TEXAS A&M UNIVERSITY

College Station, Texas

TEXAS TRANSPORTATION INSTITUTE

MIRAFI® FABRIC TACK COAT REQUIREMENTS FOR ASPHALT OVERLAYS

by

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and

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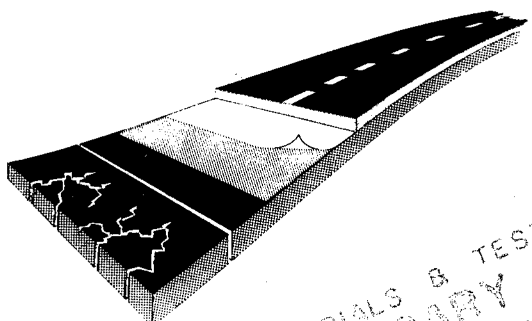
Interim Report RF 3424-1



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Prepared for

Celanese Fibers Marketing Company

by

Texas Transportation Institute
Texas A&M University
College Station, Texas

July, 1977

EXECUTIVE SUMMARY

Laboratory experiments were conducted to determine certain bond strength characteristics of Mirafi® 140 fabric on three different pavement surfaces as well as one control surface. Asphalt cements were used to bond the fabric to the test surfaces. The tests consisted of measuring the load requirements while (1) peeling and (2) shearing a strip of fabric from the test surface to which it was bonded. Bond strength was measured as a function of asphalt cement type, film thickness, temperature, loading rate, and surface texture.

As one would expect, bond strength increased with the use of harder asphalts, lower temperatures, and faster loading rates. Maximum bond strength occurred at an optimum asphalt film thickness which was found to be dependent on the texture depth of the surface.

Tack Coat Quantity

Based on tests performed on actual roadway samples, the optimum tack coat quantity lies between 0.15 and 0.20 gallon per square yard (0.679 and 0.905 ℓ/m^2). This range applies to the normal types of pavements utilized in the United States without regard to pavement surface texture. When pavement surface textures are known, the equation shown on the following page can be used to compute the design quantity of tack coat for a particular job:

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$$Q_{design} = 0.18 \pm Q_c$$

where:

Q_{design} = tack coat quantity to apply

Q_c = correction to tack coat quantity based on surface texture measurement (from Table 5)

However, a more convenient tool for determining tack coat quantity as a function of surface texture is shown in Figure i.

Type of Tack Coat

The material to be utilized as a tack coat to "cement" Mirafi 140 fabric to a pavement surface must have several unique properties. The material must be capable of being applied in a uniform manner with existing construction equipment. The material must be fluid enough after application to accept and "cement" the fabric to the old pavement but not so soft that it will not resist the shearing action of truck tires and asphalt laydown equipment. Additionally, the asphalt-cement-tack must be hard enough at high temperatures to resist "bleeding through" the asphalt concrete overlay but yet soft enough at low temperatures to allow the fabric-tack-coat combination to act as a stress-relieving interface. The tack coat must maintain these desirable properties over a long time span and must be cost-effective and energy-efficient.

Based on these requirements, it is suggested that asphalt cements be utilized as tack coat materials. The advantages the emulsions may have over asphalt cements in terms of lower application temperature requirements, increased time available for fabric application, and

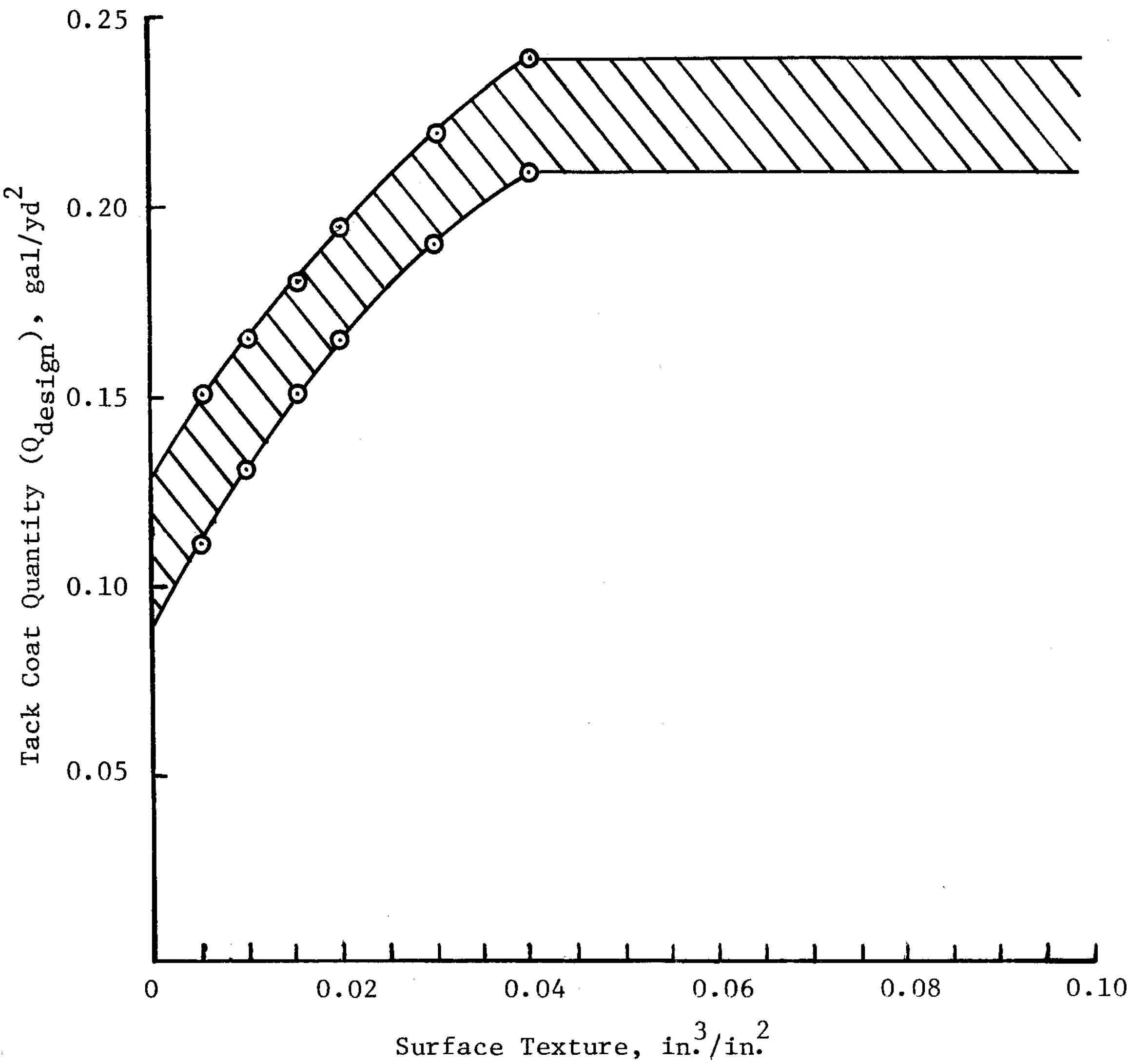
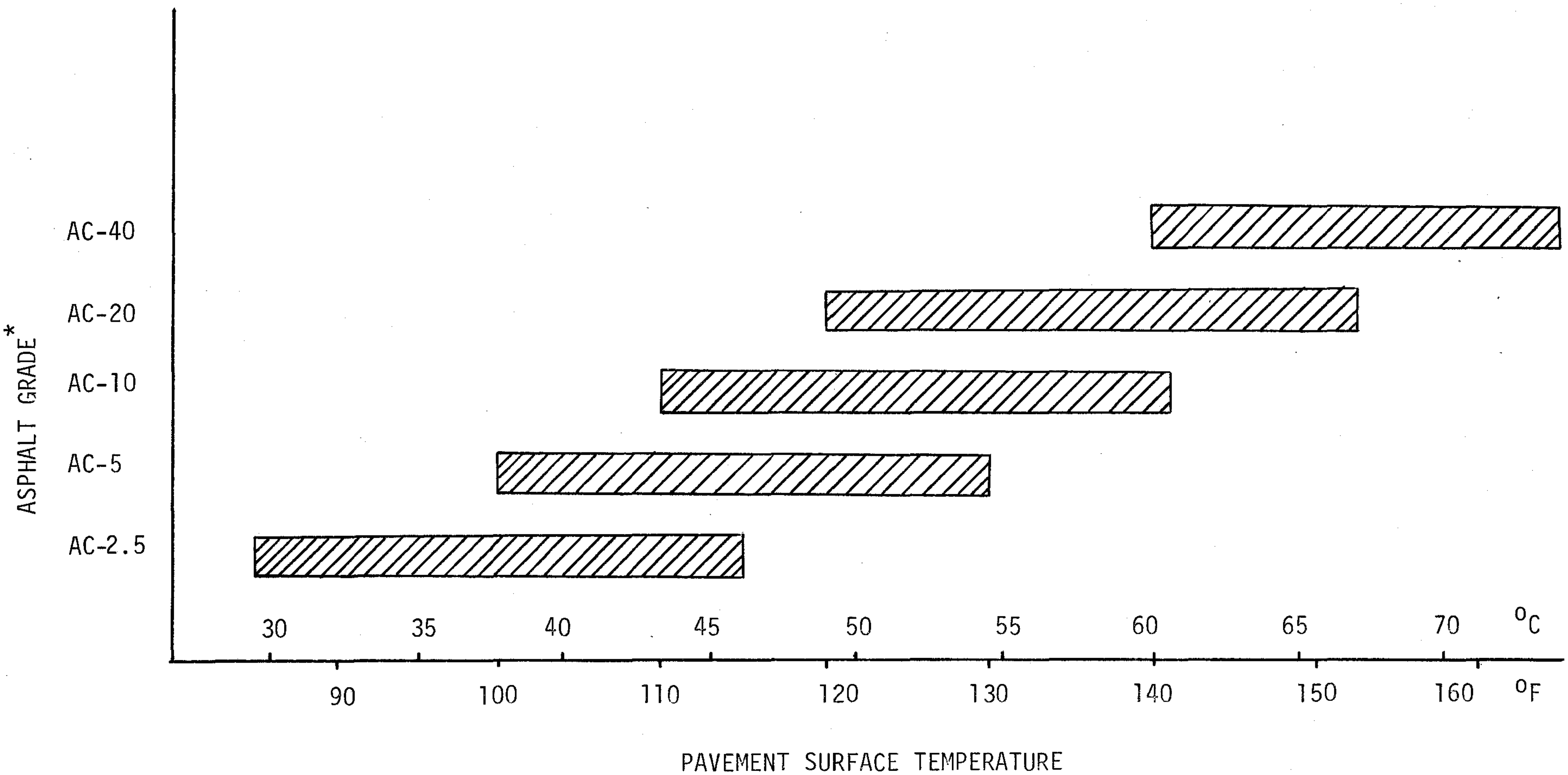


Figure i. Tack Coat Quantity as a Function of Surface Texture increased ability to seal cracks in the old pavement are offset by problems during construction associated with emulsion curing and the sometimes resulting fabric wrinkling and/or pickup. Nevertheless, under certain special conditions, medium and rapid setting emulsions may be used. Under no circumstances should cut-back asphalts be used since their solvents are detrimental to synthetic fabrics.

The grade of asphalt cement to utilize as a tack coat for a particular job is based on the maximum pavement temperatures expected to be reached during construction. Figure ii can be used for selection of the type of asphalt cement.



*AFTER AASHTO 226-73

Figure ii. Asphalt Type and Serviceability Range Corresponding to Pavement Surface Temperature

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INTRODUCTION

Permanent or even long-term repair of cracked pavements has been a dream of highway maintenance engineers for decades. The persistent problem -- reflection cracking. Reflection cracking is associated with the migration of cracks from the old surface through the new overlay. It is generally caused by movement of the cracks in the underlying pavement, or lack of proper bridging of underlying cracks or joints (1).

A number of repair techniques have been employed in an attempt to solve this problem. Some of these include crack sealing or filling with compressible or elastic materials followed by overlays of bituminous pavement, repaving using a heater-scarifier treatment plus an asphalt rejuvenating agent, rubber-slurry strain-relieving interlayers, and special bituminous overlay treatments such as macadam or mixtures containing asbestos fibers or other fillers. A repair technique that has shown a great deal of promise in reducing the amount of reflection cracking or retarding its occurrence is the application of a layer of strong, stable fabric between the old cracked pavement and the new overlay. One such fabric, supplied by the Celanese Fibers Marketing Company, is called "Mirafi 140". Pavement trials in North Carolina (2) indicated Mirafi 140 fabric to be an effective means of reducing reflection cracking through an overlay. However, proper installation and satisfactory performance of the overlay system also depend on other factors such as type and quantity of tack coat used to bond the fabric to the existing pavement.

The objective of the experiments described in this report is to determine an optimum quantity and type of bituminous material to be applied as a tack coat for bonding Mirafi 140 fabric to an existing pavement of known surface texture under various environmental conditions. Specifications for standard bituminous materials used as tack coats are listed in Appendix D.

Laboratory experiments were conducted to determine some of the bond strength characteristics of Mirafi 140 fabric on three different pavement surfaces as well as one control surface of uniform texture. Asphalt cement was used as an adhesive between the fabric and the test surface (similar to a tack coat). Bond strength was measured as a function of asphalt cement type, asphalt film thickness or quantity, temperature, loading rate, and surface texture.

The knowledge gained from these experiments was used as a guide to determine interim tack coat requirements for field application of Mirafi 140 fabric.

DESCRIPTION OF MATERIALS

Mirafi 140 Fabric

The fabric, Mirafi 140, is supplied by Celanese Fibers Marketing Company. Mirafi 140 fabric is a unique nonwoven fabric constructed from two types of continuous-filament fibers. One is wholly polypropylene (a homofilament) and the other is a heterofilament comprised of a polypropylene core covered with a nylon sheath. A random mixture of these filaments is formed into a sheet that is heat bonded; the result is direct fusion at points of contact between heterofilaments. No bonding agent or resin is used. The polypropylene filaments remain unaffected during the heat-bonding process. Purely mechanical links operate between these homofilaments (3).

Asphalt Cement

The binders selected for use in these experiments were viscosity-graded AC-5, AC-10, and AC-20 petroleum asphalt cements produced by the American Petrofina Company in Mt. Pleasant, Texas. Standard tests (4, 5) were performed on these asphalt cements to determine the basic physical and chemical characteristics. The results are presented in Table 1.

Test Surfaces

Control Surface. The control surface selected for the study was Carborundum brand Red-I-Cut Floor Combination C-3 1/2 commonly called "sandpaper". This material consists of a fiber-reinforced backing coated with randomly distributed fractured particles of silicon carbide approximately 0.05 inch (1.3 mm) in diameter. The particles were glued to the cloth by coating them and the cloth with a thin film of adhesive. These very uniform surfaces had an average texture depth (Putty Method described in Appendix C) of 0.03 cubic inch per square inch (0.08 cm^3/cm^2) (6), a typical average value that exists widely on pavements throughout the United States.

Portland Cement Concrete. Slabs of portland cement concrete approximately 1 1/2 inches (3.8 cm) thick were cast in the laboratory. The semi-finished test surfaces were relatively smooth with an average

Table 1. Summary of Asphalt Cements

Grade of Asphalt	AC-5	AC-10	AC-20
Viscosity @ 77°F (25°C), poise	2.8×10^5	5.8×10^5	3.0×10^6
Viscosity @ 140°F (60°C), poise	468	1576	1989
Viscosity @ 275°F (135°C), poise	2.34	3.76	4.19
Penetration @ 39.2°F (4°C), dmm	82	26	18
Penetration @ 77°F (25°C), dmm	189	118	63
Penetration Ratio, %	43	22	29
R & B Softening Pt, °F (°C)	104 (40)	107 (41.7)	120 (48.9)
Specific Gravity @ 60°F (16°C)	1.017	1.020	1.034
Flash Point (COC), °F (°C)	580 (304.4)	615 (323.9)	578 (303.3)
Solubility in $C_2H_3Cl_3$, %	99.8	99.9	99.9
Spot Test	Negative	Negative	Negative
Thin-Film Oven Test, Residue Properties			
Viscosity @ 140°F (60°C), poise	1135	3054	5151
Penetration @ 77°F (25°C), dmm	103	68	38
Ductility @ 77°F (25°C), cm	150	150	150

texture depth (Putty Method) of 0.024 cubic inch per square inch ($0.061\ cm^3/cm^2$).

Asphalt Concrete. Test specimens were removed by sawing from an old highway pavement surface course. The asphalt concrete contained rounded siliceous gravel with a gradation similar in appearance to ASTM D 3515. The slightly weathered, somewhat worn surface had an average texture depth (Putty Method) of 0.022 cubic inch per square inch ($0.056\ cm^3/cm^2$).

Seal Coat. These test specimens came from an old highway pavement surface course. The aggregate contained in the seal coat was a rounded siliceous gravel ranging in size from approximately 0.1 to 0.3 inch (2.5 to 7.5 mm). Generally, the surface was slightly flushed and the exposed aggregate was quite polished. The average texture depth (Putty Method) of this surface was 0.048 cubic inch per square inch ($0.122\ cm^3/cm^2$).

The above surfaces were selected to represent typical highway surfaces presently existing in the United States. Figure 1, which illustrates the range of surface textures associated with various types of pavement surfacing materials, was utilized as a guide in selecting these surfaces. Pavement surfaces were selected such that their surface textures represented a value close to the mean value for a particular pavement type as indicated in Figure 1.

