

ASPHALT CONCRETE PROPERTIES AND PERFORMANCE IN ALASKA

EXECUTIVE SUMMARY

by

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Abstract

A major study of asphalt concrete properties and performance of Alaska's highways was completed in 1982. The project data base was obtained from 117 statewide pavement sections through numerous core samples and measurements of cracking, patching and rutting. Primary research objectives were to: 1) provide an idea of the in-service composition of asphalt concrete, and 2) determine composition variations which produce the best performance. Because of the apparent rapidity of asphalt age hardening, performance relationships were derived using aged properties.

Results indicate that best long-term performance is obtained from asphaltic materials which retain softness and relatively low tensile strengths throughout the pavement's service life. Aged materials specifications are presented which have provided optimum performance.

Introduction

This study is part of a comprehensive effort to relate the field performance of Alaskan pavements to the materials used in their construction. More specifically, it examines the nature of hot mix pavements installed within the State between 1953 and 1973. Asphalt concrete materials and performance measurements were obtained from 117 statewide road sections, each ranging between $\frac{1}{2}$ and 1 mile in length. These sections were not selected at random, but rather to provide a performance range of older pavements. In addition, the overall selection was numerically weighted toward examples of good performance, as these were of prime interest. The research approach was as follows:

- 1) obtain a reasonably large sampling of pavement sections;
- 2) characterize the condition and asphalt concrete properties of each section;
- 3) determine those properties most closely related to performance;
- 4) quantify optimum values of the most important asphalt properties.

Objectives

- Characterize in-service asphalt concrete materials.
- Typify asphalt properties associated with good long-term pavement performance.

Data Acquisition

Field Data

Approximately 8 pavement core samples were obtained from each section, i.e., 2 samples each from center line, both wheel paths and shoulder. Pavement performance was based on objective measurements of cracking, patching, and wheel path ruts.

Laboratory Testing

The following properties were quantified:

- asphalt cement penetration @ 39.2°F and 77°F (dmm)
- asphalt cement absolute viscosity @ 140°F (poises)
- % asphalt cement by weight of aggregate
- aggregate gradation
- SSD density of core sample (pcf)
- % voids of core sample
- tensile strength of core sample

Material Characteristics

Similarity of Climate Zones

Frequency distributions of asphalt cement consistency indicate a basic similarity of materials from older pavements regardless of general climate zone location. This relationship, shown in Figure 1, is especially apparent in the case of 77°F penetration distributions. The apparent equivalence of field aging in different areas of the State provided justification for lumping these data for further analyses.

Asphalt Aging

The apparent average variation of absolute viscosity and penetration with time is shown in Figure 2. Curves for "Northern Alaska" denote original 200-300 penetration grade asphalts and an Interior Region climate. "Southern Alaska" indicates original 120-150 penetration grade asphalts and a Central or Southeastern Region type climate. These curves are averaged from highly variable individual data points, but indicate a tendency for reduced aging in colder areas of the State and in the wheel paths. It should be noted that on the average, 80% of originally specified 77°F penetration is lost within 10 years. Table 1 indicates actual data extremes associated with increasing pavement age.

Table 1
Aged Asphalt Properties -- Extreme Values

Pavement Age (years)	Penetration @ 77°F (dmm)		Absolute Viscosity @ 140°F (poises)		Asphalt Content (% Aggregate)	
	Low	High	Low	High	Low	High
3	--	--	--	--	5.0	8.5
6	--	--	--	--	4.0	7.5
7	15	80	1000	21000	--	--
10	--	--	--	--	3.8	6.8
15	10	60	1000	25000	3.5	6.4
20	--	--	--	--	3.5	5.9
25	8	40	5000	31000	3.5	5.8

The age hardening of asphalt concrete is a highly variable process and results in a final product very much different than that originally selected.

Wheel Path Versus Non-Wheel Path Properties

It is not possible to accurately estimate the asphalt concrete properties of non-wheel path areas from tests performed on wheel path materials. Since maximum aging occurs outside the wheel paths, it is this area which should be sampled in most cases. Correlation coefficients (r values) between wheel path and non-wheel path areas ranged from 0.6 to 0.8 for measurements of viscosity, penetration and asphalt cement content.

Cumulative Frequency of Asphalt Concrete Properties

Cumulative frequencies shown in Figure 3 typify the important physical properties determined from pavement core samples. These provide an interesting comparison with present specifications and indicate the overall variability which can be expected in aged materials.

