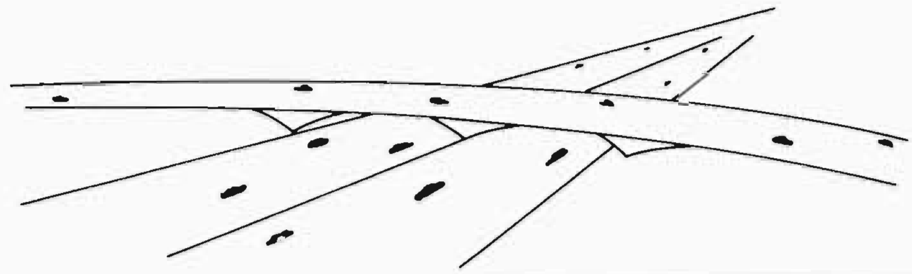

DEPARTMENTAL RESEARCH

Report Number 187-10

A REVIEW OF TINES TEXTURING OF PORTLAND CEMENT CONCRETE PAVING

STATE DEPARTMENT OF HIGHWAYS
AND PUBLIC TRANSPORTATION

A Review Of Tines Texturing of Portland Cement Concrete Paving

by

Kenneth D. Hankins

Research Study No. 1-10-77-187

"Demonstration and Field Test Support"

Research Report 187-10

Conducted by

Transportation Planning Division

Research Section

The State Department of Highways

and Public Transportation

In Cooperation with the

U. S. Department of Transportation

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16. Abstract

This report describes the tests conducted by the Transportation Planning Division, Research Section of the State Department of Highways and Public Transportation to review the methods and effectiveness of Tines Texturing of Portland Cement Concrete Pavements in Texas. It includes average texture values, percent by texture groups, wear measurements, operator variations and surface variations within a project also the opinions, concerns and comments of several engineers in various Districts were discussed. It was concluded that the majority of Districts have experienced trouble in obtaining the required Tines Texture levels, are concerned with the damage and possibility of structural strength loss caused by tining and do not believe the possible reduction in wet weather accidents achieved by tines is worth the possible reduced loss in structural life caused by tining. Recommendations were made to reduce the average texture depth requirements and delete the minimum texture depth requirement. Minimum cross slope requirements and alternate methods of finishing were suggested. Also, revision of the roughness requirements were suggested as well as additional study of concrete finishing techniques.

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TEXTURE TESTS ON TRANSVERSE TINES FINISH OF P. C. CONCRETE PAVING

BACKGROUND

In the early part of the 1970's the Texas Department of Highways and Public Transportation attempted to upgrade methods of reducing hydroplaning and increased skid resistance on P. C. Concrete pavement on new construction in the state. Research projects studied methods of improving the surface texture. Reports were received from other agencies indicating 1/8 inch wide transverse tines spaced at ¼ to ½ inch centers were being used by others. The Research studies verified the skid resistance adequacy of the tines texture. These studies also indicated the wear down or texture loss would be approximately 25 to 35 percent. Other research studying wet weather accidents indicated a texture depth of about 0.035 inch would be desirable in reducing wet weather accidents in rural conditions. To achieve a texture of 0.035 inch after wear down and assuming 30% weardown some 0.050 inch would be needed initially.

Based on this information a specification requiring a transverse tines finish similar to that mentioned above was developed. This specification also required an average texture depth of 0.060 inch with no one test less than 0.050 inch when tested in accordance with Texas Test Method, Tex-436A. After some use as a special specification the item was placed in the 1982 standard specifications.

Recently, questions have developed concerning the depth requirements and the adequacy of the texturing method. To obtain the required average texture and more particularly the minimum texture requirement, methods were needed which possibly caused structural damage to the surface of the paving. Coupled with surface smoothness requirements, it was decided that concern and confusion must soon develop with state and FHWA personnel monitoring the construction. Therefore, the study reported herein was developed.

The study was to review the past tines texturing techniques and study the values being obtained. Measurements were to be made on recently constructed projects to determine the level of texture being achieved and the variability being experienced. Operator variance was to be studied along with texture wear loss. Measurements were to be obtained on older surfaces to compare texture values in the wheel paths with values out of the wheel paths in an attempt to develop additional weardown information. A subjective evaluation of structural damage was to be studied by questioning experienced engineers.

METHOD OF DATA COLLECTION

Some 700 sand patch texture tests were obtained in the winter and spring months of 1984. These tests were collected on 18 projects in five Districts and Houston-Urban. Measurements were gathered on eight new construction projects where the surface had received little or no traffic.

Little information could be found as to where or at what location to perform the test on new construction. District operators appear to develop a location selection procedure and generally stay with that procedure, however, procedures vary. One operator tested new construction in a wheel path and maintained a log of the location by engineering station with offset distance and direction. Other operators select test spots at random. The tests performed in this study were generally obtained in the left wheel path and at the even station where engineering stations were available. It was decided that this procedure would eliminate some of the bias of selecting sites where one might be prone to select a location with large or small texture. However, at several locations some of the tests were obtained in the right wheel path or at randomly located spots, particularly on the ramp locations. Tests were obtained longitudinally at the mid-point of the shoulder construction on IH 35 in District 3. Since the study was concerned with transverse tines finish on P.C. Concrete, the tests were made on surfaces with this type of finish. There were exceptions where tests were obtained on a burlap drag finish at a project on US-82 in Wichita Falls and two experimental projects placed in 1971 and 1973.

RESULTS OF TESTS

Attachment #1 contains a summary of the tests obtained. Note the different construction jobs are listed in the columns and the "items studied" form the rows. Attempts have been made to form separate columns for (1) portions of the construction job that had received traffic and (2) portions that had not been opened to traffic even though the two parts were in the same construction job. One section on IH 35 in District 15 which was known to be below standard is listed separately. This section is to be retextured, probably by sawing. Average Texture Operator Variance will be discussed separately, so for simplicity only the values obtained by D-10 operators will be discussed. Eight sections were tested which had been recently constructed where the surface had received "little to no" traffic. The average texture was found to range from 0.041 inch to 0.098 inch. Two of the eight newly constructed sections were found to have average textures below 0.060. As stated previously one of these sections had been recognized as having deficient texture and plans for retexturing had been made. It should be recognized that the average texture over a long length or a completed job is not representative of the "average texture" mentioned in the standard specifications. The Construction Manual suggests three tests for each days production. The presentation in "percent by Texture Groups" indicates that on several occasions there is the possibility that the average texture over a days production could be less than the required 0.060 inch. However, the specifications require revisions in application technique to obtain the required texture once deficiencies are found. There is every evidence that this requirement is being pursued. For example the later portions of the job or the additional third lane generally have much larger texture values as compared to the initial construction. Once a section with deficient texture is found, correction methods could involve undesirable techniques. It appears that excessive texture is produced in order to achieve the desirable "average texture". There is a need to reduce or eliminate the need for this practice.

Percent by Texture Groups - Texture groupings in Attachment 1 were selected with breaks at 0.050, 0.060 and .100 inch. The 0.050 and 0.060 inch relate to the minimum value and the average values mentioned in the standard specifications. The 0.100 was arbitrarily selected as a point where there seems to be too much texture. The tests on the new construction which had not been traveled were the only sections indicating values greater than 0.100 inch. This would tend to indicate much of the wear down or texture loss generally comes from the heavily textured areas.

Of the eight newly constructed sections studied only one met the specification requirement of having no texture value less than 0.050 inch. This should be expected. Recent studies into the development of statistically based specifications indicate variations around the required value can be expected - both high and low. In statistically based specifications, this variance is recognized and permitted - but controlled. When excessive variance is found, penalties are imposed. Obviously 82 percent of values falling below 0.050 inch as found on the IH 35 section (to be retextured) is too large. Percentages on the order of 30 to 50 percent below 0.050 inch can be expected, and perhaps 15 to 30 percent would be desirable. The wording in the existing standard specifications should be revised to eliminate the statement "no one test shall be less than 0.050 inch".

Figure 1 shows the distribution of texture values of the projects studied. Probably insufficient data was collected to develop accurate frequency distributions of texture but the texture on several projects tend to tail off to the smaller values and large percentages are found in the heavy texture ranges.

WEARDOWN

Loss in texture due to breaking or dislodging of small particles under traffic is to be expected. The loss will probably be greater and more immediate on areas with larger texture values because the tines tend to plow and pile up mortar when deep penetration is experienced. Three methods of studying wear down were pursued. The first was the measurement of texture in the wheel path or traveled area in comparison with measurements made out of the wheel path. The second was a group of measurements obtained by Mr. Lonny Traweek and Mr. John Britigan in District 18 (Dallas) on IH 30. These measurements were repeat measurements obtained after only a short wear down period. The third method of study was to observe the wear down developed by a series of measurements over a long time period.

