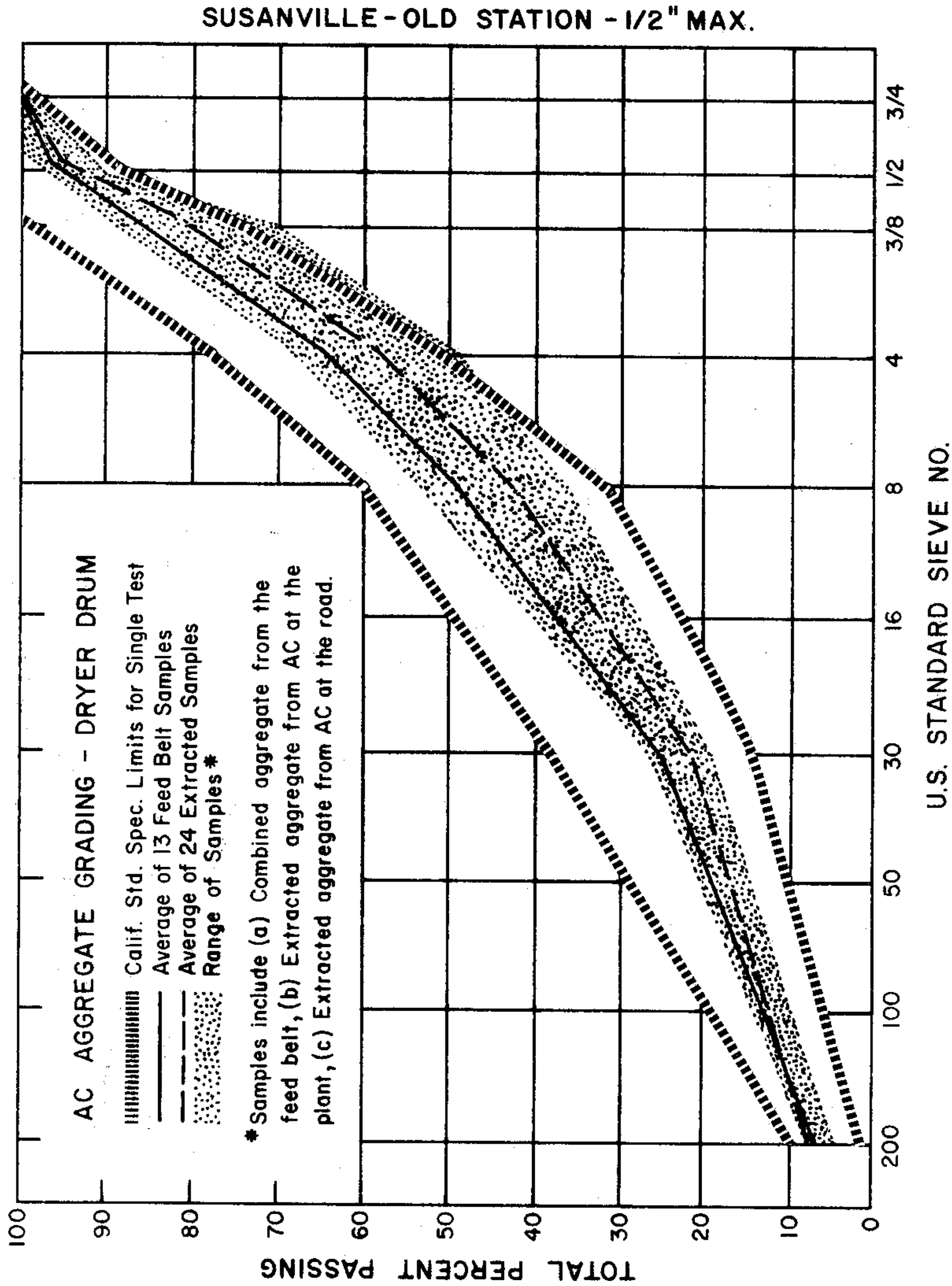
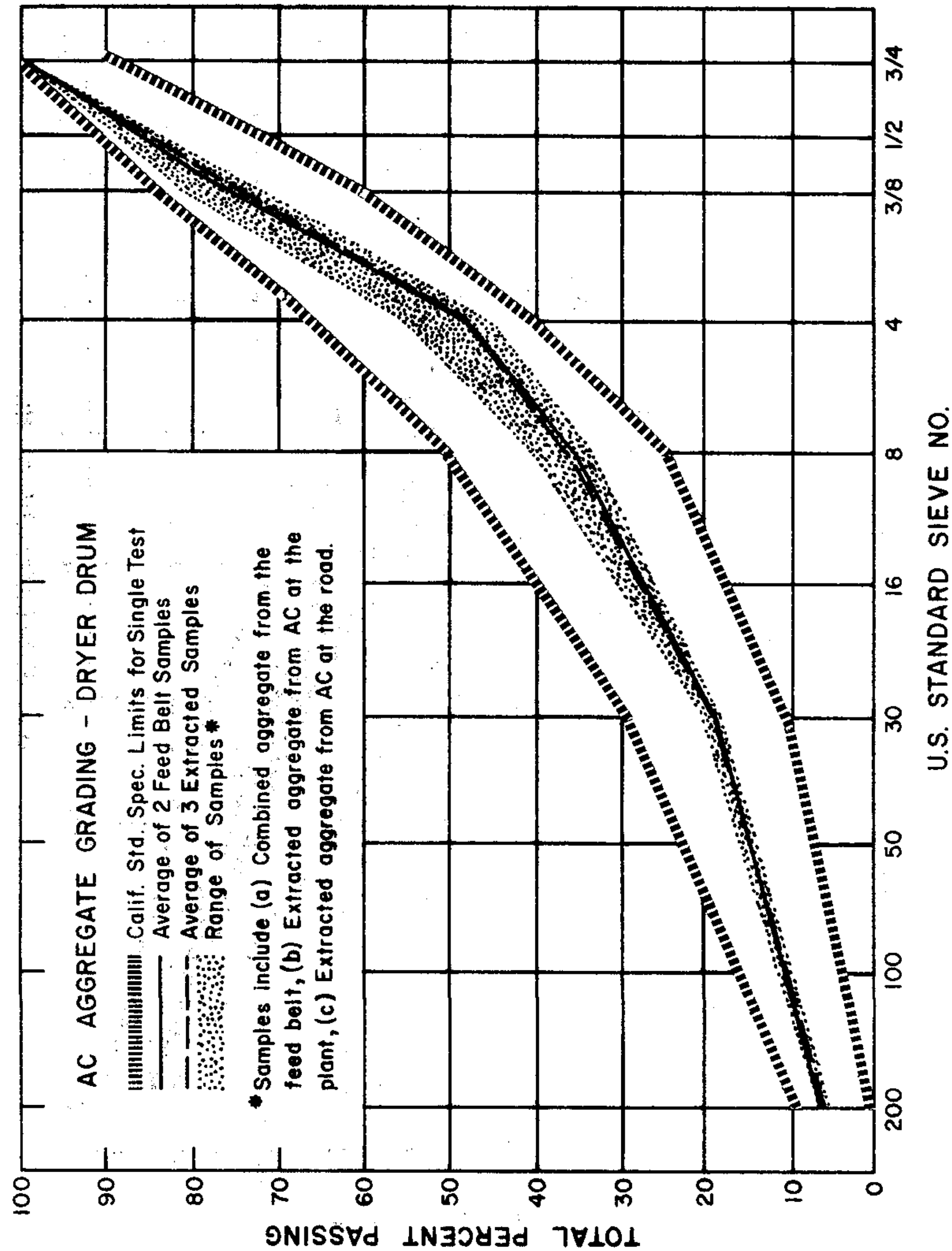

SUSANVILLE-OLD STATION - 1/2" MAX.
AC AGGREGATE GRADING - DRYER DRUM
Calif. Std. Spec. Limits for Single Test
Average of 13 Feed Belt Samples
Average of 24 Extracted Samples
Range of Samples *
* Samples include (a) Combined aggregate from the feed belt, (b) Extracted aggregate from AC at the plant, (c) Extracted aggregate from AC at the road.
U.S. STANDARD SIEVE NO.
3/4
1/2
3/8
4
8
16
30
50
100
200
TOTAL PERCENT PASSING
100
90
80
70
60
50
40
30
20
10
0

Figure 6

SUSANVILLE - OLD STATION - 3/4" MAX.



samples. (This was not done for the Macdoel project.) The results of these tests, shown in Figure 7 and Table 5, indicate that the asphalt content variation obtained did center about the target value, with a standard error of ± 0.3 percent asphalt (this magnitude is ± 4.5 percent of the target value). This uniformity matches the capabilities of many conventional batch plants as reported by Granley and Olsen in the September, 1973, issue of "Public Roads". Figure 8 is reprinted from this publication and the standard error of the samples from the Susanville-Old Station project is superimposed on their bar graph.

