Pavement Microtexture and Its Relation to Skid Resistance

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This paper presents the findings of a study conducted to investigate the quantitative role played by small-scale surface texture (microtexture) in determining the skid resistance of a pavement. Specific objectives were to understand better the microtexture's influence on skid resistance and to determine if optimal dimensions of microtexture exist that should be sought when designing a pavement or selecting aggregate materials. Measurements of microtexture profiles were obtained on a series of pavement cores using a noncontact image analysis system in the laboratory. Correlations were determined between these measurements and British Portable Tester numbers (BPNs), obtained on the same cores. (BPNs are friction measurements believed to be closely related to microtexture.) Finally, the microtexture measurements were combined with estimated tire-contact area measurements (representing macrotexture) and the results correlated with skid resistance measurements taken on the same pavements. Correlation coefficients of up to 0.70 were attained. Examination of the data indicates that some improvement in this correlation may be possible. It is concluded that pavement microtexture can be characterized by one profile parameter. Additionally, pavement macrotexture can be characterized by estimating the percent contact a vehicle tire would have on the pavement surface in question. A combination of these two measurements shows a good correlation with skid measurements and should be further investigated.

The skid resistance (frictional properties) of the surface of a pavement is one of the major factors in determining the overall safety of a highway. The critical aspect of skid resistance is the friction available when a pavement is wet, since almost all pavements have more than adequate friction for safe vehicle maneuvering in dry conditions. Previous studies (*1–3*) have clearly demonstrated that the friction levels developed by a pavement in contact with a given tire are largely dependent on two characteristics: surface macrotexture and surface microtexture. (See ASTM E867, Standard Definitions of Terms Relating to Traveled Surface Characteristics.)

Macrotexture is generally defined as those surface textural features that are greater than 0.5 mm in height and therefore provide a drainage system for water on the pavement surface, thus preventing a buildup of water between the tire and the pavement and resultant hydroplaning. Additionally, the macrotexture provides the hysteresis component of the tire-pavement friction—that is, the energy loss as the tire deforms around the macrotexture asperities.

Microtexture is defined as those surface features less than 0.5 mm in height. Its role in friction development is to penetrate the thin water film present on a wet pavement so that intimate tire-pavement contact is maintained.

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This report summarizes work done in the second of two studies investigating the profile measurement and interpretation of aggregate and pavement surface microtexture. In the first study (*4*) microtexture profiles of coarse-sized aggregate particles (as used in British Polishing Wheel specimens) were measured to determine if a correlation exists between the profile characteristics and measurements (initial friction values and polish values [*PVs*]) obtained using the British Portable Tester (BPT). A suite of aggregates ranging from polish-susceptible to polish-resistant was examined both before and after being subjected to the British Polishing Wheel test (ASTM D3319).

The study results indicated the presence of a definite positive correlation between microtexture profiles and friction measurements made with the BPT. The correlation coefficient for all data was 0.73.

The next step in this program was to attempt to correlate microtexture profile measurements on pavement core samples with BPT measurements on those cores and full-scale skid resistance measurements taken on the same pavement section at the same time as the core sample was obtained. This was the objective of the study reported herein. Because of the influence of both scales of texture on skid resistance, the microtexture measurements on the core samples must be combined with a macrotexture measurement in order to attempt a direct correlation with the skid resistance measurements.

This study addressed two specific objectives:

1. To understand better the influence of microtexture in determining a pavement's skid resistance, and
2. To determine if optimal dimensions of microtexture exist that should be sought when choosing an aggregate for a particular application.

DATA COLLECTION

Samples

Samples used in this study were pavement cores either 6 or 8 in. (153 or 204 mm) in diameter. The 8-in. (204-mm) cores were preferred because the necessary slider path length for the BPT measurement was more easily obtained on them. The larger cores also have a greater surface area for making sand patch texture (ASTM E965) measurements. Cores were obtained from Virginia, North Carolina, New Mexico, and Nebraska, and a complete listing of the cores examined is given in Table 1. The pavements sampled included grooved

TABLE 1 PAVEMENT AND CORE INFORMATION

PAVEMENT INFORMATION No.	Description	SN40	CORE INFORMATION No.	BPN	MTD (in)	Microtexture Data Av Hgt (μm)	Av Dens pks/μm	Av S.F.
1	AC overlay,	52	1-1	71	.018	54.5	.0025	.14
	gravel C.A.,	57	1-6	77	.030	53.0	.0026	.14
	3/8 max.	55	1-4	73	.022	50.4	.0035	.18
		55	1-2	75	.024	57.7	.0029	.17
		56	1-7	75	.031	57.5	.0032	.18
		54	1-3	76	.024	53.2	.0035	.19
2	AC overlay,	53	2-5	77	.058	44.9	.0029	.13
	gravel C.A.,	52	2-2	69	.053	57.9	.0029	.17
	3/8 max.	57	2-4	74	.058	53.5	.0037	.20
		55	2-7	73	.058	57.5	.0033	.19
		55	2-3	78	.058	59.1	.0032	.19
3	PCC,	33	3-3	65	.009	42.5	.0028	.12
	ungrooved.	34	3-2	70	.006	40.5	.0040	.16
4	AC overlay,	56	4-7	71	.031	53.1	.0026	.14
	gravel C.A.,	53	4-5	75	.038	53.5	.0029	.16
	3/8 max.	55	4-3	68	.034	53.7	.0031	.16
		51	4-6	72	.030	55.8	.0032	.18
		53	4-4	75	.049	55.9	.0032	.18
		51	4-2	73	.036	52.3	.0030	.16
5	AC overlay,	32	5-A	62	.047	51.1	.0034	.17
	cr.limest.C.A.	32	5-B	54	.044	48.0	.0030	.15
	1/2 max.							
6	AC overlay,	37	6-1	55	.042	47.9	.0026	.13
	cr.limest.C.A.	34	6-3	57	.044	46.8	.0026	.12
	1/2 max.	39	6-7	59	.034	51.9	.0022	.12
7	AC overlay,	50	7-1	66	.020	47.7	.0033	.16
	cr.granite	49	7-5	70	.018	49.4	.0030	.15
	C.A.,3/8 max.	44	7-2	70	.017	48.8	.0033	.16
		47	7-4	64	.024	47.4	.0033	.16
		46	7-7	73	.022	47.9	.0033	.16
8	Grooved PCC	39	8-3	61	.035	39.1	.0032	.13
		39	8-2	57	.034	36.0	.0032	.12
		36	8-5	59	.032	35.7	.0034	.12
		34	8-1	56	.034	42.4	.0033	.14
		32	8-4	57	.032	43.4	.0028	.12
9	AC open grad	51	9-4	72	.066	48.9	.0032	.15
	overlay,	50	9-2	70	.058	46.4	.0031	.14
	cr.gneiss C.A.	52	9-6	75	.055	51.5	.0029	.15
		52	9-5	72	.060	52.0	.0028	.1[illegible]
		51	9-3	72	.054	56.5	.0027	.15
		51	9-1	64	.060	51.9	.0027	.14
10	AC,cr.gneiss	45	10-2 (79)	69	.010	44.5	.0029	.13
	C.A.							
		47	10-4	65	.010	48.2	.0024	.11
		39	10-3	68	.010	49.3	.0037	.18
		43	10-6	68	.010	46.2	.0037	.17
		39	10-2 (81)	68	.015	48.2	.0037	.18
11	AC overlay,	38	11-4	60	.020	44.2	.0024	.11
	cr.limest.C.A.	38	11-3	61	.025	41.8	.0030	.13
	1/2 max.	34	11-6	63	.029	44.3	.0032	.14
		37	11-2	62	.016	44.6	.0030	.14
		36	11-1	63	.016	46.4	.0023	.13