DESCRIPTION OF TESTS AND RESULTS

General

Bond strength of Mirafi 140 fabric to the previously described types of surfaces using asphalt cement as the binder was measured in

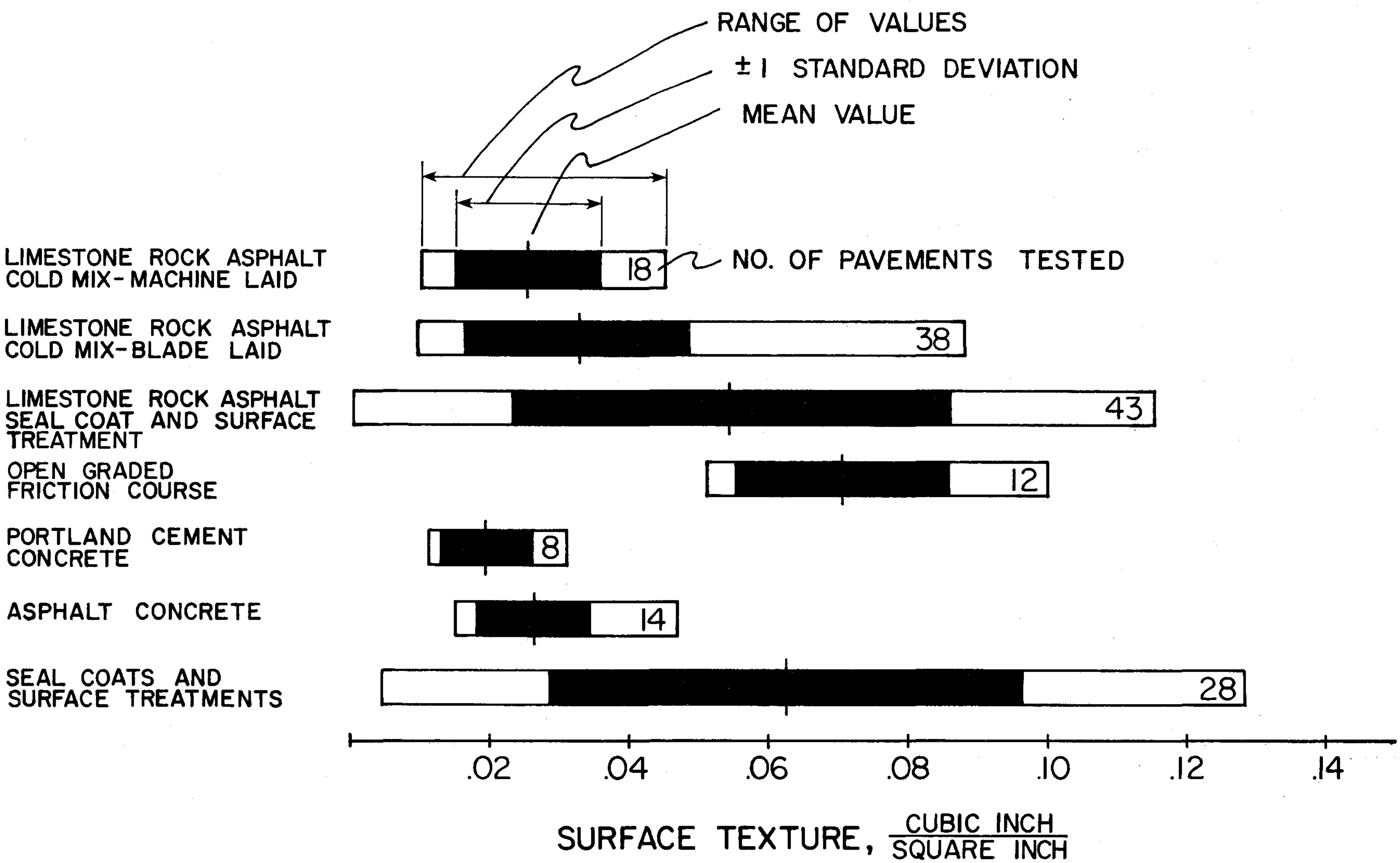


Figure 1. Typical Values of Surface Texture as Measured by Putty Test

the laboratory at Texas A&M University. Two non-standard methods were employed to determine bond strength: (1) 180-Degree Peel Strength Test, (2) Zero-Degree Fabric Bond Shear Strength Test. The test program for the peel strength tests is summarized in Table 2. The test program for the fabric bond shear strength test is described in Table 3. Test temperatures were selected to represent the high range of pavement temperatures as determined from references 7 and 8. The distribution of pavement surface temperatures over a one year period at two locations in the United States is shown in Figure 2.

Laboratory tests were also conducted to estimate the quantity of asphalt cement required to saturate Mirafi 140 fabric.

Preparation of Samples

All test surfaces were 10 inches (25.4 cm) in length and 2 inches (5.08 cm) in width. The control surface (sandpaper) was fastened to a block of wood which provided rigidity. A predetermined quantity of asphalt cement was heated to approximately 250°F (121°C) and applied to each test surface. For tests with the thicker asphalt films, masking tape was affixed to the sides of the test surfaces to provide a lip that prevented the asphalt from flowing off the test surface. While the asphalt cement was hot, a 10-inch (25-cm) strip of Mirafi 140 fabric about 25 inches (63.5 cm) in length was applied (Figure 3). The fabric was seated on all but the seal coat surfaces by covering with waxed paper, placing a foam rubber cushion over the fabric, and applying a 50-psi (3.45×10^5-pascal) load for one minute. The seal coat specimens were quite fragile; therefore, the fabric was seated by smoothing it with gloved fingertips.

Table 2. Summary of Program for Peel Strength Tests*

Type of Asphalt	Tack Coat Quantity, gal/yd^2 (ℓ/m^2)	Temperature of Test			
		68°F (20°C)	104°F (40°C)	122°F (50°C)	140°F (60°C)
AC-5	0.05 (0.23)	S	S	S	S
	0.15 (0.68)	S	S	S	S
	0.25 (1.13)	S	S	S	S
	0.35 (1.58)	S			
AC-10	0.05 (0.23)	S	S	S,AC,PCC,SC	S
	0.10 (0.45)			S,AC,PCC,SC	
	0.15 (0.68)	S	S	S,AC,PCC,SC	S
	0.20 (0.91)			S,AC,PCC,SC	
	0.25 (1.13)	S	S	S,AC,PCC,SC	S
	0.30 (1.36)	S		S	
	0.35 (1.58)	S		S	
	0.40 (1.81)	S		S	
AC-20	0.05 (0.23)	S	S	S	S
	0.15 (0.68)	S	S	S	S
	0.25 (1.13)			S	S

Surface Types:

S - Standard Sandpaper
AC - Asphalt Concrete Obtained from Pavement
PCC - Portland Cement Concrete Cast in Laboratory
SC - Seal Coat Obtained from Pavement

*All tests conducted at deformation rates of 5, 12 and 20 inches per minute.

Table 3. Description of Program for Shear Strength Tests*

Temperature	Tack Coat, Gallons Per Square Yard (ℓ/m^2)		
	0.05 (0.23)	0.15 (0.68)	0.25 (1.13)
75°F (24°C)	5	5	5
97°F (36°C)	5	5	5

*All tests performed at deformation rate of 5 inches per minute (12.5 cm/min) with AC-10 as the tack coat material and fabric Lot No. 68606 on sandpaper surfaces.

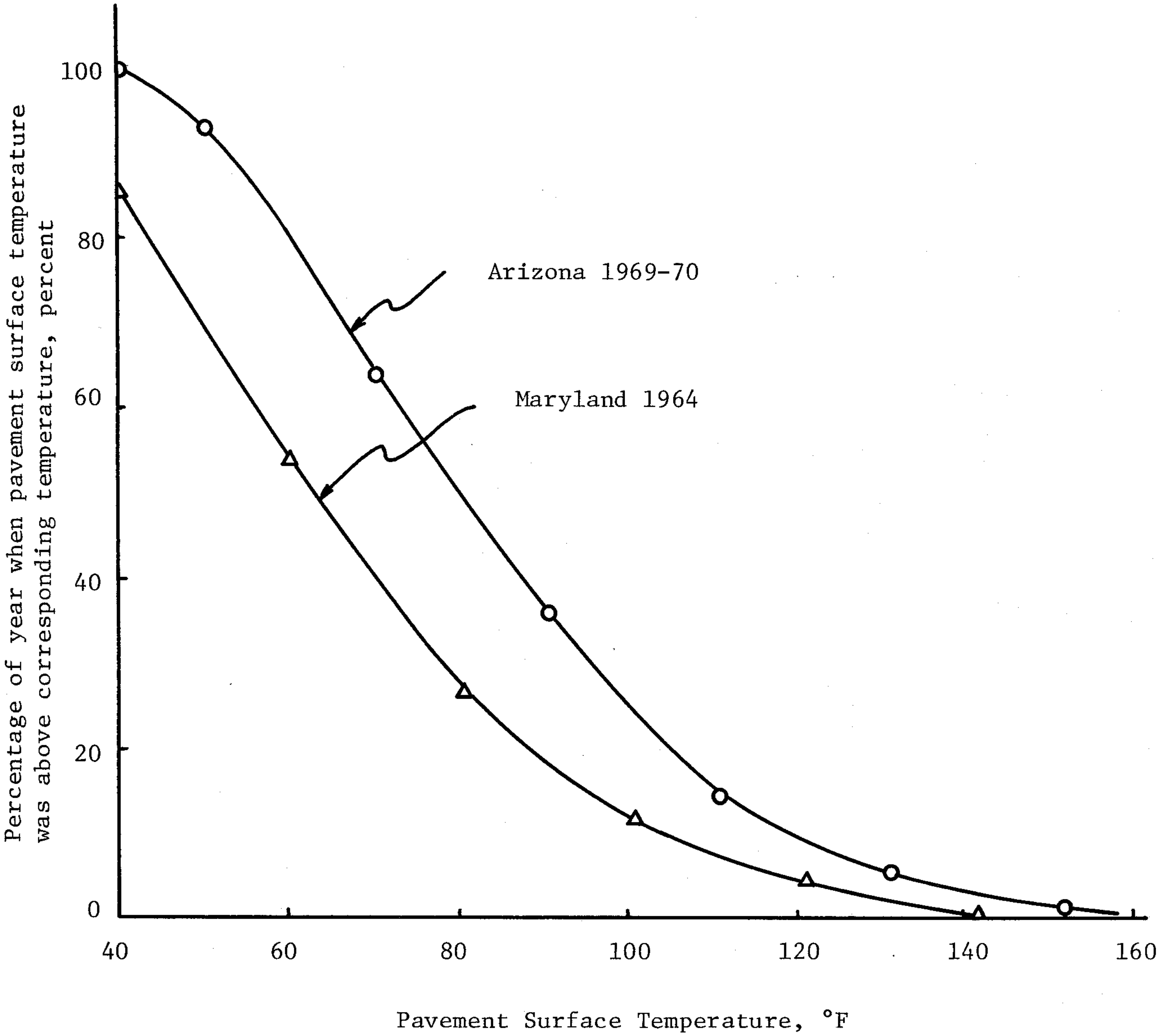


Figure 2. Percentage of Time a Pavement Surface May be Expected to be at a Given Temperature

After references 7 and 8

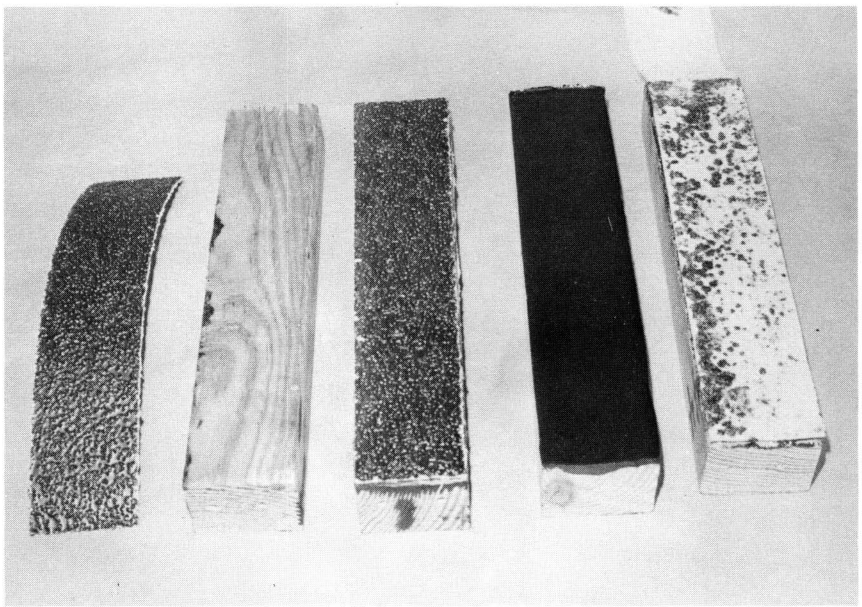


Figure 3. Sample Preparation Illustration Using "Sandpaper".

Left to right sequence:

a. sandpaper

b. wood block

c. sandpaper fastened to block

d. asphalt tack coat after application

e. fabric application

The asphalt cement quantity was carefully controlled and ranged from 0.05 to 0.40 gallon per square yard (0.226 to 1.81 ℓ/m^2) (Figures 4 and 5). When preparation was completed, the samples were placed in an environment of appropriate test temperature. Tests were conducted at temperatures of 68°F (20°C), 104°F (40°C), 122°F (50°C), and 140°F (60°C) as shown in Tables 2 and 3.

Peel Strength Tests of Tack Coats

The test specimens were fastened in a specially prepared frame, on the Instron Universal Testing Machine (Figure 6), with the loose end of the Mirafi 140 fabric downward. The loose end of the fabric was turned upward and clamped in the grips of the testing machine (Figure 7). This configuration facilitated a 180-degree peel test. These tests were conducted at constant displacement rates of 5, 12, and 20 inches per minute (13.7, 30.5, and 50.8 cm/min). The results of these tests are presented in Appendix A.

Shear Strength Tests of Tack Coats

For the shear strength tests, the test specimens were fastened in the frame as in the peel test except the loose end of the fabric was positioned at the top. As before, the loose end of the fabric was clamped in the grips of the testing machine (Figure 8). The shear strength tests were also conducted at displacement rates of 5, 12, and 20 inches per minute (13.7, 30.5, and 50.8 cm/min). The test results are presented in Appendix B.

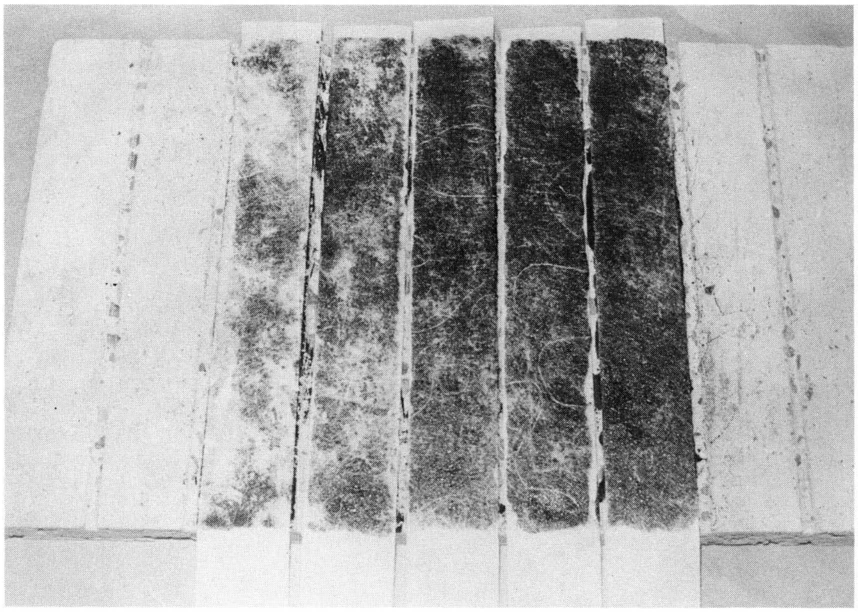


Figure 4. Mirafi 140 on Portland Cement Concrete with the Following Asphalt Thicknesses: 0.05, 0.15, 0.25, 0.35, 0.40 gal/yd^2. Surface Texture of Portland Cement Concrete Approximately 0.024 in.^{3}/in.^{2}

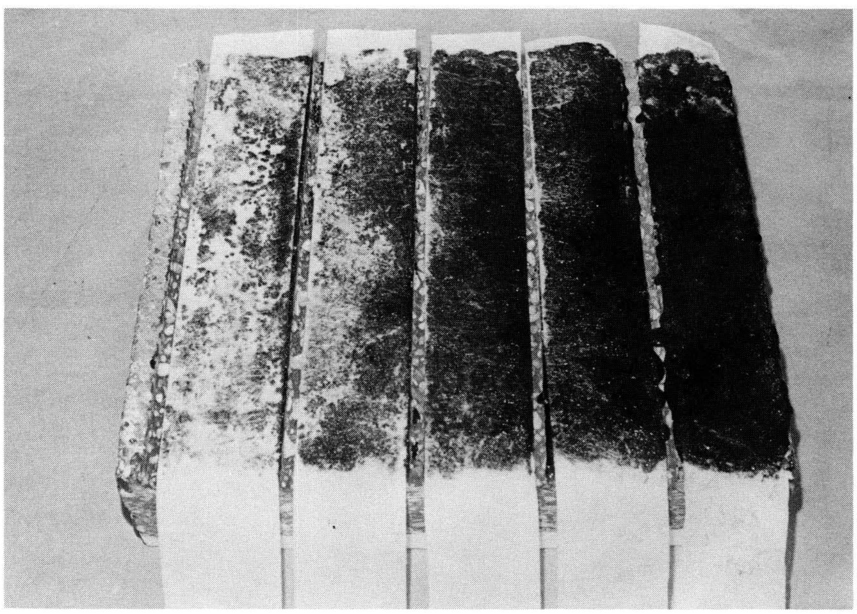


Figure 5. Mirafi 140 on Asphalt Concrete with the Following Asphalt Thicknesses: 0.05, 0.15, 0.25, 0.35, 0.40 gal/yd^2. Surface Texture of Asphalt Concrete Approximately 0.022 in.^{3}/in.^{2}

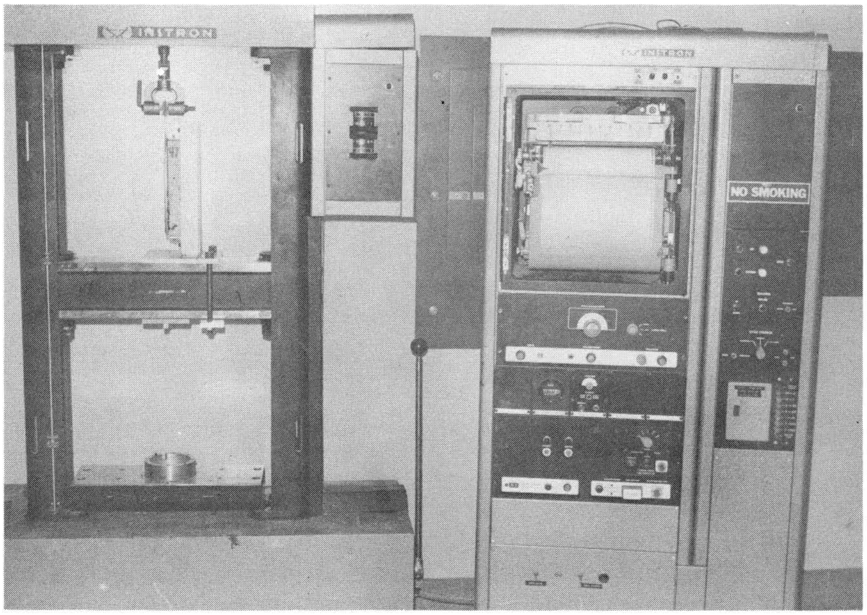


Figure 6. The Instron Universal Testing Machine with Peel Test Specimen

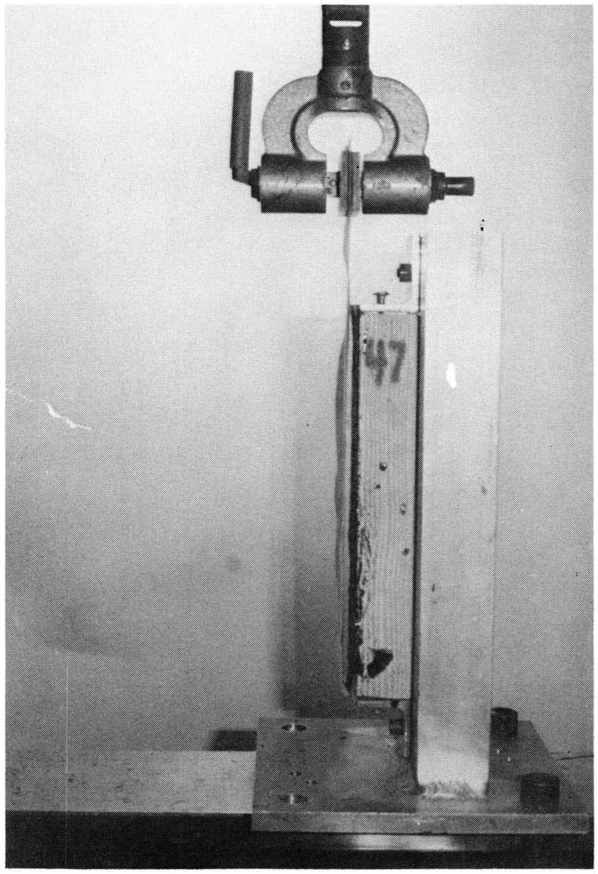


Figure 7. Test Specimen in Position for Peel Strength Test

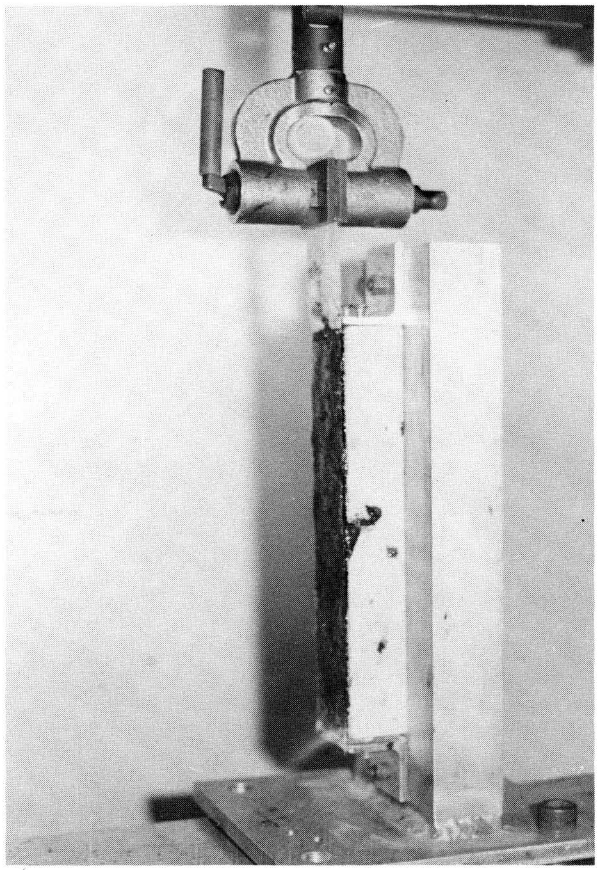


Figure 8. Test Specimen in Position for Shear Strength Test

Asphalt Content of Saturated Fabric

Three methods were utilized to determine the amount of asphalt required to saturate Mirafi 140 fabric. Two methods involved laboratory testing and the third method involved calculations based on fabric physical properties (porosity and thickness).

