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Reduction Of Accidents By Pavement Grooving

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**16. ABSTRACT**

Providing and maintaining a skid resistant surface on concrete pavements is discussed. Studies of the effect of grooving the pavement to reduce wet weather accidents were conducted. The objective of the studies was to determine the efficiency of serrations in raising the skid resistance, to determine resistance of a grooved pavement to wear and polish of traffic, and to determine the extent of reduction in wet weather accidents by serration of the pavement. Results show that pavement grooving parallel to the centerline will reduce the wet weather accident rate in low friction value areas of PCC pavements. Friction value is raised following grooving. Wear and polish of grooved areas appear to depend on characteristics of the pavement.

**17. KEYWORDS**

Pavements, pavement skidding characteristics, pavement surfaces, grooving, accidents, accident rates, wear, polishing

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# HIGHWAY RESEARCH REPORT

## REDUCTION OF ACCIDENTS BY PAVEMENT GROOVING

John L. Beaton  
Ernest Zube and John Skog

Presented at the Western Summer Meeting  
of the Highway Research Board  
Denver, Colorado  
August, 1968

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**STATE OF CALIFORNIA**  
**TRANSPORTATION AGENCY**  
**DEPARTMENT OF PUBLIC WORKS**  
**DIVISION OF HIGHWAYS**

**MATERIALS AND RESEARCH DEPARTMENT**

**RESEARCH REPORT**

**NO. M & R 633126**

Prepared in Cooperation with the U.S. Department of Transportation, Bureau of Public Roads August, 1968

STATE OF CALIFORNIA  
TRANSPORTATION AGENCY  
DEPARTMENT OF PUBLIC WORKS  
DIVISION OF HIGHWAYS  
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REDUCTION OF ACCIDENTS  
BY PAVEMENT GROOVING

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REFERENCE: Beaton, J. L., Zube, E., and Skog, J. B.  
"Reduction of Accidents by Pavement Grooving",  
State of California, Department of Public  
Works, Division of Highways, Materials and  
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Results show that pavement grooving parallel to  
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accident rate in low friction value areas of  
PCC pavements. Friction value is raised  
following grooving. Wear and polish of grooved  
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KEY WORDS: Pavements, pavement skidding characteristics,  
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## ACKNOWLEDGMENT

This paper is based on data collected during a research project financed by the U. S. Department of Transportation, Federal Highway Administration, Bureau of Public Roads. The opinions, findings and conclusions expressed in this publication are those of the authors and not necessarily those of the Bureau of Public Roads.

## INTRODUCTION

Providing and maintaining a skid resistant surface is of primary importance to the proper performance of any highway. All types of pavement surface will eventually show some reduction in coefficient of friction values during their service life. This reduction is caused by wear and polish of traffic, especially by heavy trucks.

Several years ago California Division of Highways accident analysis showed that some sections of concrete freeways, especially on curves, were having an unusual number of accidents occurring during wet or rainy weather. After considering the use of acid treatment of the surface or the application of a coal tar-epoxy screening seal coat or some other thin organic overlay, it was decided to study the effect of grooving the pavement. The objectives of the program are as follows:

1. To determine the efficiency of serration in raising the skid resistance.
2. To determine the resistance of a grooved pavement to wear and polish of traffic.
3. To determine the extent of reduction in wet weather accidents in critical areas by serration of the pavement.

## MEASUREMENT OF SKID RESISTANCE

The California Skid Tester used in determining the coefficient of friction of pavement surfaces has been

previously described<sup>1</sup>. The presently used test method is shown in the attached appendix. The tester has been calibrated with the towed trailer equipment constructed by Professor R. A. Moyer of the University of California, Institute of Transportation<sup>2</sup>. Previous studies by Professor Moyer and others indicated that the skid resistance value for any given surface approaches a low figure when the brakes are locked on a vehicle having smooth tread tires and traveling at speeds of fifty miles per hour on a wet pavement. Therefore, in the correlation program, the coefficient of friction values obtained from Moyer's unit using locked wheels, smooth tires, wet pavement and a speed of fifty miles per hour were compared to our readings obtained under identical operating conditions.

We are presently using a value of  $f=0.25$  as the minimum requirement for indicating the need for remedial action, and a minimum of  $f=0.30$  for new PCC pavement. An active program is underway to study the adequacy of these values, especially the figure for remedial action. The program involves the use of recommended minimum friction values from other sources, and an accident frequency correlation with skid resistance of the pavement surface.

C. G. Giles<sup>3</sup> on the basis of a comprehensive accident analysis in England has provided a set of suggested values of skid resistance for use with the British Portable

Tester. A comprehensive correlation program was performed by us in order to obtain the relation between the California Tester and the British Portable Tester.

On the basis of the correlation, a comparison of the recommended British values with the tentative California minimum figure is shown in Figure 1. Also shown is the Virginia minimum figure which was attained by using the correlation chart of D. C. Mahone<sup>4</sup> which provides an approximate correlation between the British Portable Tester and the Virginia test car at 40 mph.

Preliminary studies in California on a wet weather accident frequency correlation with skid resistance indicates that most single car accidents occurred on curves, the average value for the friction factor being  $f=0.22$ . However, twenty-eight percent of the accidents that occurred on curves were on pavements of  $f=0.25-0.28$  range. The maximum value attained in this study was  $f=0.28$ .

On the basis of these results, it is concluded that the present  $f=0.25$  remedial action value is a minimum figure, and it appears that the value may be too low for curves of rather short radius. A better value may be  $f=0.28$  which is the same as the British minimum for all sites. Further studies are underway.

#### PATTERN STUDIES

Grooves may be cut in the pavement in either a longitudinal (parallel to the centerline), transverse or

skewed direction. All grooving (except for a few short experimental sections) to date on State Highways has been performed in a longitudinal direction. We are of the opinion that this leads to increased lateral stability, and tends to guide the vehicle through a critical curve area. This has been confirmed by studies performed in Texas<sup>5</sup>. However, studies in England<sup>6</sup> indicate that grooving perpendicular to the centerline is better in this connection - further effort will be required to resolve the problem.

Groove patterns vary. The most common type is rectangular in form and may be varied in width and depth and distance between centers of grooves. Other types have rectangular form, but the bottom is partially rounded, and the edges at the pavement surface are also rounded. Others have a large V cut separated by smaller V cuts. Figure 2 shows two types of patterns.

A number of patterns have been used in our serration work to date. This was done in order to determine the increase in the friction factor, wear resistance, and possible vehicle handling problem. In all cases the grooves are all in a longitudinal direction. Figure 3 shows the patterns used on the various projects, and Table A the increase in the friction value after grooving and the change during service life. Figure 4 shows the effect of grooving on the average coefficient of friction value for the various PCC pavement projects.

In all cases the friction value is raised by pavement grooving. However, it appears that the nature of the existing concrete surface and the type of pattern effect the degree of improvement in the friction value. As an example there is a much greater improvement in the friction value for project H than on projects F and G for a  $1/8'' \times 1/8''$  on 1" centers with a rectangular groove. This is also confirmed by the results from projects J and K where two different patterns are compared on two different projects.

The type of pattern on any specific project effects the degree of improvement. On project K three different Christensen patterns (Table A) were placed in consecutive one hundred foot test sections in the travel lane. The original coefficient of friction values were identical, but two of the patterns produced a very high degree of improvement as compared to the third pattern.

Project I in District 07 is an aged asphalt concrete pavement. The surface was rather dry in appearance and quite brittle. Therefore, it was decided to groove this pavement using  $1/4'' \times 1/4''$  grooves on 1" centers. Shortly after completion several complaints were received from drivers of motorcycles and light cars. The complaints were that the vehicle tended to "track" and appeared to be caught in a manner resembling being caught in streetcar tracks. This was confirmed by Highway Patrolmen. On the other hand, Christensen Style 15 with V cuts  $1/4''$

wide on the Placerita Canyon Bridge provided no problems with test motorcycles driven up to 70 mph. There was some vibration up to 50 mph with Style 9, but this tended to fade out at higher speeds. Style 9, see Table A project J, has 3/16" wide rectangular grooves with rounded bottom and edges. These studies indicate that rectangular longitudinal grooves should not be wider than 1/8" in order to prevent possible problems from motorcycles and light passenger cars. However, V cuts do not appear to cause problems although 1/4" wide at the surface.

A very important characteristic of any treatment for raising the existing friction value is its resistance to wear and polish of traffic. Results of variations of friction measurements with time on various grooved projects are shown in Table A and Figure 5. Not sufficient time has elapsed on the majority of the projects to draw any firm conclusions. It appears, however, that the nature of aggregate and mortar strength may influence the resistance to wear and polish of the grooved areas. However, it is interesting to note that projects A and B cover the travel lanes of heavily travelled freeways having a high percentage of trucks. All the projects shown in Figure 5 are in snow free areas. Project H in Table A is in a partial snow region where chains may be required. After the first winter the surface does not appear to be damaged by chain action. This project will be closely watched since project M in Table B has shown considerable

spalling between the grooves which are on one inch centers. This spalling has been caused by chain action and has resulted in some complaints in regards to controllability of a car even under dry pavement conditions.