TABLE 1 (*continued*)

No.	PAVEMENT INFORMATION Description	SN40	CORE INFORMATION No.	BPN	MTD (in)	Microtexture Data Av Hgt (μm)	Av Dens pks/μm	Av S.F.
12	AC cr.limest.	59	B5021B	66	.060	41.8	.0030	.12
13	AC sand asphalt	70	B5022A	78	.015	69.7	.0034	.24
14	AC gravel C.A.	65	B5023B	72	.026	51.7	.0032	.17
15	AC cr.limest.	72	B5024B	71	.060	41.5	.0030	.13
16	AC cr.granite-gneiss	64	B5025C	67	.031	60.9	.0036	.22
17	AC cr.quartzite	71	B5026C	63	.028	46.1	.0037	.17
18	AC cr.granite-gneiss	62	B5027C	70	.044	51.7	.0035	.18
19	AC cr.granite-gneiss	66	B5028B	78	.049	57.7	.0036	.21
20	AC cr.quartzite	62	B5029A	71	.018	60.5	.0033	.20
21	AC cr.quartzite	67	B5030A	86	.049	62.0	.0028	.17
22	AC gravel C.A.	58	B5031A	66	.044	51.6	.0035	.18
23	AC cr.limest.-gravel C.A. 3/4 - 1 max.	41	79-4	52	.016	42.2	.0025	.11
		41	79-1	48	.021	41.5	.0026	.11
		40	79-2	55	.015	43.1	.0030	.13
		44	79-3	50	.021	38.6	.0026	.10
24	AC cr.gravel 3/8 max.	32	90-1	54	.007	44.6	.0030	.14
25	AC cr.limest.-gravel	39	444-4	55	.018	41.5	.0028	.12
26	AC cr.limest.-gravel	50	382-1	61	.047	53.9	.0028	.15
27	AC cr.gravel 3/8 max.	51	x-5-3	69	.009	52.2	.0030	.15
28	AC open graded cr. gravel	52	x-1-1	65	.033	52.0	.0028	.15
29	AC open graded cr. gravel	53	x-3-4	67	.052	47.6	.0027	.13
30	AC cr. gravel 3/8 max.	45	x-1-2	64	.009	44.5	.0030	.14
31	AC open graded cr. gravel	51	x-1-3	61	.022	44.0	.0030	.13
32	AC cr.gravel 3/8 max.	51	85-2	59	.016	53.6	.0031	.16
33	AC open graded cr. gravel	48	183-2	64	.038	47.6	.0032	.15
34	AC open graded cr. gravel	48	x-7-1	64	.042	46.6	.0031	.14

(*continued on next page*)

TABLE 1 (*continued*)

PAVEMENT INFORMATION			CORE INFORMATION					
No.	Description	SN40	No.	BPN	MTD (in)	Microtexture Data Av Hgt (μm)	Av Dens pks/μm	Av S.F.
35	AC cr. gravel 3/8 max.	52	x-6-1	68	.008	38.7	.0035	.14
36	AC cr. gravel 3/8 max.	54	x-5-2	62	.038	44.9	.0028	.13
37	AC open graded cr. limest.	38	x-4-4	49	.034	44.7	.0025	.11
38	AC open graded cr. gravel	55	x-3-2	66	.044	50.3	.0028	.14
39	AC open graded cr. gravel	51	x-2-3	63	.010	46.2	.0031	.15
40	PCC,ungrooved	34	1(30)	69	.008	48.9	.0026	.13
41	AC open graded cr.gravel	48	2(30)	66	.062	46.6	.0033	.15
42	AC open graded cr. gravel	59	3(30)	83	.055	52.8	.0041	.22
43	PCC,ungrooved	43	4(30)	73	.008	48.6	.0025	.12
44	AC open graded cr limest.	28	5(30)	48	.062	44.1	.0021	.09
45	AC cr. gravel 1/2 max.	11	6(30)	48	.010	32.1	.0027	.09

Key to abbreviations:
AC = asphaltic concrete
PCC = portland cement concrete
C.A. = coarse aggregate
cr. = crushed
[3/8] max. = maximum size of coarse aggregate, inches

and ungrooved portland cement concrete (PCC) as well as dense- and open-graded asphaltic pavements. They were of various ages and had been subject to a range of traffic and environmental conditions.

Measurement Procedures

In an initial series of measurements, the microtexture of all features encountered on the test surfaces was measured. To perform these microtexture measurements, the first step is to apply a thin, white opaque coating to the sample surface so that, when the surface is illuminated, the light is uniformly reflected from it and does not penetrate it. The sample is then mounted on the viewing stage, and a semicircle of light is projected onto it at a 45° angle. The straight side of this semicircle is sharply focused on the sample. Where this straight edge hits the sample's surface, it produces a profile that, when viewed from above, duplicates a vertical profile through the sample because of the incidence angle and viewing angle. The profile image is gathered by a microscope attached to a television camera for transmitting the profile to the viewing screen for measurement and analysis (see Figure 1). A typical microtextural profile is shown in Figure 2.