The first laboratory method involved the soaking of Mirafi 140 (Lot No. 68606) in an AC-10 asphalt cement for 0.5 hour at 305°F (152°C). The 4-inch by 4-inch (10.2-cm by 10.2-cm) samples were then drained by hanging in a 305°F (152°C) oven for periods up to 2 hours. Weight measurements were made at 0.5, 1.0 and 2.0 hours. After 2 hours, pin holes of light could be observed in limited areas of the fabric. The measured asphalt saturation for Mirafi 140 as defined by this test method is 0.06 gallon per square yard (0.272 ℓ/m^2) of the fabric. This quantity of asphalt is based on the fabric area prior to shrinkage, as the fabric was observed to shrink about 19 percent during the saturation and draining procedures.

A second laboratory method involved the saturation of fabric 4-inches by 32-inches (10.2-cm by 81.3-cm). The fabric was soaked for 1 hour in AC-10 asphalt cement at 300°F (149°C). The saturated fabric was allowed to cool and then pressed with a hot iron between two absorbent paper towels. This method appeared to produce a uniformly coated fabric without an excessive asphalt cement buildup on any area of the fabric. Test results are shown in Table 4. Fabric Lot No. 68606 has an average asphalt cement saturation content of 0.06 gallon per square yard (0.272 ℓ/m^2) of fabric and fabric Lot No. 68002 has an average asphalt cement saturation of 0.11 gallon per square yard (0.498

Table 4. Results of Fabric Saturation Tests

Test No.	Mirafi 140 Lot No.	Quantity of Asphalt Absorved,* gal/yd^2	(ℓ/m^2)	Average Quantity of Asphalt Absorbed, gal/yd^2	(ℓ/m^2)
1		0.13	(0.59)		
2		0.09	(0.41)		
3	68002	0.10	(0.45)	0.11	(0.50)
4		0.14	(0.63)		
5		0.10	(0.45)		
6		0.11	(0.50)		
7		0.04	(0.18)		
8		0.06	(0.27)		
9	68606	0.07	(0.32)	0.06	(0.27)
10		0.05	(0.23)		
11		0.05	(0.23)		
12		0.08	(0.36)		

*Quantity based on original area of the fabric as determined prior to saturation.

The third method utilized to calculate fabric asphalt demand was based on fabric porosity measurements. The following equation can be used for this determination:

$$Q = 5.61\ t\ n$$

where: Q = quantity of asphalt required to saturate the fabric, gallons per square yard

t = thickness of fabric, inches

n = porosity of fabric, the ratio of the volume of the voids to the total volume

For a fabric of 0.030-inch (0.0762-cm) thickness and a porosity of 0.78, an asphalt demand of 0.13 gallon per square yard (0.588 ℓ/m^2) is indicated.

DISCUSSION OF RESULTS

Appendix A and Appendix B contain data obtained in the study. Selected graphs and data will be discussed briefly in this section of the report. The reader should refer to Appendix A to appreciate the amount of data scatter associated with the testing.

Control Surface

Results of testing performed on the control surfaces are shown in Figures A-1 to A-14 of Appendix A. Sandpaper was selected as a control surface due to its uniformity and relatively low cost as compared to the cost of removal and/or casting and aging of specimens of asphalt concrete, portland cement concrete and seal coats. The sandpaper surfaces also allowed realistic surface textures with which to establish testing procedures including specimen fabrication procedures and selection of test temperatures, deformation rates, and tack coat rates.

Data obtained from tests conducted on the sandpaper surfaces illustrated the anticipated effects of deformation rate (Figure A-5), test temperature (Figure A-13) and type of asphalt (Figure A-14) on peel strength. Figure A-5 is only one example of the effect of increased deformation or loading rate on peel strength. The magnitude of the increase in peel strength with deformation rate appears to be independent of the amount of tack coat; however, it is somewhat dependent upon the test temperature. The higher the test temperature the greater the difference in peel strength for a given increase in deformation rate. Figure A-13 shows the effect of test temperature on peel strength. An increase in temperature decreases the peel strength. Data from Appendix A can be utilized to illustrate this effect for a variety of deformation rates and asphalt types.

Figure A-14 illustrated the anticipated increase in peel strength with an increase in asphalt viscosity or decrease in asphalt penetration. The harder the asphalt, the higher the peel strength for fixed testing temperatures and deformation rates. It should be pointed out that high peel strength is not necessarily what is required. An adequate peel strength is required together with adequate deformation for applications such as those discussed in this report.

The tests conducted on sandpaper (control) surfaces illustrate the wide range of peel strengths possible depending upon the test temperature, deformation rate and tack coat quantity. From a field performance standpoint it is apparent that a serious problem can occur when temperatures are high, traffic is moving slowly, soft asphalts are used as tack coats and small quantities of tack coat are applied. From these data, the engineer can therefore gain an appreciation for the magnitude of the effects of these very basic variables on peel strength and hence performance.

Roadway Surfaces

Samples of asphalt concrete, portland cement concrete and an asphalt-aggregate seal coat were obtained and samples prepared. As shown on Figures A-15, A-16, and A-17, an AC-10 asphalt cement was utilized as a tack coat and all testing was performed at 122°F (50°C). (This temperature should be representative of common pavement temperatures in the United States during regular working hours in the summer months.) Three loading rates and from three to five tack application rates were investigated (Table 2). The optimum tack coat quantity as defined by the peak strength from the peel test is of the order of 0.15 to 0.20 gallon per square yard (0.679 to 0.905 ℓ/m^2) for both the asphalt concrete and portland cement concrete. Sufficient tack coat quantities were not utilized to define a peak peel strength for the seal coat surface. The greater texture of the seal coat probably requires an increase in tack coat quantity to produce the peak peel strength.

SELECTION OF ASPHALT TYPE FOR TACK COAT

The material to be utilized as a tack coat to "cement" Mirafi 140 fabric to a pavement surface must have several unique properties. Prior to making recommendations as to the type of material to use, it is important that the engineer understand several of the key properties which are outlined on the following page:

1. The material to be selected as a tack coat would preferably be capable of application with existing pavement construction equipment in current use by contractors performing the work.

2. The tack coat material must have properties which allow it to be applied in a uniform manner on a pavement surface, to accept and "cement" the fabric to the old pavement, and to resist satisfactorily the shearing action of truck tires and asphalt laydown equipment. These requirements imply that the material must have a fairly carefully controlled viscosity-temperature relationship.

3. The material must have properties at high temperatures which will prevent or reduce its tendency to "bleed through" the asphalt concrete overlay.

4. The material must have satisfactory properties at low temperatures which will allow the fabric/tack-coat combination to act as a stress-relieving interface and thus prevent or reduce the number of cracks reflecting through the new overlay from the old pavement.

5. The material must be durable, resist oxidation and other hardening physical-chemical reactions, and must be compatible with the fabric.

6. The material must be cost-effective and energy-efficient.

Based on the above general requirements it appears that asphalt products are currently the best available materials. Asphalt cements, cutback asphalts and emulsified asphalts must therefore be considered. Cutback asphalts will not be considered further because of incompatibility with the fabric. Asphalt cements and emulsified asphalts can be selected to satisfy the requirements outlined above. A brief description of the advantages and disadvantages of these materials is presented on the following page.

Asphalt cements and emulsified asphalts can both be applied in a uniform manner with conventional construction equipment. Asphalt cement must, however, be heated to a higher temperature to lower its viscosity to an acceptable level. After application, these two materials will quickly cool to the temperature of the existing or old pavement upon which they are placed. In the case of the asphalt cement, the fabric must be placed on the tack coat as quickly as possible to insure that the viscosity of the asphalt is sufficiently low to allow the fabric to adhere to the tack coat. On hot days, this will usually not present a problem. However, on cool days the tack coat application must be closely followed by the fabric laydown.

The time delay between tack coat application and fabric laydown is usually not as critical for emulsified asphalt tack coats as compared to asphalt cement tack coats. For a given temperature, the viscosity of the partially cured emulsion tack coat will be lower than a corresponding asphalt cement. Thus, adhesion can be obtained more easily. However, the disadvantage of this emulsion system is related to the magnitude of this adhesion. If adequate curing of the emulsion has not taken place, high winds may blow the fabric off the tack coat and construction traffic may wrinkle the fabric.

Once the fabric adheres to the tack coat, the next critical requirement is the magnitude of the shear strength between the fabric and the old pavement. Sufficient shear strength must be developed to insure that construction equipment (trucks and laydown equipment) will not wrinkle or pick up the fabric. As shown above, the strength developed at the pavement-fabric interface is a function of the type of tack coat, the type of surface, quantity of tack coat and the temperatures. In the case of asphalt cements, high-viscosity materials were required on hot days. An emulsion must be selected that will cure adequately prior to laydown of the overlay. The curing of the emulsion is controlled to a significant degree in many applications by the environmental conditions (temperature and humidity). Thus, the use of emulsions under rapidly changing weather conditions may create problems.

Asphalt cements and emulsified asphalts can be selected and their applied amounts controlled to prevent "bleeding". The low-viscosity (high-penetration) materials are more susceptible to "bleed through" than are the high-viscosity materials.

Asphalt cements and emulsified asphalts can be selected such that their low-temperature properties can be optimized. These requirements suggest that low-viscosity materials should be used.

From the above discussion it is apparent that for certain considerations the high-viscosity materials are preferred, and for other considerations the low-viscosity materials are preferred. Thus, a compromise will be necessary for most applications.

It is suggested that asphalt cements be utilized as tack coat materials. The advantages the emulsions may have in terms of lower spray temperature requirements, increased time available for fabric application and increased ability to seal cracks in the old pavement are offset by problems during construction associated with emulsion curing and the sometimes resulting fabric wrinkling and/or pick up. The grade of asphalt cement to utilize as a tack coat for a particular job is based on the maximum pavement temperature expected during construction.

As a guide in the selection of the proper tack coat, Figure 9 has been prepared. This figure indicates the acceptable temperature range (by use of a bar) on which a particular asphalt can be expected to perform as a fabric tack coat. The engineer should enter this figure with the maximum pavement temperature expected during construction. The vertical line drawn through this temperature will in most cases intersect two or three "bars" representing acceptable limits of the particular asphalt cement. The asphalt whose "bar" is intersected the most centrally should be the first choice. If this material is unavailable, a harder asphalt cement should be selected.

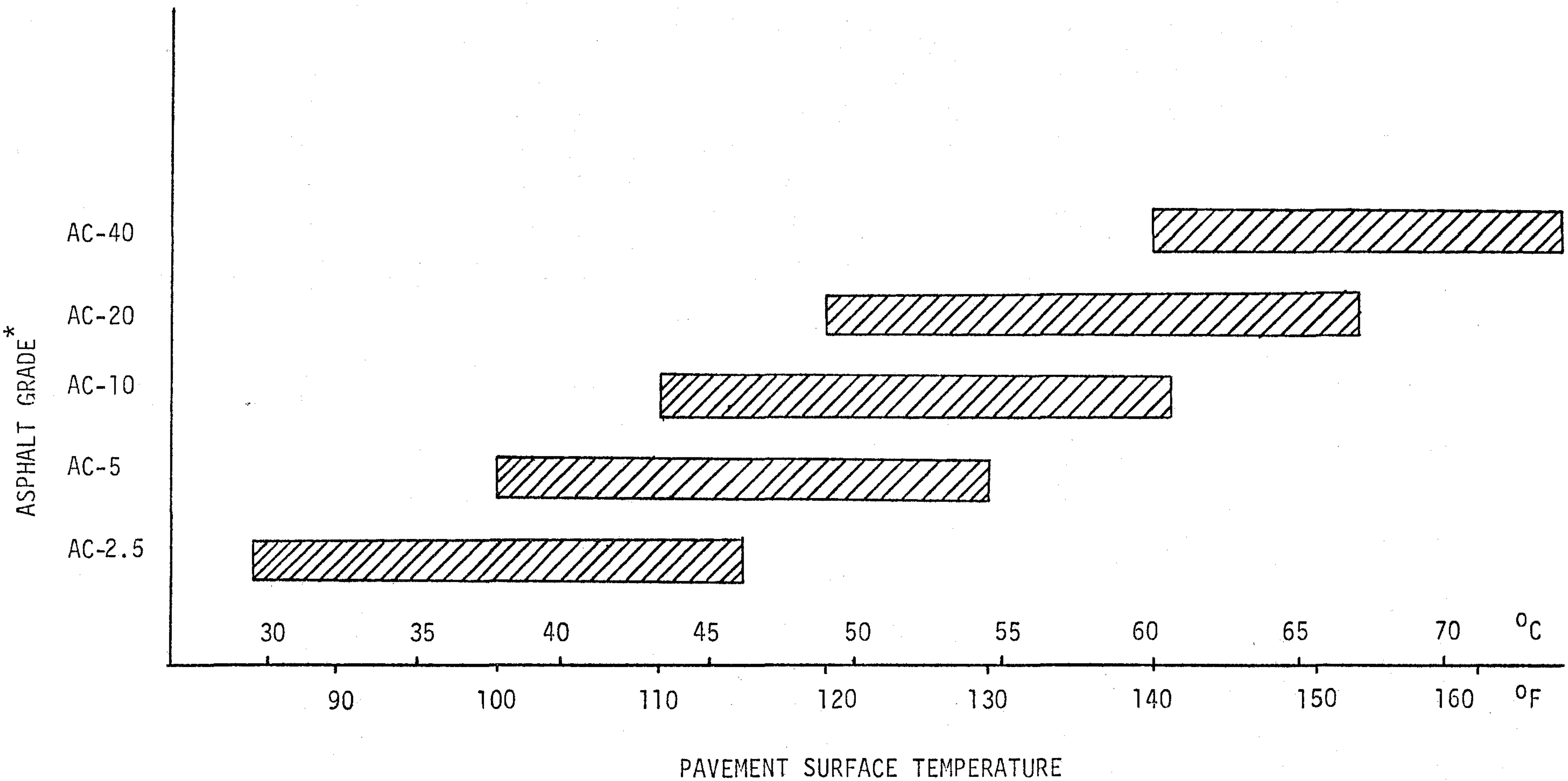
Determination of the maximum pavement temperatures should be performed between about 2 and 4 p.m. Three acceptable temperature measurement techniques are described below.

1. Laboratory mercury-bulb thermometer. A twenty-penny nail should be driven to a depth of about one inch (0.0254 m) into the pavement surface. The nail should be removed, the hole filled with a 10 to 30 W oil and the thermometer inserted into this oil-filled hole. Normally 5 to 10 minutes are required for the oil to reach the pavement temperature.

2. Surface contact thermometer.

3. Thermocouple.

It should be recognized that the information in Figure 9 is preliminary and should be used only as a guide. It is expected that the limits of the asphalt grades will be altered as field performance information becomes available.



*AFTER AASHTO 226-73

Figure 9. Asphalt Type and Serviceability Range Corresponding to Pavement Surface Temperature

CONCLUSIONS AND RECOMMENDATIONS

Tack Coat Quantities

Based on tests performed on roadway samples of asphalt concrete and portland cement concrete (with surface textures within the range of surface textures normally associated with these types of pavement surfaces), the optimum tack coat quantity is between 0.15 and 0.20 gallon of asphalt cement per square yard (0.679 and 0.905 ℓ/m^2).

Results obtained from fabric saturation tests tend to support the quantity mentioned above. For example, the calculated saturation of a Mirafi 140 type fabric is 0.13 gallon per square yard (0.588 ℓ/m^2). The measured saturation quantity is 0.06 to 0.11 gallon per square yard (0.272 to 0.498 ℓ/m^2). Tack coat quantities required to provide necessary adhesion between old pavements and conventional overlays are of the order of 0.05 to 0.10 gallon per square yard (0.226 to 0.453 ℓ/m^2). The addition of these two quantities (asphalt required to saturate the fabric and asphalt to satisfy the demand of the old surface and new surface) results in quantities of the order of 0.15 gallon per square yard (0.679 ℓ/m^2) depending upon the type of fabric and the asphalt demand of the pavement surface.

Results obtained on the control surface samples indicated that a somewhat higher asphalt quantity is required (0.20 to 0.25 gallon per square yard or 0.91 to 1.13 ℓ/m^2). It should be noted that the peaks are not well defined by this sequence of tests.

Until field performance information can be obtained, it is suggested that tack coats to be utilized with Mirafi 140 be asphalt cements. The type of asphalt cement should be selected based on Figure 9 and applied at the rate of 0.18 gallon per square yard (0.815 ℓ/m^2). Under ideal application conditions, variations of the order of $\pm$ 15 percent are not unusual (9).

Surface textures should be obtained on future field installations. These data perhaps can then be utilized to determine an asphalt correction depending on surface texture such as that shown in Figure 10. (Figure 1 or Table 5 can be used to estimate surface textures of projects previously constructed.) Thus, the quantity of tack to be utilized for a particular job can be calculated from the equation shown below.

$$Q_{design} = 0.18 \pm Q_c$$

where:

Q_{design} = tack coat quantity to apply, gallons per square yard

Q_c = correction to tack coat quantity based on surface texture measurement, gallons per square yard

The above equation in concert with Table 5 was used to calculate tack coat quantities for several surface textures. The results were plotted (Figure 11) and thus produced a convenient tool for determining appropriate tack coat quantities for Mirafi 140 fabric when surface textures are known.