#### ACCIDENT STUDIES

A summary of all of the presently available accident data are shown in Tables B, C and D. Six of these locations were on urban freeways in the vicinity of Los Angeles. Accident data was also reviewed for comparison purposes on a mile of unserrated asphalt concrete freeway, see Table D. The Los Angeles projects had one year before and after accident analysis periods. An additional project M on Interstate 80 near the Nevada state line had a two year period for before and after accident analysis. This freeway is rural and required longer periods to obtain meaningful data. In the case of the Los Angeles area freeways, the number of wet or rainy days was determined in both the before and after accident periods. There were 30 wet days in the before period and approximately 15 wet days in the after period. Fifteen additional wet days were accumulated from the following year and the accidents on these days were added to the after period.

A study of Table B indicates that the total accidents were reduced 78 percent; of this, wet pavement accidents were almost completely eliminated (96 percent)

and dry pavement accidents dropped 32 percent.

The reduction in dry weather accidents, if confirmed by further observation, appears to be significant. There is no reason to doubt that the dry friction value of these pavements was sufficiently high. In our opinion the decrease in dry weather accidents may be the result of the ability of the grooves to "track" or aid as a guide for a vehicle nearing an out of control condition in the curve area. Such loss of control would most commonly be caused by entering the curve at excessive speed and then rapid deceleration within the curve area. Such action could cause loss of control. The longitudinal grooves by acting as "tracks" could resist lateral movements and add stability to the vehicle. In the case of the wet pavement condition we may, therefore, assume that longitudinal grooving in curve areas not only increases the friction factor, but also acts as a stabilizer against lateral instability. It probably also serves as a quick surface drain to minimize any water buildup on the pavement.

Table C shows the exposure in million vehicle miles, accident rates, and other information. Both wet and dry pavement accident rates were calculated relative to the number of wet or dry days. These rates could not be calculated at the Interstate 80 location, project M, since the number of wet days was not available.

All of the accident rates on wet days were much higher than the average state highway rates at both

urban and rural locations. Since the number of wet days is relatively minor in southern California, the resulting exposure is small. When this is divided into the overall large number of accidents occurring on wet pavement, the result is an unusually high rate. All locations (excepting one) had higher than average total accident rates in the before grooving period. The concrete surfaced urban free-ways all had below average ( $\leq 1.61$ ) rates in the after period. The two rural locations (both concrete surfaced) still had higher than average total accident rates ( $\leq 1.00$ ) despite sizable drops in rates after pavement serration.

For comparison purposes the accident rate on a one mile stretch of asphaltic concrete pavement just south of the serrated project N was compared with the unserrated control section. The results are shown in Table D and clearly indicate the excellent reduction in wet weather accidents following grooving. In the same period the control section had a gain in wet weather accidents.

It is proposed to continue this accident analysis, and periodical skid resistance surveys to determine possible increase in accidents as the friction values change during service life.

#### COST OF GROOVING

On seven jobs in District 07 the cost of grooving was in the range of seven to nine cents per square foot. In some other Districts the cost is somewhat higher. The

best estimate is approximately ten cents per square foot.

#### SUMMARY

In summary it appears that pavement grooving performed in a direction parallel to the centerline will definitely reduce the wet weather accident rate in low friction value areas of PCC pavements. Excellent reduction of wet weather accidents occurred after grooving of an old asphalt concrete pavement. However, this pavement was very hard and brittle, and we do not recommend grooving of normal asphalt concrete pavement, since kneading by traffic may rapidly close the grooves. It seems preferable to apply a screening seal coat, slurry seal coat or dense or open graded blanket.

The friction value is raised following grooving. The rate of change in friction value by wear and polish of the grooved area appears to depend on the characteristics of the original concrete pavement, since two pavements with heavy truck traffic showed little change in friction values after a number of years of service. On the other hand some pavements show quite rapid drops after only seventeen months of traffic. Further tests are required.

Motorcycle and light car tests clearly indicate that 1/4" x 1/4" grooves will create problems in vehicle control. It is recommended that cuts no greater than 1/8" x 1/8" be used if vertical grooves are cut in the pavement. However, 1/8" deep x 1/4" wide V grooves do not appear to create any problems. Further studies are

required before any specific spacing may be recommended. However, since approximately equal accident reductions were noted for 1/2" and 3/4" spacing, it is recommended that 1/8" x 1/8" on 3/4" centers be used. It is highly desirable that further areas be grooved with a series of patterns as was done on the Ventura project in order to determine effectiveness in raising the original coefficient of friction, and resistance to wear and polish under equivalent concrete and traffic conditions.

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TABLE A

## Change in Average Friction Values Following Grooving

Project No.	Pavement Type	Location	AADT 1000	Serration Pattern	Age Mos.	Ave. Friction Value
A	PCC Bridge Deck	10-Sta-4-A	24	Rectangular Grooves 1/8"x1/8" on 3/8" Centers	Before	0.26
					After 45 101	0.33 0.33 0.36
B	PCC Bridge Deck	04-A1a-7-A1b	80	Rectangular Grooves 1/8"x1/8" on 3/8" Centers	Before	0.26
					After 41	0.32 0.28
C	PCC	06-Kern-5- PM6.94-7.47	16	Rectangular Grooves 1/8"x1/8" on 3/8" Centers	Before	0.19
					After 67	0.32 0.34
D	PCC	07-Ora-5- PM23.3-23.6	45	Rectangular Grooves 1/8"x1/8" on 1/2" Centers	Before	0.25
					After 17	0.35 0.30
E	PCC	07-IA-5 PM29.5-30.0	104	Rectangular Grooves 1/8"x1/8" on 3/4" Centers	Before	0.23
					After 17	0.31 0.27
F	PCC	07-IA-405 PM2.1-2.6	131	Rectangular Grooves 1/8"x1/8" on 1" Centers	Before	0.20
					After 17	0.24 0.22

TABLE A  
Change in Average Friction Values Following Grooving

Project No.	Pavement Type	Location	AADT 1000	Serration Pattern	Age Mos.	Ave. Friction Value
G	PCC	07-LA-405 PM3.8-4.1	139	Rectangular Grooves 1/8"x1/8" on 1" Centers	Before After	0.19 0.21
H	PCC	03-Pla, Nev-80 Var.	9	Rectangular Grooves 1/8"x1/8" on 1" Centers	Before After	0.24 0.37
H-1		E. B. Lane PM42.56-42.77		"	12 Mo.	0.34
H-2		W. B. Lane PM45.45-45.60	9	"	Before After	0.25 0.32
H-3		W. B. Lane PM5.00-5.27	9	"	12 Mo.	0.29
H-4		E. B. Lane PM6.55-6.65	9	"	Before After	0.19 0.29
H-5		W. B. Lane PM9.01-9.19	9	"	12 Mo.	0.27
					Before After	0.15 0.30
					12 Mo.	0.25
					Before After	0.19 0.30
					12 Mo.	0.27

TABLE A

Change in Average Friction Values Following Grooving

Project No.	Pavement Type	Location	AADT 1000	Serration Pattern	Age Mos.	Ave. Friction Value
I	AC	07-LA-101 PM8.8-9.3	134	Rectangular Grooves 1/4"x1/4" on 1" Centers	Before	0.23
					After 17	0.28 0.29
J	PCC	07-LA-14-27.89 Placerita Canyon Bridge	13	Christensen Co. Style #9	Before	0.16
					After	0.26
K	PCC	07-Ven-101	21	Christensen Co. Style #15	Before	0.16
					After	0.33
				Christensen Co. Style #6	Before	0.20
					After	0.37
				Christensen Co. Style #9	Before	0.20
					After	0.31
Christensen Co. Style #15	Before	0.19				
	After	0.37				

TABLE B

Effect on Number of Accidents Following Grooving

Proj. No.	Location & Pvt. Type	Serration Pattern	Curvature Radius Ft.	Dir.	AADT 1000	Accidents								
						Before		After		% Change				
						Wet	Dry	Wet	Dry	Wet	Dry			
D	07-Ora-5 PM23.3-23.6 PCC	1/8"x1/8"on1/2" Centers-Rect. Grooves	2000'	Rt.	45	46	4	50	1	7	8	-98	+75	-84
E	07-LA-5 PM29.5-30.0 PCC	1/8"x1/8"on3/4" Centers-Rect. Grooves	2000'	Lt.	104	12	6	18	2	2	4	-83	-67	-78
L	07-LA-10 PM22.6-22.8 PCC	1/8"x1/8"on3/4" Centers-Rect. Grooves	1020'	Lt.	164	26	16	42	0	6	6	-100	-63	-86
F	07-LA-405 PM2.1-2.6 PCC	1/8"x1/8"on 1" Centers-Rect. Grooves	Tangent		131	21	9	30	0	11	11	-100	+22	-63
G	07-LA-405 PM3.8-4.1 PCC	1/8"x1/8"on 1" Centers-Rect. Grooves	3000'	Rt.	139	4	6	10	0	4	4	-100	-33	-60
M	03-Nev-80(1) PM19.8-20.2 PCC	1/8"x1/8"on 1" Centers-Rect. Grooves	1400'	Lt.	9	5	9	14	0	6	6	-100	-33	-57
N	07-LA-101 PM8.8-9.3 AC	1/4"x1/4"on 1" Centers-Rect. Grooves	2050' 2052'	Revers- ing	134	139	55	194	6	35	41	-96	-36	-79
Total						253	105	358	9	71	80	-96	-32	-78

(1) Two year before and after period. All others one year.

