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FINAL REPORT

COMPARE TEST RESULTS OF THE CALIFORNIA SKID TESTER WITH THE ARIZONA MU-METER

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Final Report

Compare Test Results of the California Skid Tester with the Arizona Mu-Meter

Introduction

Skid testing is performed by numerous agencies with a variety of test equipment. Some of these are locked wheel tractive force devices complying with Test Method ASTM E274. The California Division of Highways primary skid test equipment complies with this test method. The Mu-Meter friction recorder is one device that does not measure the locked wheel tractive force but rather a slip force developed by a toe-out wheel position. For published test values measured with the Mu-Meter to have any significance to us, a correlation between the Mu-Meter and the towed trailer was necessary. Also, it was believed that the Mu-Meter might measure the increased lateral resistance to skidding that is provided with logitudinal pavement grooving and, hence, the test values would reflect the significant reduction in wet weather accidents better than the towed trailer test values. Therefore, when the Arizona State Highway Department requested a correlation program, this project was established.

The primary purpose of this investigation was to compare skid resistance values obtained with California's towed trailer to those obtained with Arizona's Mu-Meter for a variety of surfaces. A secondary objective was to determine if the Mu-Meter test values reflect the reduction of wet weather accidents that is achieved by pavement grooving better than the values obtained with the towed trailer.

Conclusions

1. A linear correlation exists between skid resistance values obtained with the towed trailer skid tester and the Mu-Meter. The best correlation was obtained on PCC pavements.

2. The Mu-Meter does not consistently measure the lateral resistance to skidding that is provided by longitudinal grooves in pavement surfaces.

3. The towed trailer with a smooth tire provided the strongest indication that grooving increases skid resistance.

4. No further tests or investigations are recommended with the Mu-Meter.

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Test Results and Discussion

All tests were performed at 40 mph with approximately 0.02 inch water on the surface.

Tests were performed on AC, PCC and grooved PCC surfaces to provide as great a range of test conditions as possible.

Tests were made in succession with the Soiltest towed trailer - smooth tire, with the Mu-Meter, and with the Law towed trailer - ribbed tire (ASTM E249). The Mu-Meter test interval is approximately 500 feet. Because the towed trailer test interval is approximately 110 feet, two tests were taken within the 500 foot interval and averaged to compare with each Mu-Meter test.

A few preliminary tests indicated that prescrubbing the pavement surface was not necessary to obtain reliable values with the first tester. Being able to drop the scrubbing from the proposed procedure permitted taking many more tests.

The correlation curve used to adjust Soiltest values to Law values may not be valid for the smooth tire. Therefore, all smooth tire results are as-measured Soiltest values.

In order to determine the increase in skid numbers due to grooving, tests were performed on areas scheduled to be grooved and then repeated after the surface had been grooved. Only one contractor worked to the schedule so only four test sections were measured. These data are presented in Figure 1. Also, an estimate of the increase in skid numbers due to grooving was obtained by comparing measured values of surfaces adjacent-to-grooved areas to values obtained in the grooved areas of the numerous sections tested. This second method is probably conservative because the surfaces that are grooved were probably smoother than the adjacent surfaces that were not grooved. A regression analysis was performed on the grooved vs adjacent ungrooved data for each skid tester. The results are presented in Figure 2.

It can be noted that the regression lines cross the line of equality. It is assumed that at this point the grooves increase the skid resistance by the same value that the removed area contributed to skid resistance.

The slope of the regression line, the F test, and also the before/after test results shown in Figure 1 indicate that the towed trailer - smooth tire is the strongest indicator that grooving increases skid resistance.

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A regression analysis was performed on data collected for each surface and for all surfaces combined. These curves are shown in Figures 3 and 4. Also, the statistics are listed in Table 1. The measured data is listed in Tables 2, 3 and 4. Measured data from the shoulder areas were not included in the regression analysis of AC surfaces with the Mu-Meter because extraneous materials such as soil or a heavy fog seal prevented our testing the same surfaces in some cases.

Although a reasonable correlation exists between the towed trailer and the Mu-Meter, it appears that the Mu-Meter values become somewhat erratic on the rougher surfaces. Correlation coefficients and F tests show a lesser regression for the comparably rougher AC and the grooved PCC surfaces. Also, these indicators are much stronger between the towed trailers than they are between either towed trailer and the Mu-Meter.