Peel Strength and Shear Strength

Data have been included in this report indicating the magnitude of the peel strength and shear strength for a wide range of loading rate, temperature and tack coat conditions. These data are useful to the engineer in determining not only the quantity of tack coat but also the

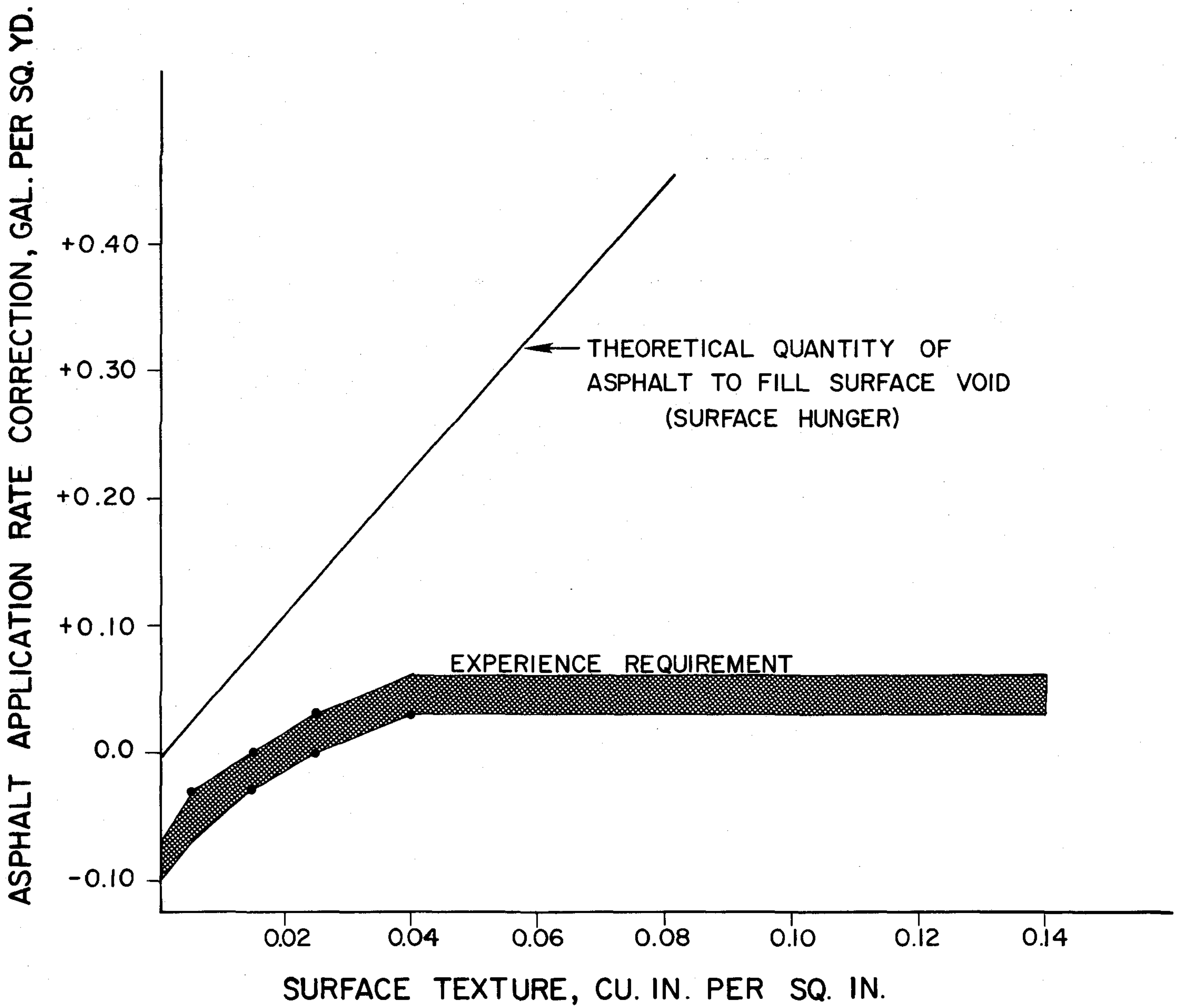


Figure 10. Asphalt Application Rate Correction for Pavements of Various Surface Textures

Table 5. Asphalt Application Rate Correction Due to Existing Pavement Surface Condition

Description of Existing Surface	Approximate Surface Texture, cubic inch per square inch (cm^3/cm^2)*	Asphalt Quantity Correction, gallon per square yard (ℓ/m^2)**
Flushed Asphalt Surface	0.001 to 0.005 (0.002 to 0.013)	-0.06 (-0.27)
Smooth, Nonporous Surface	0.005 to 0.015 (0.013 to 0.038)	-0.03 (-0.14)
Slightly Porous, Slightly Oxidized Surface	0.015 to 0.025 (0.038 to 0.064)	0.00
Slightly Porous, Oxidized Surface	0.025 to 0.040 (0.054 to 0.102)	+0.03 (+0.14)
Badly Pocked, Porous, Oxidized Surface	0.040 and above (0.102 and above)	+0.06 (+0.27)

*Putty Method
**Correction to standard tack coat of 0.18 gal/yd^2

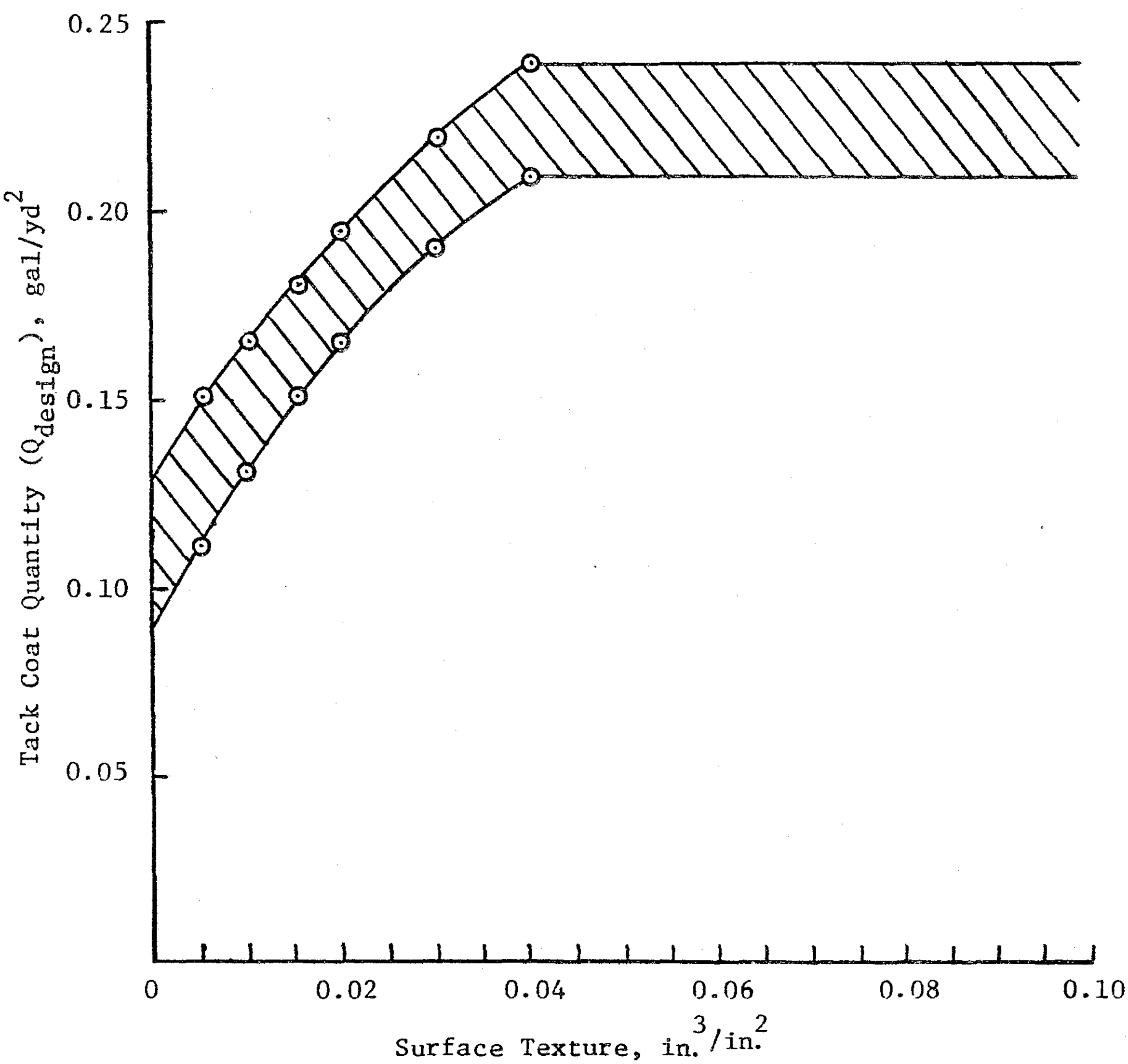


Figure 11. Tack Coat Quantity as a Function of Surface Texture

type of tack coat for given environmental and traffic conditions. For example, fabric installation in a hot climate where traffic will be accelerating and decelerating will require the use of data obtained at 140°F (60°C) and slow deformation rates. A hard asphalt would be the preferred tack coat material.

It should be remembered that a tack coat that gives high peel strength is not necessarily the tack coat to use on a given installation. Adequate strength certainly must be achieved between the old pavement and the fabric and between the fabric and the new overlay. Other factors that must be considered to be of equal importance include the stress-strain characteristics of the fabric-asphalt system and prevention of bleeding from migration of excessive tack coat to the surface of the new overlay.

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Appendix A

Peel Strength Test Results

Sandpaper - AC-5 @ 20, 40, 50, 60°C

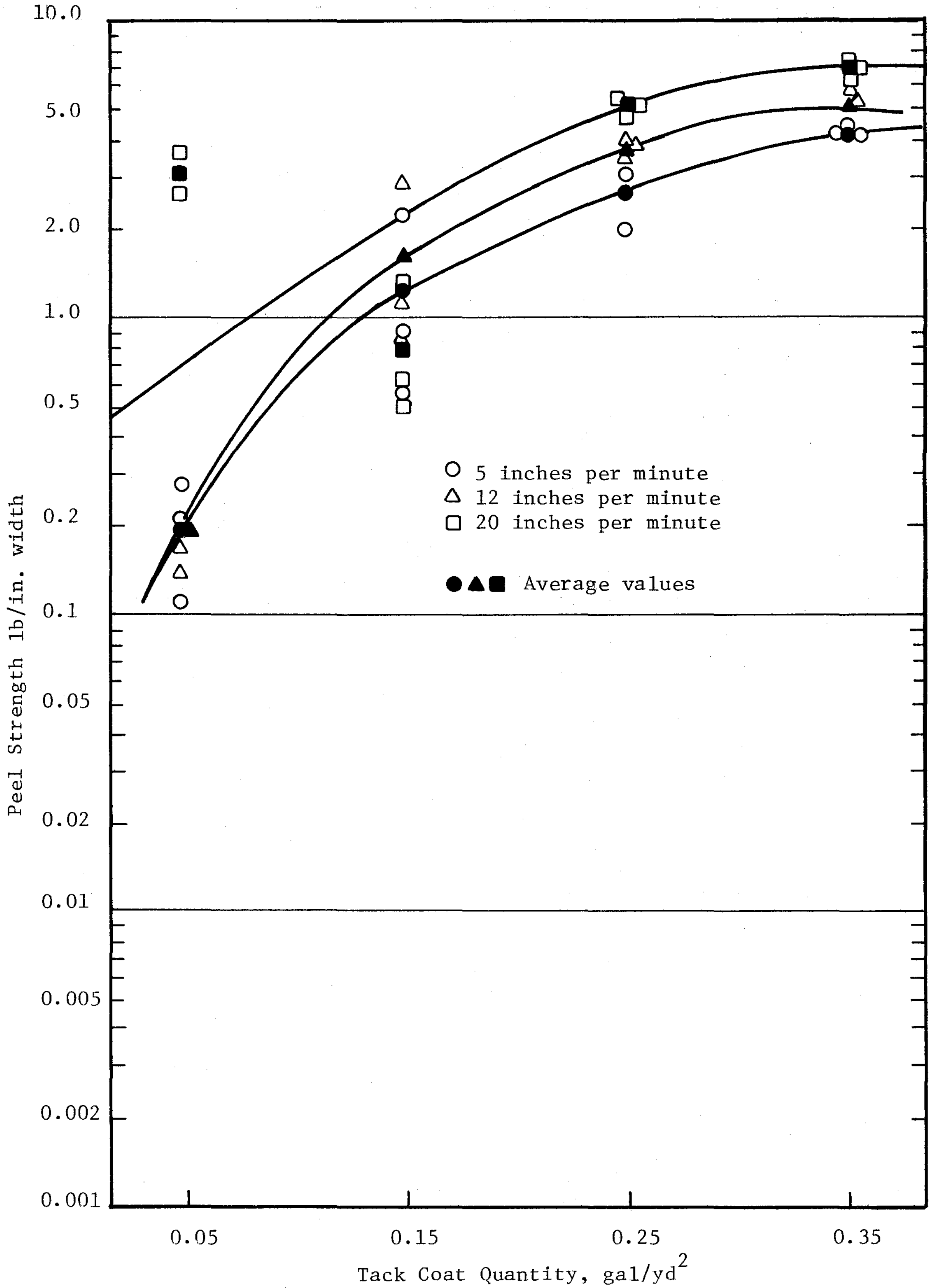

Figure A-1. Sandpaper, AC-5, 68°F (20°C)

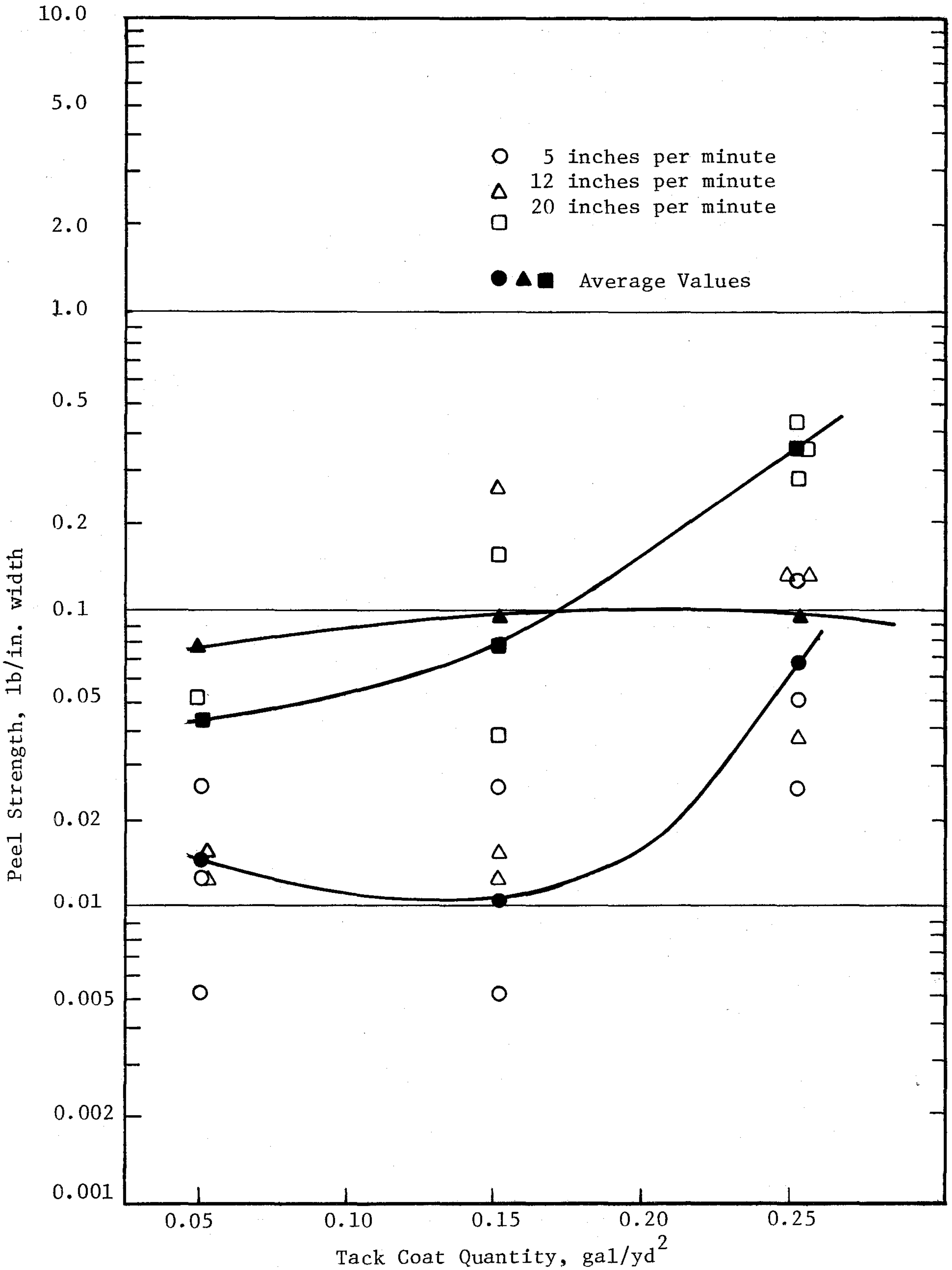

Figure A-2. Sandpaper, AC-5, 104°F (40°C)

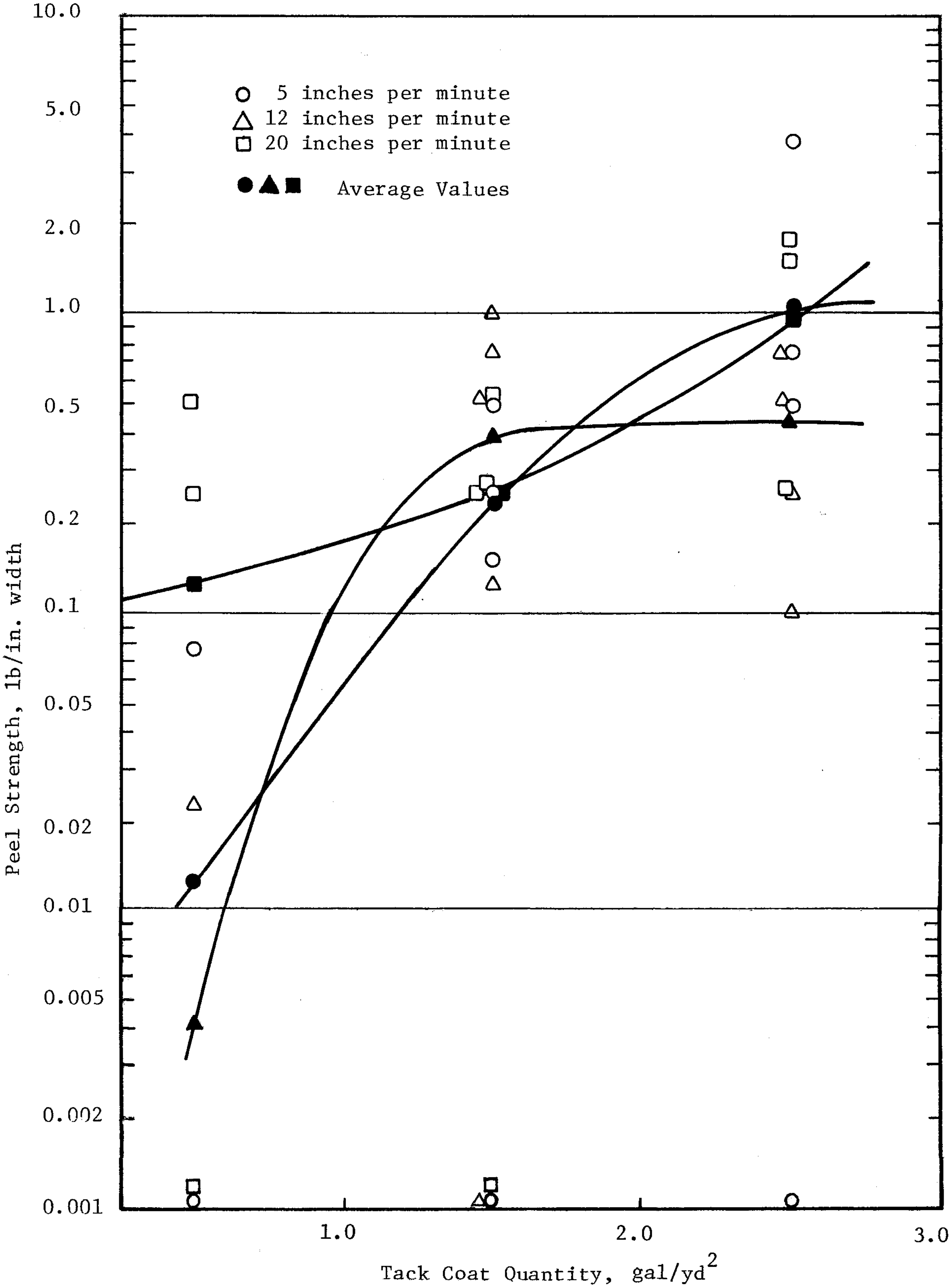

Figure A-3. Sandpaper, AC-5, 122°F (50°C)