Asphalt Properties Versus Performance

Identification of Important Properties

Standard statistical procedures were used to identify asphalt properties most strongly related to specific forms of pavement distress. These methods included the use of scatter plots, Pearson product -- moment correlation, partial correlation and multiple variable regression techniques. In addition to identifying those factors controlling performance it was possible using these techniques to quantify the relative strengths of such relationships.

Determination of Optimum Values

Having identified important performance related material properties, an optimum value for each was determined. An analytical approach was used which assumed that a specific range of performance is characterized by a specific range of material variables. Figure 4 is an example of this approach where each point represents the central value (either mean or median) of data within a selected range (level) of performance. Trends resulting from such plots allow an obvious interpretation of optimum values. Figure 4 indicates, for example, that a decrease in tensile strength and absolute viscosity is associated with less alligator cracking. Optimum properties, i.e., those associated with 0% alligator cracking, would in this case be a tensile strength of less than 40 psi and a retained viscosity below 5000 poises. Information obtained from plots such as Figure 4 were verified by simply looking at the properties associated with selected groups of good pavements. Table 2 indicates the composition of asphalt cements from the best of all 117 pavement sections. Of the 3 pavement groupings shown on Table 2, only a small sampling (n=15) of all 117 sections is rated best in terms of all types of pavement damage. Properties of these particular sections are closely comparable to the summary of optimum properties which follows.

Optimum Properties

Based on samplings of field aged asphalt concrete, good pavement performance is associated with:

- * pavement thickness $\geq 2''$
- * tensile strength < 40 psi
- * penetration @ 77°F > 40 dmm (100 gm, 5 sec)
- * penetration @ 39.2°F > 15 dmm (200 gm, 60 sec)
- * absolute viscosity @ 140°F $< 8,000$ poises
- * bitumin content $> 5.5\%$ (by % of aggregate)
- * % - #10 aggregate $< 39\%$
- * % - #40 aggregate $< 19\%$
- * % - #200 aggregate $< 7\%$

Implementation of Findings

The findings of this study can be applied in the areas of design, reconstruction and budget planning.

Highway Inventory

Occasional and selective sampling of asphalt concrete materials should become part of the yearly inventory process. It should be possible, through examination of pavement deflections and asphalt concrete properties, to estimate the remaining life potential of a road surface. Where anomalously low penetration asphalts are found in combination with relatively high deflections, early cracking should be anticipated.

Maintenance/Planning Cost Projections

Using a sampling approach such as noted above, long-term funding allocations can be weighted to reflect the number of early failure possibilities in a particular region or maintenance jurisdiction.

Reconstruction Applications

Pavement recycling should use a mix design process which produces a material of acceptable age hardening characteristics. Tests can be run on R.T.F.O. and extended R.T.F.O. aged

residue to verify that an acceptable degree of long-term softness is obtained in the mixture of recycling additive and recycled asphalt.

Consideration of optimum aged asphalt properties is obviously important where an overlay project is intended. In fact, the basic decision between an overlay and recycling alternative should rely as much on physical properties of the existing asphalt pavement as its visible surface condition. It is suggested that no pavement be overlaid which does not contain asphalt cement of at least optimum softness.

New Pavement Designs

New hot asphalt pavements should be designed with an asphalt concrete thickness of 2 or more inches. Mix designs should incorporate, whenever possible, $-3/8$ inch aggregate which is on the coarse end of the present specification (Type I and Type II) band.

Material Specifications

Acceptance specifications can be developed for normal paving asphalts which require tests on the residue of artificially aged material. For this purpose, a laboratory aging process must be developed which can simulate 6-8 years of field aging.

New Testing Procedures

Recent literature suggests several new testing methods which can aid in the prediction of long-term pavement performance. These procedures are generally of two types; where one involves the asphalt concrete as a whole while the other requires laboratory conditioning and testing of only the asphalt cement.

Conditioning and Testing of Asphalt Cement

In this approach, a specimen of asphalt cement is subjected to an extended period of oven heating for periods of 100 hours or more.

The most common method of this type was developed as the "California Tilt Oven Durability Test" and is basically an extended-time R.T.F.O. procedure. An Alaskan version of this test should simulate about 8 years of field aging. Residue materials would be examined through penetration/viscosity testing and the results compared to specification requirements for aged asphalt cements.