Profile Parameters

The profiles are characterized using those parameters developed in the earlier study (*4*). Two parameters are measured directly, and a third is derived from these two. The average asperity (peak) height is defined as the sum of the vertical heights (above the "valley" immediately to the right of each asperity) of all asperities divided by the total number of asperities (see Figure 3). The average asperity density is the total number of asperities divided by the profile length. The average shape factor (SF), which is the derived parameter, is calculated by multiplying the asperity height by the asperity density. Since asperity density, as defined here, closely approximates the inverse of asperity width, SF approximates

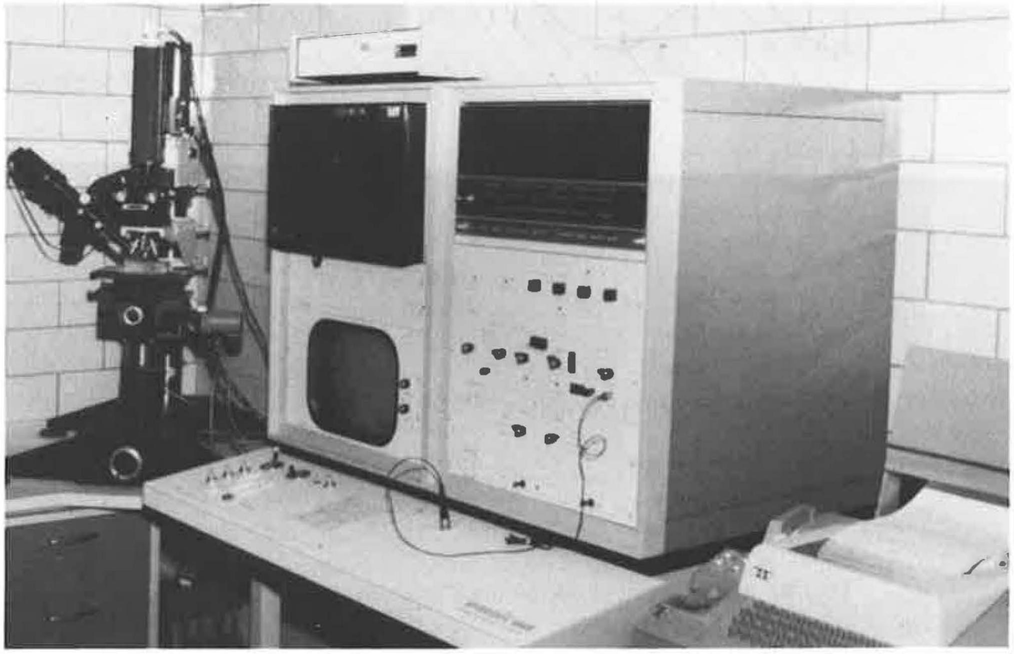


FIGURE 1 Image analysis system used for microtexture measurements.

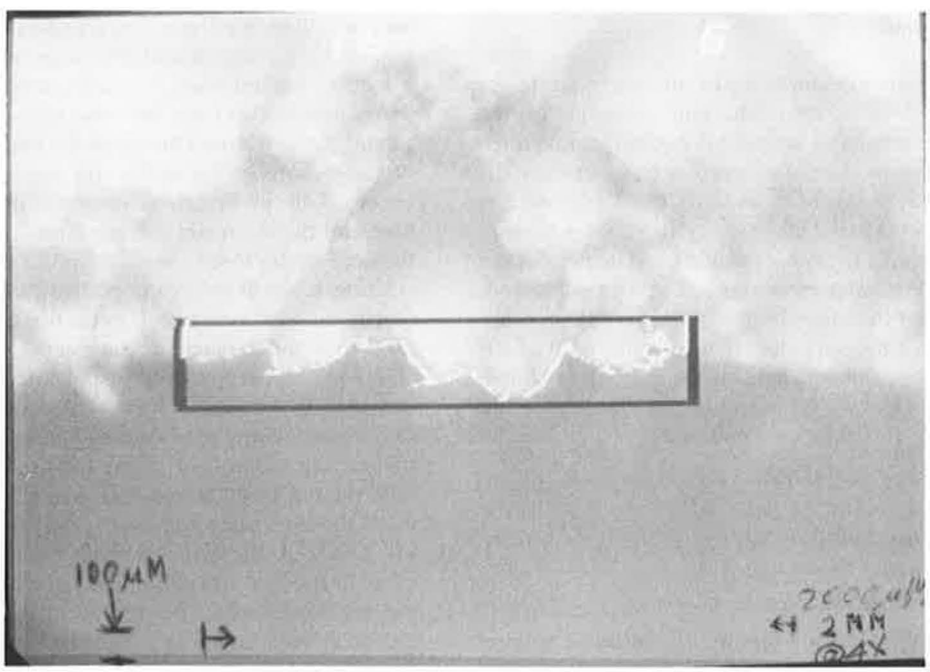
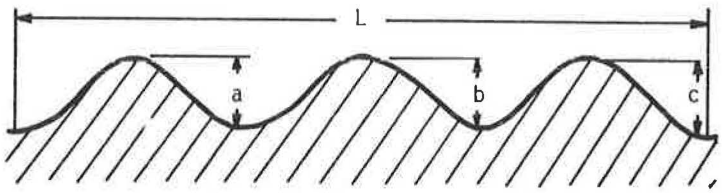


FIGURE 2 Typical microtextural profile on pavement sample.



$$\text{Average asperity density} = \frac{\text{count of peaks}}{\text{length of profile}} = \frac{3}{L}$$

$$\text{Average asperity height} = \frac{\text{sum of heights}}{\text{counts}} = \frac{a+b+c}{3}$$

$$\text{Average shape factor} = \frac{\text{average height}}{\text{average width}} = \frac{\frac{a+b+c}{3}}{\frac{L}{3}}$$

FIGURE 3 Definitions of microtextural parameters.

an average height-to-width ratio for the asperities measured. Experimentation indicated that 100 profiles, each approximately 2 mm long, are sufficient to characterize the microtexture of a sample.

Parameter Significance

As already noted, microtextural peaks are necessary under wet conditions for penetration of the thin water film on the surface, thereby maintaining intimate tire-pavement contact. Optimal peak height has been theorized as being in the 0.01- to 0.1-mm range (*2*, p.32). Microasperity density or spacing is also important because it determines the adhesion component of a pavement's frictional properties. The greater the asperity density, the greater the number of contact points and, therefore, the higher the tire adhesion to the pavement. Since the shape factor is a measure of height-to-width ratio of the asperities, larger shape factors indicate sharper, more closely spaced asperities, which in turn tend to promote better tire adhesion to the pavement in wet conditions.

DATA ANALYSIS

Microtexture and BPNs

After the measuring procedure had been finalized, a total of 87 cores were measured for microtexture, macrotexture (sand patch), and British Portable Tester numbers (BPNs). The first correlations investigated were between the average shape factors (SFs) and BPNs, which are believed to indicate the friction of a surface due mainly to microtexture. The plot of these values is shown in Figure 4.

A linear regression fit of these data yielded a correlation coefficient of .68. Compared with the results of the previous study, this coefficient is somewhat low; therefore, reasons were sought for the discrepancy. Since these specimens were all cores from pavement surfaces that were in service, they had been subject to traffic. It was hypothesized that in samples with substantial macrotexture, portions of the surface would never be in contact with the vehicle tires and that these portions would neither have any effect on the microtextural portion of the measured skid resistance of the pavement nor be subject to the polishing action of traffic (see Figure 5). It was therefore theorized that the areas of contact would have measurably lower microtexture than the noncontact areas, because of this polishing. To define the areas that would come in contact with the tire on each specimen, first a typical vehicle load and tire footprint were used to calculate pressure over the area of the footprint.