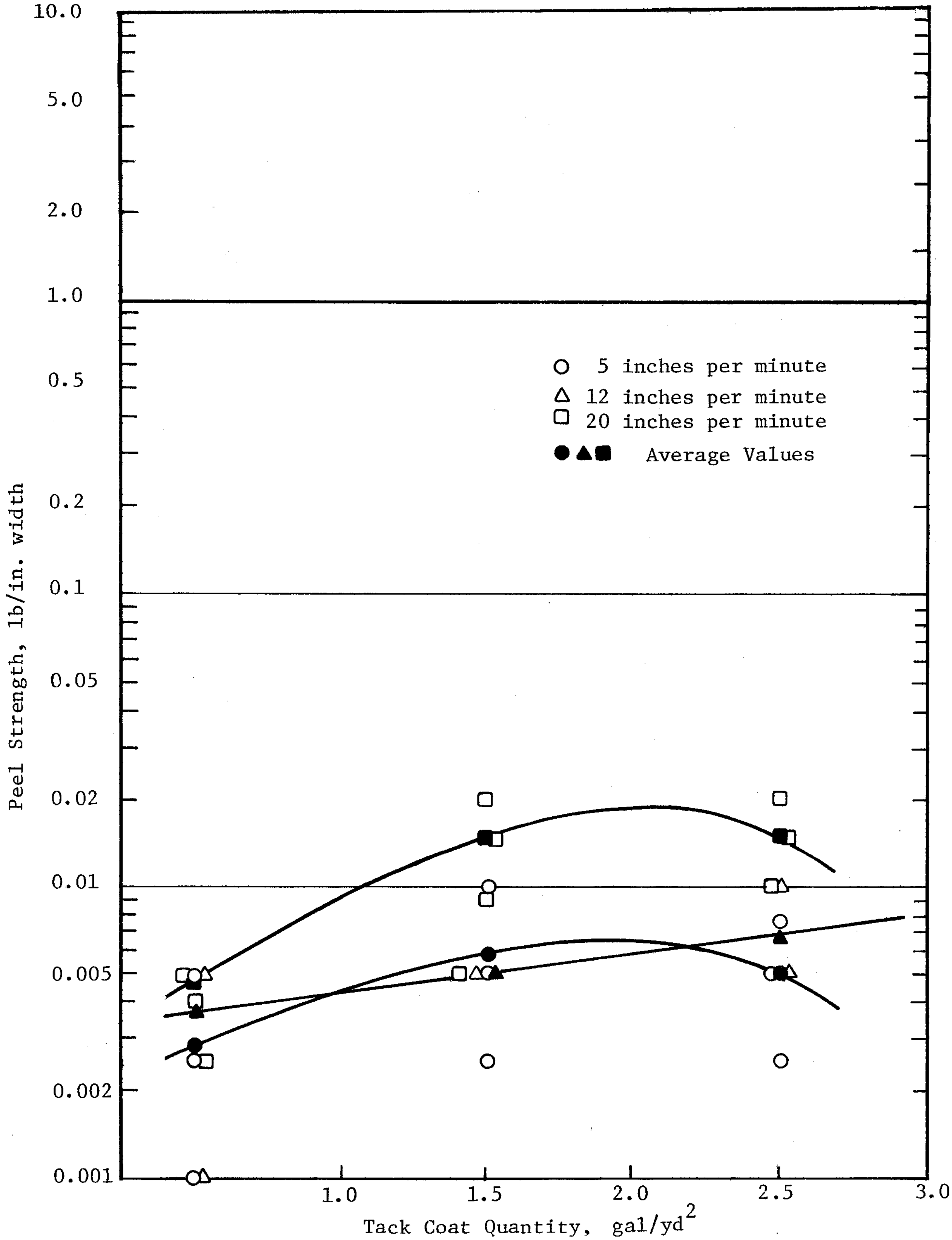

Figure A-4. Sandpaper, AC-5, 140°F (60°C)

Sandpaper - AC-10 @ 20, 40, 50, 60°C

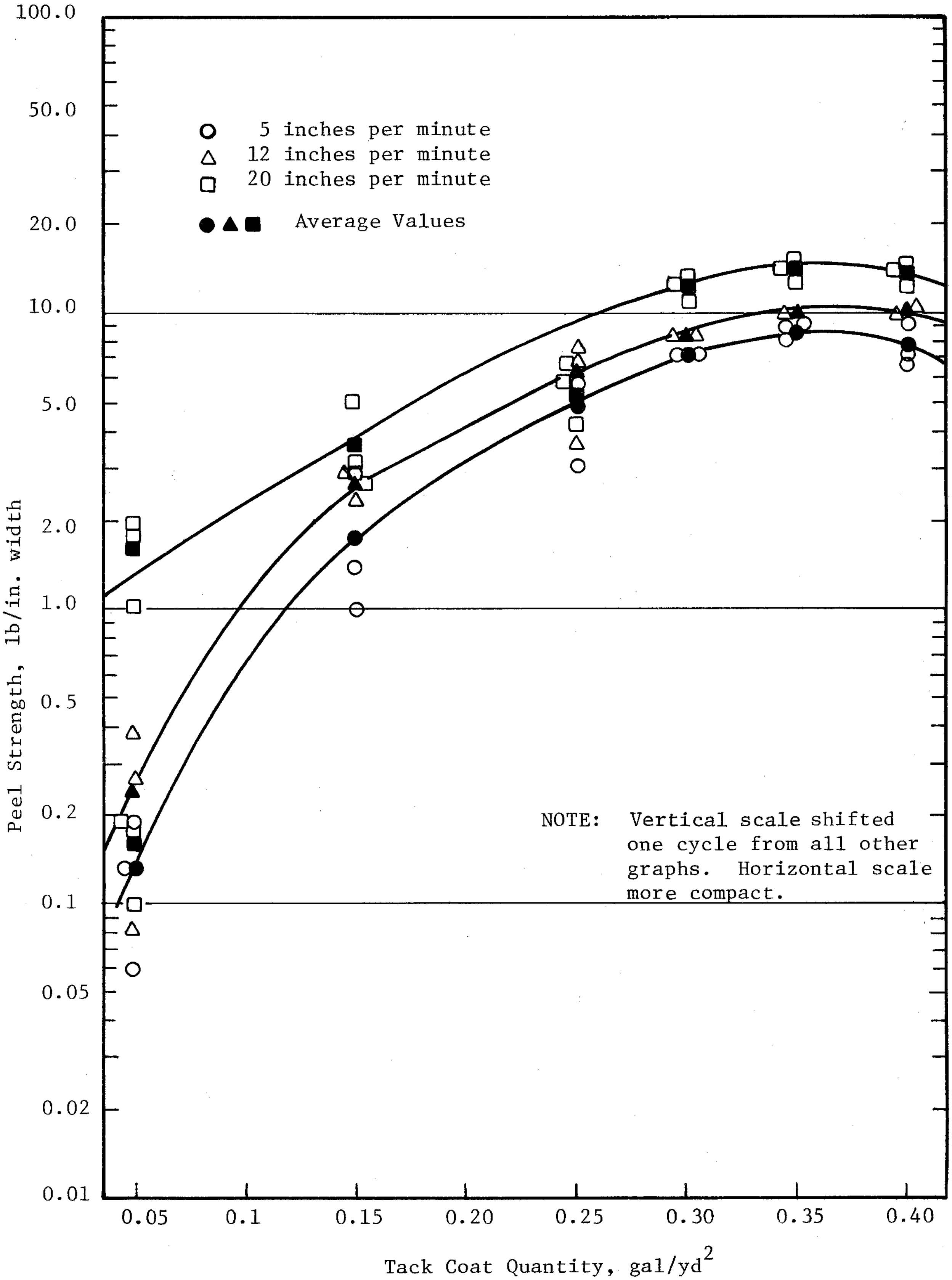

Figure A-5. Sandpaper, AC-10, 68°F (20°C)

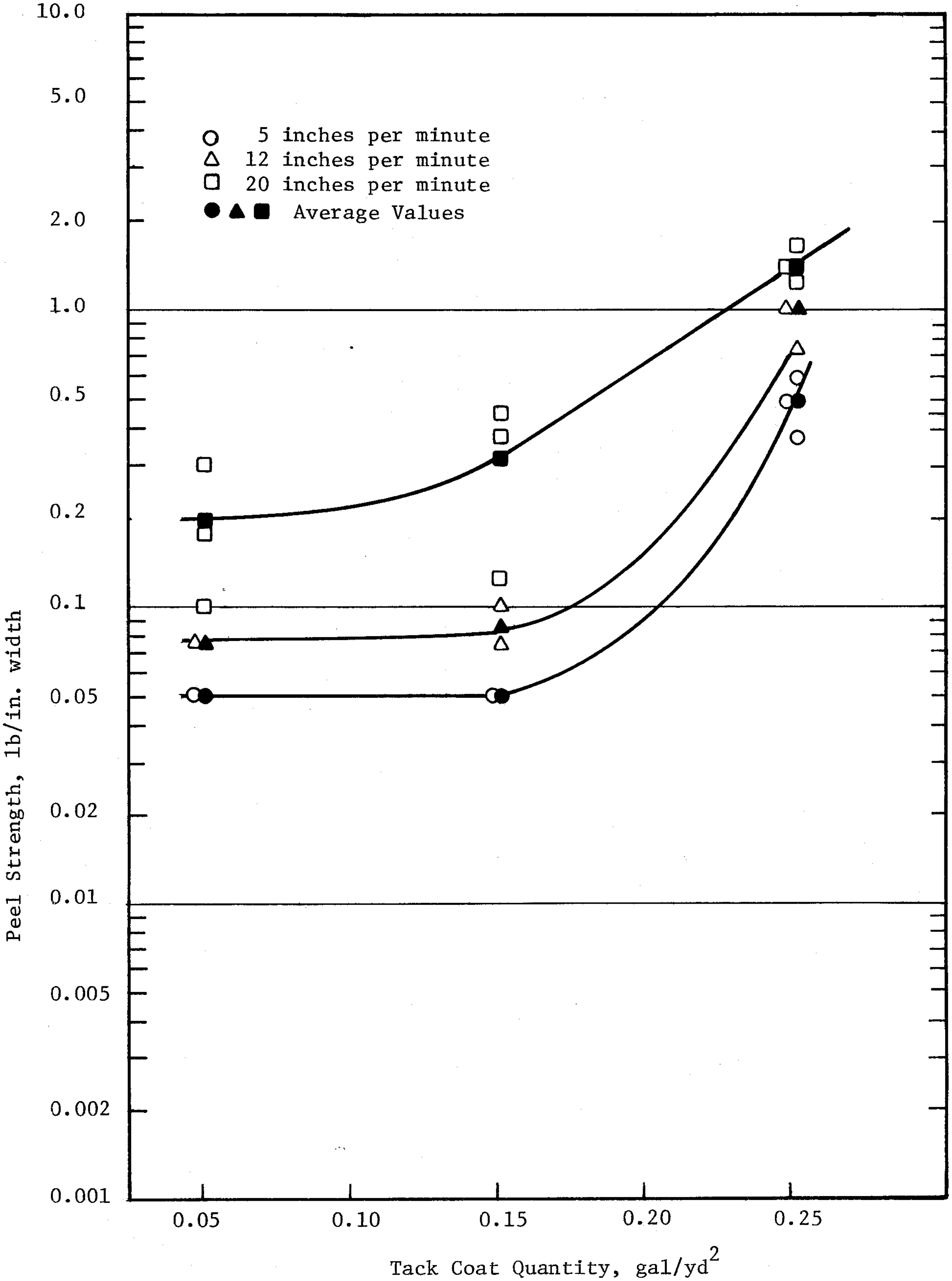

Figure A-6. Sandpaper, AC-10, 104°F (40°C)

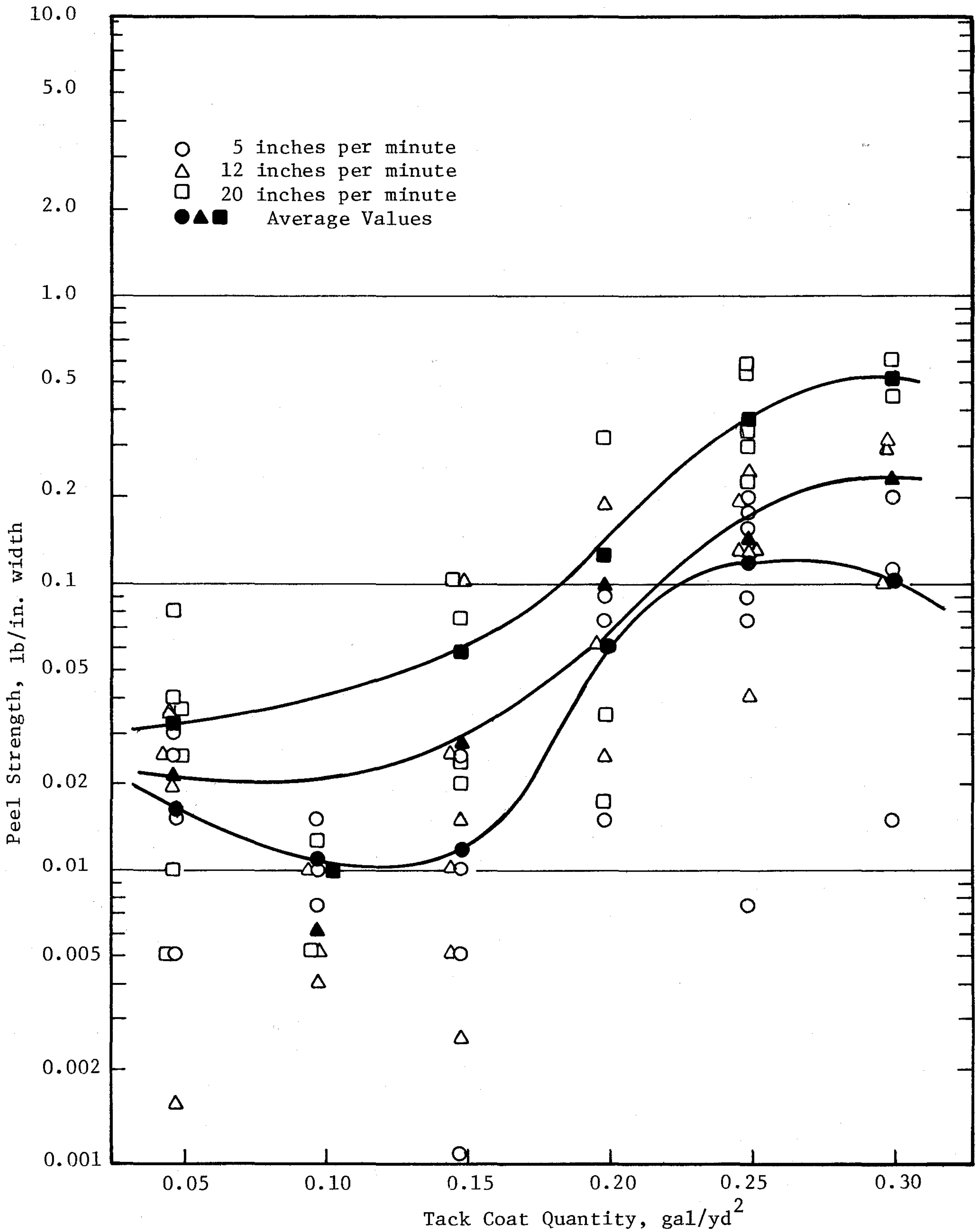

Figure A-7. Sandpaper, AC-10, 122°F (50°C)

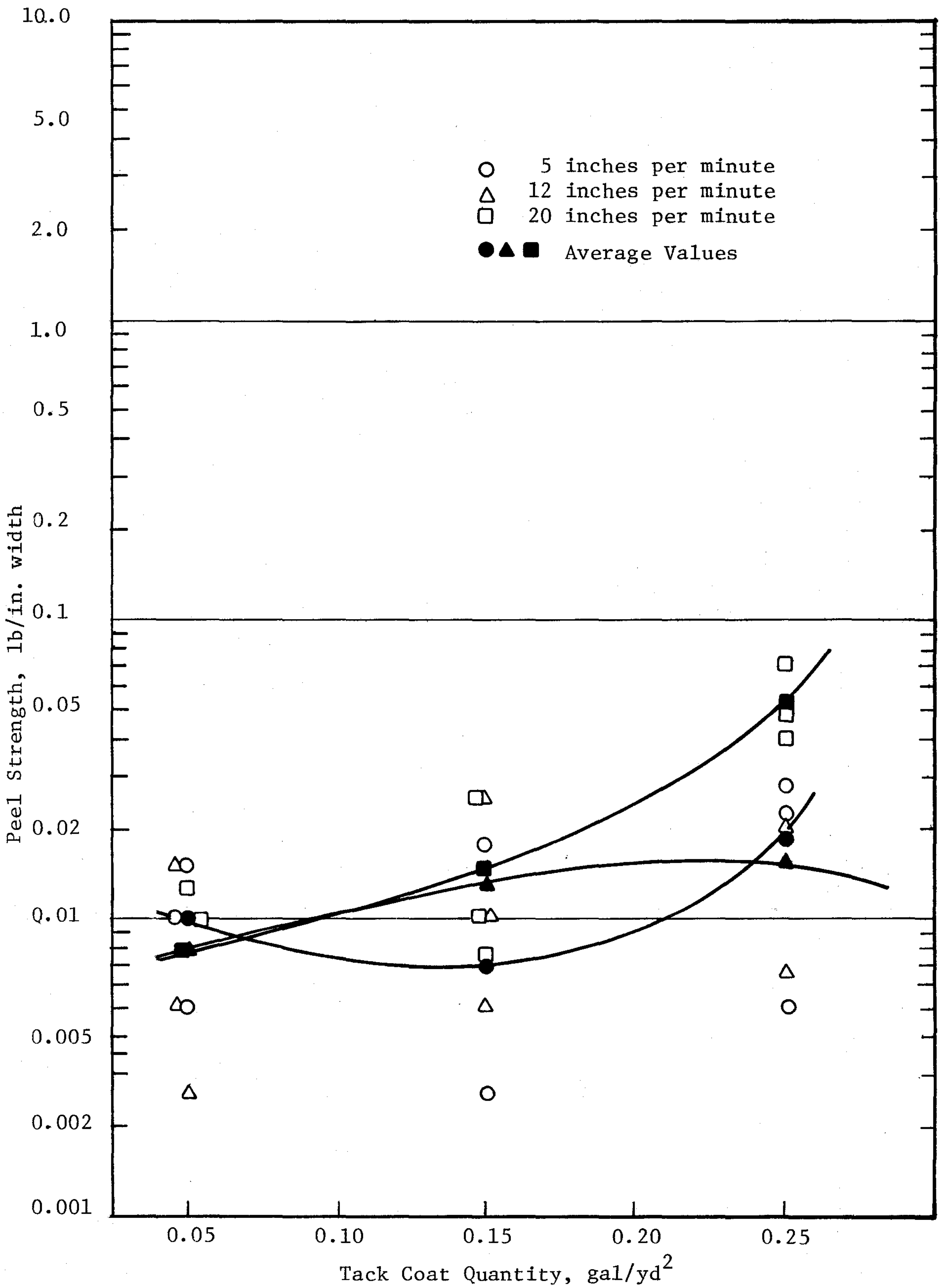

Figure A-8. Sandpaper, AC-10, 140°F (60°C)