Asphalts from two sources, "Standard" and "Douglas", were used in the second project. Both were of 120-150 penetration grade. As shown in Table 6, penetration tests on the original asphalts gave average values of 133 and 130 for "Standard" and "Douglas", respectively. Asphalt obtained from the A.C. samples by the Abson recovery method yielded average penetrations of 134 and 138 for "Standard", and 118 and 125 for "Douglas", from the plant and street samples, respectively. These penetrations indicate that the hardness of the asphalt in the A.C. mix was approximately the same as that of the original. The penetration, as stated previously, would be expected to drop about 30 to 40 percent in a normal pug-mill mixer. The absolute viscosity results (Table 7) show that the recovered asphalt was approximately the same, or perhaps slightly harder than the original, but still much softer than would be expected from a conventional pug-mill (rolling thin film residue). These low viscosities may have caused slow-setting problems in a warmer climate.

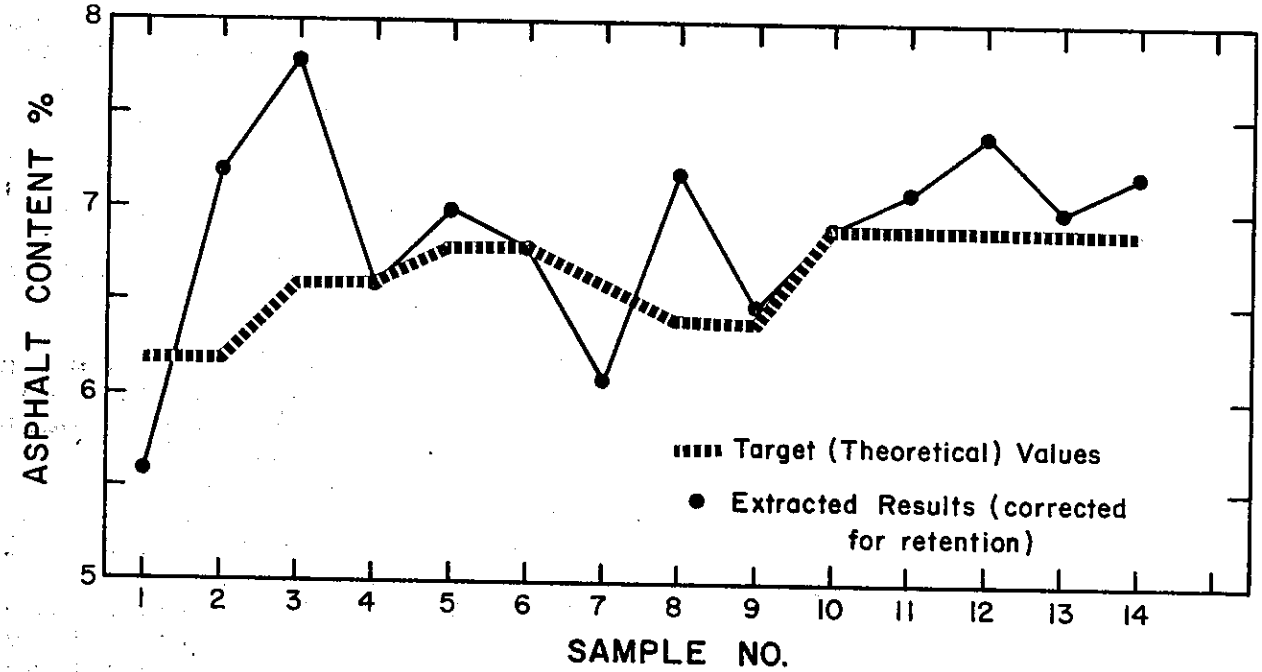
The difference in asphalt hardening between the first and second project is probably due to better burner efficiency (less contamination by burner fuel). It was also expected that the higher A.C. mix temperatures, which were used because of the longer haul distance in the second project (average 241°F at the plant vs. 214°F for the first project), would tend to burn off more volatiles and increase hardening. Comparisons of each sample temperature versus its penetration value did not support the latter assumption, but this may be due to the small sample size. Asphalt recovered from the core samples taken after approximately 3 months' traffic had an average penetration of 86, again exhibiting the characteristic hardening of the asphalt with time and exposure to the elements. After this length of time, no conclusion can be drawn as to the relative contribution of evaporation of volatiles and oxidation.

The aggregate stockpile moisture in the second project was also low (between 3 and 4.5 percent by weight), and thus the opportunity to study the effect of higher retained moisture in the mix did not present itself. The mix moisture content of 0.5 to 1.0 percent is typical of most asphalt concrete in California.

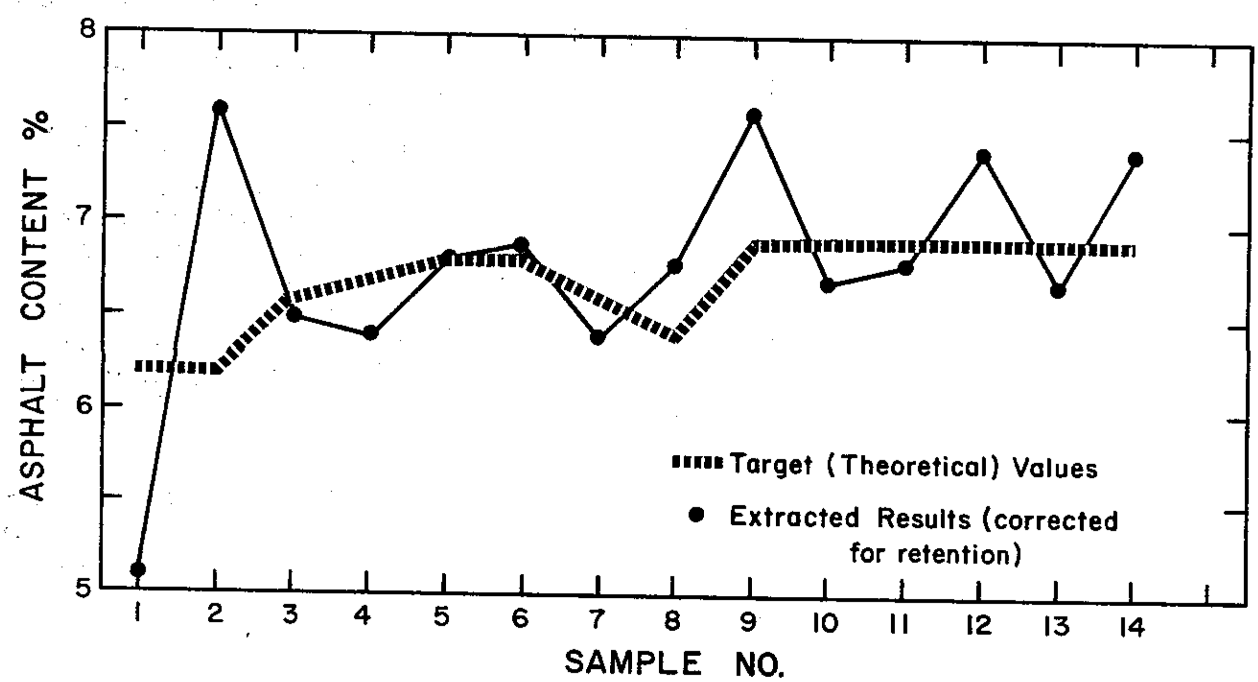
Figure 7

ASPHALT CONTENT VARIATION

Susanville - Old Station



7A - Asphalt content of AC sampled at the plant



7B - Asphalt content of AC sampled at the plant

TABLE 5

ASPHALT CONTENT

(Reported as % of dry aggregate weight)