Using 1,000 lb as a conservative (high) estimate of a passenger car load per wheel and a tire contact area of 48 in.^{2} (.031 m^2), the contact pressure equals approximately 20 psi (137.9 kPa). A rectangular piece of ASTME501 rubber, 3 in. × 1 in. (76 × 25 mm), was used to simulate the tire rubber. The white coating (as described earlier) was applied to the rubber; then, before it dried, the rubber was placed on the core surface being tested and loaded with a 60-lb (27.3-kg) mass, thereby producing 20 psi (137.9 kPa). When the rubber was removed, the areas of contact with the core were delineated by the paint transfer (see Figure 6). Nineteen cores with the contact areas so defined were then used to conduct a second series of microtexture. The results of these measurements were called SF_c (shape factor on contact area) and were plotted versus the BPNs. This plot is shown in Figure 7, and it has a linear regression correlation coefficient of only 0.45. The data points (SF vs. BPN) for these 19 cores from the original 87-point database already discussed had a correlation coefficient of 0.56, as shown in Figure 8. The data for these cores are shown in Table 2. The approach of measuring microtexture only on the contact area therefore unexpectedly

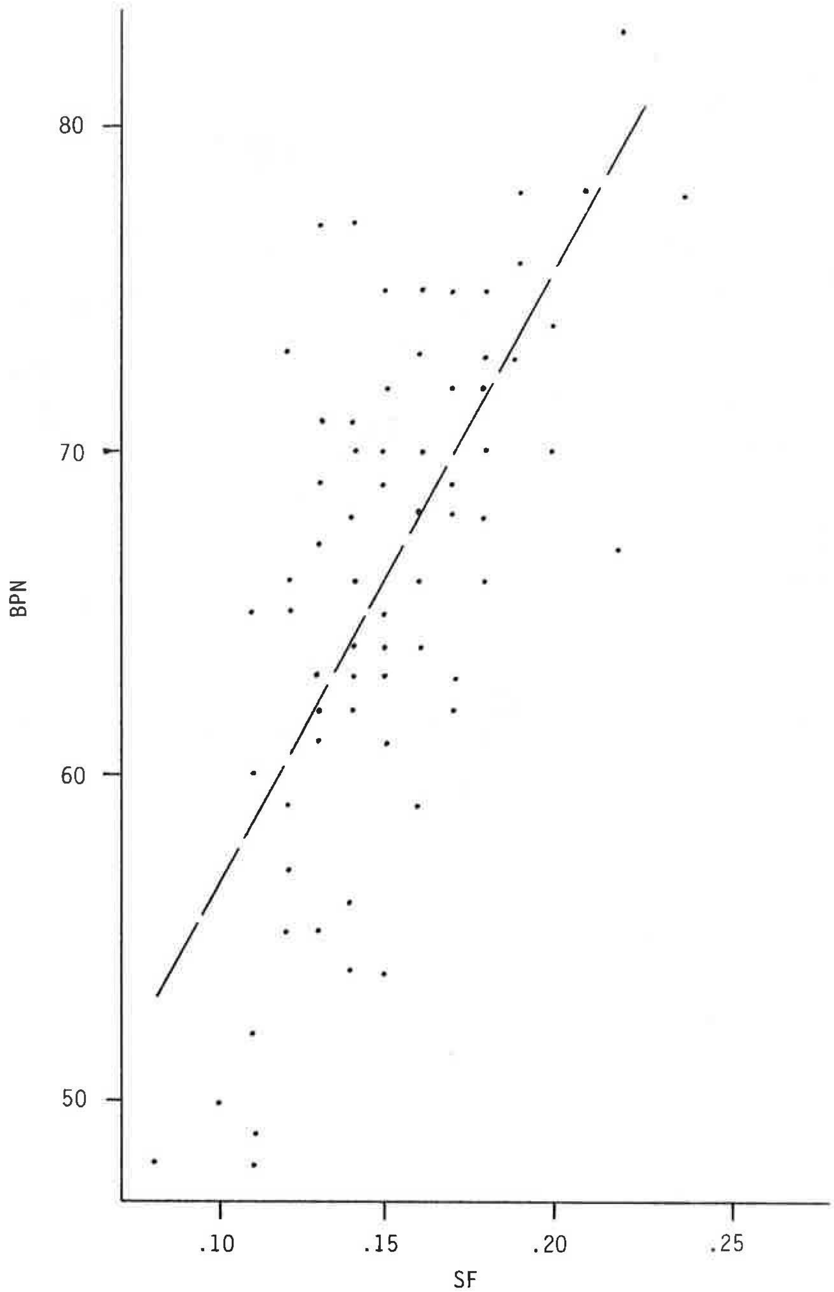


FIGURE 4 Plot of BPN versus SF for eighty-seven cores examined.

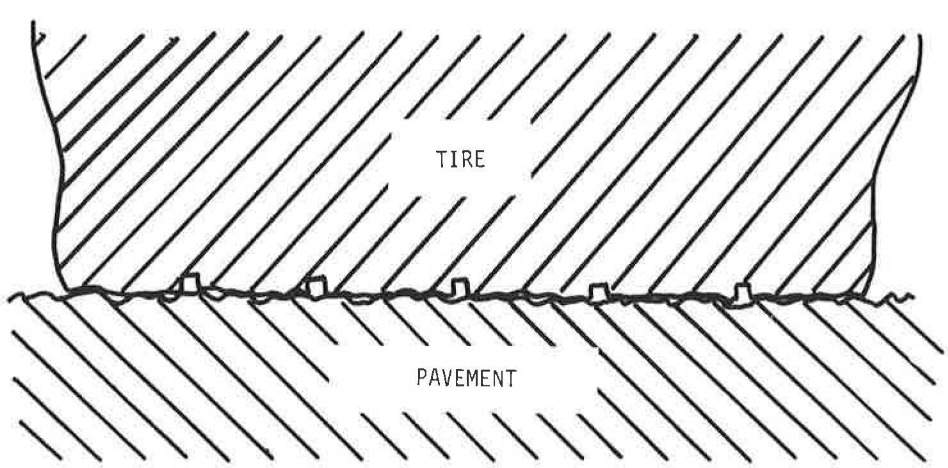


FIGURE 5 Cross section through tire/pavement contact area.

FIGURE 6 Photograph of three cores showing their contact areas.

appeared to worsen the relationship, even though the contact microtexture was, as predicted, in most cases measurably lower than the noncontact microtexture (see Table 2).

Another aspect of the contact area that might influence the correlation between SF and BPNs was therefore considered next. In defining the contact area by means of the coating transfer technique already described, it quickly became obvious that the actual contact area as a percent of the total footprint area could vary over a substantial range. This variation depends directly on the amount of macrotexture present at the pavement surface. It follows that the BPN obtained on the surface (and also the skid resistance) should vary with this variation in contact area.