TABLE C

Effect on Accident Rate Following Grooving

Proj. No.	Pvt. Type	U- Urban	R- Rural	State Ave. Acc. Rate	Before						After					
					Wet		Dry		Total		Wet		Dry		Total	
					MVM	Rate	MVM	Rate	MVM	Rate	MVM	Rate	MVM	Rate	MVM	Rate
D	PCC	R		1.00	0.18	255.56	1.96	2.04	2.14	23.36	0.20	5.00	2.26	3.10	2.46	3.25
E	PCC	U		1.61	0.77	15.58	8.54	0.70	9.31	1.93	0.78	2.56	8.71	0.23	9.49	0.42
L	PCC	U		1.61	0.49	53.06	5.46	2.93	5.95	7.06	0.49	0.00	5.50	1.09	5.99	1.00
F	PCC	U		1.61	0.97	21.65	10.80	0.83	11.77	2.55	0.98	0.00	10.97	1.00	11.95	0.92
G	PCC	U		1.61	0.59	6.78	6.64	0.90	7.23	1.38	0.63	0.00	6.98	0.57	7.61	0.53
M	PCC	R		1.00	-	-	-	-	1.02	13.73	-	-	-	-	1.31	4.58
I	AC	U		1.61	2.04	68.14	22.78	2.41	24.82	7.82	2.01	2.99	22.45	1.56	24.46	1.68
Total for PCC Pvts.				1.48	3.00	36.33	33.40	1.23	37.42	4.38	3.08	0.97	34.42	0.87	38.81	1.00

Note

MVM = Million Vehicle Miles

Rate =  $\frac{\text{Number of Accidents}}{\text{MVM}}$

TABLE D

Comparison of Number of Accidents on Grooved  
and Control Asphalt Concrete Pavement

Proj. No.	Location & Pvt. Type	Serration Pattern	Curvature		AADT 1000	Accidents								
			Radius Ft.	Dir.		Before		After		% Change				
						Wet	Dry	Wet	Dry	Wet	Dry	Tot.	Tot.	
I-1	07-LA-101 PM7.8-8.8 AC	No Serration (Control)	Var.	Revers- ing	123	36	59	95	41	75	116	+14	+27	+22
I	07-LA-101 PM8.8-9.3 AC	1/4"x1/4"on 1" Centers-Rect. Grooves	2050 2052	Revers- ing	134	139	55	194	6	35	41	-96	-36	-79

# CORRELATION STUDIES ON MINIMUM FRICTION VALUE FOR REMEDIAL ACTION

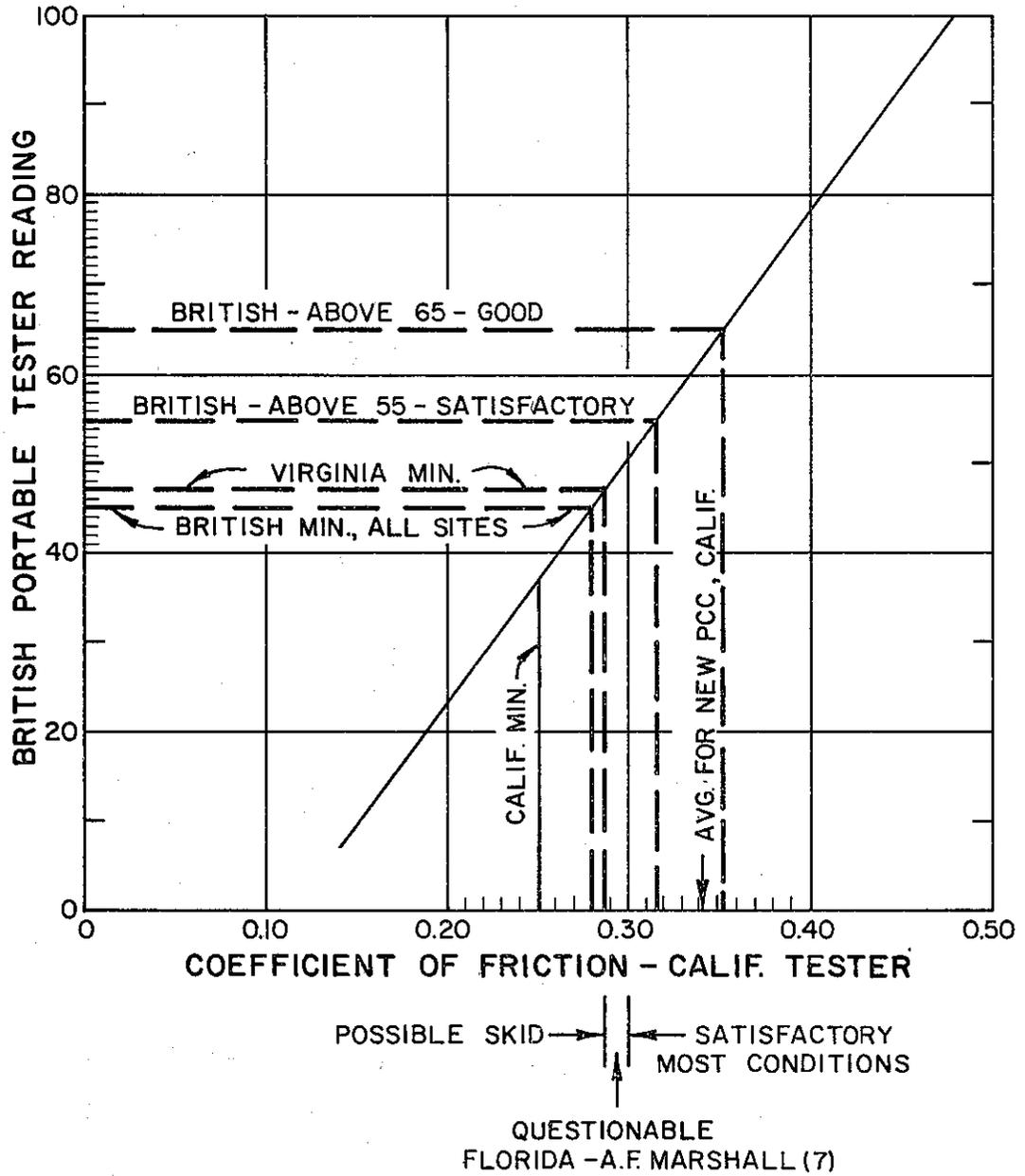
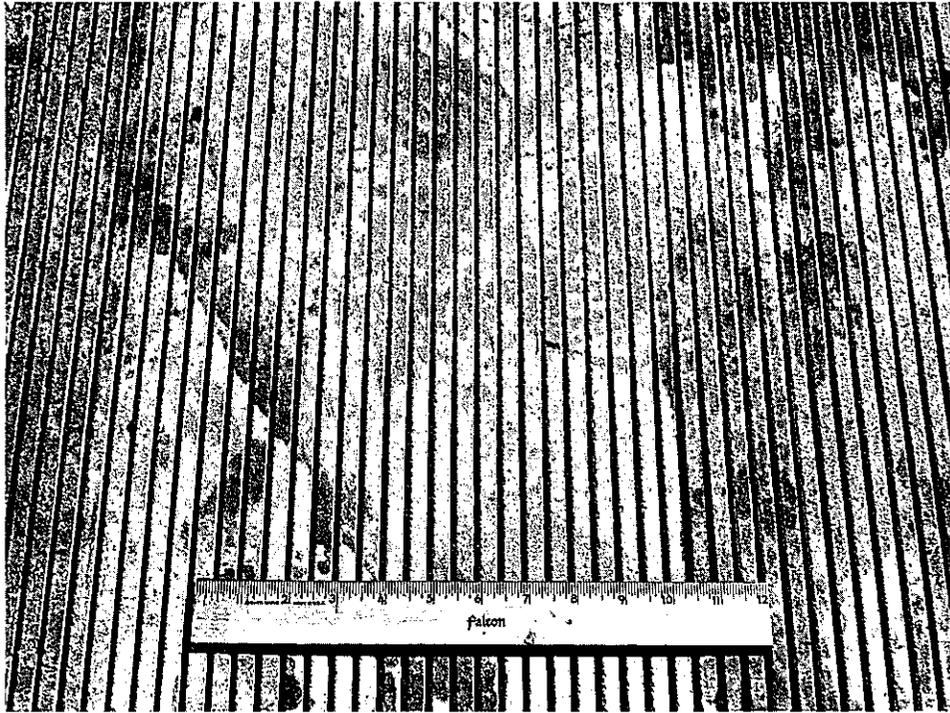