SUSANVILLE-OLD STATION

Sample No.	Target Value	From Truck At Plant*	From Street During Paving*	From Core 80-103 Days After Paving*
1	6.2	5.1 (5.6)	5.6 (5.1)	6.2 (6.8)
2	6.2	6.2 (7.2)	6.6 (7.6)	5.3 (6.1)
3	6.6	7.1 (7.8)	5.9 (6.5)	5.9 (6.5)
4	6.6[a]	6.1 (6.6)	5.9 (6.4)	5.7 (6.2)
5	6.8	6.5 (7.0)	6.3 (6.8)	6.2 (6.7)
6	6.8	5.9 (6.8)	6.0 (6.9)	5.7 (6.6)
7	6.6	5.7 (6.1)	6.0 (6.4)	5.5 (5.8)
8	6.4	6.1 (7.2)	5.8 (6.8)	5.5 (6.5)
9	6.4[b]	5.5 (6.5)	6.5 (7.6)	5.9 (6.9)
10	6.9	6.2 (6.9)	6.0 (6.7)	6.6 (7.4)
11	6.9	6.6 (7.1)	6.3 (6.8)	6.3 (6.8)
12	6.9	6.3 (7.4)	6.3 (7.4)	6.6 (7.8)
13	6.9	6.6 (7.0)	6.3 (6.7)	6.3 (6.7)
14	6.9	6.2 (7.2)	6.4 (7.4)	6.2 (7.2)
Avg. diff. (Corrected Value - Target Value) Absolute Value		(0.39)	(0.44)	(06.7)
Standard Error of the Difference		(0.3)	(0.3)	(0.3)

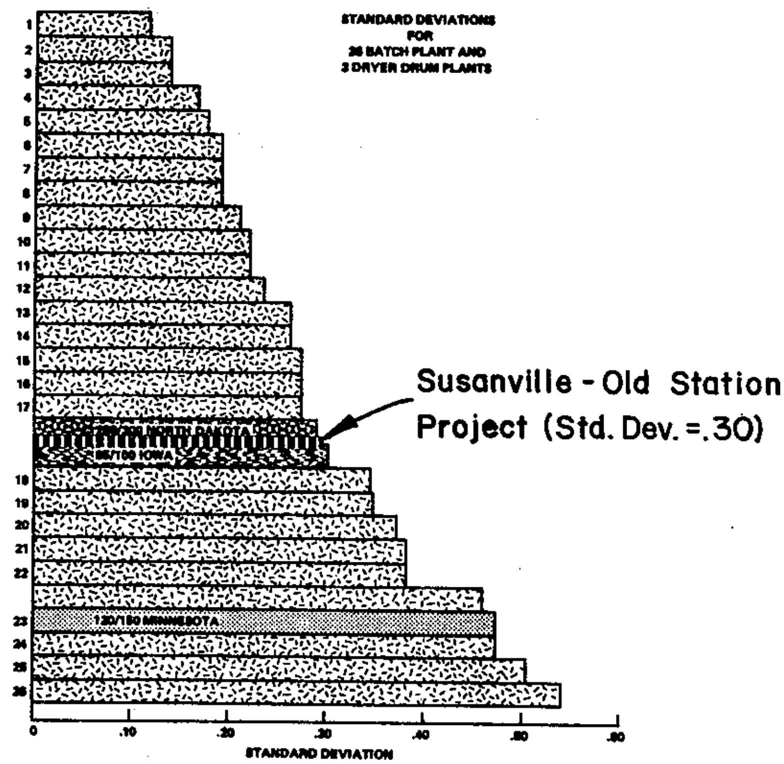
a: Sample No. 4 from Road may have had a target value of either 6.6 or 6.8%

b: Sample No. 9 from Road probably had a target value of 6.9%

*: Values in brackets are corrected for aggregate retention throughout the extraction process (see text).

Figure 8

STANDARD DEVIATIONS FOR ASPHALT CONCRETE PLANTS
(26 Batch Plants and 3 Dryer Drum Mixing Plants)



Asphalt Content

*Chart from September 1973 issue of "Public Roads".

TABLE 6

ASPHALT PENETRATION

SUSANVILLE-OLD STATION

Sample No.	Original Asphalt From Tank	Abson Recovery Residues: From Truck At Plant	Abson Recovery Residues: From Street During Paving	Abson Recovery Residues: From Core 80-103 Days After Paving
1	136	146	151	78
2	---	121	151	78
3	138	136	147	82
4	---	142	132	83
5	137	142	140	78
6	132	121	128	85
7	127	152	162	92
8*	132	137	119	85
9*	---	109	125	80
10*	128	107	132	83
11	132	118	144	92
12	---	135	124	88
13	---	131	122	90
14	128	---	120	95
"Standard" Average	133	134	138	86
Standard Error	4	12	14	6
Penetration Retained	---	101%	104%	65%
"Douglas" Average	130	118	125	83
Standard Error	3	17	7	3
Penetration Retained		91%	96%	64%

*"Douglas" 120-150 pen. asphalt. All other samples are "Standard" 120-150 pen. asphalt.

TABLE 7

ABSOLUTE VISCOSITY OF ASPHALT (140°F)

SUSANVILLE-OLD STATION

Sample No.	Original Asphalt Sample	Rolling Thin Film Residue From Original Asphalt	Abson Recovery Residues: From Truck At Plant	From Street During Paving	From Core 80-103 Days After Paving
1	811	1785	678	614	1677
2	- -	- -	917	732	1849
3	772	1656	856	884	1714
4	- -	- -	808	876	1543
5	796	2116	788	809	1899
6	826	1749	1004	906	1482
7	847	2075	835	770	1535
8*	1150	4644	1230	1821	2633
9*	- -	- -	1892	1651	2895
10*	1123	3620	1687	1320	2325
11	790	2048	1002	820	1576
12	- -	- -	892	985	1481
13	- -	- -	968	1034	1500
14	778	2048	- -	932	1387
"Standard" Average	803	1925	875	851	1604
Standard Error	27	188	103	119	162
"Douglas" Average	1136	4132	1603	1597	2618
Standard Error	19	724	339	255	285

*Douglas 120-150 pen. asphalt. All other samples are Standard 120-150 pen. asphalt

Visual inspection of the A.C. mix indicated that the aggregate was properly coated with asphalt, and the mix behaved in a normal fashion in the placing and rolling operations.

Compaction and finish rolling was performed by the same vibratory and static rollers used in the first project. The relative compaction results averaged 92 percent, which is considered substandard (Table 8). These low compaction values were attained despite improved operation of the vibratory roller, a problem that was evident on the first project. The roller's required vibration frequency and amplitude were checked often. The required maximum speed of the paver and number of passes may not always have been adhered to, however. The low compaction could, therefore, be attributed to one or more of three factors: (a) improper operation of the vibratory roller, (b) lower-than-conventional mix temperatures, and (c) lower moisture content in the completed mix than anticipated in the dryer-drum process.

The exhaust stack emitted billowing clouds of dust despite the built-in cyclone collector. Consequently, the contractor erected a water-scrubber on the stack on October 9, 1973. The water-scrubber emitted a substantial quantity of steam, and necessitated the creation of a settling pond for the effluent, but was successful in trapping the majority of the dust. The resulting opacity, as checked by Lassen County Air Pollution Control District officials, was improved from 80 percent to an acceptable 5 percent or less (Figures 9 and 10).

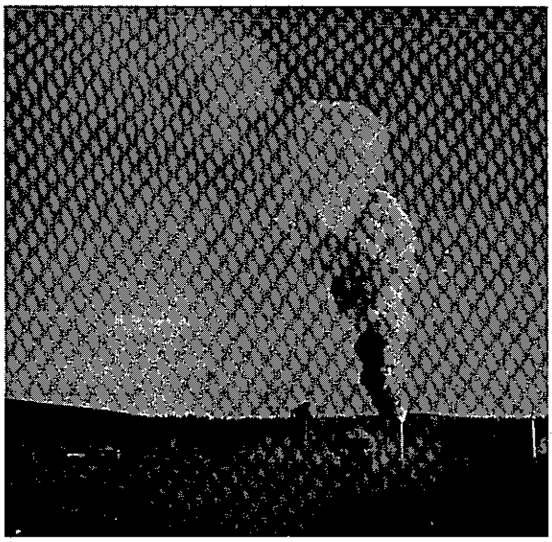


Figure 9

Steam Emitted by Water-Scrubber at the Susanville-Old Station Project

TABLE 8

DENSITY OF AC (lbs/ft^3)

SUSANVILLE-OLD STATION

Sample No.	From Truck At Plant (Laboratory Compaction)	From Street During Paving (Laboratory Compaction)	From Street During Paving (Nuclear Gauge)	From Core 80-103 Days After Paving (Lab re-Compact)	From Core 80-103 Days After Paving (Density as Rec'd.)
1	141	141	125	142	134
2	142	142	129	140	131
3	145	141	130	143	134
4	143	141	132	144	136
5	143	143	128	144	134
6	143	142	131	142	135
7	142	142	134	143	139
8	142	142	130	143	134
9	143	144	133	144	139
10	143	144	129	144	137
11	142	143	136	144	138
12	143	142	132	144	137
13	143	143	133	145	138
14	142	143	136	145	139
Average	143*	142	131	143	136
Standard Error	1	1	3	1	2
Relative Compaction			91.6%		95.1%