(1) Tests were made both in and out of the wheel path on the sections which had been under traffic for some period of time. The idea was to let the "out of the wheel path" tests simulate the before or non traveled condition. The "in the wheel path" tests would have been traveled or worn. A comparison of "in" versus "out" would give a measure of wear or loss of texture due to traffic. Using this method of study the wear down seems to be about 14 to 15 percent after about six months of traffic (2.3 million applications per lane) and 27 to 29 percent after six or seven years (9.4 million applications per lane). However, this method of comparison proved to be inadequate since on several occasions the "out of the wheel path" area was originally finished with significantly less texture than the "in the wheel path" areas. Percent wear calculations result in negative values similar to those experienced in the Paris (1) and El Paso (24) Districts as shown in Attachment I. For example, the data on US-54 in El Paso shows the traveled section to have a negative 13 percent loss and the non traveled area to have an even greater negative loss of 32 percent. It does appear that values as large as 0.047 inch can remain after six to seven years of traffic (9.4 million applications per lane).

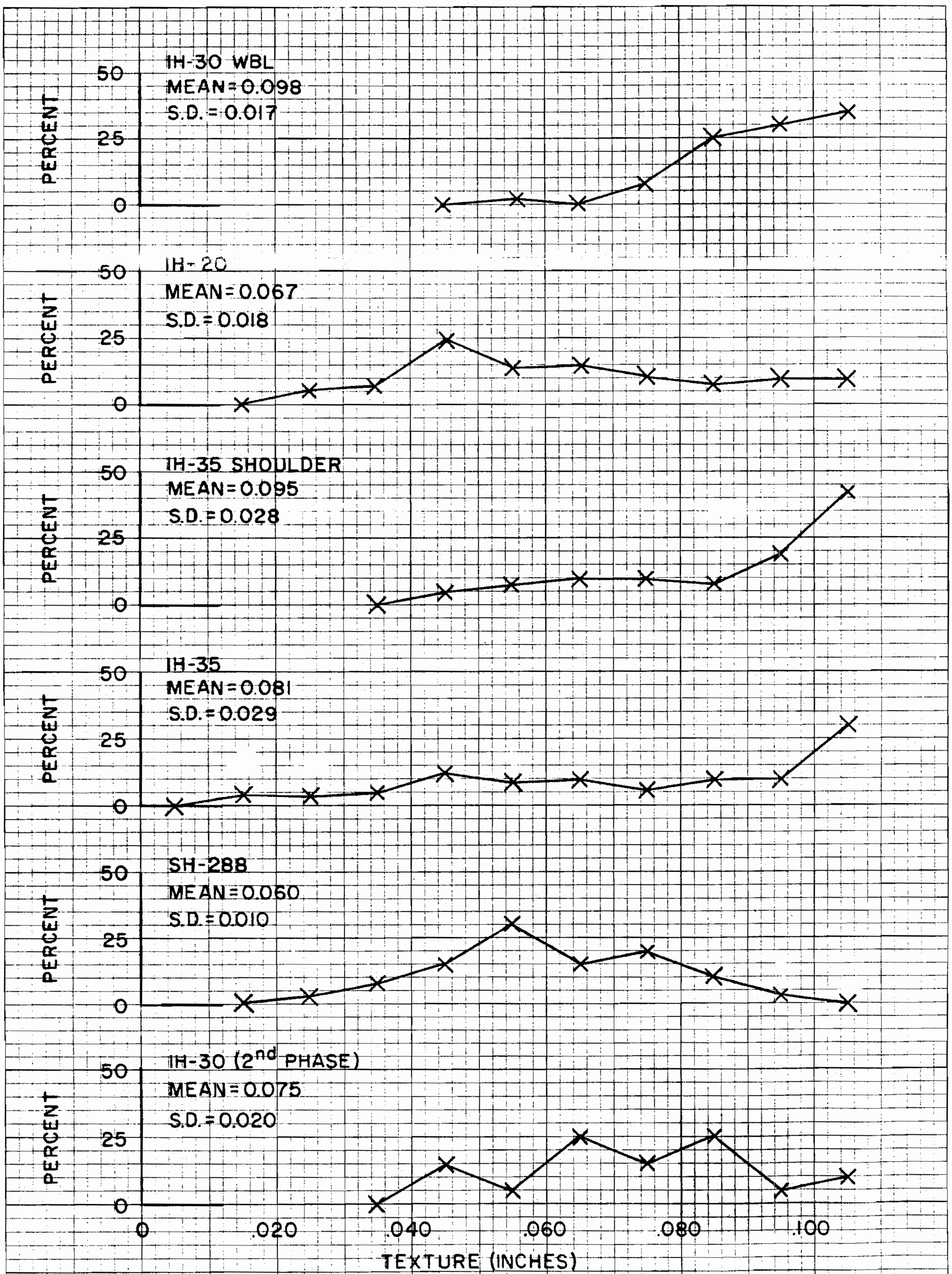

FIGURE I-FREQUENCY DISTRIBUTIONS OF NON-TRAVELED ROADS

(2) The data for the second method of study as collected by District 18 (Dallas) personnel may be found in Attachment II. The second or "after" test was obtained about 6 months after the initial or "as constructed" test. The test locations are within the group previously reported and found in Attachment I from Station 427 to Station 327 on IH-30 in the Westbound lanes and Station 442 to Station 335 in the Eastbound lanes. The surface had experienced approximately 2.3 million traffic applications per lane between the test periods. The District found the initial texture on the Westbound lanes averaged 0.072 inch. The "after" texture averaged 0.065 inch or a 10% wear down was found during this period. The Eastbound lanes had an average texture of 0.056 inch initially and 0.035 inch after six months. The wear down on the Eastbound lanes was about 37%.

(3) The third method of studying wear down involved two areas of pavement where the initial research projects of tines texturing was performed by Dr. W. B. Ledbetter and Dr. A. H. Meyer in 1971 and 1973. In these projects experimental texturing was placed on P. C. Concrete pavement surfaces during construction. The locations were (a) on SH 6 near Bryan, Texas and (b) on IH 10 near Van Horn, Texas. (1,2) During the initial studies it was postulated that the texture wear down would level off at a value of about 30-35 percent of the initial. The recent tests conducted for this project in April and June, 1984 indicate this postulation was in error. Attachments III and IV indicate the wear down can be as low as 22 percent and as large as 74 percent when expressed as a percent of the original. The smaller wear down percentages occur on surfaces with small initial textures. These small initial textures generally occur on surfaces with texturing methods other than tines, but large wear downs can be experienced on tines as shown by Section F-16 on the IH 10 study. The F-16 Section was a 1/8 inch longitudinally tined surface which was originally constructed with 0.065 inch texture. After 17 million (5.1 million in travel lane) vehicle applications a value of 0.017 inch was found, so wear down can be severe.

Figures 2 and 3 are plots of the data shown in Attachments III and IV. A texture depth was not required at the time the experimental sections were placed. However, of the 18 sections placed, four sections were constructed with less than 0.035 inch texture and six were constructed with greater than 0.060 inch. Only four sections had texture values greater than 0.035 inch after 5 million vehicle passes (per lane) and most of the sections lost a significant amount of texture within one year of being subjected to traffic. It is believed that initial texture needs cannot be based on percent wear down expected since texture "life" must be dependent on several items such as:

1. Initial texture depths or values

2. Strength of P. C. Concrete on the surface (mix design, construction practices, adding moisture during finishing, etc.)

3. Mix workability (harshness levels could be related to aggregate movement and reconsolidation of the surface after passage of the tines.)