Figure 2

Photographs of Several Patterns Used on Various Projects



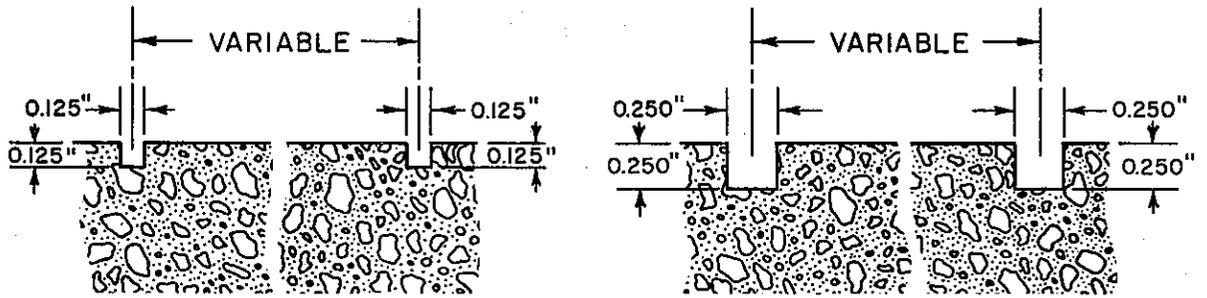
Rectangular Grooves



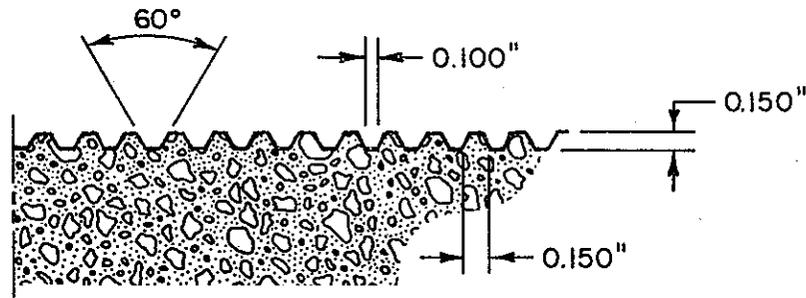
Style 15

Figure 3

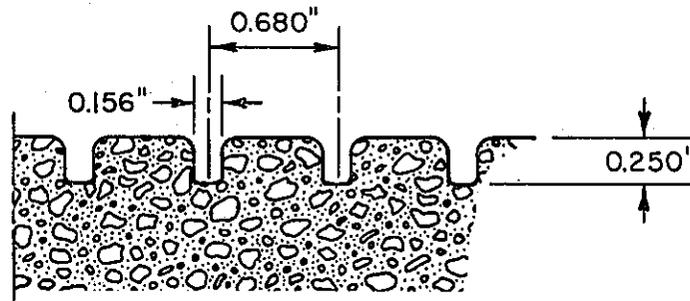
# GROOVING PATTERNS USED ON VARIOUS PROJECTS



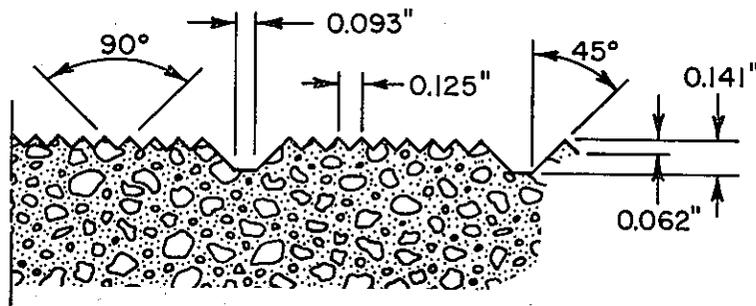
RECTANGULAR PATTERNS



STYLE 6-47 GROOVES PER FT.



STYLE 9



STYLE 15

Figure 4

## EFFECT OF GROOVING PATTERN ON AVERAGE COEFFICIENT OF FRICTION VALUE OF PCC PAVEMENTS

KEY

- x 1/8" on 1/8" Centers, Rectangular Grooves
- △ Christensen Style 6
- ▲ Christensen Style 9
- ◇ Christensen Style 15

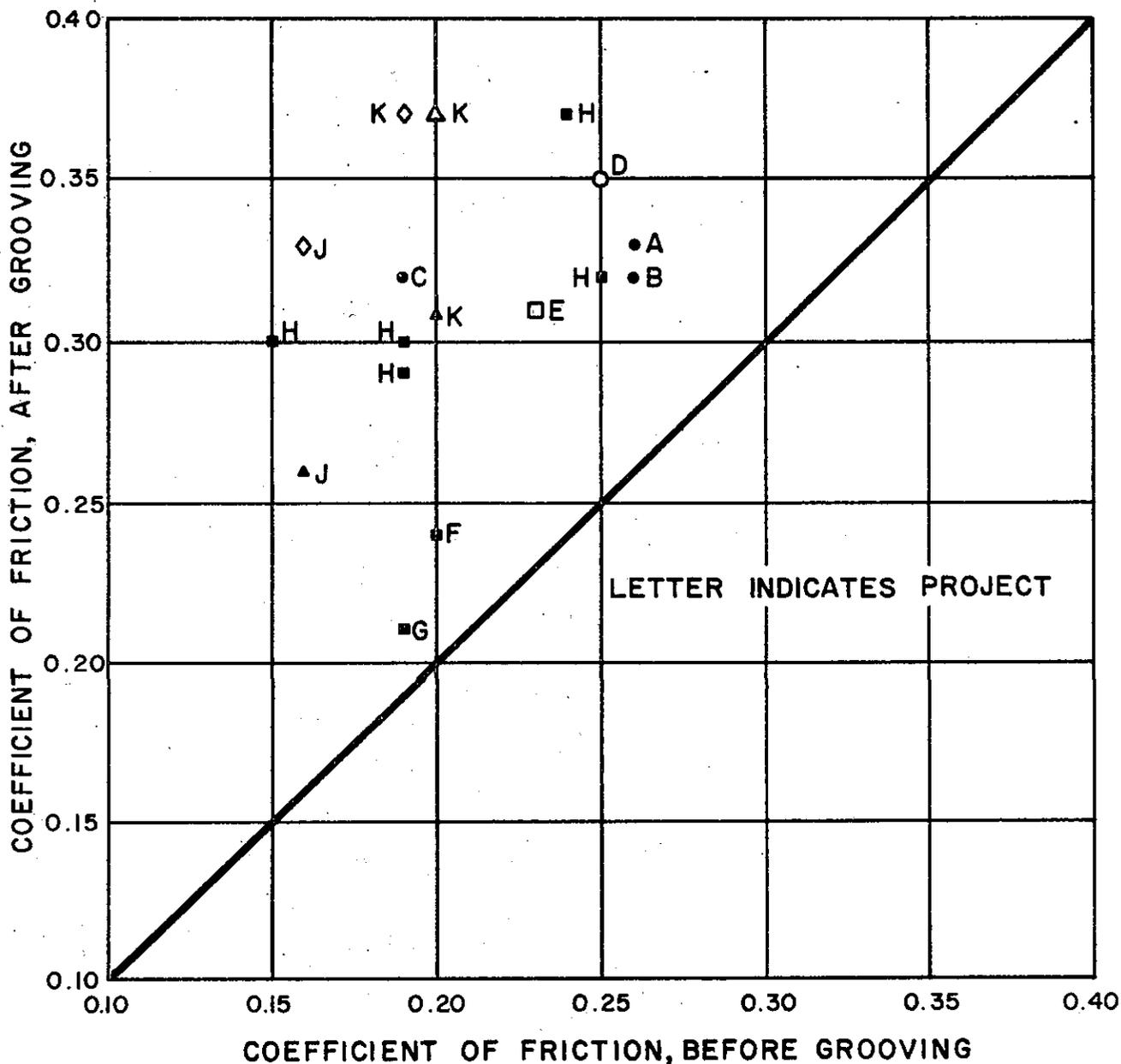
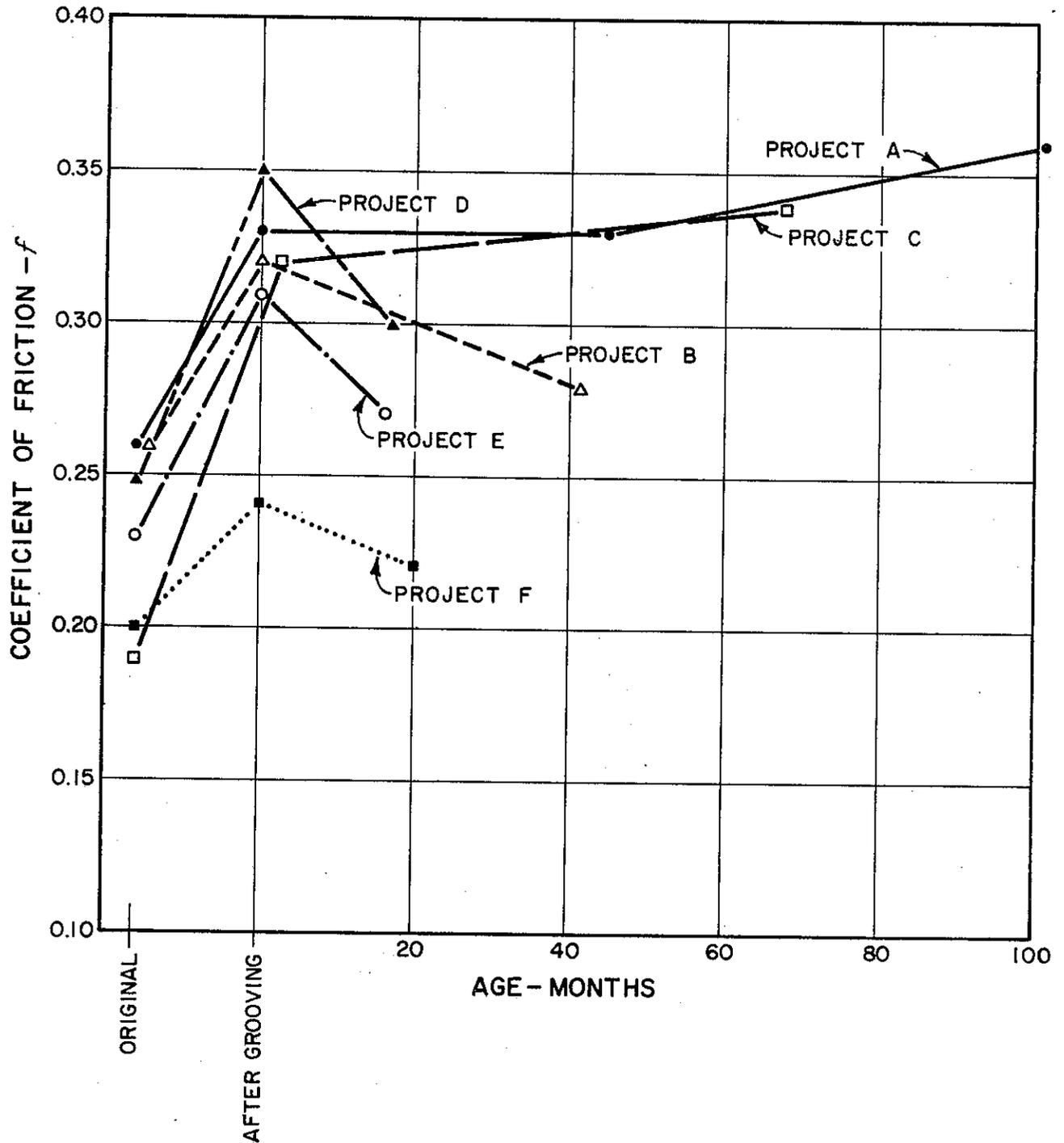