*Value used for 100% compaction as per Calif. Test Method 304

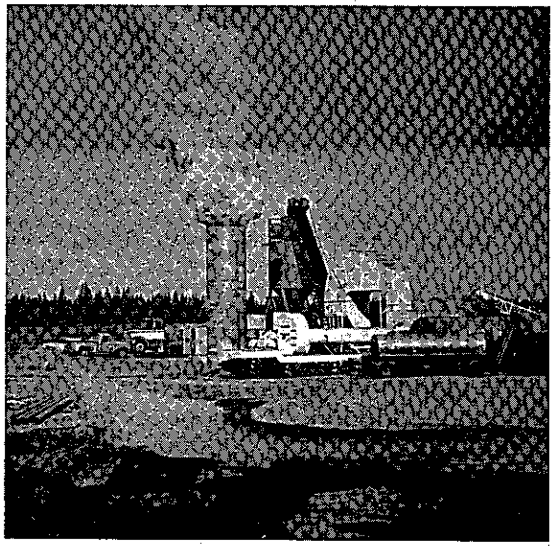


Figure 10

Plant in Operation, with the Settling Pond of Scrubber Effluent in the Foreground. The Discharge Line of Still-Steaming Effluent is Visible at the Bottom of the Stack.

Subsequent visual inspection of the pavement revealed that the A.C. overlay was in good condition after approximately 9 months' traffic which included some chain traffic. Further coring and inspection will be accomplished.

Effects of Diesel-Oil Contamination of Asphalt

A laboratory study was conducted in order to verify the assumption that the softening of the asphalt was due to contamination by unburned diesel oil. Samples of "Standard" 120-150 penetration asphalt from the second project were mixed with varying small quantities of the same diesel oil which fueled the burner. Each sample was then subjected to the Abson recovery process and the recovered asphalt again tested for penetration. The results, shown on Table 9, indicate that the Abson process does not remove all of the diesel fuel. This reinforces the assumption that contamination was indeed occurring in the A.C. mix.

TABLE 9

LABORATORY-CONTAMINATED SAMPLES OF ASPHALT*

Percent Diesel	Penetration at 77°F After Abson Recovery
0	116
0.5	122
1.0	131
2.0	163
5.0	218

*Original (uncontaminated) sample penetration at 77°F = 126

Iron Mountain Road - U.S.F.S.

During this study, an opportunity to sample a dryer-drum mixing plant of different manufacture and using different burner fuels presented itself. The U. S. Forest Service was in the process of overlaying a two-lane road using A.C. produced by the dryer-drum mixing process. The plant was manufactured by the Boeing Construction Equipment Company. Because of time limitations and considerable plant operation difficulties, inspection and sampling was brief. The major item of interest was that the burner fuel was being changed from No. 2 diesel oil to propane gas during the operation, depending on available supplies. Since propane gas could not contaminate the asphalt, this presented an opportunity to sample A.C. produced with a plant using both burner fuels and study the effect, if any, of the burner fuel on the A.C. mix produced.

Inspection and sampling was conducted on September 27, 1973 when propane was used, and on October 31, 1973 when No. 2 diesel was used.

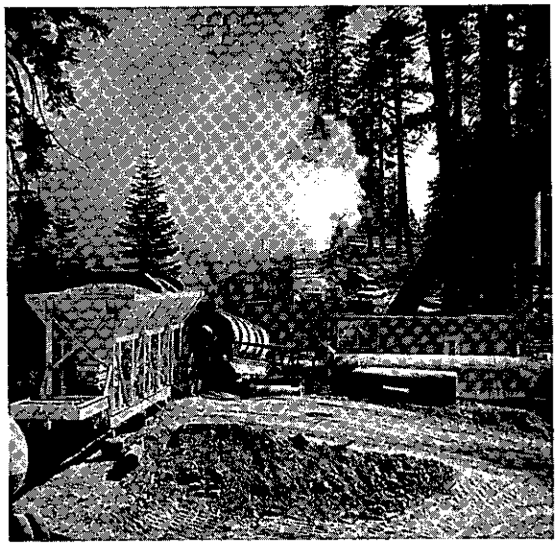


Figure 11

The Dryer-Drum Plant Operating at Iron Mountain, Calif.

The penetration test results, shown in Table 10, indicate that the asphalt had hardened an average of 29 percent using propane and 27 percent using diesel fuel. These values are only slightly less than those encountered in conventionally-produced A.C., indicating that diesel fuel contamination was not taking place. It is important to view these indications with some skepticism, however, partly because of the very limited sample size and partly because the contractor was producing a mix at relatively high temperatures -- varying from 255° to 280°F at the plant -- as opposed to 214° and 241°F for the two California State projects. A characteristic bluish-white smoke emitted by the stack indicated a loss of volatiles. The stack also emitted considerable amounts of dust, partly because of the nature of the aggregate stockpile and also because no cyclone dust collector or water-scrubber was used. The opacity of the emissions was not measured but was judged to be very dense (similar to the CMI plant without the water-scrubber).

TABLE 10

ASPHALT PENETRATION

IRON MOUNTAIN ROAD

	Original Asphalt	Abson Recovery Residues	
Sample No.	From Tank	From Belt Feed at Plant	From Street During Paving
1*	177	126	---
2*	- -	127	126
3	131	86	---
4	- -	99	---
5	- -	102	---
6	132	---	---
Average "Propane"	177	126	126
Average "Diesel"	132	96	---
Penetration Retained "Propane"		71%	
Penetration Retained "Diesel"		73%	

*Samples 1 and 2 were produced using propane-fueled burner; Samples 3 through 6 were produced using diesel-fueled burner. (Except for the fuel, all equipment was the same.)

REFERENCES

1. William L. Allen, Jr., "Producing Asphalt Concrete Mixtures by the Dryer-Drum Mixing Method", Federal Highway Administration, Olympia, Washington, April 28, 1971.

2. C. T. Keasey, "Asphalt Concrete Production By the Dryer-Drum Mixer Process in Oregon", Oregon State Highway Division, Salem, Oregon, 1973.

3. Edwin C. Granley and Robert E. Olsen, "Progress Report on Dryer-Drum Process for Producing Bituminous Concrete Mixes", Public Roads, September, 1973.

4. Ronald L. Terrell and Emory S. Richardson, "Asphalt Paving Mixtures Produced by the Dryer-Drum Process", Federal Highway Administration, Vancouver, Washington, August, 1972.

5. Edwin C. Granley, "The Dryer-Drum Process for Producing Bituminous Concrete Mixes", Federal Highway Administration, Washington, D. C., November 28, 1972.

Dryer-Drum Mixing Plant Description

The plant was built by the CMI Corporation and referred to by them as a "turbulent mass plant". The drum was 9 ft. x 32 ft. and produced A.C. mix during the times it was observed at a rate of 300-400 tons per hour. The maximum capacity was stated by the manufacturer to be considerably higher. The asphalt was discharged inside the drum approximately 12 feet from the burner. No additives were used for the asphalt concrete mixes for these California projects.

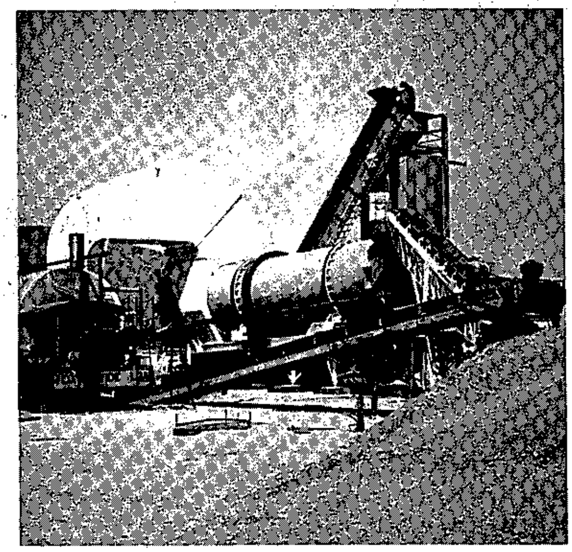


Figure 12

View of the Dryer-Drum Mixing Plant Showing, From Left, the Asphalt Tank, Cyclone Dust Collector, Drum, and Aggregate Feed Belt. The Belt in the Foreground Carries Return Fines From the Cyclone. The A.C. Drag Flight Conveyor to the Surge Hopper is Visible in the Background.