For asphalt pavements, there are several possible reasons for this macrotexture (and therefore contact area) variation. The first and primary reason is the gradation of the aggregate used in the mix. At one extreme is an open-graded asphalt friction coarse (OGAFC) that has a very open gradation; consequently, the surface consists of nearly all coarse aggregate. At least initially, vehicle tires are riding only on the upper portion of these coarse aggregate particles, leaving some portion of the road surface that never comes in contact with the tires. At the other extreme are the sand-asphalt mixes that have no coarse aggregate and, consequently, virtually no macrotexture. As a result, tire contact is virtually 100 percent. Dense-graded asphalt mixes are all between these two extremes. Their contact area may be nearly as low as an OGAFC or as high as a sand asphalt mix, depending on the particular gradation of the aggregate used as well as the percent asphalt. The contact area may increase with age as the pavement becomes denser under traffic or as the macrotexture is worn away.

For PCC pavements, the situation is quite different. Initial macrotexture (and therefore contact area) is basically dependent on the finish applied to the new concrete, since coarse aggregate is not exposed. This texture is usually a result of some combination of burlap or turf drag plus tining. With time and traffic, this imposed texture wears off, resulting in less macrotexture and greater contact. If surface wear is sufficient to expose the coarse aggregate in the concrete, the macrotexture could conceivably begin to increase again and therefore decrease the contact area. Several rehabilitative methods used on concrete pavements also significantly alter the macrotexture. These are grooving, grinding, and milling. Again, these textures will wear off with time and traffic.

To include contact area percentage in the correlation, the SF_c (obtained on the area of contact) was divided by the percent contact area (CA) and the result multiplied by 1,000. This series of values is plotted in Figure 9 versus the BPNs. The correlation coefficient was improved to 0.62 by this factor.

Since one of the purposes of the study was to attempt correlation of microtexture measurements with skid resistance measurements, that subject was addressed next and no further correlation with BPNs was attempted. That is, the objective was to improve on BPN as a measure of microtexture, not to duplicate it.

Texture vs. Skid Measurements

To estimate skid resistance (as measured in ASTM E274) from texture, it is generally agreed that measures of both microtexture and macrotexture must be included. The SF_c, as described earlier, therefore would have to be combined with some measure of macrotexture before attempting correlation with skid numbers (SNs). In previous research (*2,3*), workers have often suggested combining BPNs (microtexture) and sand

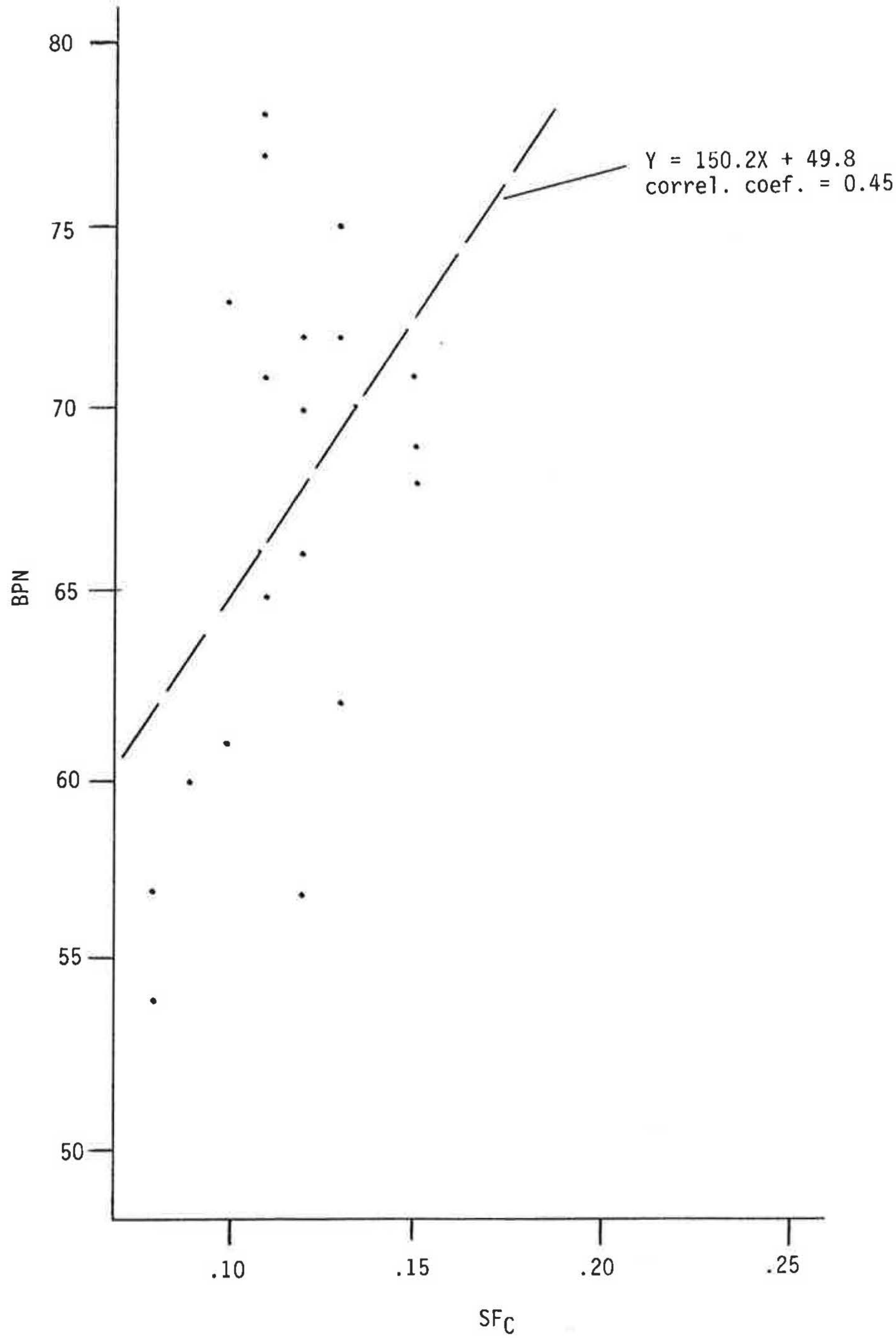


FIGURE 7 Plot of BPN versus SF_c for nineteen cores listed in Table 2.