Figure 5

### CHANGE IN FRICTION VALUES FOLLOWING GROOVING OF PCC PAVEMENTS



Handwritten text at the top of the page, possibly a title or header, which is mostly illegible due to the low resolution and noise.

The table structure is highly obscured by noise and low resolution. It appears to have multiple columns and rows, but the data within the cells is completely unreadable. The grid lines are faint and difficult to discern against the background noise.

**METHOD OF TEST FOR PAVEMENT SURFACE SKID RESISTANCE****Scope**

This method describes the apparatus and procedure for obtaining surface skid resistance values of Bituminous and Portland Cement Concrete pavements.

**Procedure****A. Apparatus**

## 1. Skid test unit.

a. Reference is made to Figures I through III in connection with the following description of the construction of the test unit. A 4.80/4.00 x 8, 2-ply tire with ( $25 \pm 2$  psi) air pressure ( $\Delta$ ), manufactured with a smooth surface, together with rim, axle and driving pulley is mounted on a carriage (B). The tire is brought to desired speed by motor (H). The carriage moves on two parallel guides (C), and the friction is reduced to a low uniform value by allowing three roller bearings fitted at  $120^\circ$  points to bear against the guide rod at each corner of the carriage. The bearing assembly may be noted on Figure III (D). The two guide rods (C) are rigidly connected to the end frame bars (E). The front end of this guide bar frame assembly is firmly fastened to a restraining anchor. The bumper hitch provides for swinging the skid tester to the right or left after positioning the vehicle. The rear end of the frame assembly is raised by a special adjustable device (F), Figure II, so as to hold the tire  $\frac{1}{4}$ -inch off the surface to be tested. This device is so constructed that the tire may be dropped instantaneously to the test surface by tripping the release arm (G), Figure II. Tachometer (K) indicates the speed of the tire.

2. Hitch for fastening unit to vehicle.

3. Special level to determine grade of pavement.

a. A 28" long standard metal carpenter's level, Fig. IV, is fitted at one end with a movable gauge rod which is calibrated in % of grade.

**B. Materials**

1. Glycerine.

2. Water.

3. 2-inch paint brush.

4. Thickness gauge  $\frac{1}{4}$ -inch ( a piece of  $\frac{1}{4}$ -inch plywood 2' x 1" is satisfactory).

**C. Test Procedure**

1. Determine and record grade with special level, see Fig. IV.

a. Place level on pavement parallel to direction of travel with adjustable end down grade.

b. Loosen locking screw and raise level until bubble centers and then tighten locking screw on sliding bar.

c. The grade is indicated on the calibrated sliding bar.

2. Remove apparatus from vehicle and attach to bumper hitch, Fig. V.

3. Position apparatus with tire over selected test area and parallel to direction of traffic.

4. Raise tire and adjust to  $\frac{1}{4}$ -inch ( $\frac{1}{16}$ " tolerance) above surface to be tested with device (F).

5. Wet full circumference of tire and pavement surface under tire and 16" ahead of tire center with glycerine, using a paint brush.

6. Set sliding gauge indicator (P) against carriage end.

7. Depress starting switch (J) and bring the speed to approximately 55 mi/hr.

8. Release starting switch.

9. The instant the tachometer shows 50 mi/hr trip arm (G) dropping tire to pavement.

10. Read gauge (N) and record.

11. Release rebound shock absorber.

12. Move to next section and repeat.

13. In any one test location, test at 25' intervals in a longitudinal direction over a 100' section of pavement.

**D. Precautions**

1. The rear support rod (O), Fig. II, must be cleaned by washing frequently with water and a detergent to prevent sticking.

2. Sliding gauge indicator (P) must be kept clean so that it will slide very freely.

3. On slick pavements glycerine remaining on the pavement should be flushed off with water to prevent possible traffic accidents.

**E. Field Construction Testing of Portland Cement Concrete Pavement**

The following procedure shall be followed in the field testing of a portland cement concrete pavement for specification compliance of the minimum friction value. A minimum of seven days after paving shall lapse before testing.

1. Visually survey the total length of pavement for uniformity of surface texture. Note all areas which do not have definite striations or which appear smooth. Conduct this survey with the Resident Engineer or an Assistant who has knowledge of any difficulties in attaining a proper surface texture during construction. The attached photograph, Figure VIII, may be used as an aid in the evaluation of the existing texture in relation to the coefficient of friction, but is not to be used in lieu of actual coefficient of friction measurements.

2. The determination of test locations, as outlined below, shall apply only to that portion of the pavement which has well formed striations. All areas that appear smooth, or those that have been ground shall be excluded. (See E-3 for procedure to follow for smooth pavements).

a. Select a minimum of three test locations for each day's pour and check a minimum of three pour days per contract.

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October 3, 1966

Determine the location of test sites in a random manner through use of a Random Number table. The use of this method requires that the area for test be uniformly textured and placed in one operation. As an example, a 4-lane pavement may be placed with a three lane width in one operation and the fourth lane placed separately. Each of these areas must be treated separately in selecting test locations. The following example illustrates the use of this table.

A section of pavement is 24' wide and 4000' long and is part of a 4-lane freeway. This section of pavement has been placed in one operation and skid tests are required. From 2-a, it is required that three test locations be determined.

Using the random numbers, as shown, choose the three locations in the following manner:

Longitudinal	Random Numbers Lateral
0.6	6
0.9	9
0.2	2
0.7	7
0.5	5
0.1	11
0.4	4
0.8	8
0.3	3

Starting at any point and proceeding up, or down, but not skipping any numbers, read three pairs of numbers and set up each location as follows:

	Distance from Start of Pour	Distance from Right Edge of Pour Looking up Station
Location A -----	$0.6 \times 4,000' = 2,400'$	$6 \times 2 = 12'$
Location B -----	$0.9 \times 4,000' = 3,600'$	$9 \times 2 = 18'$
Location C -----	$0.2 \times 4,000' = 800'$	$2 \times 2 = 4'$

In case any location as determined above falls in a smooth or ground area which does not appear representative of the general surface texture, then choose the next number in the random table and select a new location.

At each test location obtain the first reading at the specified random location (using the method described under C-Test Procedure). Obtain the next four readings at 25' intervals beyond the first reading. Obtain all readings at sites parallel to the centerline of the lane. After correction for grade as shown

in F, average the five readings. Record this average as the friction value for the specific test location.

3. In all areas that present a smooth textured appearance or have been ground, the following shall apply:

a. Check a minimum of three ground area locations and all smooth appearing surfaces on each contract.

b. If the area is less than 100' in length perform at least three individual tests in separate spots, correct for grade and average the results.

c. If the area is greater than 100' in length, select sufficient test locations to insure that the area is above the minimum requirement. If the average value of all locations is below the required minimum then perform additional tests until the area is localized for remedial action.

## F. Calculations

1. Make grade corrections using charts shown in Figures VI and VII.

2. Average the 5 corrected readings in any one test location. *Example*—The following readings were taken at 25' intervals in a test location. The grade of the pavement, determined as described in C-1, was +4%.