Conditioning and Testing of Asphalt Concrete

Test methods such as those developed by R. Lottman and T. Kennedy (see Reference listing) involve the asphalt concrete mix in repeated cycles of freeze-thaw followed by some form of stress application. The idea behind such tests is to estimate the strength, and therefore performance, potential of the asphalt mix rather than rely on predictions based on testing a single mix component, i.e., asphalt cement.

It is the author's opinion that asphalt concrete age-conditioning should be combined with fatigue testing. This approach simulates the application of actual vehicle loadings and may well lead to the most realistic estimates of pavement life.

Conclusions

- 1) The performance of an asphalt concrete pavement is determined to a significant degree by the age hardening characteristics of the asphalt mix and its components.
- 2) Optimum pavement component properties have been indicated and can be utilized in:
 - pavement reconstruction
 - budget estimates
 - new pavement designs
 - material acceptance specifications
- 3) Laboratory methods should be revised to allow evaluation of aged materials properties.

FREQUENCY DISTRIBUTION OF EXTRACTED OIL PROPERTIES WITHIN SPECIFIC CLIMATIC ZONES

CUMULATIVE PERCENT OF TOTAL SAMPLES

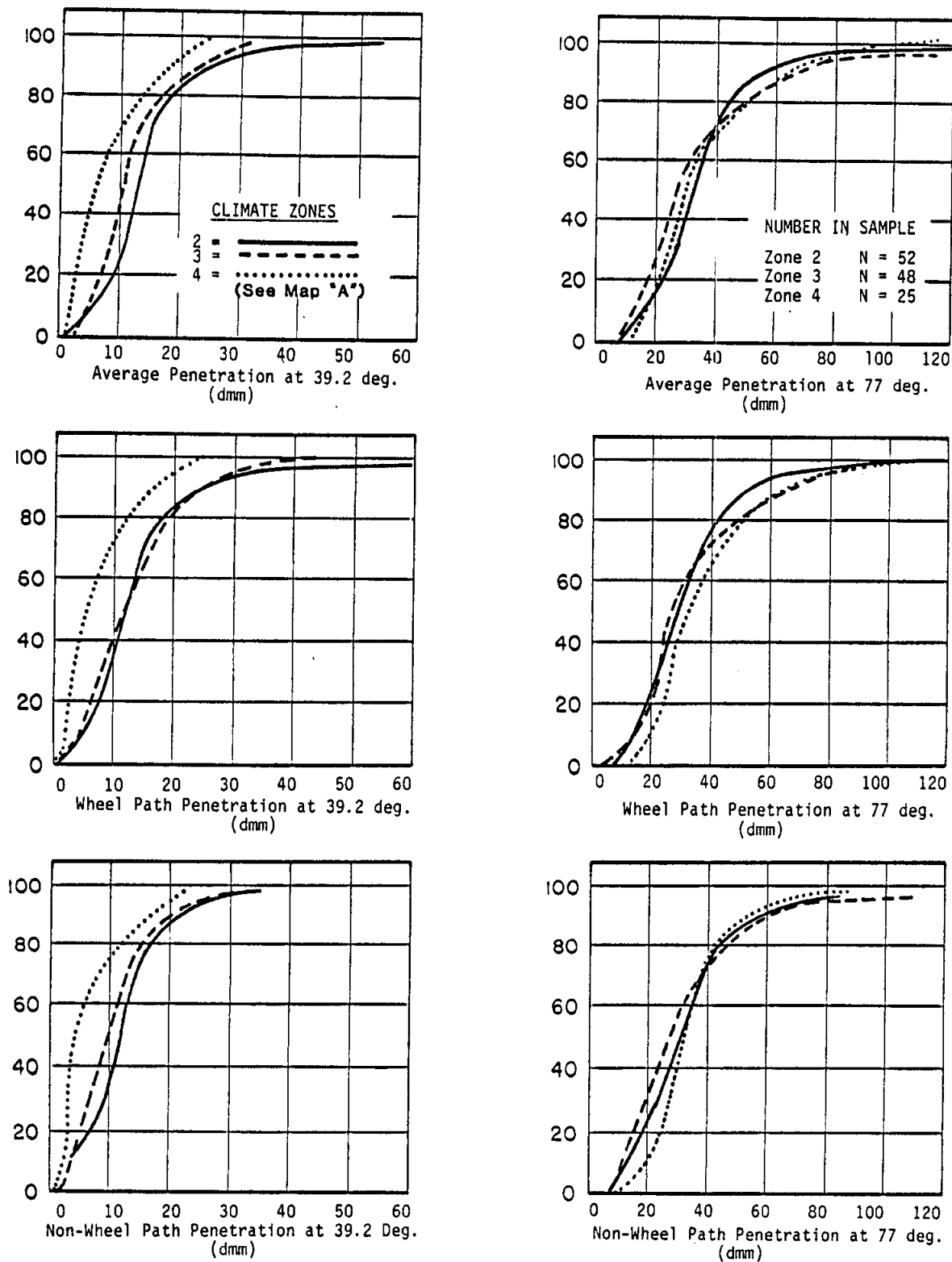


Figure 1

THE AGING PROCESS OF ASPHALT CEMENT IN ALASKA - APPARENT BEST FIT LINES

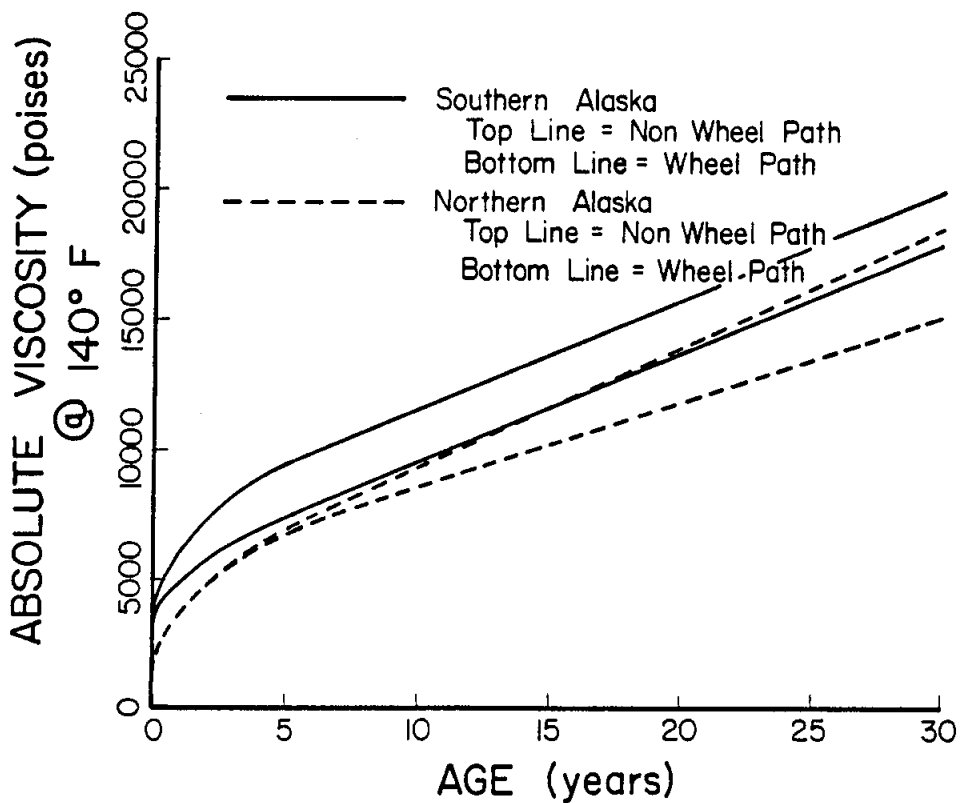
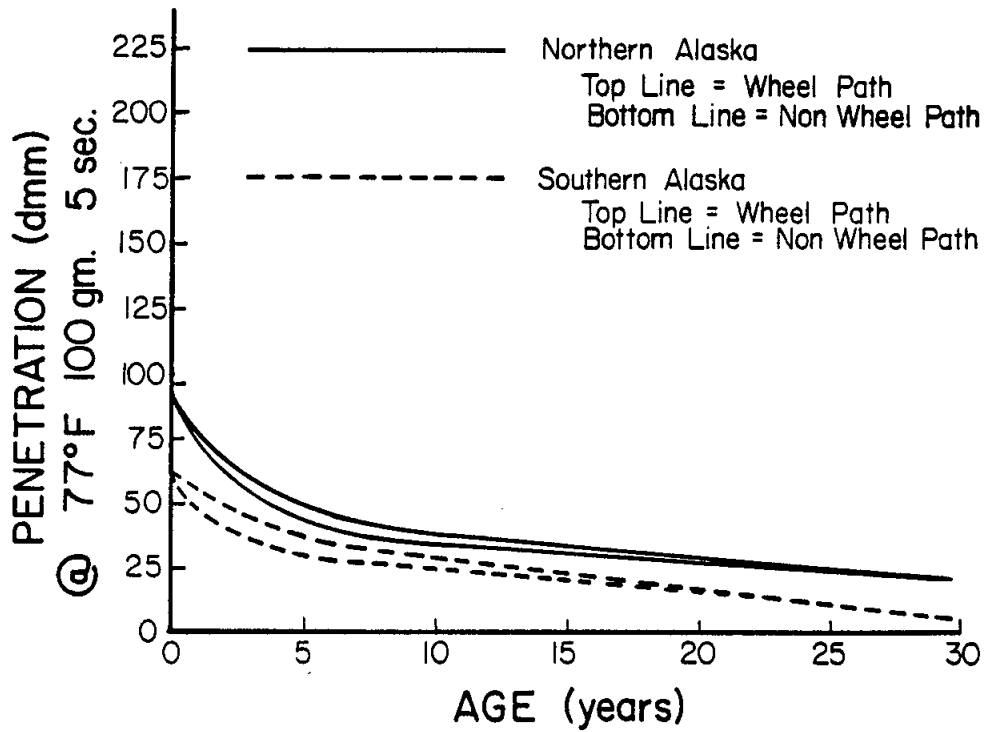