patch (macrotexture) in an equation to predict SN values. In the course of the comparison study of BPNs and SF_cs, the CAs were compared with mean texture depths (MTDs) as measured by the sand patch method (ASTM E965-83). An inverse relationship was noted, as shown in Figure 10. It was therefore theorized that the SF_c and CA combination might hold promise as a representation of macrotexture and microtexture for correlation with SNs. SN_{40} values were available for the pavements from which the cores used in this study were taken. The schedules of skid tests and coring operations were coordinated to ensure that the surfaces of the cores taken were the same, as nearly as possible, as the surfaces on which the SNs were obtained. Linear regressions were made for SN_{40} values versus various combinations of SF_c and CA for the 19 cores already discussed. The best correlation was obtained between SN_{40} and $(SF_c \times 1{,}000)/CA$. These data are plotted in Figure 11. The resulting correlation coefficient is 0.70. With SN_{40} as the dependent variable, the equation is:

$$SN_{40} = 18.6 \frac{(SF_c \times 1{,}000)}{CA} + 12.6 \quad (1)$$

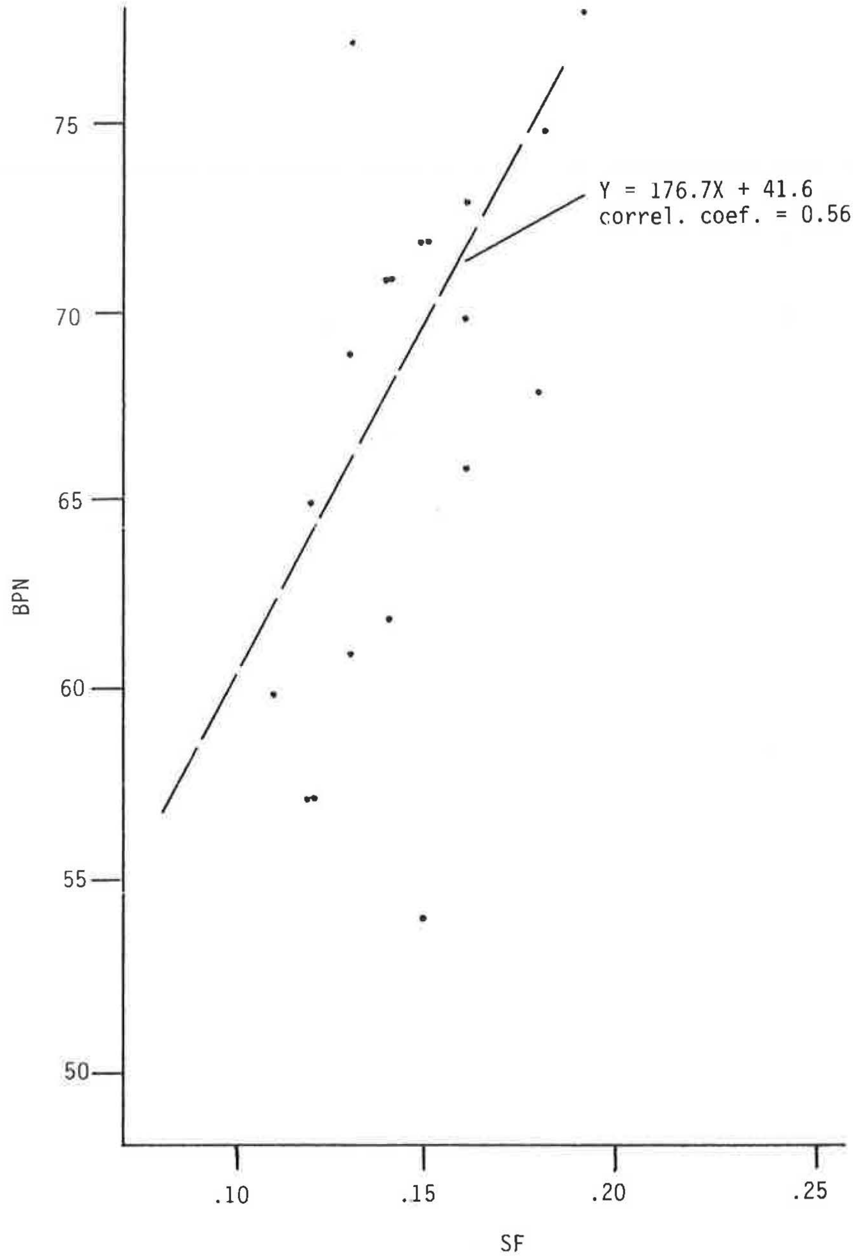


FIGURE 8 Plot of BPN versus SF for nineteen cores listed in Table 2.

Let TXT = overall (microtexture and macrotexture) texture measurement =

$$\frac{SF_c \times 1{,}000}{CA}$$

therefore,

$$SN_{40} = 18.6\ TXT + 12.6 \qquad (2)$$

Outliers were examined in an attempt to explain why they did not fit the equation more closely. As can be seen in Figure 11, samples 8-4, 6-3, and 5-B are particularly far off the line. Without these three, the correlation coefficient jumps to 0.89. Sample 8-4 is one of three PCC pavement samples included in this set of 19 (the others being 3-3 and 8-3). The 8-series samples were taken from a longitudinally grooved pavement, 8-3 in November and 8-4 in January. Sample 8-3 is much closer to the best-fit line, mainly because of a higher SN_{40}

Seasonal variation of SN could account for the difference, except that the November core is high (SN_{40} = 39) and the January core is low (SN_{40} = 32), just the opposite of the expected trend. Differences in BPN values (57 vs. 61) and MTD (.032 vs. .035 in.; .81 vs. .89 mm) are not enough to account for the difference in SN_{40}. The TXT value for the two cores varies inversely with the SN_{40} values. The other PCC core, 3-3, like 8-3, is quite close to the best-fit line and is from an ungrooved pavement. Reruns of 8-4 gave results quite close to the first run, which validated the original SF_c

TABLE 2 DATA ON THE SUBJECT OF NINETEEN CORES

Core No.	SN40	Core Measurements					
		BPN	MTD (in)	SF	SFc	C.A. (%)	TXT
5-B	32	54	.044	.15	.08	24	1.83
8-4	32	57	.032	.12	.12	47	1.59
3-3	33	65	.009	.12	.11	77	1.20
6-3	34	57	.044	.12	.08	25	1.79
11-2	37	62	.016	.14	.13	59	1.49
11-4	38	60	.020	.11	.09	46	1.41
8-3	39	61	.035	.13	.10	61	1.27
10-2(81)	39	68	.015	.18	.15	76	1.40
7-2	44	70	.017	.16	.12	51	1.55
10-2(79)	45	69	.010	.13	.15	58	1.60
7-1	50	66	.020	.16	.12	51	1.55
9-4	51	72	.066	.15	.12	32	1.93
4-2	51	73	.036	.16	.10	23	2.07
1-1	52	71	.018	.14	.15	43	1.86
9-5	52	72	.060	.15	.13	34	1.94
2-5	53	77	.058	.13	.11	26	2.04
2-3	55	78	.058	.19	.11	19	2.41
4-7	56	71	.031	.14	.11	30	1.91
1-7	56	75	.031	.18	.13	28	2.16