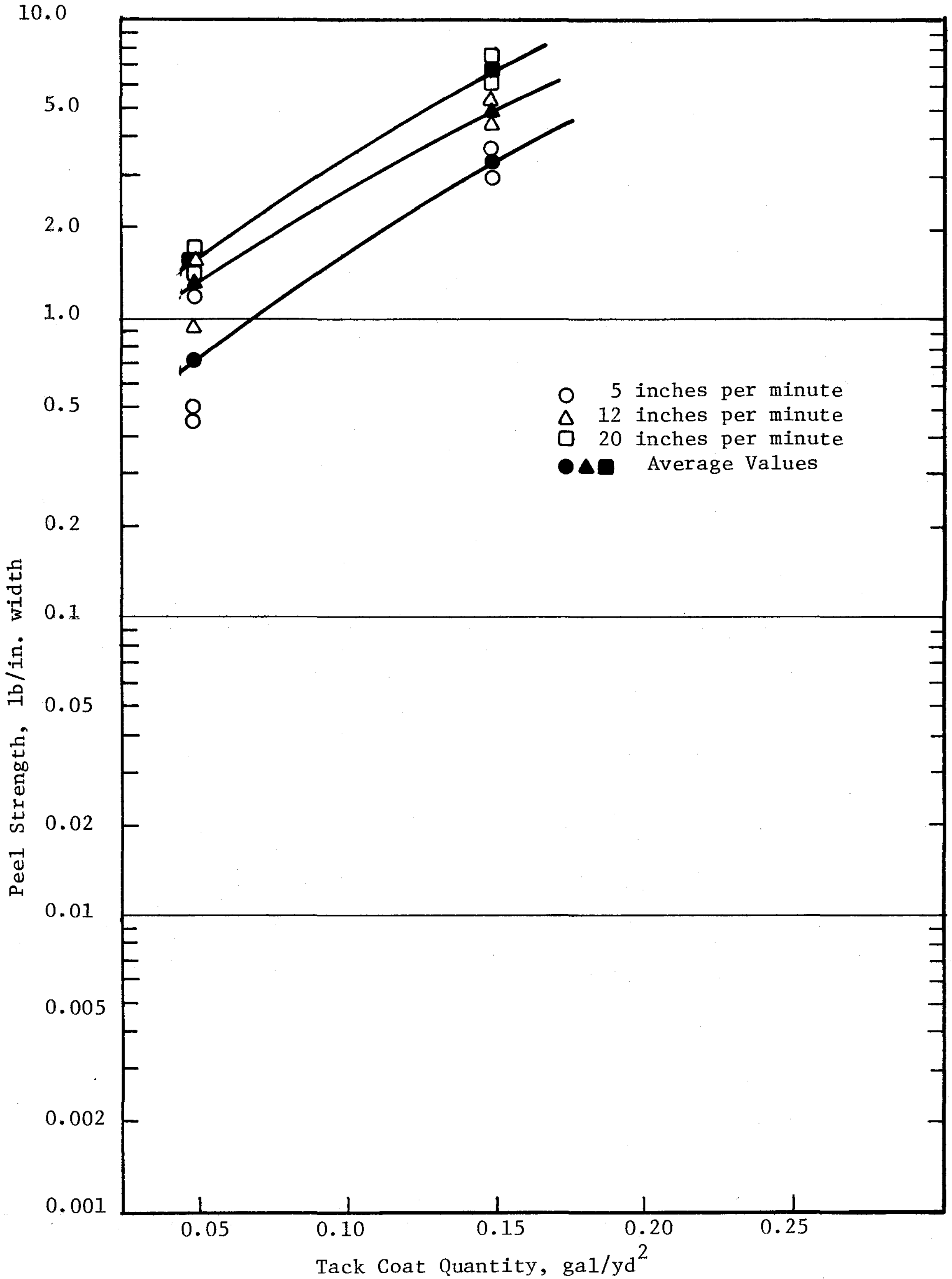

Figure A-9. Sandpaper, AC-20, 68°F (20°C)

Sandpaper - AC-20 @ 20, 40, 50, 60°C

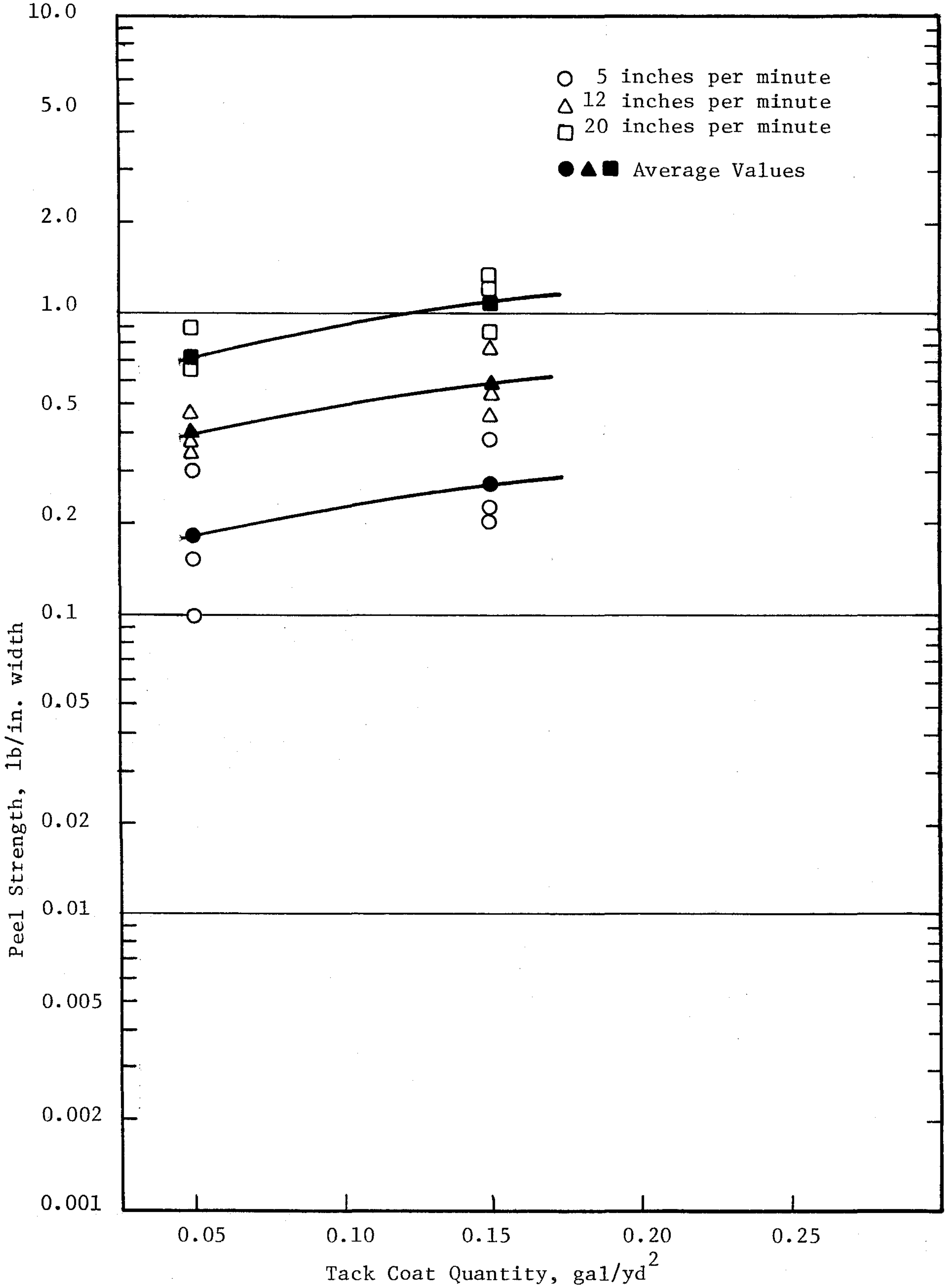

Figure A-10. Sandpaper, AC-20, 104°F (40°C)

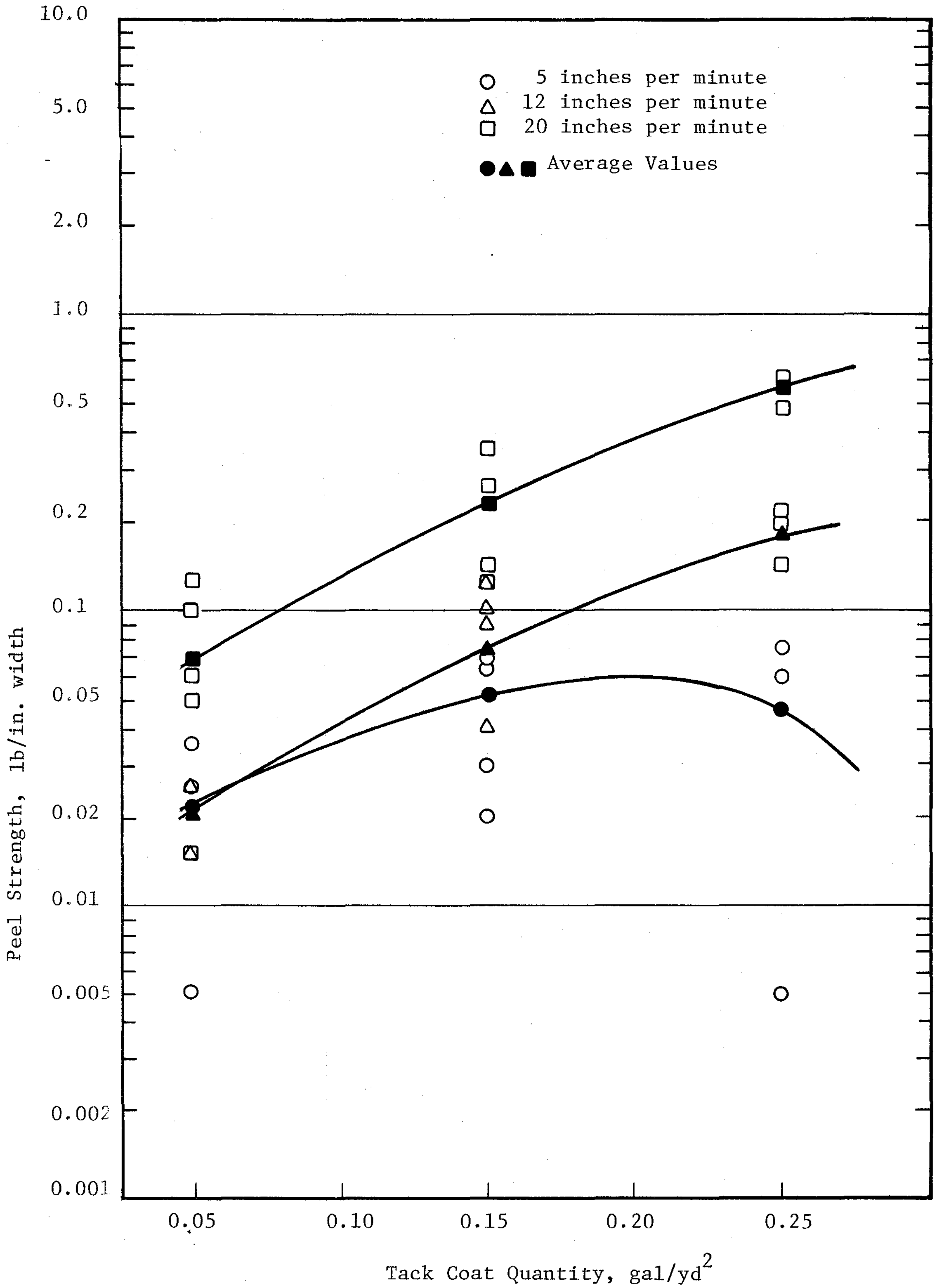

Figure A-11. Sandpaper, AC-20, 122°F (50°C)

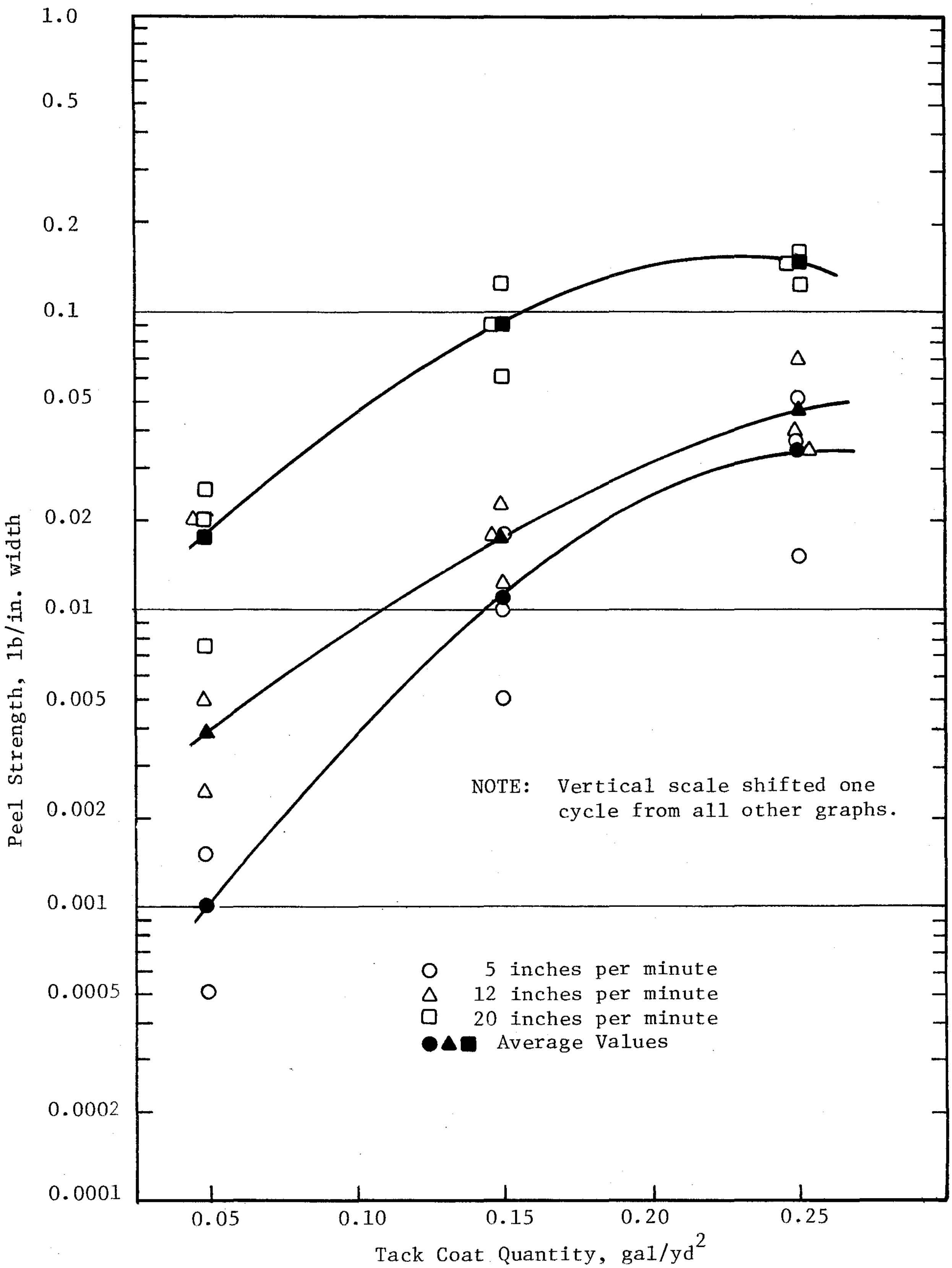

Figure A-12. Sandpaper, AC-20, 140°F (60°C)