Aggregate for the projects was transferred from the stockpiles to the bins by means of front-end loaders. Two bins contained the fines, one for the natural and one for the crushed, and the two remaining bins were used for the coarse material.

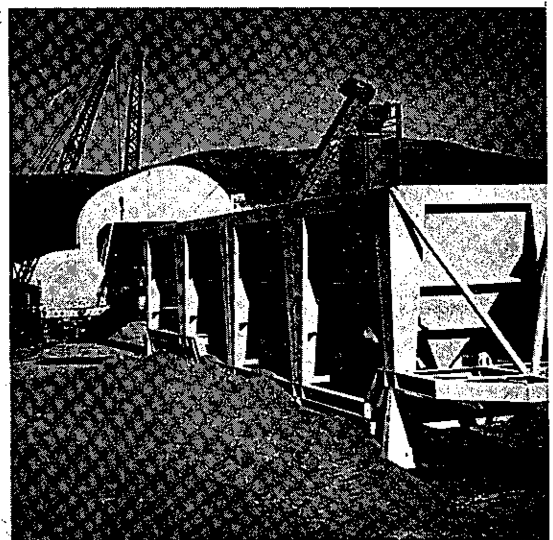


Figure 13

Multiple Hopper Arrangement for Aggregate Feed

This was the only form of gradation control (segregating by size) throughout the entire proportioning and mixing operation. Of course, the aggregate gradation for each bin was highly sensitive to the uniformity of the pre-segregated stockpiles and care in charging by the loader operator. Once the material was combined from these bins it was fed directly to the dryer-drum mixer.

To obtain the combined gradation and rate of flow, electronically-controlled feeder belts driven by D.C. motors were utilized on each bin (Figure 14).

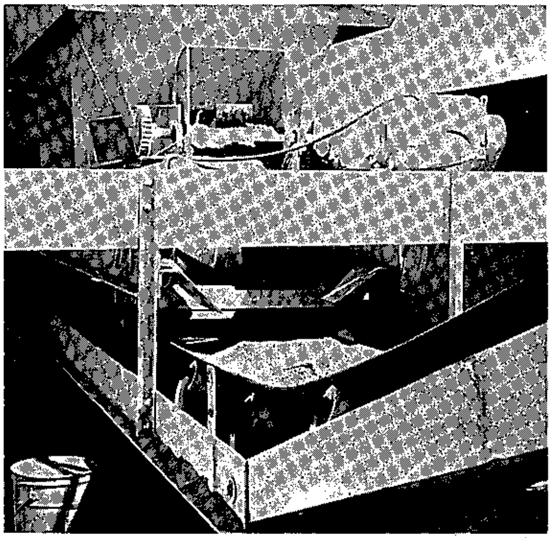


Figure 14

Feeder Belt Detail Showing the D.C. Motor, Gate, and Main Feed Belt at Bottom

The D.C. motor was regulated by a rheostat which in turn drove the short (feeder) belt beneath each bin. The speed of these belts regulated the amount of material taken from each bin. Figure 15 shows a detail of the system.

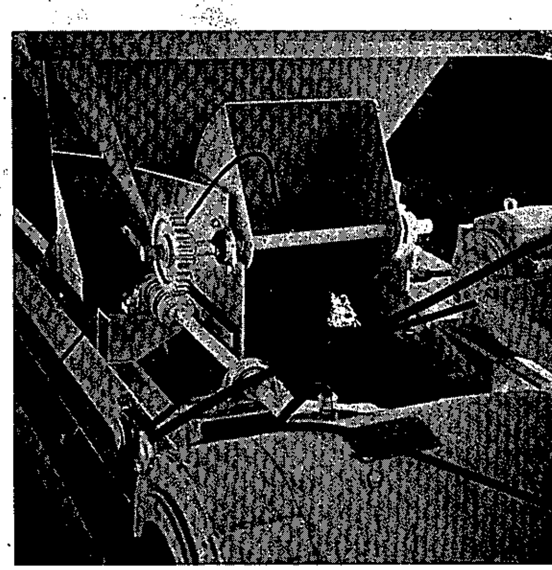


Figure 15

Detail of Electronically-Controlled Aggregate Feed Mechanism

The circular gate device was equipped with a switch which shuts down the entire material input to the plant should any one bin become empty.

The device used to calibrate each rheostat, and consequently the belt speed and material quantity, was also used to control the total volume of material or plant production (Figure 16).

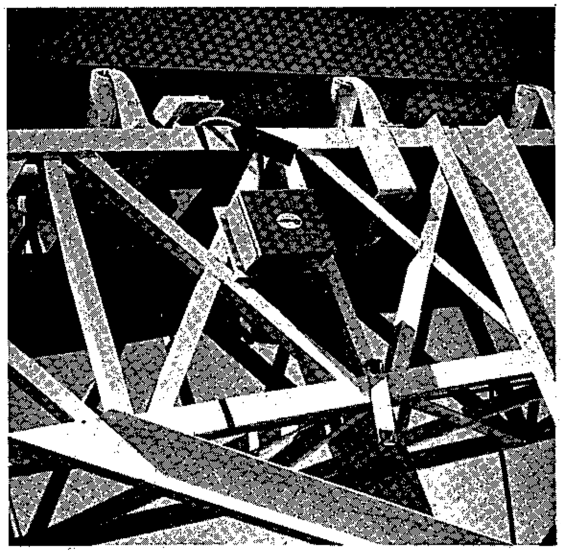


Figure 16

Aggregate Weight Sensor (Arrow) on the Combined Aggregate Feed Belt

An electronic sensing device continuously measured the weight of the material on the main cold-feed belt to the dryer-drum. When the plant first begins operating at a job location, the percentage of material from each bin can be regulated and rheostats calibrated by running material over the belt from each bin, one at a time. The electronic scale is also electronically linked to the metered pump (Figure 17) which regulates the percentage of asphalt added to the mix.

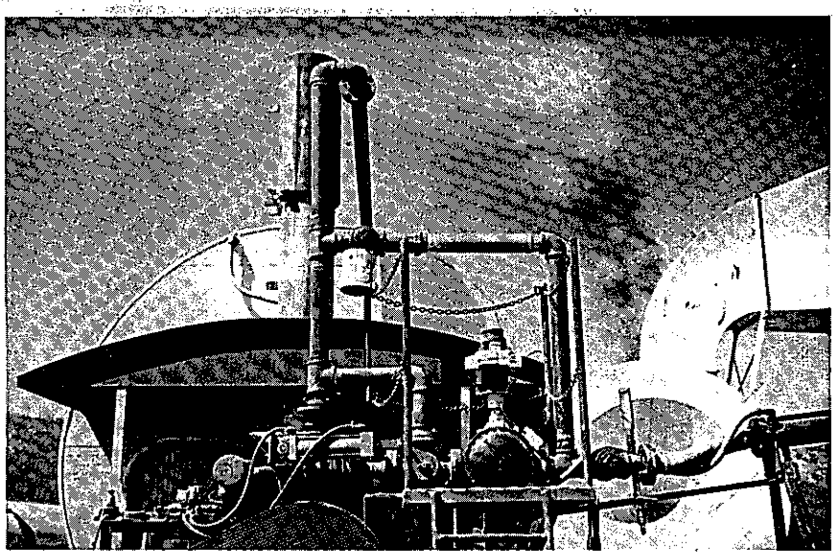


Figure 17

Asphalt Pump and Metering System

The combined aggregate is weighed with the moisture present. This is compensated for by manual controls set for a known moisture content. It is imperative, then, that the amount of moisture in the stockpile remains relatively constant and/or is checked frequently.

The dryer-drum mixer is heated by a conventional type burner (Hauck) that can operate on either diesel or liquefied gas fuels (Figure 18). The drum is 9 feet in diameter and 32 feet long (Figure 19).

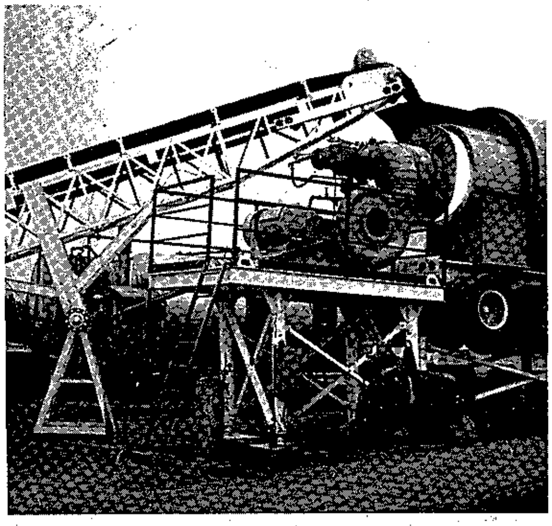


Figure 18

Burner in Operation. Combined Aggregate Delivery is Visible Above Burner

The plant was equipped with a surge hopper of 100-ton capacity (Figure 19). The drag conveyor-belt elevated the mix to a batching mechanism at the top of the hopper to avoid segregation of the mixture.