4. Weathering or Environment to which the surface is subjected.

5. Amount and type of traffic to which the surface is subjected.

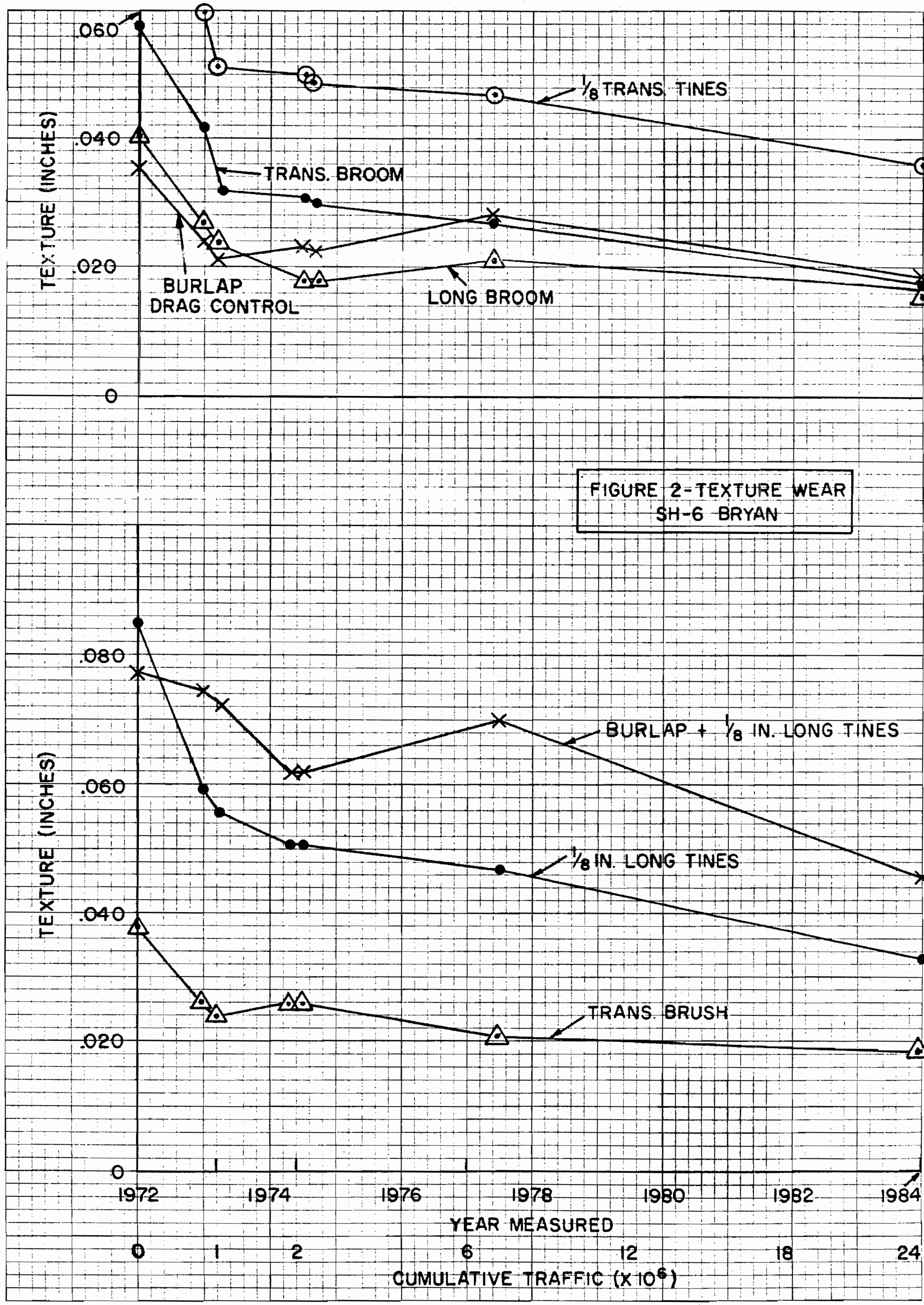

FIGURE 2-TEXTURE WEAR
SH-6 BRYAN

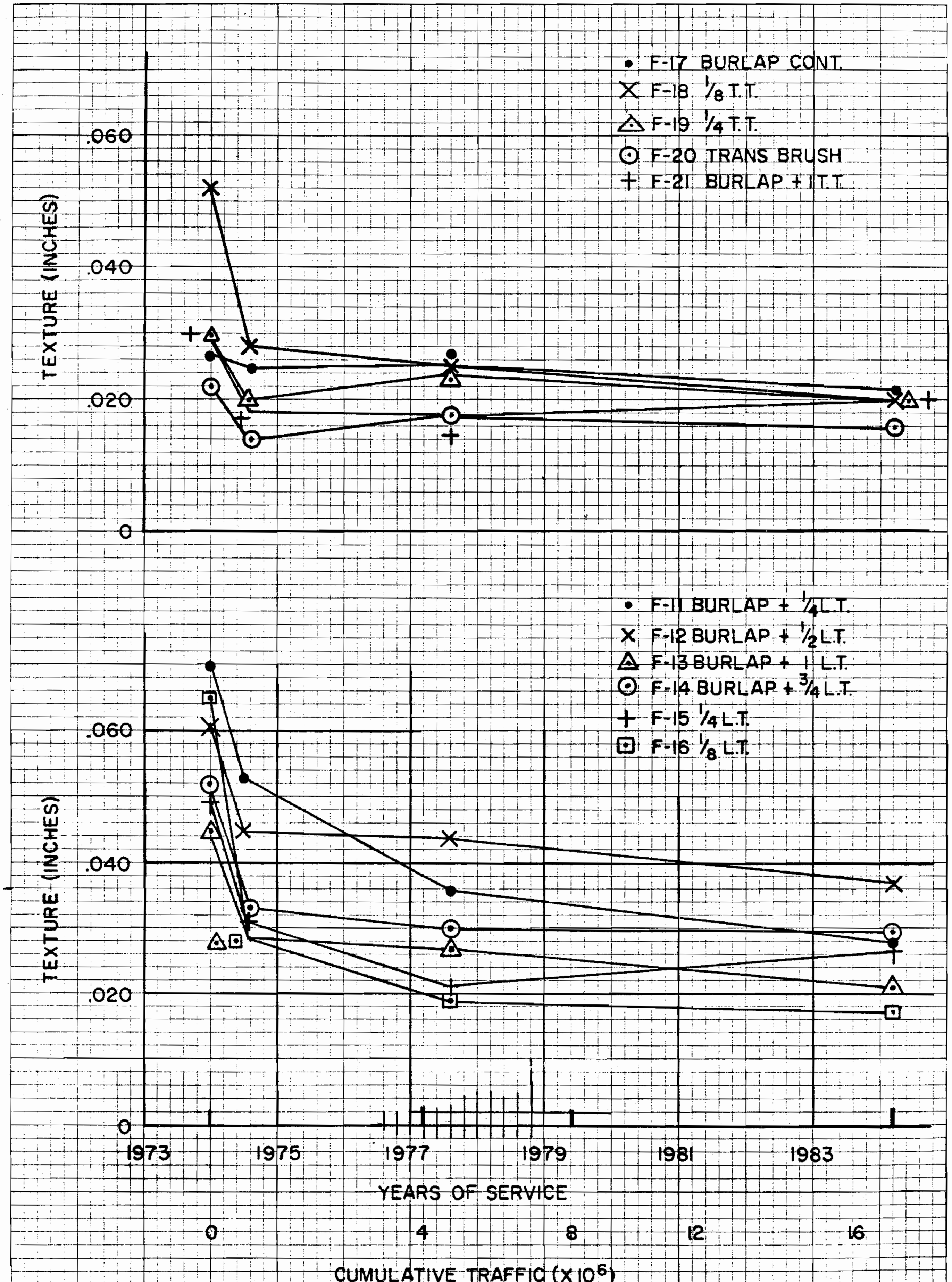

FIGURE 3 - TEXTURE WEAR, IH 10 VAN HORN

Operator Variance

Operator variance was studied by obtaining tests with two different people over the same spot. After one operator had run a test at a spot on the concrete surface, the sand was brushed away and the second operator tested on the same spot. This procedure seemed to work well. After brushing, no evidence of sand from the first test could be observed, however, to guard against a possible source of error, the operator test sequence was varied as to first to test on a spot. The largest average difference between operators was found to be 0.016 inch. The largest difference between operators at a given spot was 0.079 inch. This occurred between two D-10 operators on a very high textured spot where one operator measured 0.156 inch. A relatively high texture peak at a spot can often cause discrepancy between operators, especially in the manner in which the sand is molded around the peak with the wooden puck. Differences between operators on the order of 0.020 to 0.030 inch were found very often.

No inconsistency in performing the test according to the published procedure was noted. Each operator attempted to perform the test to the best of his ability. However, it is believed the major factor in the variation between operator values is the difference in judgement as to when the sand has been spread to the top of the texture peaks.

The difference between operators seems to be consistant. One operator will be consistantly higher. Correlation plots between operators show a linear fit with little data scatter and a high correlation. This type of fit also indicates the difference between operators will be greater when larger texture values are found.

Variation In Spots

At times when a test is obtained and the location of the spot recorded, retesting or a check of that spot is desired at a later date. This series of tests was performed to determine if variation could exist if the exact spot was not found. This testing also produced additional data for comparisons of surfaces and could show a measure of variability along the surface.

The procedure consisted of obtaining and comparing two tests collected approximately two feet apart. The test spots were generally located in a transverse manner on newly constructed surfaces. Only two of the sections were tested in this manner.

These tests indicate the average variation in spots approximately two feet apart was about 0.005 inch. The largest single difference was found to be 0.040 inch and 0.020 to 0.030 inch differences were common.