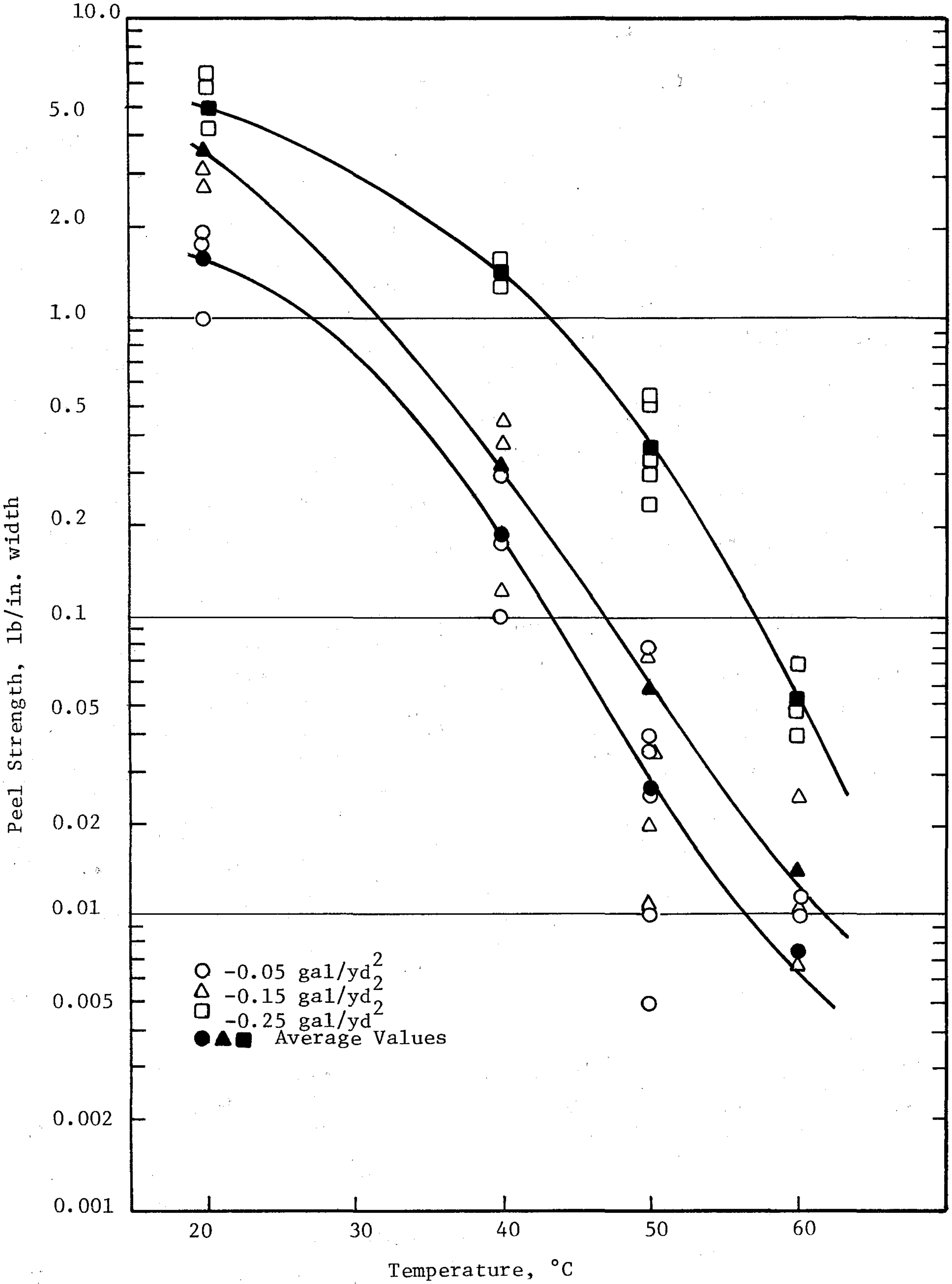

Figure A-13. Sandpaper, AC-10, 20 in/min

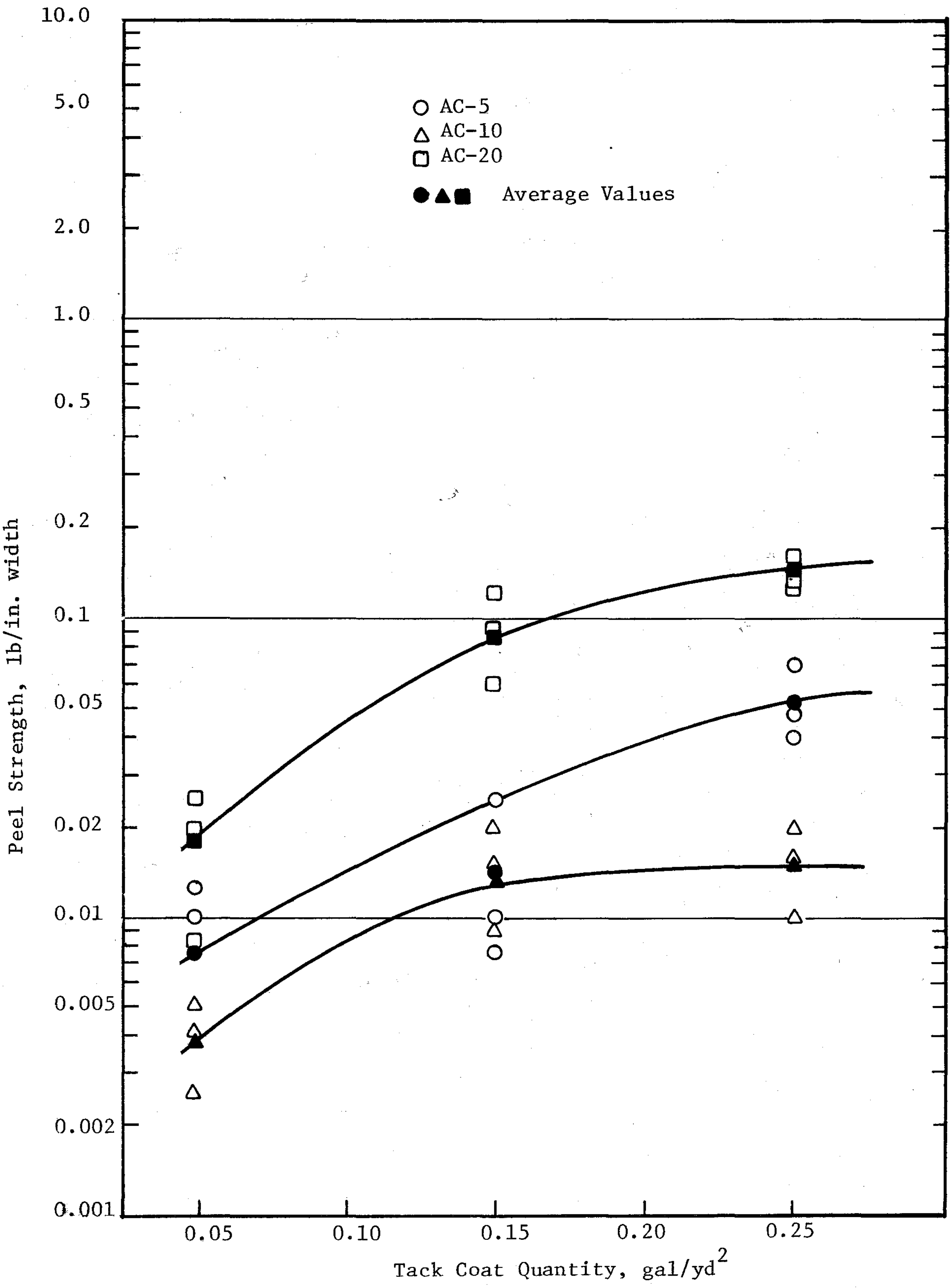

Figure A-14. Sandpaper, 20 in/min, 140°F (60°C)

AC-10 @ 50°C

1. Asphalt Concrete

2. P.C. Concrete

3. A.C. Seal Coat

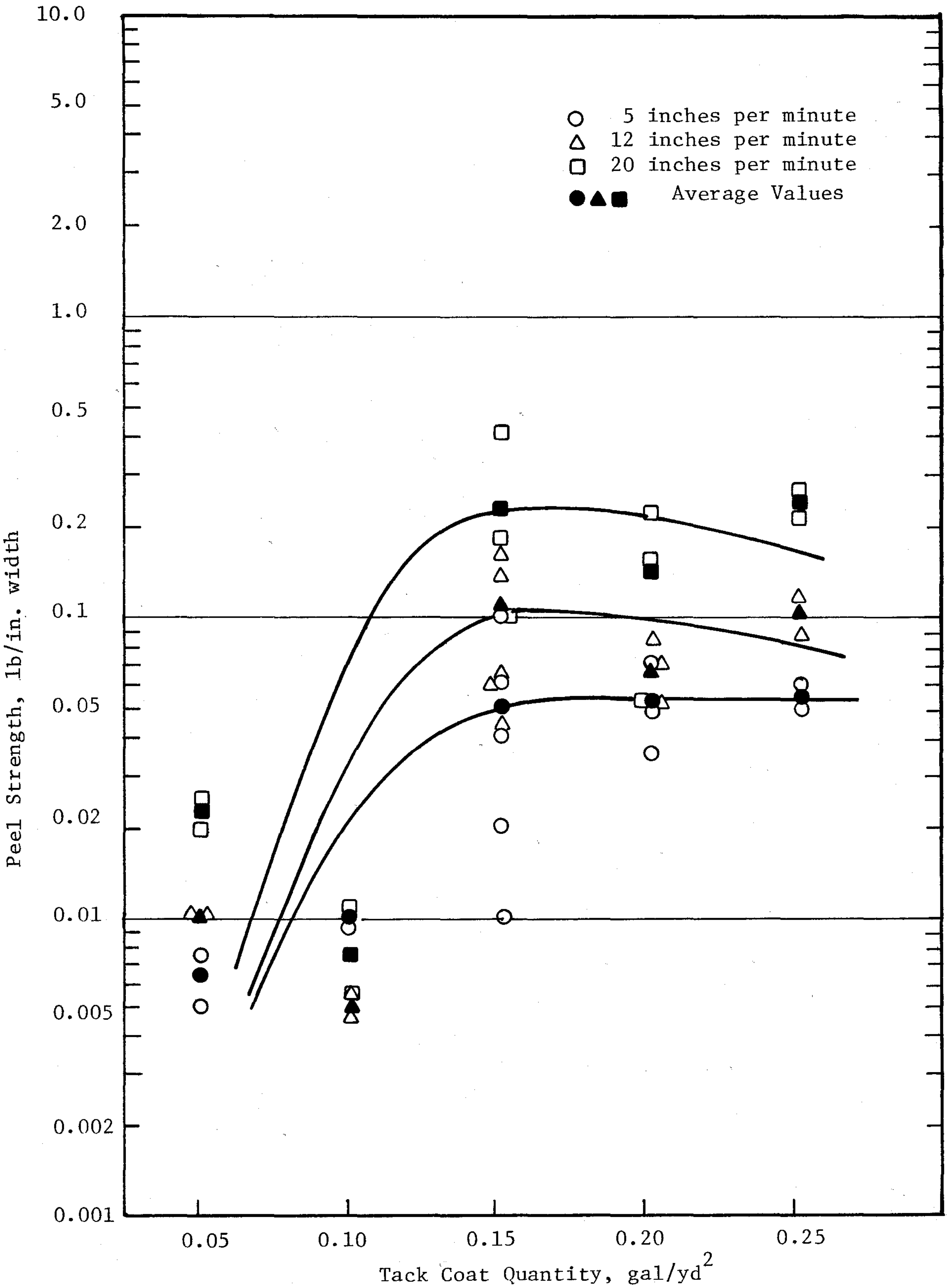

Figure A-15. Asphalt Concrete, AC-10, 122°F (50°C)

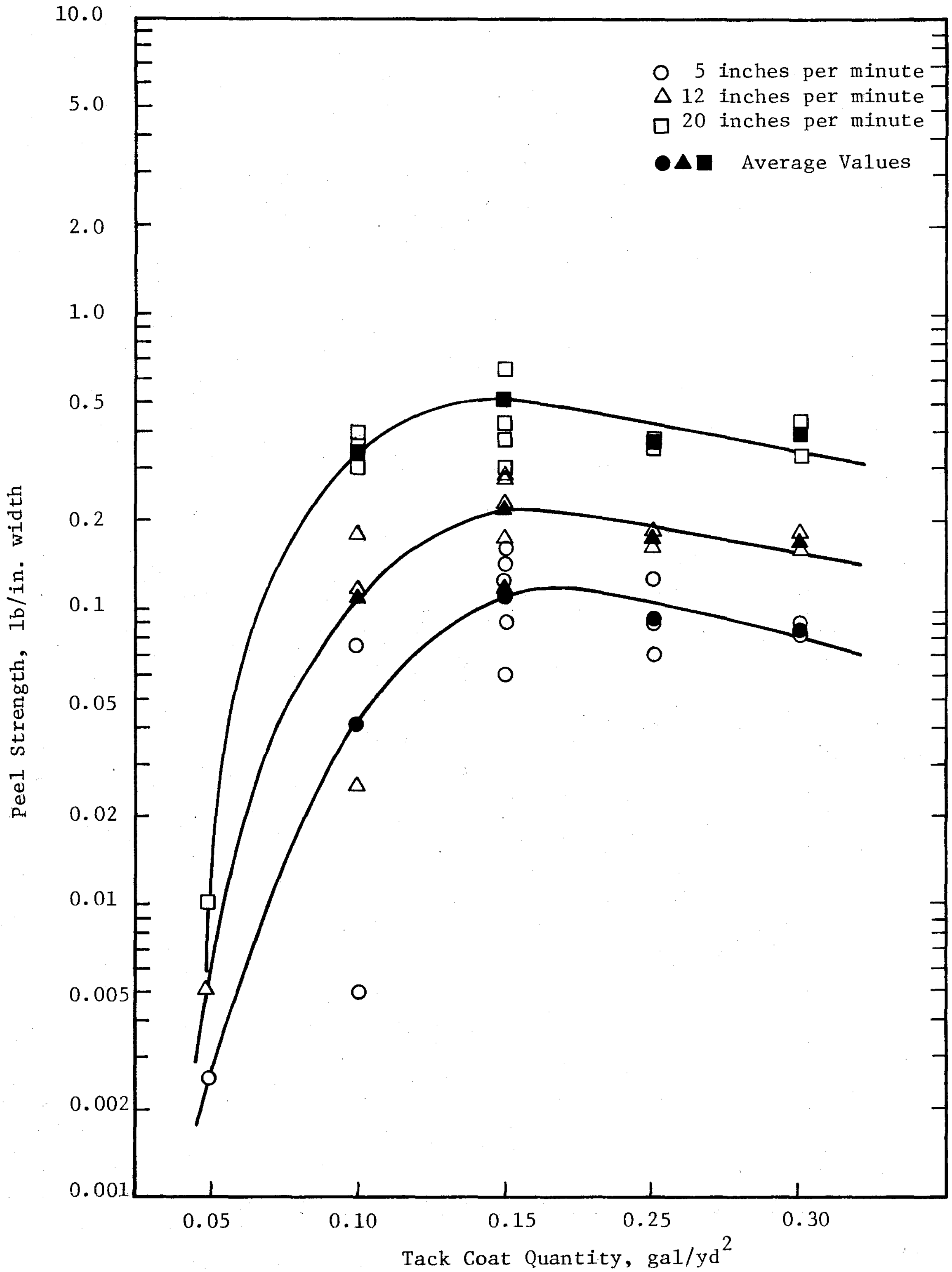

Figure A-16. Portland Cement Concrete, AC-10, 122°F (50°C)

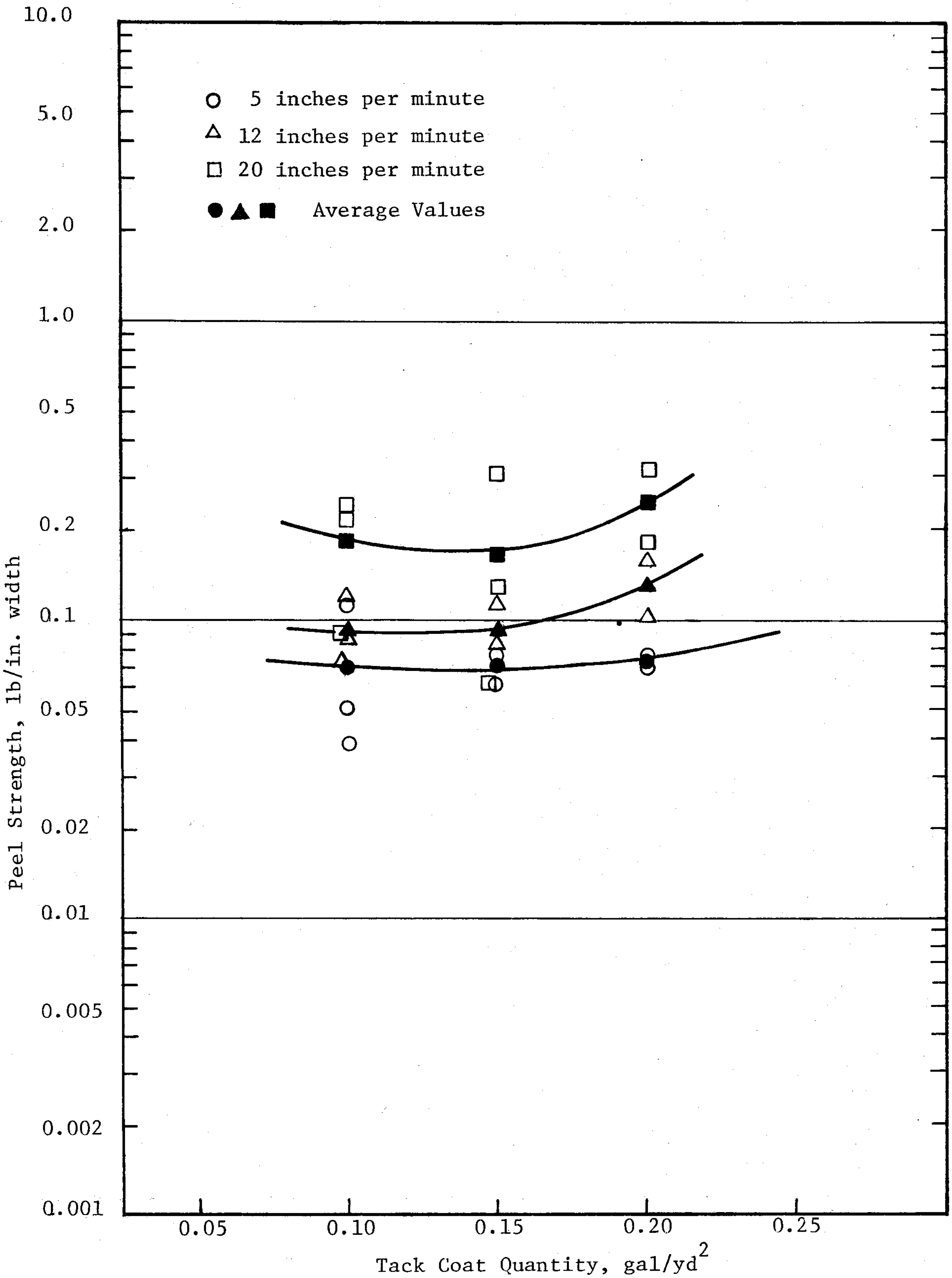

Figure A-17. Seal Coat, AC-10, 122°F (50°C)

Appendix B

Shear Strength Test Results

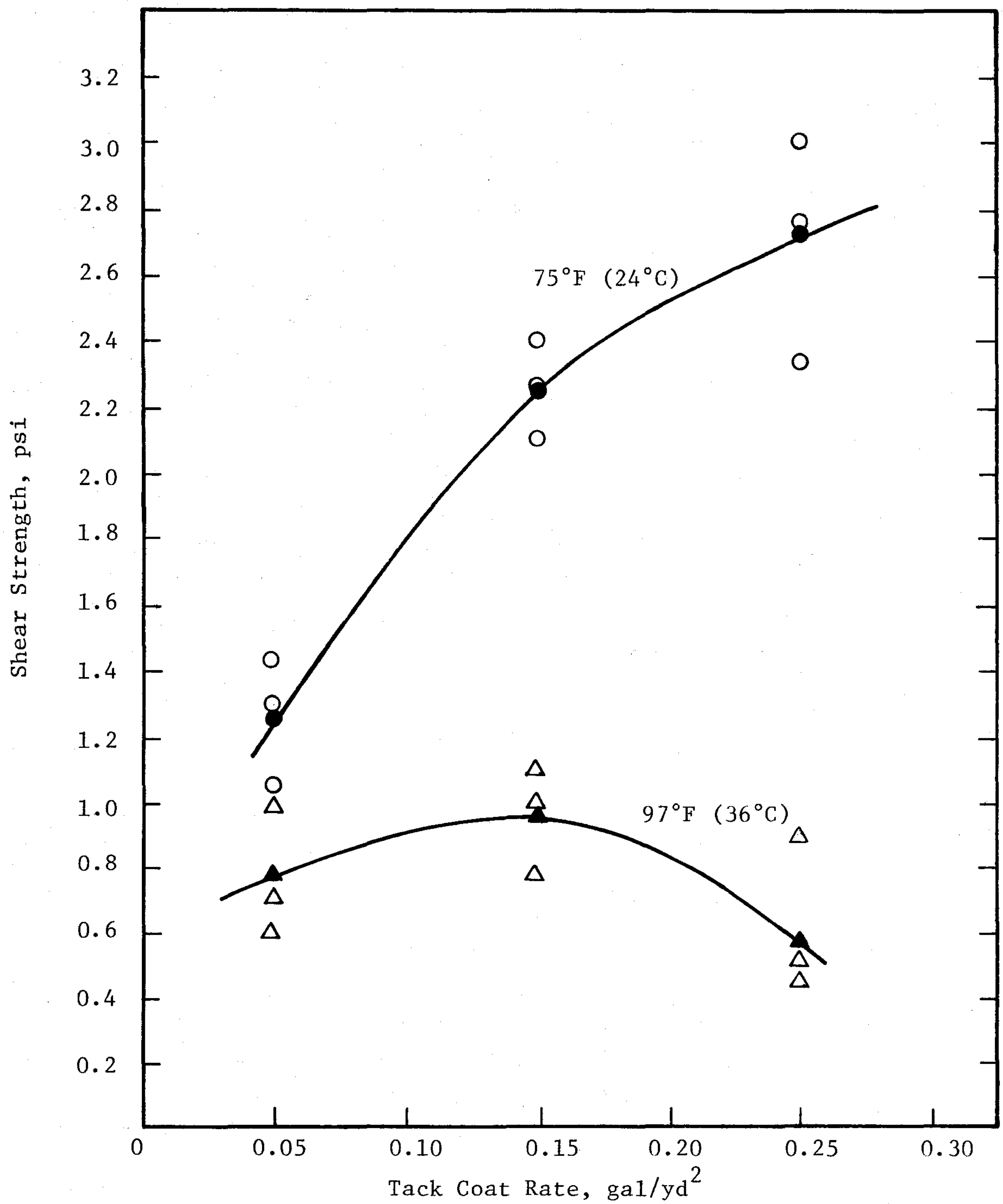

Figure B-1. Direct Shear @ 5 in/min

Appendix C

Texture Depth by the Silicone Putty Method

MEASUREMENT OF TEXTURE DEPTH BY THE SILICONE PUTTY METHOD

Scope

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

Significance

The friction between a tire and the highway surface required for various vehicle maneuvers on a wet pavement, particularly in braking, depends in part on the thickness of the water film between the contact surfaces. This thickness, in turn, is controlled by the water drainage characteristics of the pavement as well as tire tread design and condition. Pavement drainage is influenced strongly by its surface macrotexture, one measure of which is the so-called texture depth. Additionally, an important contribution to friction at the tire-pavement interface is the hysteresis energy losses which occur as a result of cyclic deformation of the tread rubber; these are also influenced by texture depth.