Station	Measured Coefficient of Friction	Corrected Coefficient of Friction*
1+00 -----	0.33	0.38
1+25 -----	0.34	0.39
1+50 -----	0.34	0.39
1+75 -----	0.33	0.38
2+00 -----	0.33	0.38

Final Average for Test Site ----- 0.38

\* Corrected coefficients of friction were taken from chart in Figure VI.

## G. Reporting of Results

For all results determined under E-2, report the result for each station location and the average of 5 readings and the grand average. For all results determined under E-3, part (b), report the result for each station location and the average. For E-3, part (c), report the result for each station location and the average for each set of five determinations.

### REFERENCE

A California Method

End of Text on Calif. 342-C

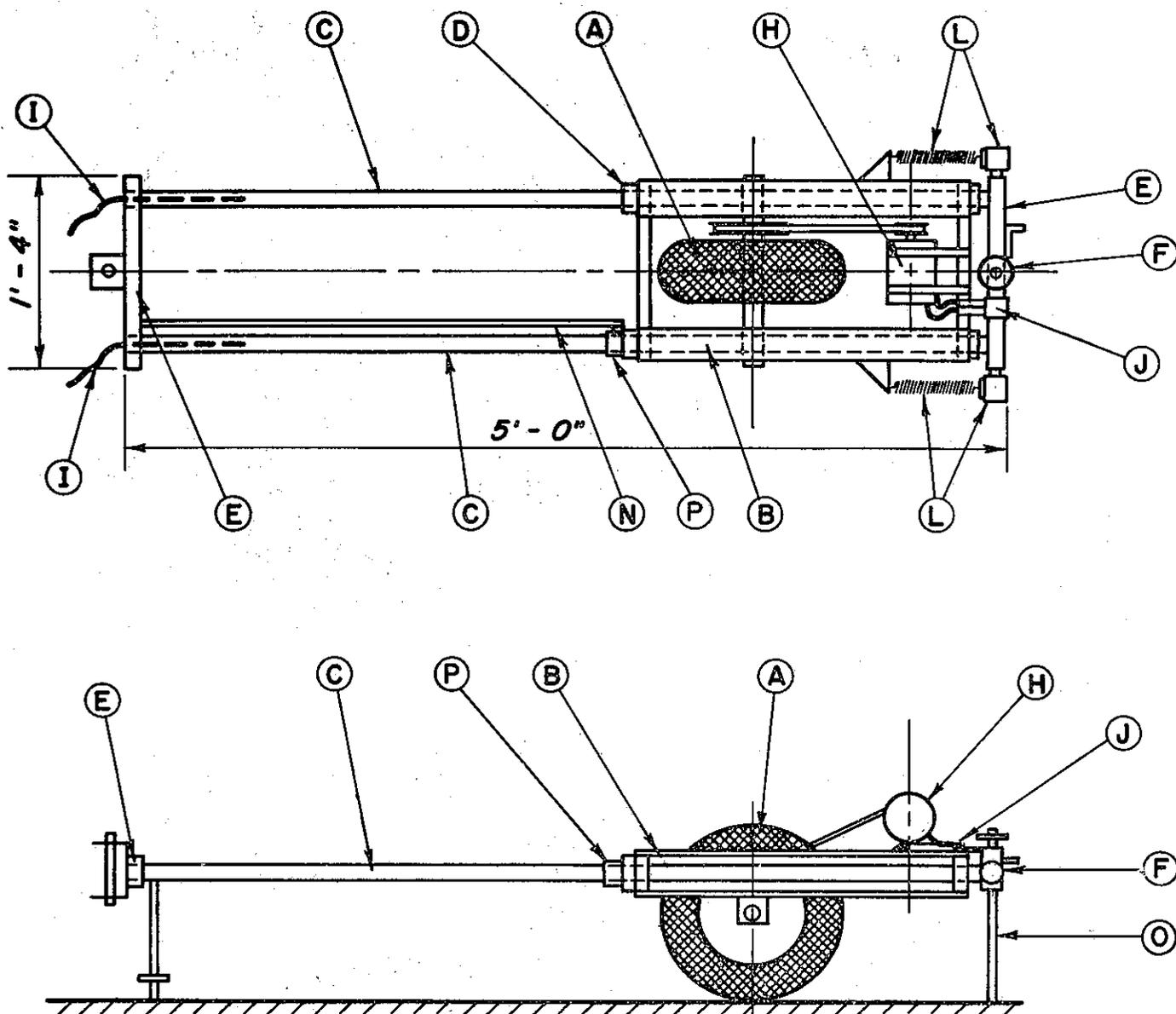


FIGURE I  
DIAGRAM OF SKID TESTER

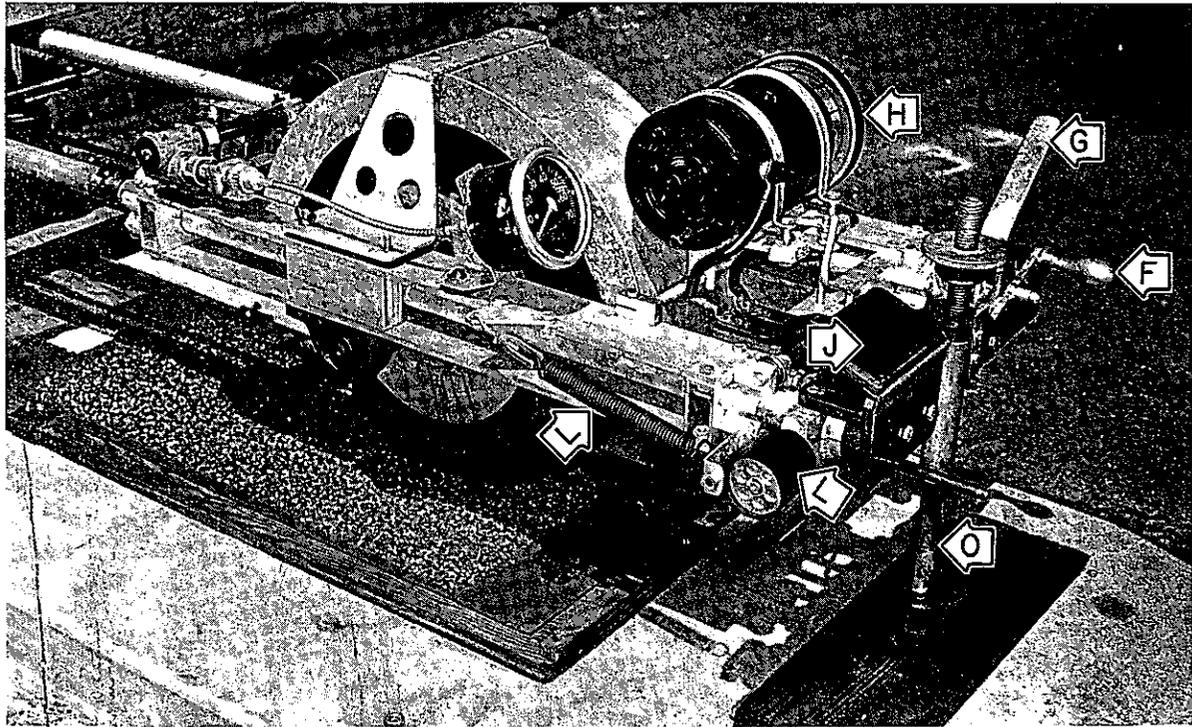


FIGURE II

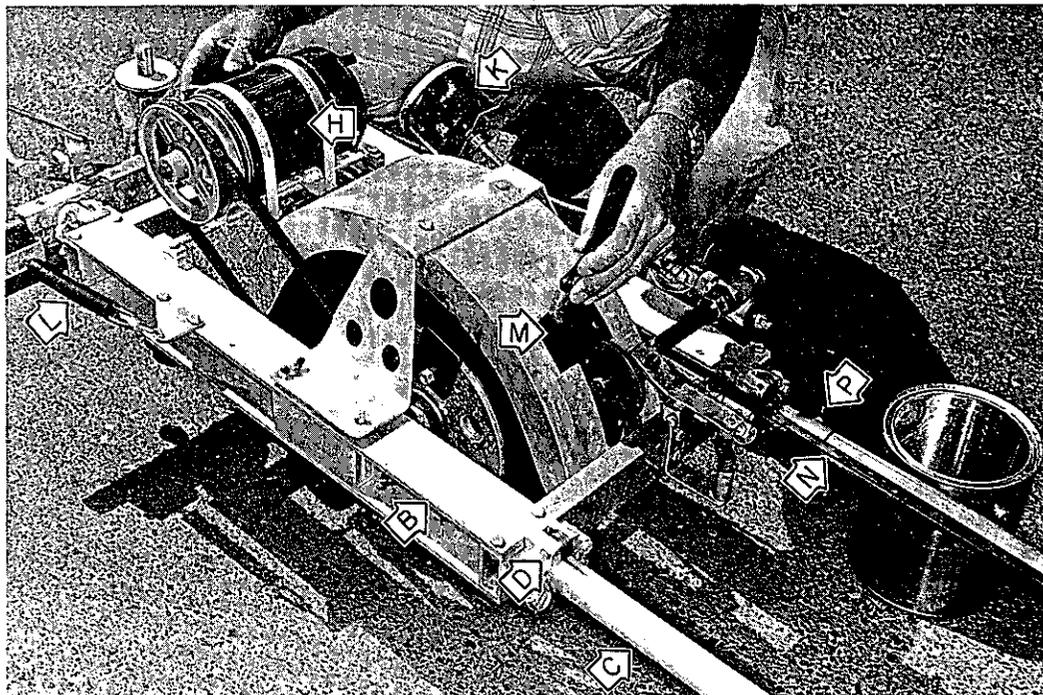


FIGURE III  
CLOSE-UP VIEWS OF SKID TESTER

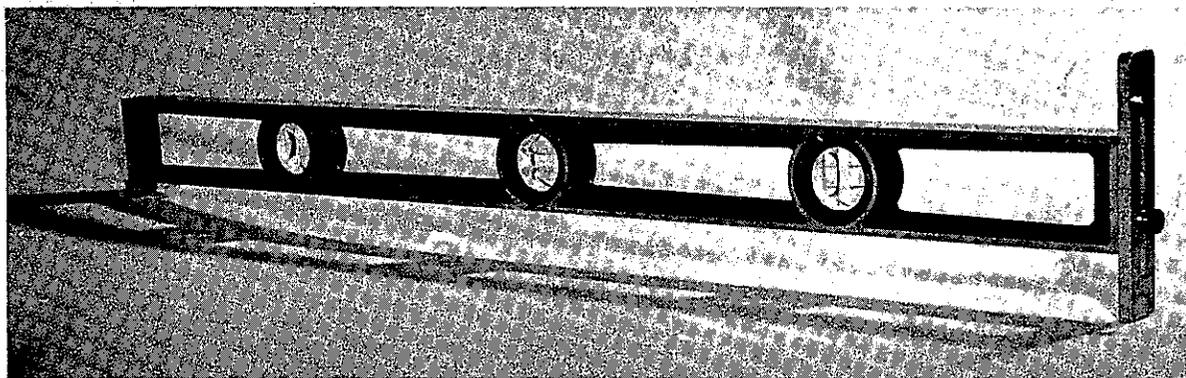


FIGURE IV  
LEVEL FOR DETERMINING GRADE

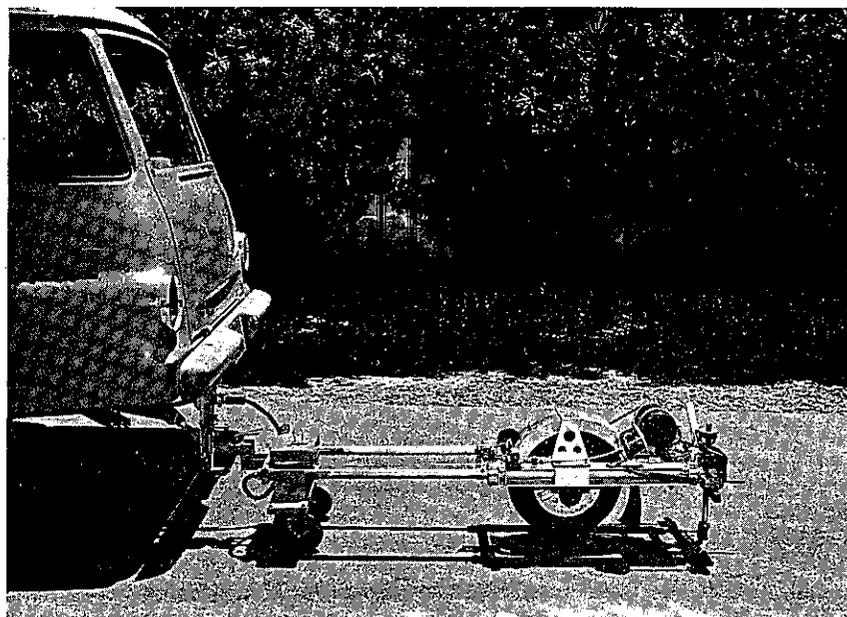


FIGURE V  