SURFACE SMOOTHNESS

In the past the standard specifications have attempted to provide ride smoothness on P. C. Concrete pavement by requiring the use of straightedge. Two requirements are mentioned. One requirement is an attempt to reduce "jerk" or rapid vertical accelerations. This specification indicates vertical profile departures from the nearest point of contact of a 10 foot straightedge of greater than 1/16 inch in a longitudinally length of one foot will not be permitted. The second requirement is related to ride roughness and specifies the maximum ordinate permitted from a longitudinally positioned 10 foot straightedge to be 1/8 inch. To obtain a required average texture of 0.060 inch, tine penetration depths on the order of 1/4 inch will be needed every 1/4 to 1/2 inch longitudinally along the roadway. Therefore, the tines texture and surface smoothness requirements contradict one another. Deletion or modification is needed.

DISCUSSIONS WITH EXPERIENCED ENGINEERS

Discussions were held with personnel in each district visited. During these discussions generally three questions were asked as follows:

> After having experience with the construction of P. C. Concrete pavement with tines texturing -
>
> 1. Explain your experience
>
> 2. With a given depth for structural design, do you think the tines finish damages the pavement structurally?
>
> 3. Do you think the use of tines has been beneficial to driver safety?

Four engineers were questioned in District 18 (Dallas), two engineers in District 3 (Wichita Falls), and one person in Districts 1, 15, 17, 24, and Houston Urban (Paris, San Antonio, Bryan, El Paso and Houston).

The discussions of experience with tines texturing generally indicated problems were experienced during construction in developing adequate texture. Large texture variability within short lengths (that is from batch-to-batch) have been experienced, however, some variation in longer, day to day, lengths have caused problems. In order to obtain the required texture the contractors have:

1. Double tined - made two passes with the tining rake.
2. Applied more pressure to the tines.
3. Changed the length of the tine in the rake.
4. Changed type of tine to a tine with stiffer member or material.

Changes have been made in vibration techniques of the P.C. Concrete and by increasing the application of the fog spray which may be applied to the surface.

Some problems with surface durability have been experienced due to the spalling or breaking of the ridges formed by the tines. This damage generally occurs where deep tine penetration or high ridges have been formed in areas where the tining was performed on a very wet surface. Some of this type spalling could be due to freeze damage since the damage was first noted after very cold weather occurring in the winter of 1983-84.

Responses to the question "do you think the tining damages the pavement structurally?" were relatively consistant. The majority of the people questioned believed that some reduced strength must occur. About one third of those questioned were not completely sure of the loss of strength or structural durability of the pavement and two people stated they did not know.

One district increases the thickness required for design structural durability by about ½ inch in order that the surface may eventually be cold milled to renew skid resistance. Observations of several continuously reinforced concrete projects during the course of this study indicated the transverse cracking was random, moving back and forth across the tined ridges. It could be postulated that if tining reduced the strength, the cracking would be in the lower portion or the "furrow" caused by the tine.

The question "Do you think the use of tines has been beneficial to driver safety?" again brought varied response. A few engineers did not believe the tines had reduced wet weather accidents more than that which had been occurring on the burlap drag texture used prior to the tines finish. Two people felt the tines finish was beneficial. The majority of engineers questioned did not give a direct answer to the question, however, several comments were offered. These comments included the following:

1. Concern that there is the possibility of damage to a concrete surface that has been tined to reduce wet weather accidents when the surface is wet only 2 to 10 percent of the time.

2. Concern that to obtain the texture value specified detrimental construction techniques will be required.

3. Since one of the major objects of specifying tines texture is to reduce the tendancy of vehicular hydroplaning by reducing water film depths, it was recommended that cross slope be increased and texture decreased.

4. It was recommended that tines texture not be used and the specifications require a burlap drag finish followed by sawed grooves.

CONCLUSIONS

Based on the results of this study, the following items may be concluded:

1. Some 20 to 25 percent of the newly constructed pavements failed to meet an average texture depth of 0.060 inch.

2. About 86 to 88 percent of the newly constructed pavements failed to meet the minimum texture requirement of 0.050 inch.

3. There appears to be a conflict between the texture and roughness requirements in the standard specifications.

4. The variance between operators can be large particularly on heavily textured pavements. Some 0.020 to 0.030 inch was common even though the average difference was 0.016 inch.

5. There has been some surface damage caused by the breaking and raveling of the ridges formed by the tines.

6. The majority of engineers contacted in the districts had experienced trouble in obtaining the required tines texture levels, were concerned with the damage and the possibility of a structural strength loss caused by tining, and did not believe the possible reduction in wet weather accidents achieved by the tines was worth the possible reduced loss in structural life caused by tining.

7. Percent "Wear Down" is inconsistant. Levels below 0.035 inch can be found before structural rehabilitation becomes necessary even though textures greater than 0.060 inch were constructed initially. However, surfaces can be found were relatively large texture values are found after several million traffic applications per lane. Surfaces with larger initial texture values generally retain larger values longer, but surface strength and proper mix design must be very important in maintaining texture under the abrasive action of traffic.

8. Sawed grooves have been used successfully in reducing wet weather accidents in maintenance applications. A typical pattern has been to use 1/8 wide grooves spaced at 3/4 inch (center to center) and sawed approximately 1/8 inch deep. The equivalent sand patch texture value for this pattern would be about 0.020 inch. This value (0.020 inch) is less than the 0.035 inch which was believed to be needed as a minimum(3). The 0.035 inch value was derived from an accident study in which the majority of the surfaces used aggregate bound by asphaltic material. Therefore, the sawed grooves on concrete paving must be very efficient in removing surface water from between the tire and pavement. First, well defined closely spaced channels are formed for rapid water dispersal. Second, when the water is removed and the tire contacts the concrete surface, relatively large tire-pavement contact areas (adhesion friction component) are provided. Third, some tire pavement interlock or intimate contact (hysterisis component of friction) is provided. Fourth, if grooves are sawed longitudinally a railroad type tracking is provided which drastically reduces the tendency of the rearend of a vehicle to move laterally causing improved vehicle control. Disadvantages of longitudinally grooving are :

   (1) the pavement remains wet longer.

   (2) transverse drainage and water removal are reduced.

   (3) dynamic drainage at the time of tire passage may be reduced slightly.

   (4) with certain types of grooves the handling characteristics of motorcycles and light automobiles are affected.

Recommendations

The following is recommended:

1. Revisions to the existing Standard Specification Item 360.8.(1) Machine Finishing should be considered. The average texture depth of 0.060 inch should be reduced and the minimum texture depth requirement of 0.050 inch on any one test should be deleted. An average texture depth of 0.050 inch is suggested and a minimum cross slope of 3/16 inch per foot should be considered with 1/4 inch per foot for drainage path lengths greater than 30 feet (more than 2 lanes wide).

2. Consideration should be given to permitting an alternate finish of a burlap drag followed by longitudinally sawed 1/8 inch wide grooves spaced at 3/4 inch center to center. Groove depths between 1/8 and 3/16 inch should be considered.

3. Revisions to the existing Standard Specification Item 360.8.(3) Surface Test should be considered. Deviations or variations based on a 10 foot straight edge should be deleted. Maximum roughness requirements based on a rolling straightedge, profilometer or Response Type Roughness Measuring equipment should be considered. This equipment should be able to average, reduce, or delete the small wave length texture from the pavement profile and only consider wave lengths greater than six inches.

4. Additional study of concrete finishing techniques should be considered. Fluted floats and various methods of providing texture and drainage of surface water should be considered were the finishing technique can be applied while the concrete is plastic.

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1. Ledbetter, W. B., and Meyer, A. H. "Evaluation of Full Scale Experimental Concrete Highway Finishes", Research Report 141-4F, Research Project 2-6-70-141, Quality of Portland Cement Concrete Pavement, Texas Transportation Institute, Texas Department of Highways and Public Transportation, Federal Highway Administration, September 1974.

2. Hankins, K. D., "Follow-up Report on Evaluation of Full Scale Experimental Highway Finishes", Research Report 187-2, Research Project 1-10-77-187, Demonstration and Field Test Support, Texas Department of Highways and Transportation and the Federal Highway Administration, August, 1977.

3. Hankins, K. D.; Morgan, Richard B.; Ashkar, Bashar; Tuft, Paul R.; "The Degree of Influence of Certain Factors Pertaining to the Vehicle and the Pavement on Traffic Accidents Under Wet Conditions", Research Report 133-3F, Research Project 1-8-69-133, Texas Department of Highways and Transportation and the Federal Highway Administration, September, 1970.