Summary of Method

A known volume of silicone putty is formed into an approximate sphere and placed on the pavement surface. A 6-inch (15.2-cm) plate with a 4-inch (10.2-cm) diameter by 1/16-inch (0.16-cm) deep recess is centered over the putty and pressed down firmly against the pavement surface. The average diameter of the flattened putty is recorded. The volume of putty is selected so that on a smooth, flat surface with no texture the silicone putty will completely fill the 4-inch (10.2-cm) diameter recess. A decrease in diameter of the deformed putty is related to an increase in texture depth thus giving a rapid and simple index of pavement macrotexture.

The texture depth determined by this method is a number representing the ratio of the volume of the putty used to the resultant measured circular area covered. Accordingly, it is only an indirect measure of pavement macrotexture wavelength and amplitude, and gives no information on shape, distribution or other factors which may influence pavement surface drainage or hysteresis losses. Additionally, it is assumed that the putty completely fills all voids under the measured circular area.

Apparatus

The apparatus required for calibration and texture depth measurement consists of the following:

1. A circular plate 6 inches (15.2 cm) in diameter by 1 inch (2.5 cm) thick machined from flat acrylic plastic sheet* with a centrally machined, 4-inch (10.2-cm) diameter by 1/16-inch (0.16-cm) deep recess on one side.
2. 50-pound (22.6-kg) weight with convenient handle.**
3. Steel-wire bristle brush.
4. Stiff-bristle general-utility scrubbing brush.
5. 250-ml polyethylene "squeeze" washing or dispensing bottle fitted with a delivery tip drawn to give a fine, directed stream of dewetting agent.

*Plastic sheets, usually known as "Plexiglas", manufactured by the Rohm & Haas Co., Philadelphia, Pa., or "Lucite", manufactured by E. I. DuPont de Nemours Co., Wilmington, Delaware, have been used satisfactorily.

**Such weights made by Fairbanks-Morse have been found to be satisfactory for this purpose.

6. Synthetically produced, wear-resistant cellulose, polyurethane, or other type of polymer foam sponge suitable for quick removal of excess dewetting agent from the pavement surface.

7. An engineer's scale capable of measuring putty diameter to 0.01 inch (0.025 cm).

8. A metal pry bar (for separation of the circular plate from the pavement at the end of test).

9. 3-ounce (88.7 ml) seamless tin plate containers with fitted lid (such as used in ASTM D 6).

10. Flat plateglass plate for use as a reference check surface, approximately 8 inch by 8 inch by 1/2 inch (20.3 cm by 20.3 cm by 1.3 cm).

Materials

The following materials are required to conduct this test:

1. A filled high-viscosity polysiloxane polymer, known as silicone putty*. Approximately 15.9 grams of this material will be required to completely fill the recess in the test plate on a flat smooth surface. It is usually possible to completely remove the putty from most pavement surfaces after a test is completed, and reuse this material in subsequent tests. However, it has proven to be advantageous to provide a number of pre-weighed putty specimens at the test site, transported in the covered 3-ounce (88.7-ml) containers described in 9 above.

2. Dilute solution of dioctyl sodium sulfosuccinate for use as a wetting and parting agent between the pavement surface and silicone putty test specimen. This solution can be made by mixing 5 ml of 75 percent aqueous Aerosol OT solution** with 5 gallons (19 ℓ) of distilled water.

*A material marketed as "Silly Putty", available from Arnold Clark, Inc., Box 741, New Haven, Conn., has been found suitable for this purpose.

**Available from many general laboratory supply houses.

Sampling

It is well known that in a given nominally uniform section of highway pavement, surface macrotexture may vary significantly from spot to spot. On the other hand, the area covered by the putty in this test is only a small fraction of the total pavement surface to be evaluated. Accordingly, appropriate selection of test locations will be a significant factor in achieving the objective of this test procedure. In a given section of pavement, putty depth measurement shall be made on at least 10 different locations. These may be selected as follows:

1. Random sampling procedure (preferred method). On a diagram of the pavement surface section to be measured, place a rectangular grid producing at least 1000 square cells, each designating a location on the pavement surface, and number these cells serially by any systematic method. Select 10 of these numbers from a table of random digits, and make tests at the center of the cell numbers so indicated.

2. Selective sampling (for preliminary or quick evaluation tests only). Visually inspect the pavement section to be evaluated, and select, on the basis of such observation, 10 locations which appear to be most representative of the texture of the entire section.

Procedure

At the locations selected for texture depth measurements, proceed as follows:

1. Remove all loose stones, other debris and contaminants by vigorous application of the steel wire brush.

2. Remove remaining sand and dust from the surface by careful dry brushing with the scrubbing brush.

3. Wet a section at least as large as the test plate with a spray of dilute Aerosol OT solution from a squeeze bottle.

4. Remove excess Aerosol OT solution by dipping and wiping the surface with the sponge.

5. Form silicone putty into an approximate sphere and place on the pavement surface.

6. Center the recess of the test plate over the putty and press the plate down in firm contact with the road surface. Use of the 50-pound (22.6-kg) weight to exert pressure for approximately 1 minute will usually suffice to bring the edges of the

test plate into contact with the pavement surface. Time intervals over 5 minutes should be avoided.

7. Make four diameter measurements with an angular spacing of 45°, with an engineer's scale to the nearest 0.01 inch (0.25 mm). The average of these readings is taken as the diameter of the flattened putty.

8. Remove the test plate from the pavement surface, using a pry bar if necessary. At the same time the putty also should be removed from the surface. In most instances, complete removal of the putty can be achieved by lightly pressing the putty ball against the few fragments which are clinging to the surface. In the few cases where more than a few hundredths of a gram of putty cannot be removed, it will be necessary to use a fresh putty specimen of the correct weight.

Calibration

Before the apparatus is used for field measurements, the standard procedure shall be followed in the laboratory, using the flat plate-glass surface as a standard. If the putty has been weighed out correctly, it should completely fill the test plate recess, i.e., the putty shall have a diameter of 4 inches (10.2 cm).

Calculation of Texture Depth or Volume of Texture per Unit Area

Texture depth is calculated from the putty diameter by the following equation:

$$Tp = \frac{1}{D^2} - 0.0625 \quad [=] \quad \frac{in^3}{in^2}\ *$$

where:

Tp = texture depth, inches

D = average putty circle diameter, inches

*The value of Tp should be used in Figure 11, Tack Coat Quality as a Function of Surface Texture, to determine the quantity of asphalt cement required for a particular pavement.

or

$$Tp = \frac{2.54}{D^2} - 0.1585$$

where:

Tp = texture depth, cm

D = average putty circle diameter, cm.

Appendix D

Specifications for Asphalt Materials

TABLE D-1. Specifications for Asphalt Materials

Material	ASTM	AASHTO
Asphalt Cement	D 946 - Asphalt Cement for Use in Pavement Construction	M20 - Penetration Graded Asphalt Cement M226 - Viscosity Graded Asphalt Cement
Cutback	Liquid Asphalt D 2026 - Slow-Curing D 2027 - Medium-Curing D 2028 - Rapid-Curing	Cutback Asphalt M81 - Rapid-Curing M82 - Medium-Curing M141 - Slow Curing Liquid Asphaltic Road Material
Emulsions	D 977 - Emulsified Asphalt D 2397 - Cationic Emulsified Asphalt	M140 - Emulsified Asphalt M208 - Cationic Emulsion Asphalt

ASTM requirements for asphalt material as given in the above ASTM specifications are shown in Table D-2, reproduced with the permission of the American Society for Testing and Materials.

AASHTO specifications are available from the American Association of State Highway and Transportation Officials, 444 North Capitol Street, N. W., Suite 225, Washington, D. C. 20001.

TABLE D-2. ASTM Requirements for Asphalt Materials

D 946

Requirements for Asphalt Cement for Use in Pavement Construction

	Penetration Grade									
	40–50		60–70		85–100		120–150		200–300	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Penetration at 77°F (25°C) 100 g, 5 s	40	50	60	70	85	100	120	150	200	300
Flash point, °F (Cleveland open cup)	450	...	450	...	450	...	425	...	350	...
Ductility at 77°F (25°C) 5 cm/min, cm	100	...	100	...	100	...	100	...	100	...
Retained penetration after thin-film oven test, %	55+	...	52+	...	47+	...	42+	...	37+	...
Ductility at 77°F (25°C) 5 cm/min, cm after thin-film oven test	...	...	50	...	75	...	100	...	100	...
Solubility in trichloroethylene, %	99.0	...	99.0	...	99.0	...	99.0	...	99.0	...

D 977

Requirements and Typical Applications for Emulsified Asphalt

Type	Rapid-Setting				Medium-Setting						Slow-Setting			
Grade	RS-1		RS-2		MS-1		MS-2		MS-2h		SS-1		SS-1h	
	min	max	min	max	min	max	min	max	min	max	min	max	min	max
Tests on emulsions:														
Viscosity, Saybolt Furol at 77°F (25°C), s	20	100			20	100	100		100		20	100	20	100
Viscosity, Saybolt Furol at 122°F (50°C), s			75	400										
Settlement,[a] 5-day, %		5		5		5		5		5		5		5
Storage stability test,[b] 24-h, %		1		1		1		1		1		1		1
Demulsibility,[c] 35 ml, 0.02N $CaCl_2$, %	60		60											
Coating ability and water resistance:														
Coating, dry aggregate					good		good		good					
Coating, after spraying					fair		fair		fair					
Coating, wet aggregate					fair		fair		fair					
Coating, after spraying					fair		fair		fair					
Cement mixing test, %												2.0		2.0
Sieve test, %		0.10		0.10		0.10		0.10		0.10		0.10		0.10
Residue by distillation, %	55		63		55		65		65		57		57	
Tests on residue from distillation test:														
Penetration, 77°F (25°C), 100 g, 5 s	100	200	100	200	100	200	100	200	40	90	100	200	40	90
Ductility, 77°F (25°C), 5 cm/min, cm	40		40		40		40		40		40		40	
Solubility in trichloroethylene, %	97.5		97.5		97.5		97.5		97.5		97.5		97.5	
Typical applications[d]	surface treatment, penetration macadam, sand seal coat, tack coat, mulch		surface treatment, penetration macadam, coarse aggregate seal coat (single and multiple)		cold plant mix, road mix, sand seal coat, crack treatment, tack coat		cold plant mix, coarse aggregate seal coat (single and multiple), crack treatment, road mix, tack coat, sand seal coat		cold plant mix, hot plant mix, coarse aggregate seal coat (single and multiple), crack treatment, road mix, tack coat		cold plant mix, road mix, slurry seal coat tack coat, fog seal, dust layer, mulch			

[a] The test requirement for settlement may be waived when the emulsified asphalt is used in less than 5 days time; or the purchaser may require that the settlement test be run from the time the sample is received until the emulsified asphalt is used, if the elapsed time is less than 5 days.

[b] The 24-h storage stability test may be used instead of the 5-day settlement test.

[c] The demulsibility test shall be made within 30 days from date of shipment.

[d] These typical applications are for use only as a guide for selecting and using the emulsion for pavement construction and maintenance.

Requirements and Typical Applications for Cationic Emulsified Asphalt

Type	Rapid-Setting				Medium-Setting				Slow-Setting			
Grade	CRS-1		CRS-2		CMS-2		CMS-2h		CSS-1		CSS-1h	
	min	max	min	max	min	max	min	max	min	max	min	max
Test on emulsions:												
Viscosity, Saybolt Furol at 77°F (25°C), s									20	100	20	100
Viscosity, Saybolt Furol at 122°F (50°C), s	20	100	100	400	50	450	50	450				
Settlement,[a] 5-day, %		5		5		5		5		5		5
Storage stability test,[b] 24-h, %		1		1		1		1		1		1
Classification test[c]	passes		passes									
or												
Demulsibility,[d] 35 ml 0.8 % sodium dioctylsulfosuccinate, %	40		40									
Coating, ability and water resistance:												
Coating, dry aggregate					good		good					
Coating, after spraying					fair		fair					
Coating, wet aggregate					fair		fair					
Coating, after spraying					fair		fair					
Particle charge test	positive		positive		positive		positive		positive		positive	
Sieve test, %		0.10		0.10		0.10		0.10		0.10		0.10
Cement mixing test, %										2.0		2.0
Distillation:												
Oil distillate, by volume of emulsion, %		3		3		12		12				
Residue, %	60		65		65		65		57		57	
Tests on residue from distillation test:												
Penetration, 77°F (25°C), 100 g, 5 s	100	250	100	250	100	250	40	90	100	250	40	90
Ductility, 77°F (25°C), 5 cm/min, cm	40		40		40		40		40		40	
Solubility in trichloroethylene, %	97.5		97.5		97.5		97.5		97.5		97.5	
Typical applications[e]	surface treatment, penetration macadam, sand seal coat, tack coat, mulch		surface treatment, penetration macadam, coarse aggregate seal coat (single and multiple)		cold plant mix, coarse aggregate seal coat (single and multiple), crack treatment, road mix, tack coat, sand seal coat		cold plant mix, hot plant mix, coarse aggregate seal coat (single and multiple), crack treatment, road mix, tack coat		cold plant mix, road mix, slurry seal coat, tack coat, fog seal, dust layer, mulch			

[a] The test requirement for settlement may be waived when the emulsified asphalt is used in less than 5 days time; or the purchaser may require that the settlement test be run from the time the sample is received until the emulsified asphalt is used, if the elapsed time is less than 5 days.

[b] The 24-h storage stability test may be used instead of the 5-day settlement test.

[c] Material failing the classification test will be considered acceptable if it passes the demulsibility test.

[d] The demulsibility test shall be made within 30 days from date of shipment.

[e] These typical applications are for use only as a guide for selecting and using the emulsion for pavement construction and maintenance.

D 2028

Requirements for Liquid Asphalt (Rapid-Curing Type)

NOTE—If the ductility at 77 F (25 C) is less than 100, the material will be acceptable if its ductility at 60 F (15.5 C) is more than 100.

Designation	RC-70		RC-250		RC-800		RC-3000	
	Min	Max	Min	Max	Min	Max	Min	Max
Kinematic viscosity at 140 F (60 C), cSt	70	140	250	500	800	1600	3000	6000
Flash point (Tag open-cup), deg F (deg C)	...	...	80+ (27+)	...	80+ (27+)	...	80+ (27+)	...
Distillation test:								
Distillate, volume percent of total distillate to 680 F (360 C):								
to 374 F (190 C)	10	...	...	...	...	...	...	...
to 437 F (225 C)	50	...	35	...	15	...	...	...
to 500 F (260 C)	70	...	60	...	45	...	25	...
to 600 F (316 C)	85	...	80	...	75	...	70	...
Residue from distillation to 680 F (360 C), percent volume by difference	55	...	65	...	75	...	80	...
Tests on residue from distillation:								
Viscosity at 140°F (60°C), P[a]	600	2400	600	2400	600	2400	600	2400
Ductility at 77 F (25 C), cm	100	...	100	...	100	...	100	...
Solubility in trichloroethylene, percent	99.0	...	99.0	...	99.0	...	99.0	...
Water, percent	...	0.2	...	0.2	...	0.2	...	0.2

[a] The penetration at 77°F (25°C), 100 g, 5 s, for all grades ranges from 80 to 120.

Requirements for Liquid Asphalt (Medium-Curing Type)

NOTE—If the ductility at 77 F (25 C) is less than 100, the material will be acceptable if its ductility at 60 F (15.5 C) is more than 100.

Designation	MC-30		MC-70		MC-250		MC-800		MC-3000	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Kinematic viscosity at 140°F (60°C), cSt	30	60	70	140	250	500	800	1600	3000	6000
Flash point (Tag open-cup), °F (°C)	100 (38)	...	100 (38)	...	150 (66)	...	150 (66)	...	150 (66)	...
Distillate test:										
Distillate, volume percent of total distillate to 680°F (360°C):										
to 437°F (225°C)	...	25	...	20	...	10	...	...	...	...
to 500°F (260°C)	40	70	20	60	15	55	...	35	...	15
to 600°F (316°C)	75	93	65	90	60	87	45	80	15	75
Residue from distillation to 680°F (360°C), percent volume by difference	50	...	55	...	67	...	75	...	80	...
Tests on residue from distillation:										
Viscosity at 140°F (60°C), P[a]	300	1200	300	1200	300	1200	300	1200	300	1200
Ductility at 77°F (25°C), cm	100	...	100	...	100	...	100	...	100	...
Solubility in trichloroethylene, %	99.0	...	99.0	...	99.0	...	99.0	...	99.0	...
Water, %	...	0.2	...	0.2	...	0.2	...	0.2	...	0.2

[a] The penetration at 77°F (25°C), 100 g, 5 s, for all grades ranges from 120 to 250.

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Requirements for Liquid Asphalt (Slow-Curing Type)

NOTE 1—Kinematic Viscosity Method D 2170 covers the range from 30 to 6000 cSt while Absolute Viscosity Method D 2171 covers the range from 42 to 200 000 P.

NOTE 2—If the ductility at 77 F (25 C) is less than 100, the material will be acceptable if its ductility at 60 F (15.5 C) is more than 100.

Designation	SC-70		SC-250		SC-800		SC-3000	
	Min	Max	Min	Max	Min	Max	Min	Max
Kinematic viscosity at 140 F (60 C), cSt.	70	140	250	500	800	1600	3000	6000
Flash point (Cleveland open cup), deg F (deg C)	150 (66)	...	175 (79)	...	200 (93)	...	225 (107)	...
Distillation test:								
Total distillate to 680 F (360 C), volume percent	10	30	4	20	2	12	...	5
Kinematic viscosity on distillation residue at 140 F (60 C), St	4	70	8	100	20	160	40	350
Asphalt residue:								
Residue of 100 penetration, percent	50	...	60	...	70	...	80	...
Ductility of 100 penetration residue at 77 F (25 C), cm	100	...	100	...	100	...	100	...
Solubility in trichloroethylene, percent	99.0	...	99.0	...	99.0	...	99.0	...
Water, percent	...	0.5	...	0.5	...	0.5	...	0.5