Figure 2

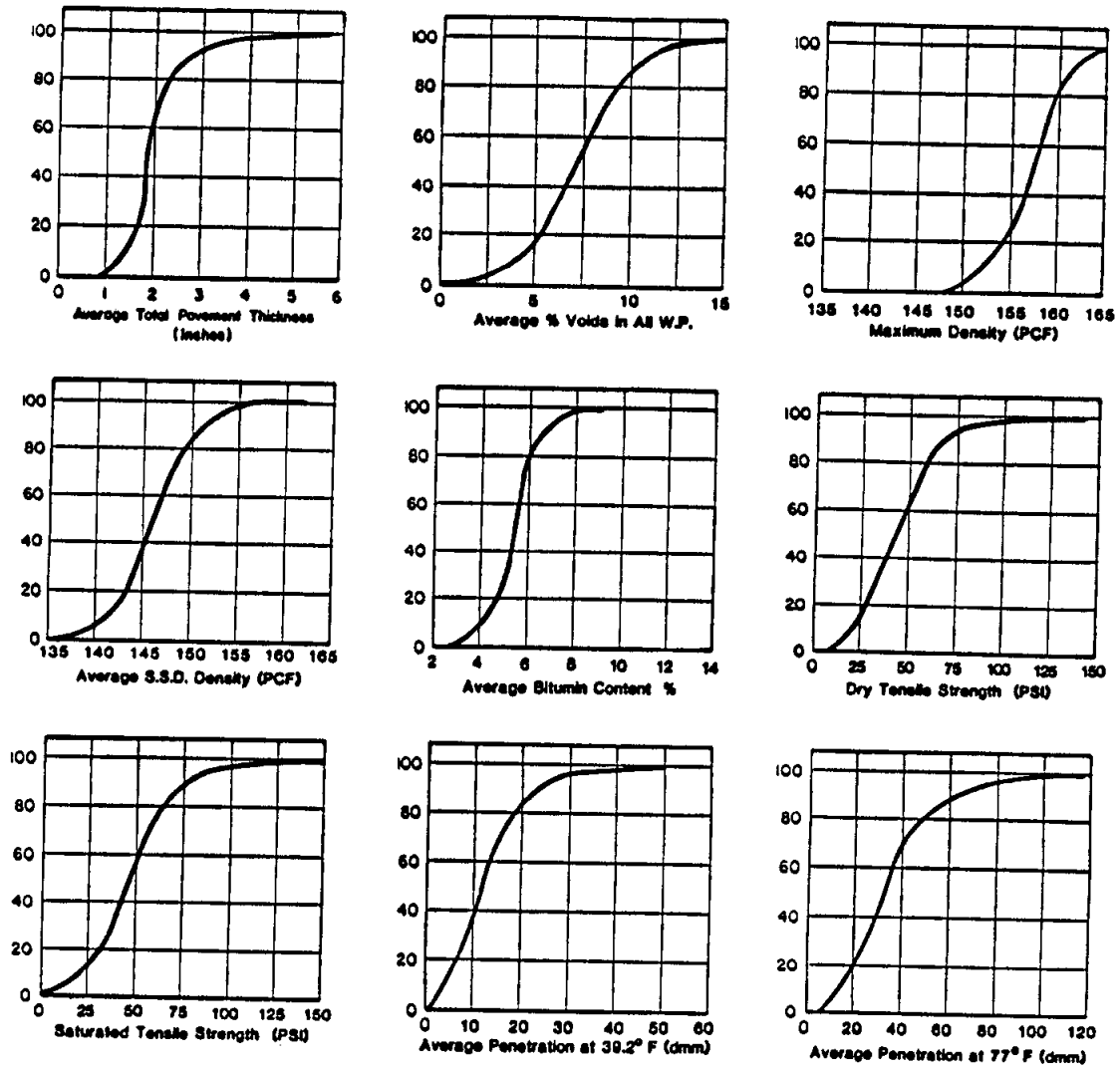
MATERIAL PROPERTIES ASSOCIATED WITH A HIGH LEVEL OF PERFORMANCE

DESCRIPTION	From Best 50% in: patching, alligatoring, longitudinal cracking, map cracking n=15			From Best 50% In: longitudinal cracking, map cracking n=25			From Best 50% In: map cracking n=47		
	MEDIAN	MEAN	STD.DEV.	MEDIAN	MEAN	STD.DEV.	MEDIAN	MEAN	STD.DEV.
Top layer pavement thickness, wheelpath	1.53 inch	1.72	0.59	1.58	1.72	0.48	1.64	1.75	0.45
Top layer pavement thickness, non wheelpath	1.59 inch	1.79	0.57	1.64	1.81	0.49	1.65	1.80	0.46
Total pavement thickness, wheelpath	1.65 inch	2.15	1.06	1.65	1.96	0.84	1.67	1.92	0.77
Total pavement thickness, non wheelpath	1.64	2.24	1.10	1.74	2.06	0.87	1.74	1.99	0.84
Gradation (Cum. % less than)									
1"	100%	100	0	100	100	0	100	100	0
3/8"	82%	81	5	82	81	7	80	80	7
#4	57%	58	6	56	58	7	56	57	6
#10	42	42	4	40	41	5	40	40	5
#40	21%	20	2	20	21	3	19	20	3
#200	7%	7	2	8	8	2	7	7	2
Maximum density of asphalt core	157.6 pcf	157.2	2.2	157.5	157.0	2.47	157.8	157.8	3.1
Average S.S.D. density	146.9 pcf	146.0	3.4	146.1	145.4	4.0	146.1	146.0	3.8
S.S.D. density in wheelpath	147.6 pcf	146.4	3.8	146.1	146.0	4.2	146.6	146.8	4.0