ATTACHMENT I
SUMMARY OF TEXTURE INFORMATION (in3/in2)

DISTRICT HWY-LOCATION	DIST.18 IH-30 WBL STA.427-327	DIST.18 IH-20 RAMPS & M.LA	DIST.18 IH-30 WBL STA.303-305	DIST.18 IH-30 EBL STA.442-335
AMOUNT OF TRAFFIC	NONE	NONE	6 MONTHS 2,300,000 per lane	DETOUR TRAF. 2,300,000 per lane
AVG. W.P. TEXTURE,D-10	.098	.067	.042	.033
AVG. W.P. TEXTURE, DIST.	.086	.069	.037	.023
AVG. DIFF. IN OPERATORS	.012,D-10	.004,Dist.	.006,D-10	.009,D-10
AVG. DIFF. 2FT APART	.005	.004		
% in FOLLOWING GROUPS:				
0.000 to 0.050	0	31	66	100
0.050 to 0.060	2	15	34	0
0.060 to 0.100	62	44	0	0
GREATER THAN 0.100	36	10	0	0
	64 VALUES	96 VALUES	6 VALUES	16 VALUES
AVG. TEXTURE OWP,D-10			.049	.039
AVG. TEXTURE OWP, DIST.			.043	.030
AVG.DIFF. IN OPERATORS			.007	
% in FOLLOWING GROUPS:				
0.000 to 0.050			50	83
0.050 to 0.060			17	4
0.060 to 0.100			33	13
GREATER THAN 0.100			0	0
			6 VALUES	24 VALUES
AVG. DIFF. BETWEEN IWP AND OWP TEXTURE			.007	.006
% DIFF. BETWEEN IWP AND OWP TEXTURE			14%	15%

NOTE: IWP is texture values "in the wheel path" or tire wear area. OWP is texture values "out of the wheel path" simulating "as built" conditions.

ATTACHMENT I
SUMMARY OF TEXTURE INFORMATION (in3/in2)

DISTRICT HWY-LOCATION	DIST.3 US-82 RAMP HOLIDAY TO KEMP	DIST.3 US-82 DALSTON-SHLD.	DIST.3 IH-35 SHLD. STA.505-883	DIST.3 US-82 LACY JOB
AMOUNT OF TRAFFIC	NONE	VERY LITTLE (BURLAP DRAG)	NONE	6,900,000
AVG. W.P. TEXTURE, D-10	.051	.028	.095	.047
AVG. W.P. TEXTURE, DIST.	.094	.024	.083	.043
AVG. DIFF. IN OPERATORS	Not Applic.	.008,D-10	.012,D-10	.005,D-10
AVG. DIFF. 2FT APART				
% in FOLLOWING GROUPS:				16% LT.035 0% LT.025
0.000 to 0.050	57	100	2	50
0.050 to 0.060	14	0	8	17
0.060 to 0.100	29	0	49	33
GREATER THAN 0.100	0	0 7 VALUES	41 61 VALUES	0 6 VALUES
AVG. TEXTURE OWP,D-10				.065
AVG. TEXTURE OWP, DIST.				.054
AVG.DIFF. IN OPERATORS				.010,D-10
% in FOLLOWING GROUPS:				0% LT.035
0.000 to 0.050				17
0.050 to 0.060				33
0.060 to 0.100				50
GREATER THAN 0.100				0 6 VALUES
AVG. DIFF. BETWEEN IWP AND OWP TEXTURE				.018
% DIFF. BETWEEN IWP AND OWP TEXTURE				28%

NOTE: IWP is texture values "in the wheel path" or tire wear area. OWP is texture values "out of the wheel path" simulating "as built" conditions.

ATTACHMENT I
SUMMARY OF TEXTURE INFORMATION (in3/in2)

DISTRICT HWY-LOCATION	DIST.3 US-82 HOLIDAY TO KEMP	DIST.3 US-82 DALSTROM	DIST.15 IH-35 N of IH410	DIST.15 IH-35 N of IH410
AMOUNT OF TRAFFIC	6,900,000	6,900,000 (BURLAP DRAG)	NONE	NONE
GROUP			40,41,43	42
AVG. W.P. TEXTURE,D-10	.017	.016	.095	.041
AVG. W.P. TEXTURE, DIST.	.015	.014	.084	.041
AVG. DIFF. IN OPERATORS	.001,D-10	.002,D-10	.011,D-10	0
AVG. DIFF. 2FT APART			.005	.004
% in FOLLOWING GROUPS:	100% LT.025	100% LT.025	0%<.035	38%<.035
0.000 to 0.050	100	100	6	82
0.050 to 0.060	0	0	10	6
0.060 to 0.100	0	0	47	12
GREATER THAN 0.100	0	0	37	0
	7 VALUES	6 VALUES	49 VALUES	16 VALUES
AVG. TEXTURE OWP,D-10	.024	.022		TO BE RETEXTURED by Contractor
AVG. TEXTURE OWP, DIST.	.021	.021		
AVG.DIFF. IN OPERATORS	.003,D-10	.002,D-10		
% in FOLLOWING GROUPS:	100% LT.035 84% LT.025	100% LT.035 67% LT.025		
0.000 to 0.050	100	100		
0.050 to 0.060	0	0		
0.060 to 0.100	0	0		
GREATER THAN 0.100	0	0		
	7 VALUES	6 VALUES		
AVG. DIFF. BETWEEN IWP AND OWP TEXTURE	.007	.006		
% DIFF. BETWEEN IWP AND OWP TEXTURE	29%	27%		

NOTE: IWP is texture values "in the wheel path" or tire wear area. OWP is texture values "out of the wheel path" simulating "as built" conditions.

ATTACHMENT I

SUMMARY OF TEXTURE INFORMATION (in3/in2)

DISTRICT	HOUSTON-URBAN	DIST.18	DIST.18	DIST.18
HWY-LOCATION	SH-288 WILLIAMS BROS.	IH-30 1st Measure 2nd Phase	IH-635 MP-31 MacArthur	IH-30 STA.427-400
AMOUNT OF TRAFFIC	NONE	NONE	11,868,000	2,300,000
GROUP	44-47	48	49-50	51
AVG. W.P. TEXTURE, D-10	.060	.075	.056	.079
AVG. W.P. TEXTURE, DIST.	.057	.075	.059	Repeat of Group 1
AVG. DIFF. IN OPERATORS	.003,D-10	0	Dist,.003	
AVG. DIFF. 2FT APART				
% in FOLLOWING GROUPS:	2%<.035	0%<.035	0%<.035	0%<.035
0.000 to 0.050	24	15	22	0
0.050 to 0.060	33	5	11	33
0.060 to 0.100	43	70	67	67
GREATER THAN 0.100	0	10	0	0
	64 VALUES	20 VALUES	18 VALUES	5 VALUES
AVG. TEXTURE OWP,D-10			.069	
AVG. TEXTURE OWP, DIST.			.069	
AVG.DIFF. IN OPERATORS				
% in FOLLOWING GROUPS:				
0.000 to 0.050			28	
0.050 to 0.060			28	
0.060 to 0.100			44	
GREATER THAN 0.100			0	
			18 VALUES	
AVG. DIFF. BETWEEN IWP AND OWP TEXTURE			.013	
% DIFF. BETWEEN IWP AND OWP TEXTURE			19%	

NOTE: IWP is texture values "in the wheel path" or tire wear area. OWP is texture values "out of the wheel path" simulating "as built" conditions.

ATTACHMENT I

SUMMARY OF TEXTURE INFORMATION (in3/in2)

DISTRICT HWY-LOCATION	DIST.18 IH-30 STA.401-397	DIST.18 IH-30 STA.367-362	DIST.18 IH-30 STA.327-324	DIST.1 SH-24 IN PARIS
AMOUNT OF TRAFFIC	2,300,000	2,300,000	2,300,000	1,553,000
GROUP	52	53	54	55-58
AVG. W.P. TEXTURE, D-10	.078	.078	.081	0.042
AVG. W.P. TEXTURE, DIST.	Repeat of Grp. 2	Repeat of Grp. 3	Repeat of Grp. 4	0.040
AVG. DIFF. IN OPERATORS				.002,D-10
AVG. DIFF. 2FT APART				
% in FOLLOWING GROUPS:	0%<.035	0%<.035	0%<.035	58%<.035
0.000 to 0.050	0	0	0	76
0.050 to 0.060	0	17	0	12
0.060 to 0.100	80	66	100	7
GREATER THAN 0.100	20	17	0	5
	5 VALUES	5 VALUES	5 VALUES	40 VALUES
AVG. TEXTURE OWP,D-10				0.041
AVG. TEXTURE OWP, DIST.				0.040
AVG.DIFF. IN OPERATORS				.001,D-10
% in FOLLOWING GROUPS:				
0.000 to 0.050				78
0.050 to 0.060				0
0.060 to 0.100				20
GREATER THAN 0.100				2
				40 VALUES
AVG. DIFF. BETWEEN IWP AND OWP TEXTURE				-.001
% DIFF. BETWEEN IWP AND OWP TEXTURE				-2%

NOTE: IWP is texture values "in the wheel path" or tire wear area. OWP is texture values "out of the wheel path" simulating "as built" conditions.