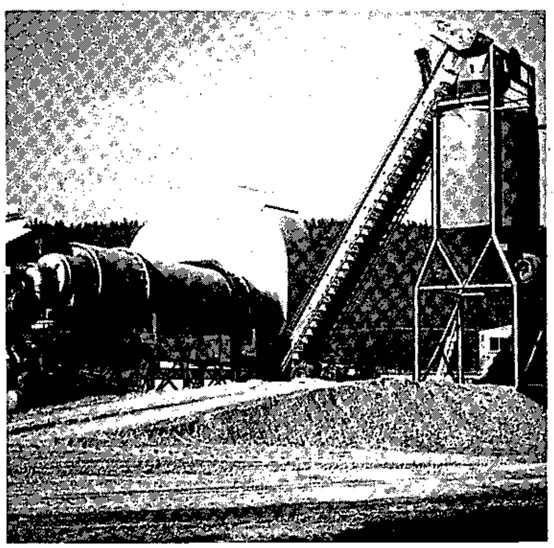


Figure 19

Dryer-Drum with Dust Cyclone at Rear. At Right is 100-Ton Surge Hopper and Drag Conveyor Belt

The internal configuration (baffles) for this particular plant is shown in Figure 20. The asphalt concrete mixing time (as per the manufacturer's representative) was 2-1/2 to 3 minutes. The temperature of the mix at discharge varied for both projects, but the range of the majority of the mix was between 220°F and 250°F.

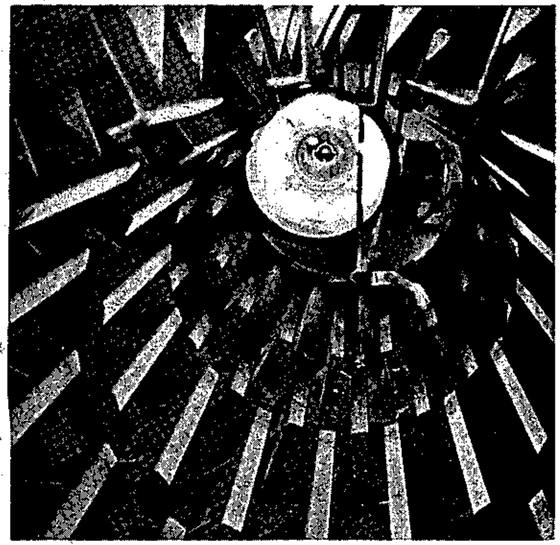


Figure 20

Interior of Drum Looking Toward Burner. Note Internal Baffle Arrangement and Asphalt Discharge (Arrow).

The dust-collection system used initially consisted of a cyclone collector (Figure 21). The collected fines were then returned via conveyor-belt onto the main feed belt, and thus back into the dryer-drum mixer. Smoke and suspended fines were carried to the exhaust stack. During the project, a water-scrubber tower was erected around the exhaust stack to trap the suspended fines and thus meet pollution control requirements (Figure 22).

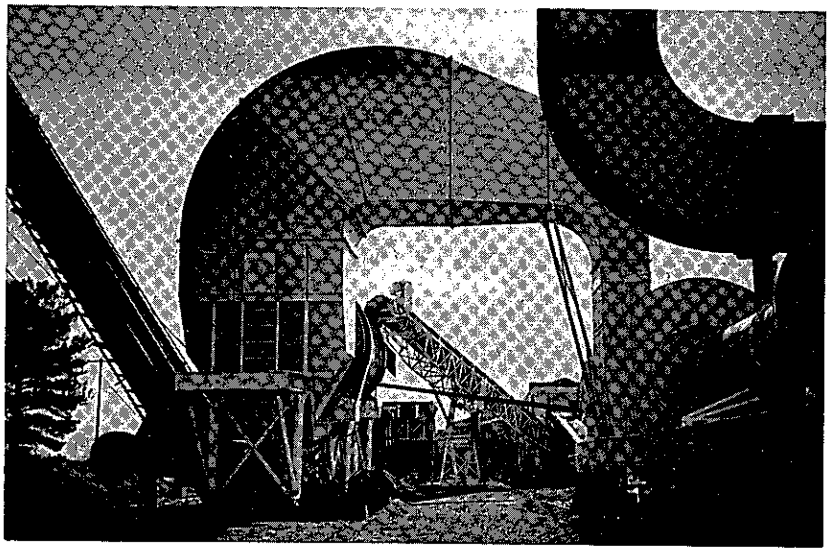


Figure 21

Intake Duct Carrying Smoke and Dust to the Cyclone Collector at Right. The Exhaust Stack is at Upper Foreground.

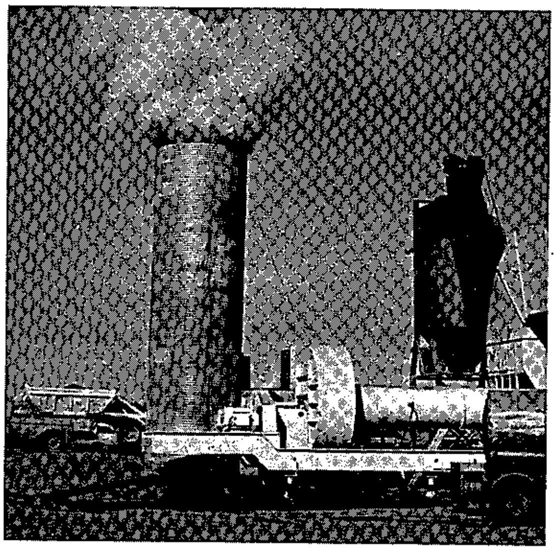


Figure 22

Water-Scrubber Attached to the Exhaust Stack

APPENDIX B

List of Test Methods

Aggregate:

Gradation	Calif. Test Method 202
Xylene Reflux Moisture	Calif. Test Method 311

Asphalt:

Penetration	AASHTO T-49
Absolute Viscosity	AASHTO T-202
Rolling Thin Film Test	AASHTO T-240

Asphalt Concrete:

Abson Recovery	AASHTO T-170
Extraction	Calif. Test Method No. 310
Kneading Compaction	Calif. Test Method No. 304
Density (Nuclear Gauge)	Calif. Test Method No. 913
Density (of core sample)	Calif. Test Method No. 308

APPENDIX C

<u>Paving Equipment Used in the California State Projects</u>

Paver: Blaw-Knox PF 180

Breakdown Roller: Vibro-Plus CC50-A vibratory

Finishing Roller: Galion 10-ton tandem

Method: Windrowing AC ahead of paver

APPENDIX D

AC Test Results: Macdoel

TEST NO.	DATE	TIME	TYPE AND LOCATION OF SAMPLE	AIR TEMP °F	SAMPLE TEMP. °F	DENSITY (NUCLEAR)	DENSITY (RE-COMPACT)	DENSITY (CORE)	VOIDS, %	ASPHALT, %	STABILOMETER	PENETR. (ABSON RESIDUE)	ABS. VISCOSITY, 140°F	MOISTURE, %	AGGREGATE GRADATION (% PASSING) 3/4	1/2	3/8	#4	#8	#30	#200
732321	8-28-73	10:35	AC AT PLANT	68	210		137		6.6	6.2	42	139		0.9	100	84	69	53	42	23	5
732317	"	10:50	AC P.M. 37.91 SBL	68	205	132	138		5.6	6.2	42	140		0.9	100	84	67	51	39	23	4
732329	9-12-73		AC " (CORE)				137	134	8.6	5.7	40	112	877		100	81	67	49	37	22	5
732314	8-28-73	14:10	AC AT PLANT	76	210		138		5.8	6.0	42	116		1.2	100	83	67	53	40	21	3
732311	"	14:30	AC P.M. 39.24 SBL	81	210	134	137		6.0	5.9	44	110		1.0	100	80	64	51	40	22	5
732330	9-12-73		AC " (CORE)				139	137	6.7	6.0	43	101	946		100	82	68	52	41	23	6
732316	8-28-73	15:50	AC AT PLANT	80	210		137		7.2	6.1	44	116		0.6	100	89	72	56	40	23	5
732315	"	16:30	AC P.M. 39.86 SBL	82	204	130	139		5.7	5.9	40	112		1.5	100	84	67	51	39	23	5
732331	9-12-73		AC " (CORE)				139	136	7.6	6.3	36	95	1012		100	83	72	55	45	24	6
732322	8-29-73	09:40	AC AT PLANT	63	225		137		6.2	6.7	44	108		0.9	100	80	70	56	43	26	4
732323	"	10:00	AC P.M. 38.46 NBL	63	215	131	137		7.1	6.7	46	130		1.3	100	87	75	64	50	29	6
732332	9-12-73		AC " (CORE)				136	135	4.3	6.5	41	95	1045		100	84	74	61	48	29	6
732320	8-29-73	11:55	AC AT PLANT	76	205		137		6.7	6.2	40	110		1.9	100	82	65	51	39	22	6
732324	"	12:25	AC P.M. 39.96 NBL	-	200	134	137		6.5	6.1	43	150		1.1	100	81	67	52	40	23	5
732333	9-12-73		AC " (CORE)				137	138	6.0	5.9	45	77	1418		100	83	68	53	41	25	8

APPENDIX D

AC Test Results: Macdoel (cont.)