S.S.D. density, non wheelpath	146.1 pcf	145.2	3.5	144.8	144.4	4.2	145.2	144.9	4.0
Average % void content	6.9%	7.2	2.2	7.3	7.5	2.3	7.4	7.5	2.0
% void content, wheelpath	6.2%	6.8	2.3	6.7	7.1	2.4	6.7	6.9	2.1
% void content, non wheelpath	7.4%	7.6	2.2	7.6	8.0	2.5	8.0	8.1	2.2
Average % bitumin content w/ash correction	6.0%	5.9	0.9	5.8	5.8	0.8	5.6	5.6	1.0
Average absolute viscosity	3871 poises	4656	3461	4681	6480	5515	7172	10473	11330
Absolute viscosity, wheelpath	2728 poises	3500	2563	3162	5360	5689	6312	9797	12155
Absolute viscosity, non wheelpath	3989 poises	5812	5440	6246	7600	6425	7571	11124	10966
Average penetration at 39.2°F	15 dmm	15	8	15	15	9	11	12	8
Penetration at 39.2°F, wheelpath	16 dmm	16	9	15	17	14	12	14	11
Penetration at 39.2°F, non wheelpath	14 dmm	14	9	13	13	7	10	11	7
Average penetration at 77°F	46 dmm	51	21	40	45	21	31	36	19
Penetration at 77°F, wheelpath	49 dmm	54	24	43	48	24	31	38	22
Penetration at 77°F, non wheelpath	45 dmm	48	21	39	42	19	31	34	17
Tensile strength, saturated core	30.0 psi	32.2	14.2	41.7	36.3	14.1	43.5	50.0	26.0
Tensile strength, dry core	29.4 psi	29.0	11.6	31.7	35.2	15.9	39.5	47.1	28.5