ATTACHMENT I
SUMMARY OF TEXTURE INFORMATION (in3/in2)

DISTRICT HWY-LOCATION	DIST.24 US-54 IN EL PASO	DIST.24 US-54 IN EL PASO	DIST.24 IH-10 MP-94/MP-97	DIST.24 IH-10 OUT 11-¼"LT.
AMOUNT OF TRAFFIC	17,280,000	NONE	2,778,000	5,100,000
GROUP	60-63	64	65-68	69
AVG. W.P. TEX-TURE, D-10	0.035	0.054	0.040	.024
AVG. W.P. TEX-TURE, DIST.	0.036	.053	0.042	
AVG. DIFF. IN OPERATORS AVG. DIFF. 2FT	.001,Dist.	.001,D-10	.002,Dist.	
% in FOLLOWING GROUPS:	56%<.035	0%<.035	38%<.035	100%<.035
0.000 to 0.050	78	50	91	100
0.050 to 0.060	13	25	3	0
0.060 to 0.100	9	25	6	0
GREATER THAN 0.100	0	0	0	0
	32 VALUES	4 VALUES	32 VALUES	
AVG. TEXTURE OWP, D-10	0.031	.041	.039	
AVG. TEXTURE OWP, DIST.	0.032	.044	.042	
AVG.DIFF. IN OPERATORS	.001,Dist.	.003,Dist.	.003,Dist.	
% in FOLLOWING GROUPS:				
0.000 to 0.050	97	100	88	
0.050 to 0.060	3	0	12	
0.060 to 0.100	0	0	0	
GREATER THAN	0	0	0	
0.100	0	0	0	
	32 VALUES	4 VALUES	32 VALUES	
AVG. DIFF. BETWEEN IWP AND OWP TEXTURE	-.004	-.013	-.001	
% DIFF. BETWEEN IWP AND OWP TEXTURE	-13%	-32%	-3%	

NOTE: IWP is texture values "in the wheel path" or tire wear area. OWP is texture values "out of the wheel path" simulating "as built" conditions.

ATTACHMENT I
SUMMARY OF TEXTURE INFORMATION (in3/in2)

DISTRICT HWY-LOCATION	DIST.17 SH-6-Bryan F-6,Bur.Drag	DIST.17 SH-6-Bryan F-7,Tr.Brush	DIST.17 SH-6-Bryan F-1,Tr.Broom	DIST.17 SH-6-Bryan F-2,1/8TT	DIST.17 SH-6-Bryan F-3,Lg.Broom
AMOUNT OF TRAFFIC					
GROUP					
AVG. W.P. TEXTURE,D-10	.020	.019	.024	.039	.020
AVG. W.P. TEXTURE, DIST.					
AVG. DIFF. IN OPERATORS					
AVG. DIFF. 2FT APART					
% in FOLLOWING GROUPS:	100%<.025	100%<.025	60%<.025 100%<.035	0%<.025 40%<.035	100%<.035
0.000 to 0.050	100	100	100	100	100
0.050 to 0.060	0	0	0	0	0
0.060 to 0.100	0	0	0	0	0
GREATER THAN 0.100	0	0	0	0	0
AVG. TEXTURE OWP,D-10					
AVG. TEXTURE OWP, DIST.	(Outside Lanes = OL) (Inside Lanes = IL)				
AVG.DIFF. IN OPERATORS	OL	OL	IL	IL	IL
% in FOLLOWING GROUPS:					
0.000 to 0.050					
0.050 to 0.060					
0.060 to 0.100					
GREATER THAN 0.100					
AVG. DIFF. BETWEEN IWP AND OWP TEXTURE					
% DIFF. BETWEEN IWP AND OWP TEXTURE					

NOTE: IWP is texture values "in the wheel path" or tire wear area. OWP is texture values "out of the wheel path" simulating "as built" conditions.

ATTACHMENT I

SUMMARY OF TEXTURE INFORMATION (in3/in2)

DISTRICT HWY-LOCATION	DIST.24 IH-10 OUT 12-½"LT	DIST.24 IH-10 OUT 13-1"LT	DIST.24 IH-10 OUT 14-3/4"LT	DIST.24 IH-10 IN 15-¼"LT
AMOUNT OF TRAFFIC	5,100,000	5,100,000	5,100,000	3,480,000
GROUP	70	71	72	73
AVG. W.P. TEXTURE, D-10	.038	.016	.025	.027
AVG. W.P. TEXTURE, DIST.				
AVG. DIFF. IN OPERATORS				
AVG. DIFF. 2FT APART				
% in FOLLOWING GROUPS:	60%<.035	100%<.035	100%<.035	80%<.035
0.000 to 0.050	80	100	100	100
0.050 to 0.060	20	0	0	0
0.060 to 0.100	0	0	0	0
GREATER THAN 0.100	0	0	0	0
AVG. TEXTURE OWP, D-10				
AVG. TEXTURE OWP, DIST.				
AVG. DIFF. IN OPERATORS				
% in FOLLOWING GROUPS:				
0.000 to 0.050				
0.050 to 0.060				
0.060 to 0.100				
GREATER THAN 0.100				
AVG. DIFF. BETWEEN IWP AND OWP TEXTURE				
% DIFF. BETWEEN IWP AND OWP TEXTURE				

L.T. Above is Longitudinal Tines

NOTE: IWP is texture values "in the wheel path" or tire wear area. OWP is texture values "out of the wheel path" simulating "as built" conditions.

ATTACHMENT I

SUMMARY OF TEXTURE INFORMATION (in3/in2)

DISTRICT HWY-LOCATION	DIST.24 IH-10 OUT 16-1/8"LT	DIST.24 IH-10 OUT 17 BUR.DRAG	DIST.24 IH-10 OUT 18-1/8"TT	DIST.24 IH-10 OUT 19-¼"TT
AMOUNT OF TRAFFIC	5,100,000	5,100,000	5,100,000	5,100,000
GROUP	74	75	76	77
AVG. W.P. TEXTURE, D-10	.017	.018	.017	.018
AVG. W.P. TEXTURE, DIST.				
AVG. DIFF. IN OPERATORS				
AVG. DIFF. 2FT APART				
% in FOLLOWING GROUPS.	100%<.035	100%<.035	100%<.035	100%<.035
0.000 to 0.050	100	100	100	100
0.050 to 0.060	0	0	0	0
0.060 to 0.100	0	0	0	0
GREATER THAN 0.100	0	0	0	0
AVG. TEXTURE OWP, D-10				
AVG. TEXTURE OWP, DIST.				
AVG. DIFF. IN OPERATORS				
% in FOLLOWING GROUPS:				
0.000 to 0.050				
0.050 to 0.060				
0.060 to 0.100				
GREATER THAN 0.100				
AVG. DIFF. BETWEEN IWP AND OWP TEXTURE				
% DIFF. BETWEEN IWP AND OWP TEXTURE				

(TT above is Transverse Tines)
(LT above is Longitudinal Tines)

NOTE: IWP is texture values "in the wheel path" or tire wear area. OWP is texture values "out of the wheel path" simulating "as built" conditions.

ATTACHMENT I
SUMMARY OF TEXTURE INFORMATION (in3/in2)

DISTRICT HWY-LOCATION	DIST.24 IH-10 OUT 20-TRAN.BRUSH	DIST.24 IH-10 OUT 21-1"TT	DIST.24 IH-10 IN 11-¼"LT
AMOUNT OF TRAFFIC	5,100,000	5,100,000	3,480,000
GROUP	78	79	80
AVG. W.P. TEXTURE,D-10	.015	.015	.031
AVG. W.P. TEXTURE, DIST.			
AVG. DIFF. IN OPERATORS			
AVG. DIFF. 2FT			
% in FOLLOWING GROUPS:	100%<.035	100%<.035	80%<.035
0.000 to 0.050	100	100	100
0.050 to 0.060	0	0	0
0.060 to 0.100	0	0	0
GREATER THAN 0.100	0	0	0
AVG. TEXTURE OWP,D-10			
AVG. TEXTURE OWP, DIST.			
AVG.DIFF. IN OPERATORS			
% in FOLLOWING GROUPS:			
0.000 to 0.050			
0.050 to 0.060			
0.060 to 0.100			
GREATER THAN 0.100			
AVG. DIFF. BETWEEN IWP AND OWP TEXTURE			
% DIFF. BETWEEN IWP AND OWP TEXTURE			

NOTE: IWP is texture values "in the wheel path" or tire wear area.[3] OWP is texture values "out o the wheel path" simulating "as built" conditions.