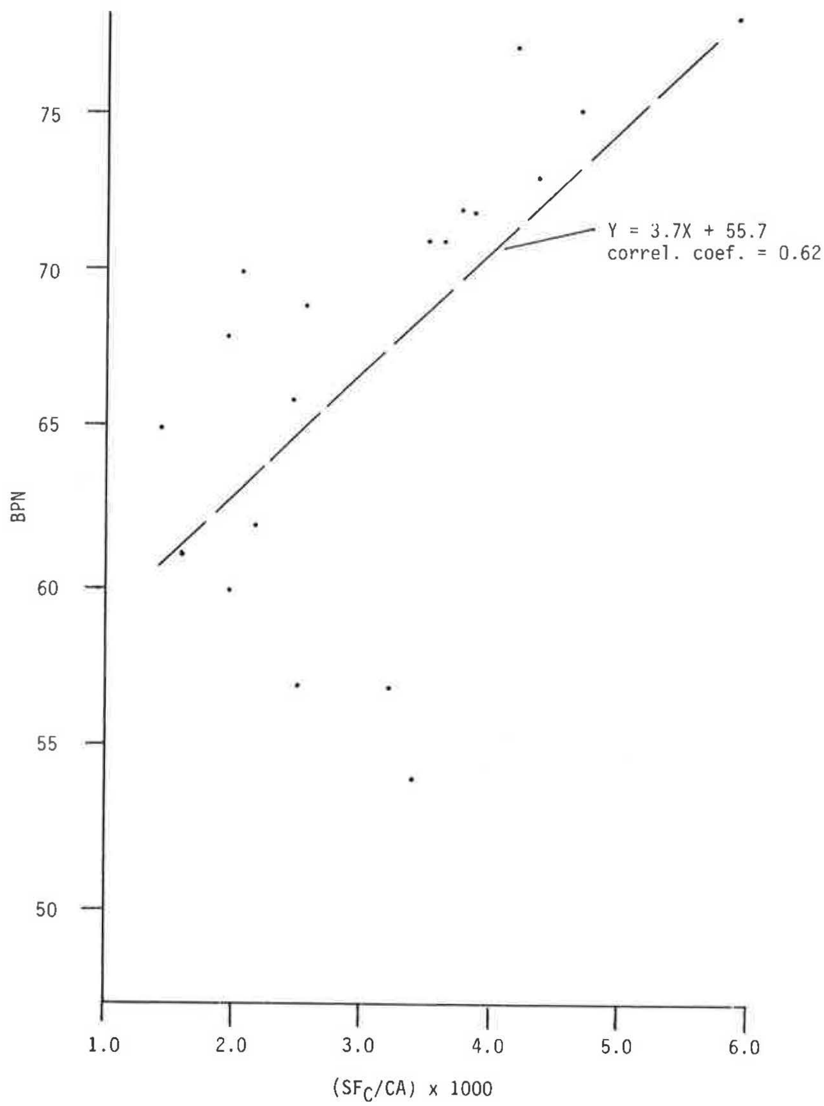


FIGURE 9 Plot of BPN versus SF_c/CA × 1,000 for nineteen cores listed in Table 2.

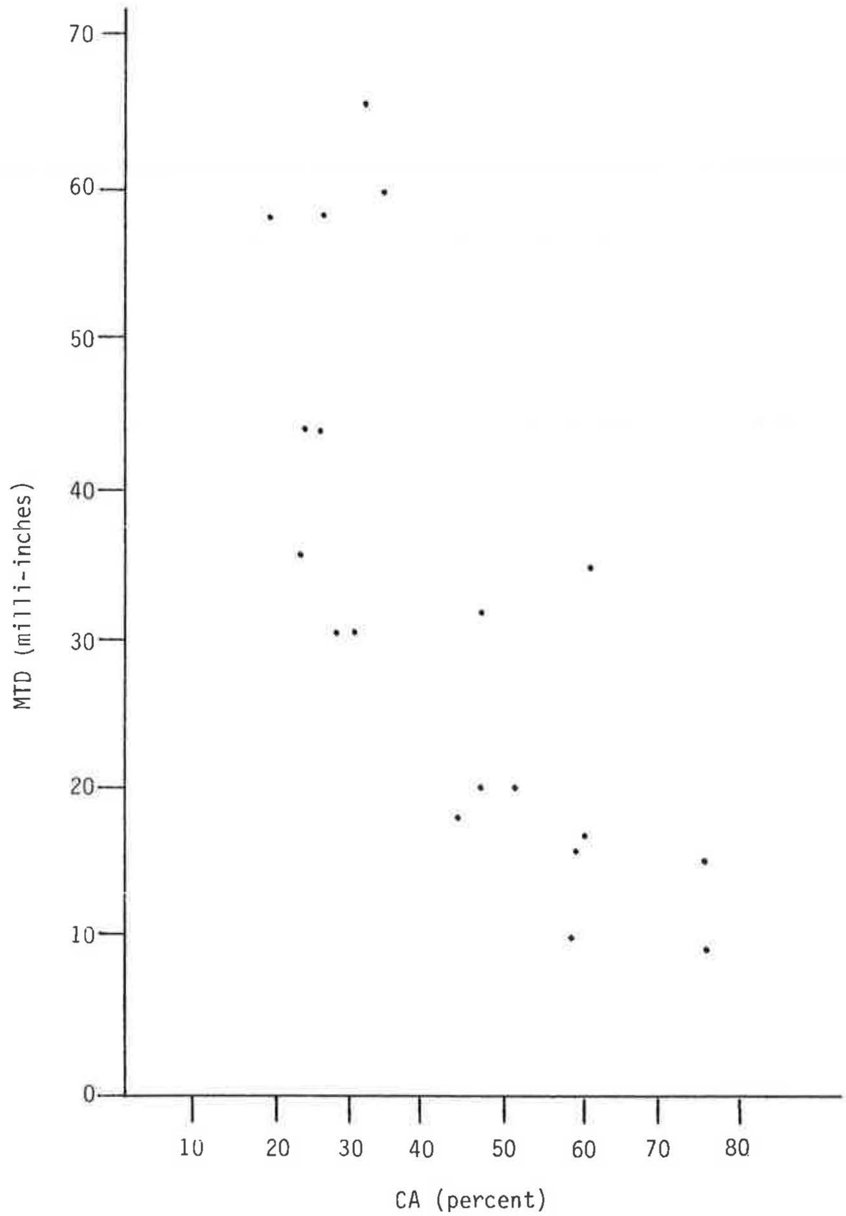


FIGURE 10 Plot of MTD versus CA for nineteen cores listed in Table 2.

and CA measurements. The conclusion from this analysis is that either the SN_{40} value was uncharacteristically low (owing to a long dry spell, for instance) at the time it was measured for 8-4 or there is some other factor influencing skid that is not accounted for by SF_c and CA.