APPARATUS IN POSITION FOR TESTING

### COEFFICIENT OF FRICTION CORRECTION CHART FOR MEASUREMENTS MADE ON GRADES

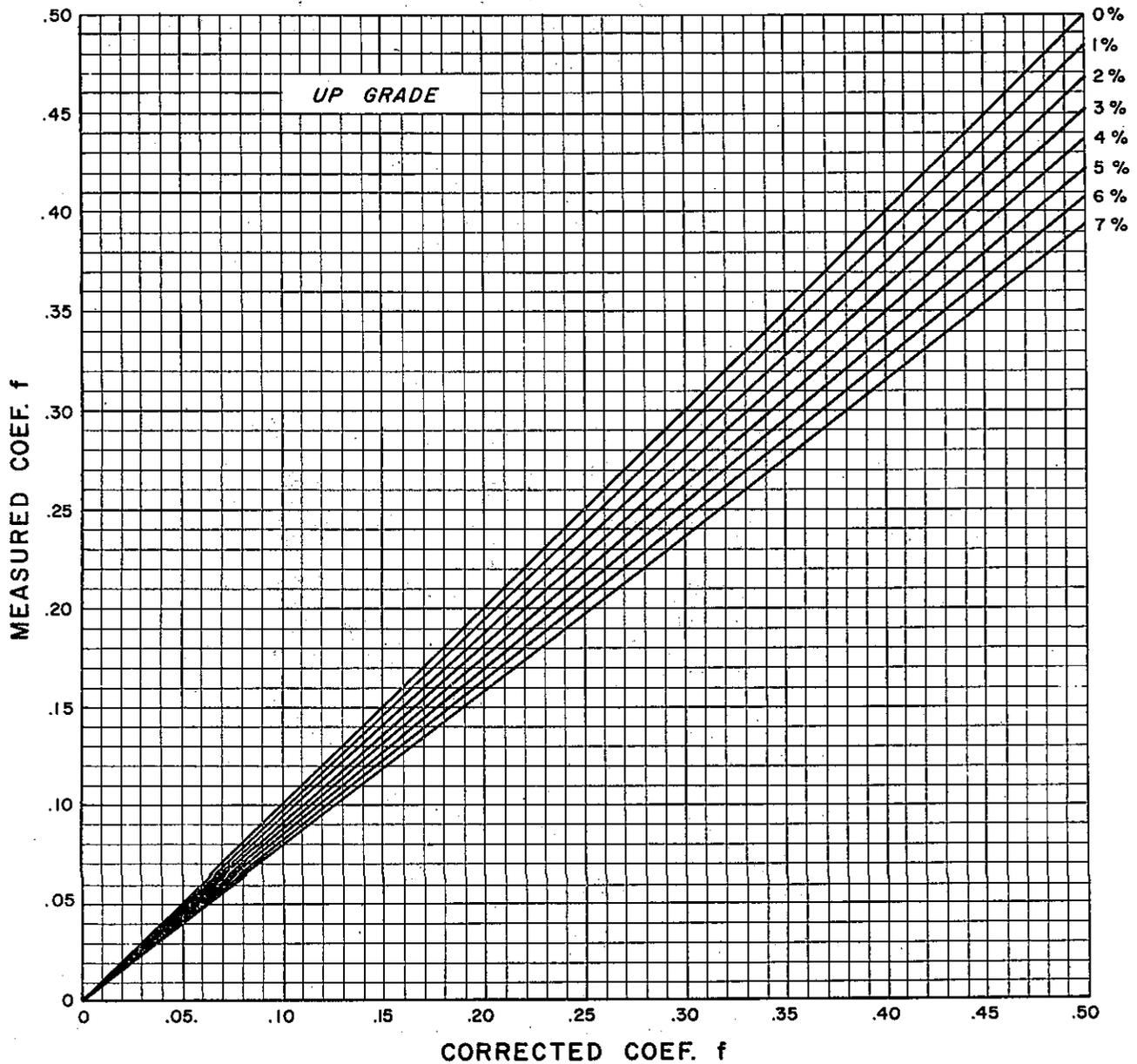


FIGURE VI

COEFFICIENT OF FRICTION CORRECTION CHART  
FOR MEASUREMENTS MADE ON GRADES

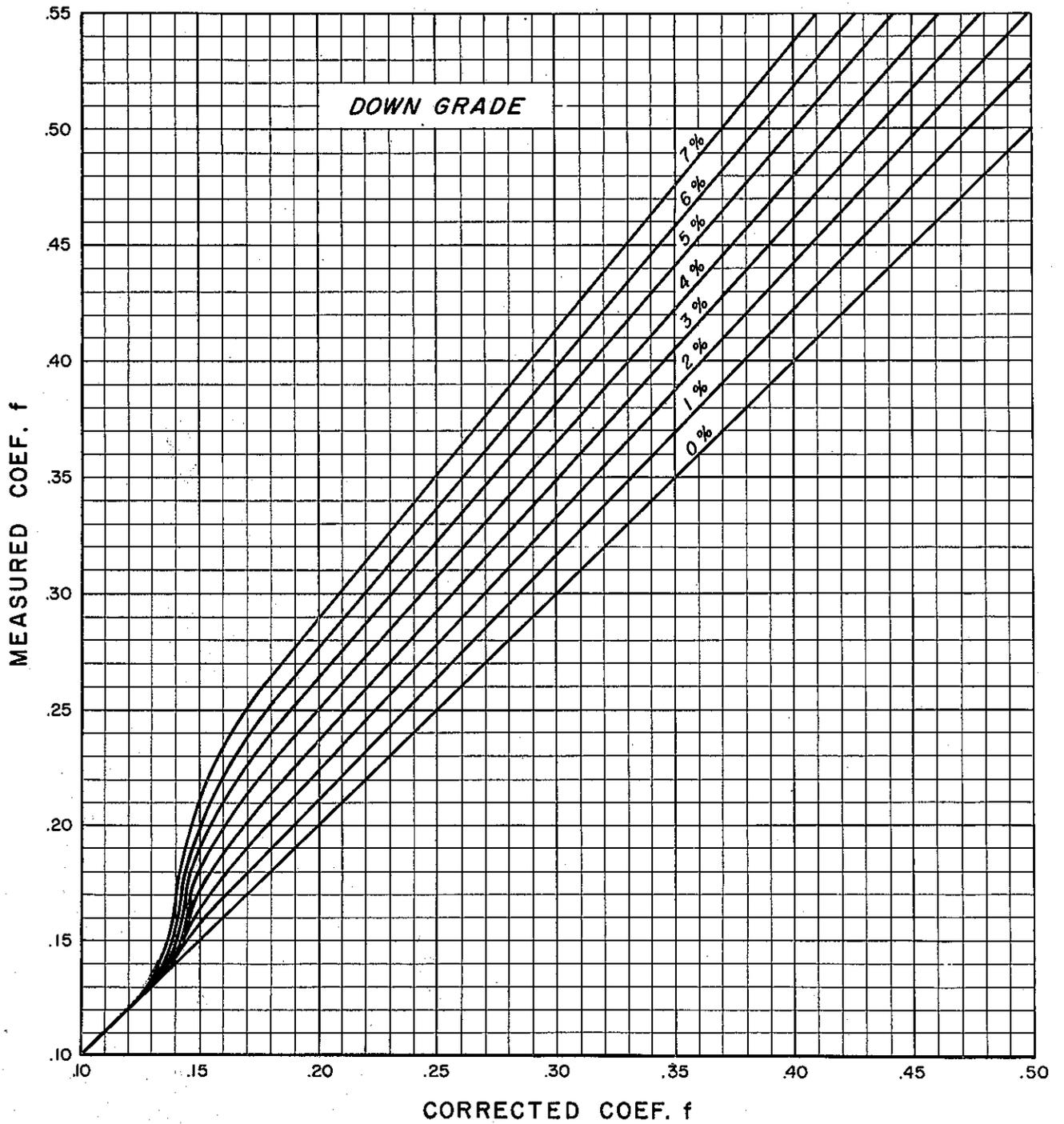


FIGURE VII

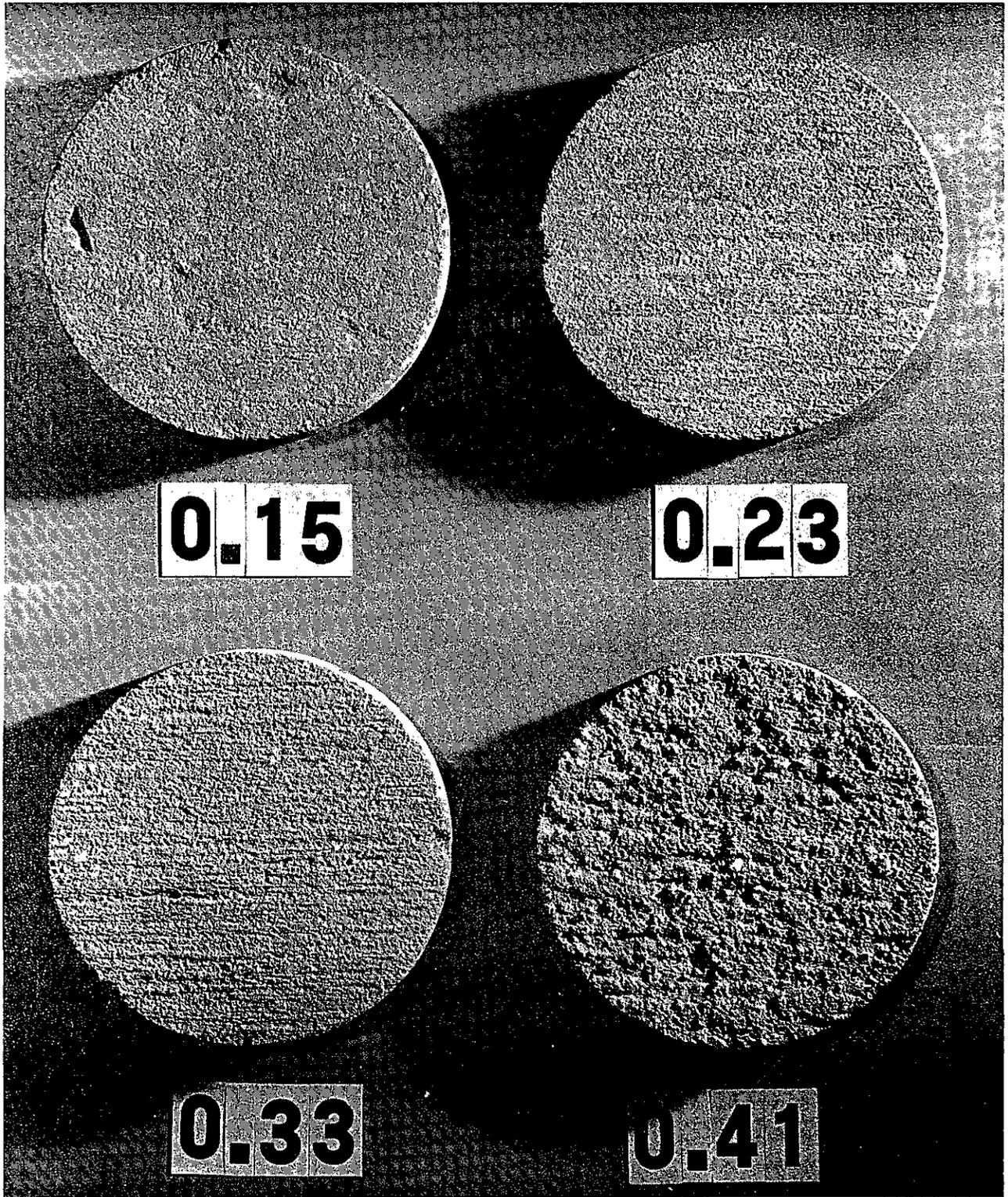


FIGURE VIII  
PHOTOS OF SURFACE TEXTURES

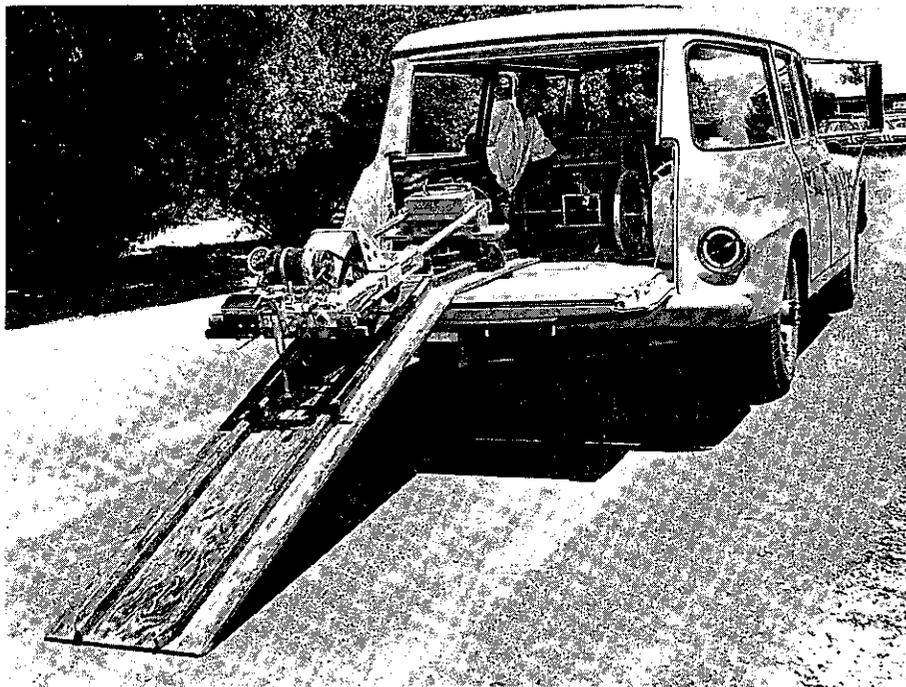


FIGURE IX  
APPARATUS BEING PLACED IN VEHICLE  
NOTE CABLE AND WINCH FOR MOVING SKID TESTER



FIGURE X  
APPARATUS IN POSITION FOR TRANSPORTATION