ATTACHMENT I
SUMMARY OF TEXTURE INFORMATION (in3/in2)

DISTRICT HWY-LOCATION	DIST.24 IH-10 IN 12-½"LT	DIST.24 IH-10 IN 13-1"LT	DIST.24 IH-10 IN 14-3/4"LT	DIST.24 IH-10 IN 17-BUR.DRAG
AMOUNT OF TRAFFIC	3,480,000	3,480,000	3,480,000	3,480,000
GROUP	81	82	83	84
AVG. W.P. TEXTURE, D-10	.035	.026	.033	.024
AVG. W.P. TEXTURE, DIST.				
AVG. DIFF. IN OPERATORS				
AVG. DIFF. 2FT APART				
% in FOLLOWING GROUPS:	80%<.035	100%<.035	80%<.035	100%<.035
0.000 to 0.050	100	100	100	100
0.050 to 0.060	0	0	0	0
0.060 to 0.100	0	0	0	0
GREATER THAN 0.100	0	0	0	0

AVG. TEXTURE OWP, D-10 (LT above is Longitudinal Tines)
AVG. TEXTURE OWP, DIST. (TT above is Transverse Tines)

AVG. DIFF. IN OPERATORS

% in FOLLOWING GROUPS:
0.000 to 0.050
0.050 to 0.060
0.060 to 0.100
GREATER THAN 0.100

AVG. DIFF. BETWEEN IWP AND OWP TEXTURE

% DIFF. BETWEEN IWP AND OWP TEXTURE

NOTE: IWP is texture values "in the wheel path" or tire wear area. OWP is texture values "out of the wheel path" simulating "as built" conditions.

ATTACHMENT I
SUMMARY OF TEXTURE INFORMATION (in3/in2)

DISTRICT HWY-LOCATION	DIST.24 IH-10 IN 18-1/8"TT	DIST.24 IH-10 IN 19-¼"TT	DIST.24 IH-10 IN 20-TRAN.BRUSH	DIST.24 IH-10 IN 21-1"TT
AMOUNT OF TRAFFIC	3,480,000	3,480,000	3,480,000	3,480,000
GROUP	85	86	87	88
AVG. W.P. TEXTURE,D-10	.023	.021	.016	.024
AVG. W.P. TEXTURE, DIST.				
AVG. DIFF. IN OPERATORS				
AVG. DIFF. 2FT APART				
% in FOLLOWING GROUPS:	100%<.035	100%<.035	100%<.035	100%<.035
0.000 to 0.050	100	100	100	100
0.050 to 0.060	0	0	0	0
0.060 to 0.100	0	0	0	0
GREATER THAN 0.100	0	0	0	0
AVG. TEXTURE OWP,D-10				
AVG. TEXTURE OWP, DIST.				
AVG.DIFF. IN OPERATORS				
% in FOLLOWING GROUPS:				
0.000 to 0.050				
0.050 to 0.060				
0.060 to 0.100				
GREATER THAN 0.100				
AVG. DIFF. BETWEEN IWP AND OWP TEXTURE				
% DIFF. BETWEEN IWP AND OWP TEXTURE				

NOTE: IWP is texture values "in the wheel path" or tire wear area. OWP is texture values "out of the wheel path" simulating "as built" conditions.

ATTACHMENT I
SUMMARY OF TEXTURE INFORMATION (in3/in2)

DISTRICT	DIST.17	DIST.17	DIST.17	DIST.17	DIST.17
HWY-LOCATION	SH-6-Bryan F-1,Tr.Broom	SH-6-Bryan F-2,1/8TT	SH-6-Bryan F-3,Lng.Broom	SH-6-Bryan F-4,1/8LT	SH-6-Bryan F-5,1/8LT
AMOUNT OF TRAFFIC	7,200,000				
GROUP	89				
AVG. W.P. TEXTURE,D-10	.017	.032	.016	.024	0.44
AVG. W.P. TEXTURE, DIST.					
AVG. DIFF. IN OPERATORS					
AVG. DIFF. 2FT APART					
% in FOLLOWING GROUPS:	100%<.025	0%<.025 100%<.035	100%<.025	60%<.025 100%<.035	0%<.025 0%<.035
0.000 to 0.050	100	100	100	100	100
0.050 to 0.060	0	0	0	0	0
0.060 to 0.100	0	0	0	0	0
GREATER THAN 0.100	0	0	0	0	0
AVG. TEXTURE OWP,D-10					
AVG. TEXTURE OWP, DIST.	(Outside Lanes = OL)				
	OL	OL	OL	OL	OL
AVG.DIFF. IN OPERATORS					
% in FOLLOWING GROUPS:					
0.000 to 0.050					
0.050 to 0.060					
0.060 to 0.100					
GREATER THAN 0.100					
AVG. DIFF. BETWEEN IWP AND OWP TEXTURE					
% DIFF. BETWEEN IWP AND OWP TEXTURE					

NOTE: IWP is texture values "in the wheel path" or tire wear area. OWP is texture values "out of the wheel path" simulating "as built" conditions.

ATTACHMENT I
SUMMARY OF TEXTURE INFORMATION (in3/in2)

DISTRICT	DIST.17	DIST.17	DIST.17	DIST.17
HWY-LOCATION	SH-6-Bryan F-4,1/8 LT	SH-6-Bryan F-5,1/8 LT	SH-6-Bryan F-6,Bur. Drag	SH-6-Bryan F-7,Tr. Brush
AMOUNT OF TRAFFIC				
GROUP				
AVG. W.P. TEXTURE,D-10	.043	.048	.018	.020
AVG. W.P. TEXTURE, DIST.				
AVG. DIFF. IN OPERATORS				
AVG. DIFF. 2FT APART				
% in FOLLOWING GROUPS:	0%<.025 60%<.035	0%<.025 0%<.035	100%<.025	100%<.025
0.000 to 0.050	80	40	100	100
0.050 to 0.060	0	100	0	0
0.060 to 0.100	100	0	0	0
GREATER THAN 0.100	0	0 5 VALUES	0	0
AVG. TEXTURE OWP,D-10				
AVG. TEXTURE OWP, DIST.	(Outside Lanes = OL) (Inside Lanes = IL)			
AVG.DIFF. IN OPERATORS	IL	IL	IL	IL
% in FOLLOWING GROUPS:				
0.000 to 0.050				
0.050 to 0.060				
0.060 to 0.100				
GREATER THAN 0.100				
AVG. DIFF. BETWEEN IWP AND OWP TEXTURE				
% DIFF. BETWEEN IWP AND OWP TEXTURE				

NOTE: IWP is texture values "in the wheel path" or tire wear area. OWP is texture values "out of the wheel path" simulating "as built" conditions.

ATTACHMENT II

WEAR MEASUREMENTS BY DISTRICT 18 PERSONNEL

WESTBOUND LANES

Station	Original Texture	After Texture
427+00	.094	.083
425+00	.083	.063
423+00	.047	.044
419+00	.103	.077
417+00	.090	.068
414+99	.065	.055
414+00	.068	.055
412+00	.051	.043
409+00	.068	.065
406+50	.051	.039
405+50	.044	.027
402+00	.050	.053
400+00	.090	.083
398+00	.055	.057
396+00	.047	.039
393+00	.063	.061
390+00	.061	.068
388+00	.051	.071
385+00	.051	.063
382+00	.063	.080
380+00	.077	.090*
378+00	.068	.086*
376+00	.068	.095*
372+00	.090	.071
370+00	.103	.098
368+00	.103	.094
366+00	.086	.063
364+00	.113	.086
363+00	.086	.090
Avg.	.072	.065
%Loss	10%	

* Surface Damaged - Ridges Broken or Spalled, Values not included in Average.

EASTBOUNDLANES

Station	Original Texture	After Texture
317+00	.080	.035
322+00	.090	.040
327+00	.050	.034
332+00	.068	.041
337+00	.068	.036
342+00	.050	.025
347+00	.059	.018
352+00	.068	.033
357+00	.059	.018
362+00	.063	.044
367+00	.103	.039
372+00	.059	.065
377+00	.032	.040
381+99	-	.063
382+00	.053	.029
387+00	.059	.025
392+00	.045	.032
397+00	.053	.048
402+00	.047	.043
407+00	.044	.031
412+00	.031	.017
417+00	.045	.031
422+00	.035	.026
427+00	.050	.034
432+00	.034	.025
437+00	.050	.038
442+00	.061	.059**
Avg.	.056	.035
%Loss	37%	

** This location was not subjected to traffic. Other locations subjected to about 6 Months of traffic or 2.3 Million applications per lane.