TEST NO.	DATE	TIME	TYPE AND LOCATION OF SAMPLE	AIR TEMP °F	SAMPLE TEMP. °F	DENSITY (NUCLEAR)	DENSITY (RE-COMPACT)	DENSITY (CORE)	VOIDS, %	ASPHALT, %	STABILOMETER	PENETR. (ABSON RESIDUE)	ABS. VISCOSITY, 140°F	MOISTURE, %	AGGREGATE GRADATION (% PASSING) 3/4	1/2	3/8	#4	#8	#30	#200
732318	8-29-73	15:00	AC AT PLANT	84	220		137		6.9	6.3	38	132		1.3	100	85	69	56	42	24	5
732313	"	15:35	AC P.M. 39.96 SB Shoulder	84	205	128	138		6.3	5.7	46	116		0.7	100	74	60	48	37	22	4
732334	9-12-73		AC " (CORE)				135	134	8.8	6.2	45	86	1350		100	80	66	53	41	24	5
732319	8-30-73	09:30	AC AT PLANT	61	215		136		6.9	6.6	40	126		1.5	100	84	72	56	43	25	4
46869	"	"	" (RUSHED TO LAB)	61	215		134		-	6.2	36	131		-	100	68	68	54	41	23	3
732312	"	09:55	AC P.M. 38.84 SB Shoulder	65	210	128	137		6.4	6.0	48	116		1.2	100	81	67	50	38	23	4
732335	9-12-73		AC " (CORE)				138	134	8.2	6.3	40	87	1133		100	85	68	53	41	24	6

APPENDIX D

Aggregate Test Results: Macdoel

TEST NO.	DATE	TIME	AIR TEMP. °F	SAMPLE TEMP. °F	MOISTURE, %	SAND EQUIVALENT	GRADATION (% PASSING) 3/4	1/2	3/8	#4	#8	#30	#200
731627	8-28-73	10:20	68	65	4.4	57	100	87	74	54	46	30	6
731628	"	12:25	70	70	4.2	59	100	84	70	55	41	23	5
731629	"	15:20	80	72	4.1	53	100	87	70	55	43	25	6
731630	8-29-73	09:25	63	64	4.6	56	99	88	74	63	49	29	8
731631	"	14:30	83	74	5.9	45	100	82	63	49	37	23	5
731625	"	14:45	86	75	–	49	100	82	66	50	37	21	4
731632	8-30-73	08:40	61	64	4.6	50	100	87	76	57	44	27	6

APPENDIX D

Asphalt Test Results: Macdoel

TEST NO.	DATE	TIME	AIR TEMP. °F	SAMPLE TEMP. °F	PENETR. (ORIG. SAMPLE)	ABS. VISC. 140°F (R.T.F.)	ABS. VISC. 140°F (ORIG.)
1422	8-28-73	09:35	68	325	90	1920	
1423	"	15:30	80	-	86	1994	
1421	8-29-73	14:10	-	-	86	1877	
1420	8-30-73	09:10	-	-	86	1822	

APPENDIX E

AC Test Results: Susanville - Old Station

TEST NO.	DATE	TIME	TYPE AND LOCATION OF SAMPLE	AIR TEMP °F	SAMPLE TEMP. °F	DENSITY (NUCLEAR)	DENSITY (RE-COMPACT)	DENSITY (CORE)	VOIDS, %	ASPHALT, %	STABILOMETER	PENETR. (ABSON RESIDUE)	ABS. VISCOSITY, 140°F	MOISTURE, %	AGGREGATE GRADATION (% PASSING) 3/4	1/2	3/8	#4	#8	#30	#200
732346	9-18-73	08:55	AC AT PLANT	52	235		141		7.8	5.1	48	146		0.5	100	96	82	57	40	21	8
732346	»	09:45	AC P.M. 65.6 EBL	63	230	125	141		6.8	5.6	46	151		0.6	100	96	82	55	39	21	8
742 11	1-29-74		AC » (CORE)				142	134	11.7	6.2	44	78	1677		100	100	87	64	48	24	9
732371	9-18-73	10:55	AC AT PLANT	61	250		142		5.6	6.2	44	121		0.5	100	94	80	55	39	21	7
732372	»	11:35	AC P.M. 64.6 EBL	70	230	129	142		5.5	6.6	45	151		0.7	100	94	82	59	43	22	6
742 10	1-29-74		AC » (CORE)				140	131	14.4	5.3	42	78	1849		100	98	84	64	49	26	9
732373	9-18-73	14:25	AC AT PLANT	70	235		145		2.6	7.1	28	136		0.4	100	93	81	58	43	23	8
732374	»	14:50	AC 150' W. of P.M. 63.7 EBL	70	220	130	141		6.5	5.9	46	147		0.4	100	95	80	57	42	21	7
742 9	1-29-74		AC » (CORE)				143	134	11.3	5.9	51	82	1714		100	96	83	59	44	23	8
732375	9-19-73	08:10	AC AT PLANT	56	245		143		4.5	6.1	43	142		0.6	100	91	70	48	36	19	7
732376	»	08:35	AC P.M. 66.5 EBL	59	205	132	141		6.6	5.9	48	132		0.6	100	92	77	55	41	20	5
742 12	1-29-74		AC » (CORE)				144	136	10.0	5.7	43	83	1543		100	94	79	55	41	22	8
732377	9-19-73	10:00	AC AT PLANT	59	220		143		4.2	6.5	44	142		0.7	100	94	79	57	43	21	8
732378	»	10:35	AC P.M. 67.5 EBL	68	220	128	143		4.9	6.3	44	140		0.9	100	97	81	57	42	20	6
742 14	1-29-74		AC » (CORE)				144	134	11.7	6.2	40	78	1899		100	97	82	64	48	26	10

APPENDIX E

AC Test Results: Susanville - Old Station (cont.)

TEST NO.	DATE	TIME	TYPE AND LOCATION OF SAMPLE	AIR TEMP °F	SAMPLE TEMP. °F	DENSITY (NUCLEAR)	DENSITY (RE-COMPACT)	DENSITY (CORE)	VOIDS, %	ASPHALT, %	STABILOMETER	PENETR. (ABSON RESIDUE)	ABS. VISCOSITY, 140°F	MOISTURE, %	AGGREGATE GRADATION (% PASSING) 3/4	1/2	3/8	#4	#8	#30	#200
732379	9-19-73	13:30	AC AT PLANT	69	285		143		5.7	5.9	44	121		0.4	100	95	81	61	44	21	7
732380	"	13:55	AC P.M. 66.9 WBL	74	235	131	142		5.8	6.0	43	128		0.6	100	92	80	60	44	22	8
742 13	1-29-74		AC " (CORE)				142	135	11.1	5.7	46	85	1482		100	92	80	60	48	23	9
732347	9-20-73	08:50	AC AT PLANT	50	230		142		6.1	5.7	48	152		0.7	100	95	79	56	40	21	8
732356	"	09:15	AC P.M. 68.3 WBL	53	240	134	142		6.0	6.0	44	162		0.4	100	96	79	58	43	21	8
742 15	1-29-74		AC " (CORE)				143	139	9.1	5.5	45	92	1535		100	94	85	63	49	24	8
732451	10-10-73	09:05	AC AT PLANT	-	250		142		5.5	6.1	47	137	1230	0.4	100	95	78	55	40	20	7
732452	"	10:10	AC P.M. 24.5 EBL	47	235	130	142		5.1	5.8	50	119	1821	0.4	100	93	76	48	35	19	7
742 16	1-30-74		AC " (CORE)				143	134	11.1	5.5	51	85	2633		100	91	74	49	37	20	7
732453	10-10-73	11:15	AC AT PLANT	58	275		143		4.8	5.5	46	109	1892	0.3	100	93	72	45	33	18	7
732454	"	12:10	AC 150' W. of P.M. 25.3 EBL	62	255	133	144		4.0	6.5	42	125	1651	0.3	100	92	78	56	42	22	7
742 18	1-30-74		AC " (CORE)				144	139	7.2	5.9	-	80	2895		100	90	74	52	40	22	8
732455	10-10-73	15:05	AC AT PLANT	63	-		143		4.6	6.2	42	107	1687	0.6	100	90	75	52	39	20	7
732456	"	16:00	AC P.M. 25.1 WBL	60	225	129	144		4.5	6.0	42	132	1320	0.5	100	93	78	54	40	20	7
742 17	1-30-74		AC " (CORE)				144	137	8.7	6.6	-	83	2325		100	95	81	59	44	23	10

APPENDIX E

AC Test Results: Susanville – Old Station (cont.)