Table 2

FREQUENCY DISTRIBUTION OF PAVEMENT SURFACING MATERIALS

CUMULATIVE PERCENT OF TOTAL SAMPLES



RANGE OF AGGREGATE GRADATION EXHIBITED BY STATEWIDE PAVEMENT SAMPLING

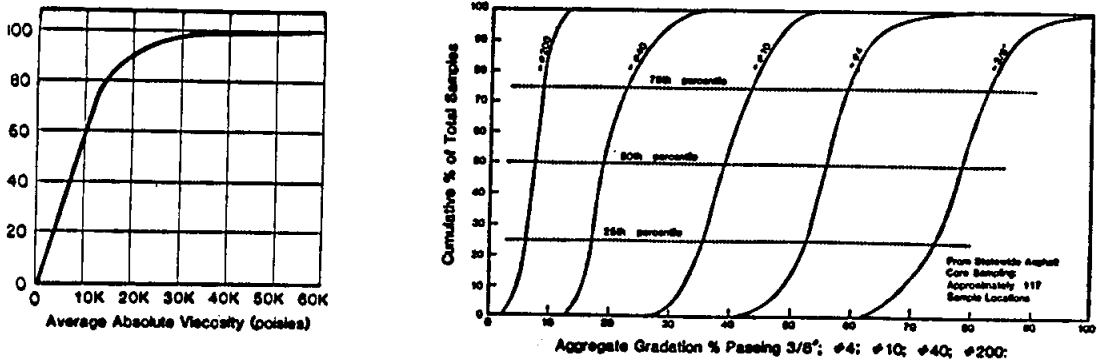
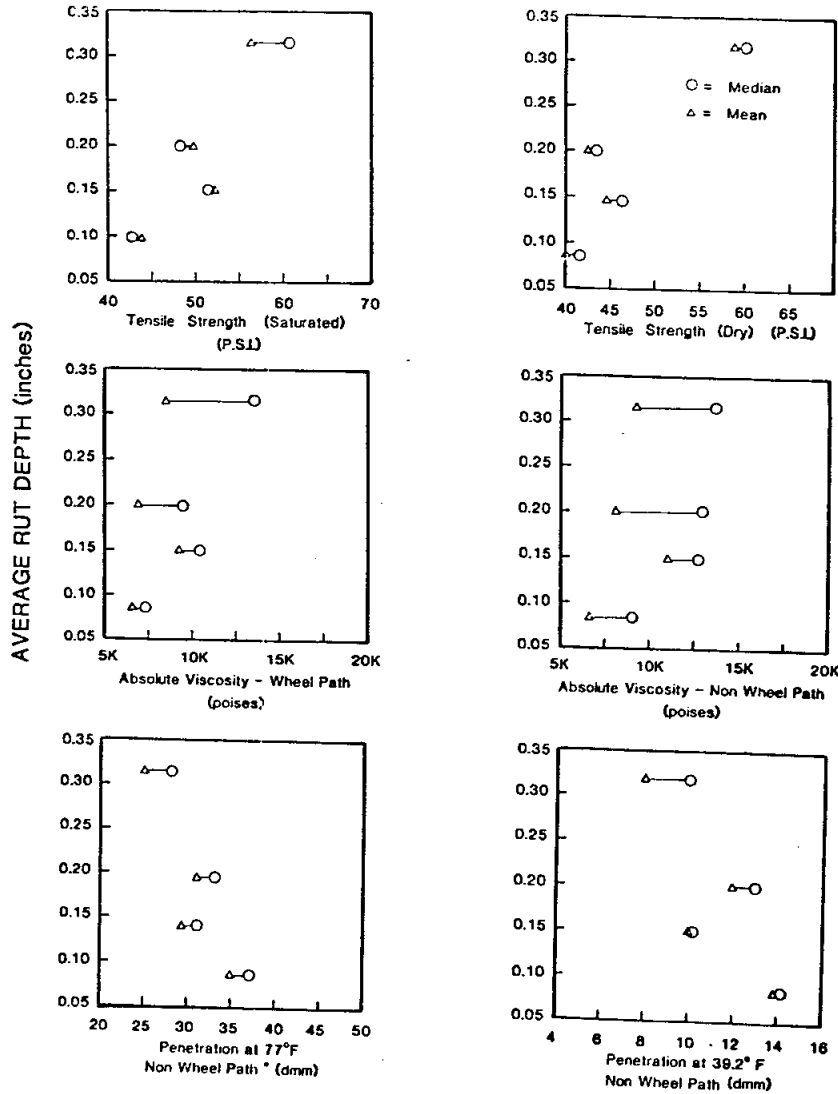