(T-1)

ATTACHMENT III

FIELD TEST MEASUREMENTS ON SH-6

Test Section	Date	Sand Patch		Cumulative Traffic (4 Lanes)
F-1	Dec. 71	(.058)		0
Trans. Broom	Jan. 73	.042		794,000
	Mar. 73	.032		938,000
	June 74	.030		2,015,000
	July 74	.030		2,097,000
	July 77	.027		6,039,000
	June 84	.018		24,007,000
			69%	
F-2	Dec. 71	(.063)		
1/8" Trans. Tines	Jan. 73	060		
	Mar. 73	.051		
	June 74	.050		
	July 74	.049		
	July 77	.047		
	June 84	.036		
			43%	
F-3	Dec. 71	(.041)		
Long Broom	Jan. 73	.027		
	Mar. 73	.023		
	June 74	.018		
	July 74	.018		
	July 77	.021		
	June 84	.018		
			56%	
F-4	Dec. 71	(.085)		
1/8" Long Tines	Jan. 73	.059		
	Mar. 73	.056		
	June 74	.051		
	July 74	.051		
	July 77	.047		
	June 84	.033		
			61%	

NOTE: Values in parenthesis were derived from Putty Impression texture data.

ATTACHMENT III

FIELD TEST MEASUREMENTS ON SH-6

Test Section	Date	Sand Patch	Cumulative Traffic (4 Lanes)
F-5	Dec. 71	(.077)	
Burlap + 1/8"	Jan. 73	.074	
Long Tine	Mar. 73	.072	
	June 74	.062	
	July 74	.062	
	July 77	.070	
	June 84	.046	
		40%	
F-6	Dec. 71	(.035)	
Burlap Drag	Jan. 73	.024	
	Mar. 73	.021	
	June 74	.023	
	July 74	.022	
	July 77	.028	
	June 84	.019	
		46%	
F-7	Dec. 71	(.038)	
Trans. Brush	Jan. 73	.026	
	Mar. 73	.024	
	June 74	.026	
	July 74	.026	
	July 77	.021	
	June 84	.019	
		50%	

ATTACHMENT IV

FIELD TEST MEASUREMENTS ON IH-10

Test Section	Date	Sand Patch		Cumulative Traffic (4 Lanes)
F-11	Dec. 73	.070		0
Burlap + ¼" Long.	July 74	.053		788,578
	Aug. 77	.036		4,497,622
	Apr. 84	.028		17,392,522
			60%	
F-12	Dec. 73	.061		
Burlap + ½" Long.	July 74	.045		
	Aug. 77	.044		
	Apr. 84	.037		
			39%	
F-13	Dec. 73	.045		
Burlap + 1" Long.	July 74	.029		
	Aug. 77	.027		
	Apr. 84	.021		
			53%	
F-14	Dec. 73	.052		
Burlap + 3/4" Long.	July 74	.033		
	Aug. 77	.030		
	Apr. 84	.029		
			44%	
F-15	73	.049		
¼" Long. Tines	July 74	.031		
	Aug. 77	.021		
	Apr. 84	.027		
			45%	

ATTACHMENT IV

FIELD TEST MEASUREMENTS ON IH-10

Test Section	Date	Sand Patch	Cumulative Traffic (4 Lanes)
F-16	Dec. 73	.065	
1/8" Long. Tines	July 74	.029	
	Aug. 77	.019	
	Apr. 84	.017	
		74%	
F-17	Dec. 73	.027	
Burlap Control	July 74	.025	
	Aug. 77	.025	
	Apr. 84	.021	
		22%	
F-18	Dec. 73	.052	
1/8" Trans. Tines	July 74	.028	
	Aug. 77	.025	
	Apr. 84	.020	
		61%	
F-19	Dec. 73	.031	
¼" Trans. Tines	July 74	.020	
	Aug. 77	.024	
	Apr. 84	.020	
		35%	
F-20	Dec. 73	.022	
Trans. Bush	July 74	.014	
	Aug. 77	.018	
	Apr. 84	.016	
		27%	
F-21	Dec. 73	.031	
Burlap + 1" Trans. Tines	July 74	.019	
	Aug. 77	.018	
	Apr. 84	.020	
		35%	

State Department of Highways and Public Transportation

Materials and Tests Division

MEASUREMENT OF TEXTURE DEPTH BY THE SAND-PATCH METHOD

Scope

This method describes a procedure for determining the average texture depth of a selected portion of a concrete pavement surface.

Apparatus

The apparatus shall consist of the following:

1. Sand spreading tool consisting of a two and one-half inch diameter flat wooden disc with a one-sixteenth inch thick hard rubber disc of the same diameter attached to one face and a short dowel serving as a handle attached to the other face.

2. Metal Cylinder with a volume of approximately 1.5 cubic inches.

3. Natural silica sand from Ottawa, Illinois, meeting the following gradation:

Retained on No. 40 sieve	0%
Retained on No. 50 sieve	0 to 4%
Retained on No. 100 sieve	96 to 100%

4. Balance sensitive to 0.1 grams.

5. Ruler, twelve inches long, with markings in divisions of 0.1 inch.

6. Wire brush and soft hand brush.

Procedure

1. Prepare a conversion table in which texture depths, T, can be determined for sand-patch diameters, D, ranging from four to twelve inches in increments of 0.1 inches.

a. Calculate the exact volume, V, of the metal cylinder. A volume of 1.50 cubic inches can be obtained by a cylinder 0.75 inches in inside diameter and 3.40 inches in height.

b. To prepare the conversion table, use the equation

$$T = \frac{4V}{\pi D^2}$$

2. Determine the weight of sand needed to fill the metal cylinder.

a. Fill the cylinder to the top with dry sand and gently tap the base of the cylinder three times on a rigid surface. Add more sand to fill the cylinder again to the top and level the top with a straight edge.

b. Determine the weight of sand in the cylinder. This weight of sand should be used for every sand-patch test. If a balance is not available, the required amount of sand can be measured for each test by filling the metal cylinder according to the method described above.

3. The pavement surface selected for test must be dry. If the concrete pavement has not been subjected to traffic, scrub the test surface with a wire brush to remove any loosely bound particles or curing compounds that will be worn away by a small amount of traffic. Otherwise the pavement surface should be swept with a soft hand brush.

4. Pour the measured weight of sand on the test surface and spread it with the rubber disc spreading tool into a circular patch with the surface depressions filled to the level of the peaks. The sand spreading tool should be kept flat on the surface and moved in a circular motion. Avoid losing any sand, especially during windy conditions. Sand used for one test should not be reused for another test.

5. Measure the diameter of the sand patch at four or more equally spaced locations and record to the nearest 0.1 inch.

6. For very smooth pavement surfaces where patch diameters are greater than 12 inches, half the amount of sand determined in Section 2 is recommended. A corresponding conversion table should be prepared.

Calculation of Texture Depth

Compute the average diameter of the sand patch and determine the texture depth by using the attached conversion table.

CONVERSION TABLE

D = Sand Patch Diameter (Inches) T = Texture Depth (Inches)

D	T	D	T
4.0	0.119	8.0	0.030
4.1	0.113	8.1	0.029
4.2	0.108	8.2	0.028
4.3	0.103	8.3	0.028
4.4	0.098	8.4	0.027
4.5	0.094	8.5	0.026
4.6	0.090	8.6	0.026
4.7	0.086	8.7	0.025
4.8	0.083	8.8	0.025
4.9	0.080	8.9	0.024
5.0	0.077	9.0	0.024
5.1	0.074	9.1	0.023
5.2	0.071	9.2	0.023
5.3	0.068	9.3	0.022
5.4	0.065	9.4	0.022
5.5	0.063	9.5	0.021
5.6	0.061	9.6	0.021
5.7	0.059	9.7	0.020
5.8	0.057	9.8	0.020
5.9	0.055	9.9	0.019
6.0	0.053	10.0	0.019
6.1	0.051	10.1	0.019
6.2	0.050	10.2	0.018
6.3	0.048	10.3	0.018
6.4	0.047	10.4	0.018
6.5	0.045	10.5	0.017
6.6	0.044	10.6	0.017
6.7	0.043	10.7	0.017
6.8	0.041	10.8	0.016
6.9	0.040	10.9	0.016
7.0	0.039	11.0	0.016
7.1	0.038	11.1	0.016
7.2	0.037	11.2	0.015
7.3	0.036	11.3	0.015
7.4	0.035	11.4	0.015
7.5	0.034	11.5	0.014
7.6	0.033	11.6	0.014
7.7	0.032	11.7	0.014
7.8	0.031	11.8	0.014
7.9	0.031	11.9	0.013
		12.0	0.013