TEST NO.	DATE	TIME	TYPE AND LOCATION OF SAMPLE	AIR TEMP °F	SAMPLE TEMP. °F	DENSITY (NUCLEAR)	DENSITY (RE-COMPACT)	DENSITY (CORE)	VOIDS, %	ASPHALT, %	STABILOMETER	PENETR. (ABSON RESIDUE)	ABS. VISCOSITY, 140°F	MOISTURE, %	AGGREGATE GRADATION (% PASSING) 3/4	1/2	3/8	#4	#8	#30	#200
732443	10-11-73	09:10	AC AT PLANT	41	250		142		6.0	6.6	46	118	1002	0.4	100	98	88	66	49	25	8
732444	"	09:45	AC P.M. 26.1 EBL	43	250	136	143		5.4	6.3	45	144	820	0.4	100	98	86	61	45	24	8
742 19	1-30-74		AC " (CORE)				144	138	8.4	6.3	42	92	1576		100	99	88	64	48	26	9
732445	10-11-73	10:30	AC AT PLANT	55	240		143		-	6.3	45	135	892	0.5	100	96	86	63	49	25	8
732446	"	11:15	AC 150' W. of P.M. 26.6 EBL	56	220	132	142		5.7	6.3	46	124	985	-	100	95	84	61	46	23	8
742 21	1-30-74		AC " (CORE)				144	137	9.0	6.6	37	88	1481		100	93	82	64	48	25	9
732447	10-11-73	12:20	AC AT PLANT	59	245		143		5.0	6.6	44	131	968	0.4	100	97	87	64	48	24	8
732448	"	13:05	AC 250' W of P.M 27.2 EBL	59	240	133	143		5.3	6.3	47	122	1034	0.5	100	93	84	60	44	23	8
742 22	1-30-74		AC " (CORE)				145	138	8.6	6.3	43	90	1500		100	97	84	62	46	24	9
732449	10-11-73	14:15	AC AT PLANT	59	230		142		5.7	6.2	48	122	1009	0.6	100	96	85	58	44	23	8
732450	"	15:00	AC P.M. 26.1 WBL	63	220	136	143		5.1	6.4	46	120	932	0.5	100	94	84	64	49	25	8
742 20	1-30-74		AC " (CORE)				145	139	7.8	7.8	-	95	1387		100	96	86	64	49	26	10

APPENDIX E

Aggregate Test Results: Susanville-Old Station

TEST NO.	DATE	TIME	AIR TEMP. °F	SAMPLE TEMP. °F	MOISTURE, %	SAND EQUIVALENT	GRADATION (% PASSING) 3/4	1/2	3/8	#4	#8	#30	#200
731672	9-18-73	08:15	46	60	3.6	56	100	96	86	67	52	27	7
731673	"	10:40	61	64	3.9	59	100	97	87	68	58	30	7
731674	"	"	61	64	3.3	63	100	96	82	57	42	22	7
731675	"	13:30	68	66	2.9	62	100	96	83	61	47	23	7
731676	9-19-73	08:00	56	62	3.6	56	100	95	83	64	49	24	8
731677	"	09:45	62	62	3.8	65	100	96	83	62	47	23	6
731678	"	13:25	69	67	3.9	55	100	96	86	68	51	24	7
731679	9-20-73	08:30	46	56	4.5	63	100	95	84	63	49	25	7
731713	10-10-73	08:35	30	51	3.2		100	93	75	47	35	20	6
731714	"	11:00	50	56	3.1		100	94	77	51	38	19	7
731715	"	14:50	62	62	3.2		100	95	83	57	41	21	7
731716	10-11-73	08:55	41	54	3.6		100	97	89	64	48	25	7
731717	"	10:20	49	59	4.0		100	97	85	59	45	23	7
731718	"	12:05	56	60	4.6		100	99	96	82	66	37	9
731719	"	13:50	57	62	3.8		100	96	88	65	50	25	8

APPENDIX E

Asphalt Test Results: Susanville - Old Station

TEST NO.	DATE	TIME	AIR TEMP. °F	SAMPLE TEMP. °F	PENETR. (ORIG. SAMPLE)	ABS. VISC. 140°F (R.T.F.)	ABS. VISC. 140°F (ORIG.)	PRODUCER
7311677	9-18-73	08:30	48	290	136	1785	811	STANDARD
7311678	"	13:55	68	305	138	1656	772	"
7311679	9-19-73	09:30	63	305	137	2116	796	"
7311680	"	13:15	69	305	132	1749	826	"
7311681	9-20-73	08:30	46	300	127	2075	847	"
7311926	10-10-73	08:50	30	330	132	4644	1150	DOUGLAS
7311927	"	14:50	-	-	128	3620	1123	"
7311928	10-11-73	08:55	41	290	132	2048	790	STANDARD
7311929	"	13:50	57	300	128	2048	778	"

APPENDIX F

AC Test Results: Iron Mountain Rd.

Test No.	Date	Time	Type and Location of Sample	Air Temp °F	Sample Temp °F	Density (Nuclear)	Density (Re-Compact)	Density (Core)	Voids, %	Asphalt, %	Stabilometer	Penetr. (Abson Residue)	Abs. Viscosity, 140°F	Moisture, %	Aggregate Gradation (% Passing) 3/4	1/2	3/8	#4	#8	#30	#200
732399	9-27-73	10:55	AC AT PLANT	70	270		151			4.5	46	126	1218	0.1	100	83	73	58	46	29	8
732401	"	"	AC "	70	255		151			4.6	41	127	1770	0.1	96	78	66	52	41	25	7
732400	"	11:45	AC FROM PAVER HOPPER	76	225		152			4.5	42	126	1403	0.1	100	80	68	57	46	28	9
732495	10-31-73	10:00	AC AT PLANT	-	280		151			4.4	46	86	2369	.04	100	89	75	52	41	24	7
732496	"	12:10	AC "	63	280		151			4.6	46	99	2426	.05	100	90	70	52	40	24	7
732497	"	13:20	AC "	62	260		150			4.8	46	102	2104	.05	100	89	75	58	43	26	7
732498	"	14:15	AC FROM PAVER HOPPER	62	250		150			4.4	44			-	100	90	76	54	40	24	7

APPENDIX F

Aggregate Test Results: Iron Mountain Rd.

Test No.	Date	Time	Air Temp. °F	Sample Temp. °F	Moisture, %	Sand Equivalent	Gradation (% Passing) 3/4	1/2	3/8	#4	#8	#30	#200
T31685	9-27-73	10:45	70	57	0.7	77	98	80	67	52	41	27	5
T31763	10-31-73	10:45	55	55	1.6	75	100	85	75	53	41	24	6
T31764	"	12:10	63	53	1.8	77	100	85	71	58	44	30	6
T31765	"	13:20	62	50	2.1	75	100	86	73	53	40	23	6

APPENDIX F

Asphalt Test Results: Iron Mountain Rd.

TEST NO.	DATE	TIME	AIR TEMP. °F	SAMPLE TEMP. °F	PENETR. (ORIG. SAMPLE)	ABS. VISC. 140°F (R.T.F.)	ABS. VISC. 140°F (ORIG.)
736	9-27-73	10:15	:	-	177	2762	-
7312105	10-31-73	10:45	55	320	131	4092	-
7312106	"	15:00	62	320	132	4182	-