Figure 3

RELATIONSHIPS BETWEEN AVERAGE RUT DEPTH AND ASPHALT CONCRETE PROPERTIES



RELATIONSHIPS BETWEEN TOTAL PERCENT ALLIGATOR CRACKING AND ASPHALT CONCRETE PROPERTIES

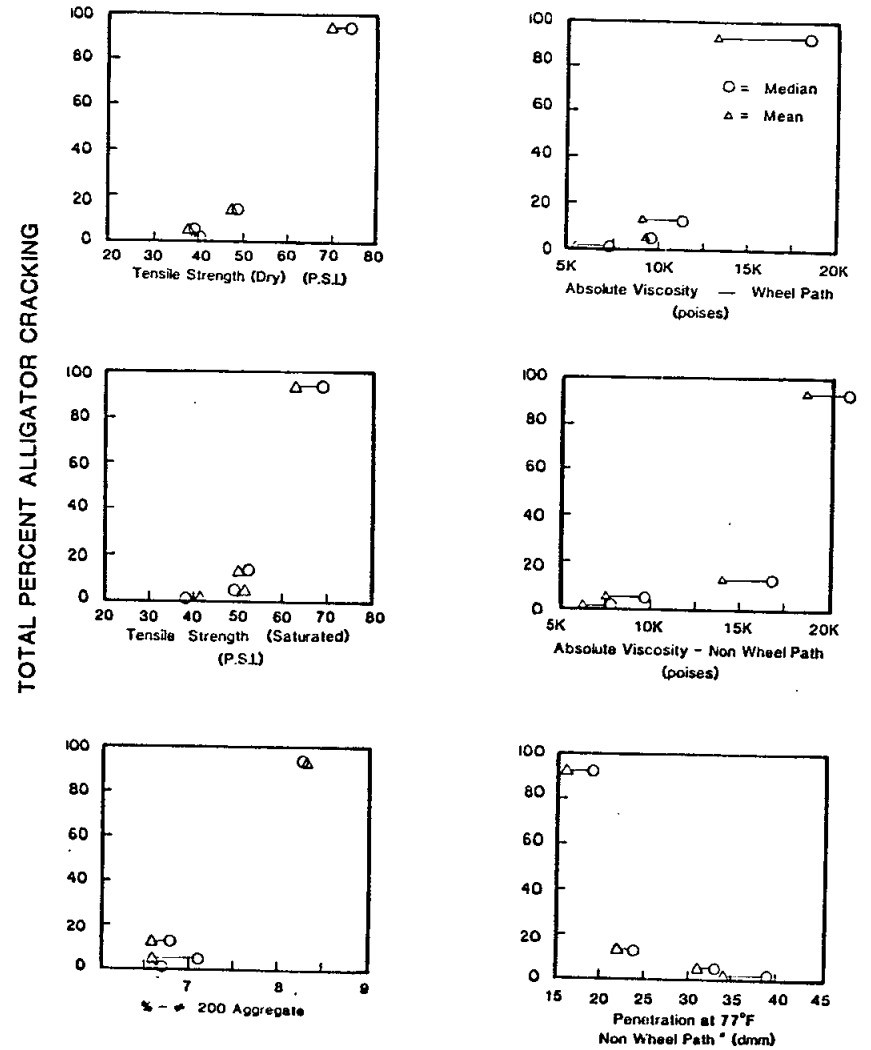


Figure 4

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