The other outliers, samples 5-B and 6-3, are both from asphalt pavements. Pavement 5 is an asphalt pavement made using crushed limestone aggregate. Pavement 6 has a bituminous surface treatment that was made using limestone screenings. Both pavements were more than 10 years old at the time of testing, so it was expected that SN_{40} values would be low with these aggregates. As shown in Figure 9, pavement 5 had an SN_{40} of 32, and pavement 6 had a value of 34. These figures deviate from the best-fit line, then, probably because of the texture term. The SF_c portion of the term is low, indicating inadequate microtexture (as expected from a polished aggregate). The CA term, however, is also low, indicating that these pavements have a good macrotexture. This may indicate that pavements with a very good macrotexture (open-graded surface, or nearly so) may have to be evaluated separately from dense-graded surfaces. This problem will require future additional work.

SUMMARY

In this study, a microscope-based, automatic image analysis system was used to measure small-scale surface texture (microtexture) on a series of 87 samples from in-service pavements. A range of asphalt and portland cement pavements was included. Based on a previous study, the microtexture was characterized by a single calculated parameter, the shape

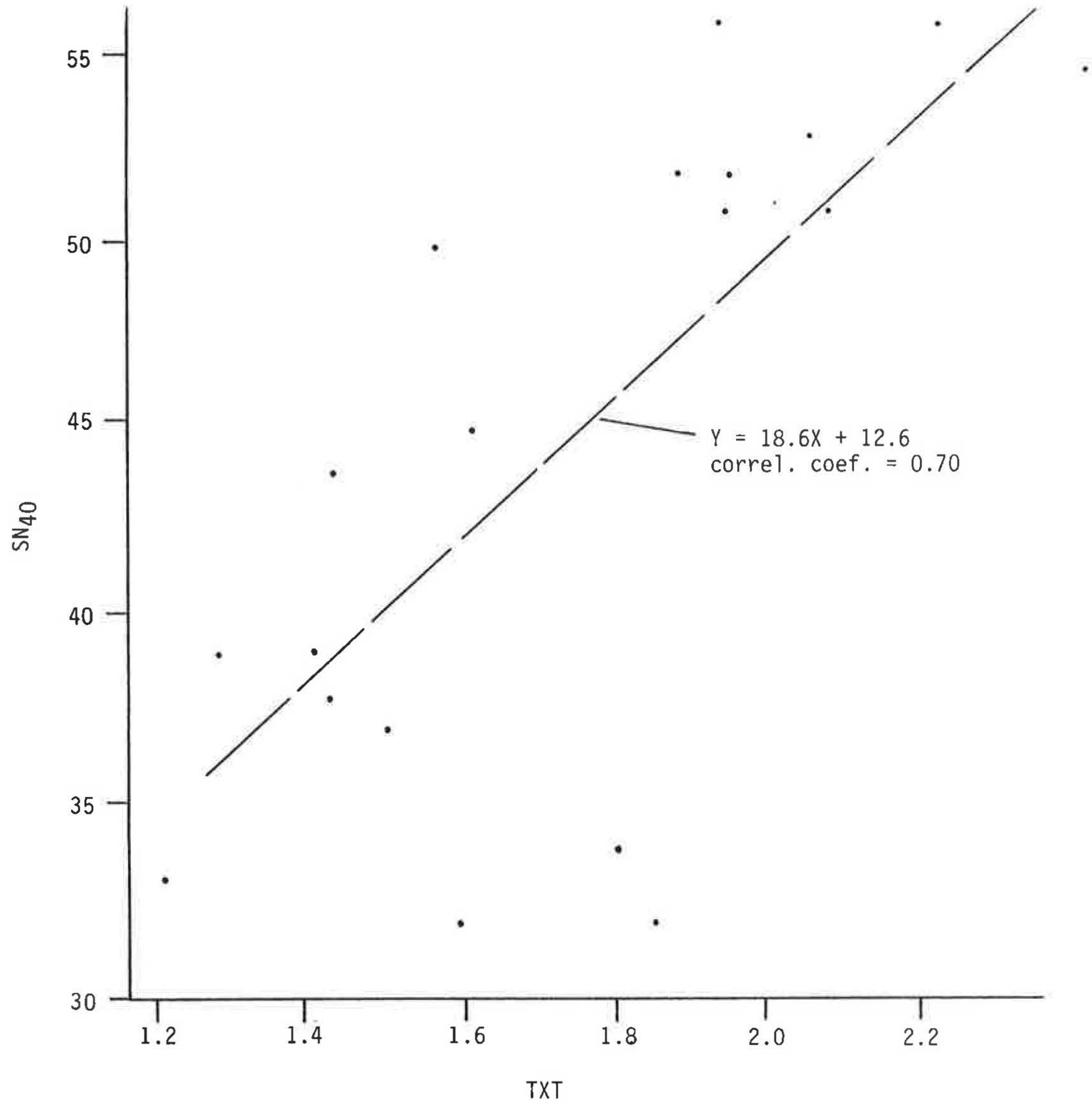


FIGURE 11 Plot of SN_{40} versus TXT for nineteen cores listed in Table 2.

factor (SF). Macrotexture was estimated by measuring contact area percentage (CA). These two texture measurements were combined as the parameter TXT for correlation with skid measurements from ASTM E274 (SN_{40} values) for a subset of 19 samples. The resulting correlation coefficient (0.70) shows promise but also indicates room for improvement. Examination of outliers indicates possible problems with both texture and skid data. Further research may be appropriate to determine if any surface characteristics that affect skid resistance are not adequately accounted for by the texture measurements defined here.

CONCLUSIONS

1. The microtexture of pavement samples can be characterized by a single parameter, the shape factor (SF). SF is a combination of average height and average spacing of the microtexture asperities.
2. Based on comparisons with MTD results from the sand patch test, the macrotexture of the pavements examined could be estimated by simulating and measuring the percentage of contact (CA) within the area of a tire footprint on the pavement surface. Additional testing would verify the universal applicability of this approach.
3. SF_c (shape factor on the contact area) and CA can be combined into an overall texture measurement (TXT) that may be correlated with skid measurements.

EXTENSIONS

1. While TXT has a fairly good correlation with SN_{40} values, additional work is needed to determine if the correlation can be improved by further refinement or the addition of one or more other parameters.
2. Although the pavement microtexture has been successfully quantified, no optimal value for SF_c has been established. For the samples examined, the friction continues to increase with SF_c over the range of values obtained. It may be that

microtexture, as it is measured by SF and as it occurs in pavements, can never attain (or exceed) the optimum. This problem needs further investigation.

3. Aggregate types could be studied and classified according to SF levels. Grouping should include not only initial levels but also ultimate polish or lower limits of SF. The practicality of grouping aggregates according to ultimate SF by general lithology is a possibility worth exploring.

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