Implementation

The results of this study can be implemented when analyzing out-of-state reports, that list Mu-Meter numbers, to obtain a relative skid number for various pavement surfaces.

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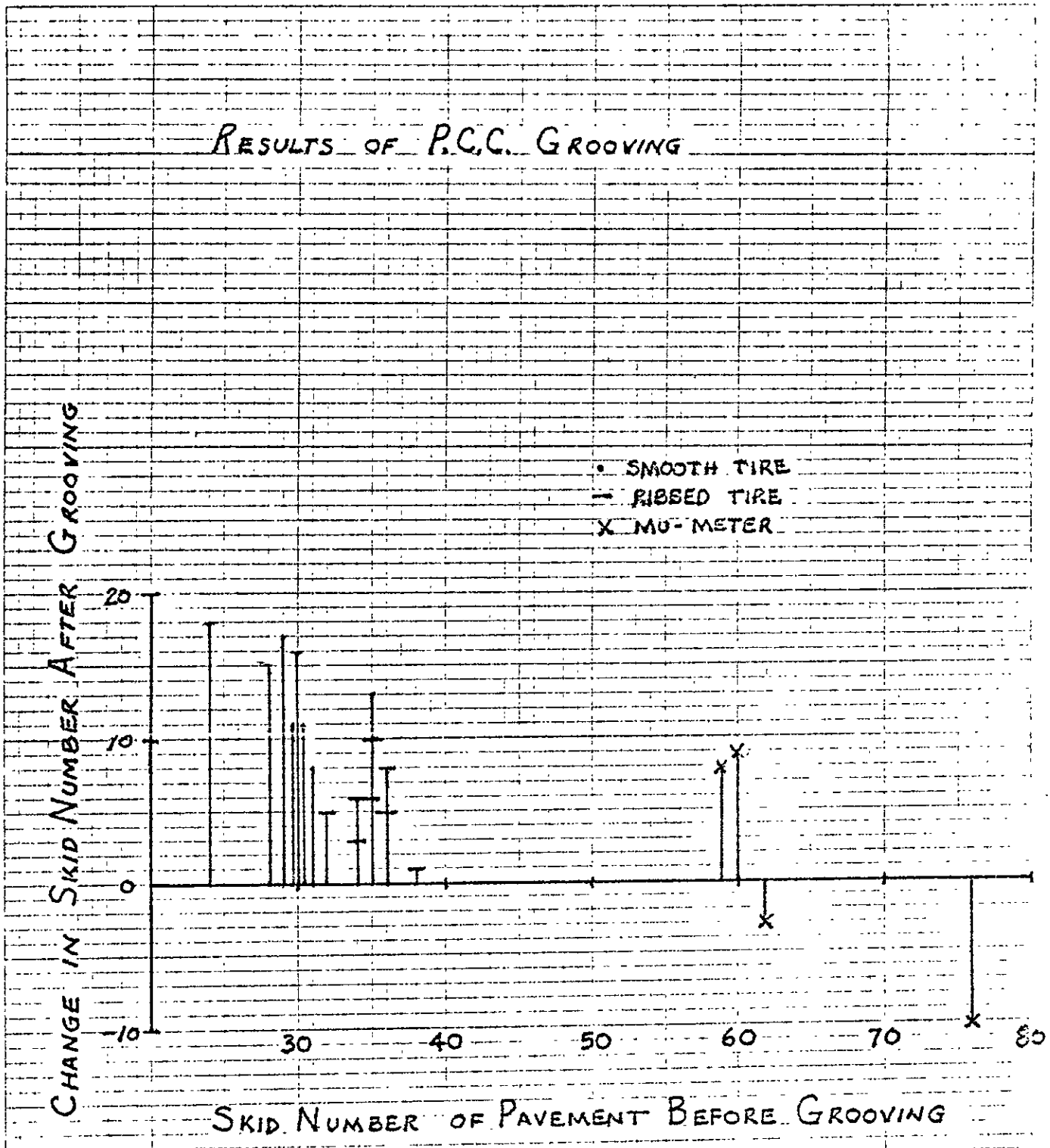

FIGURE 1

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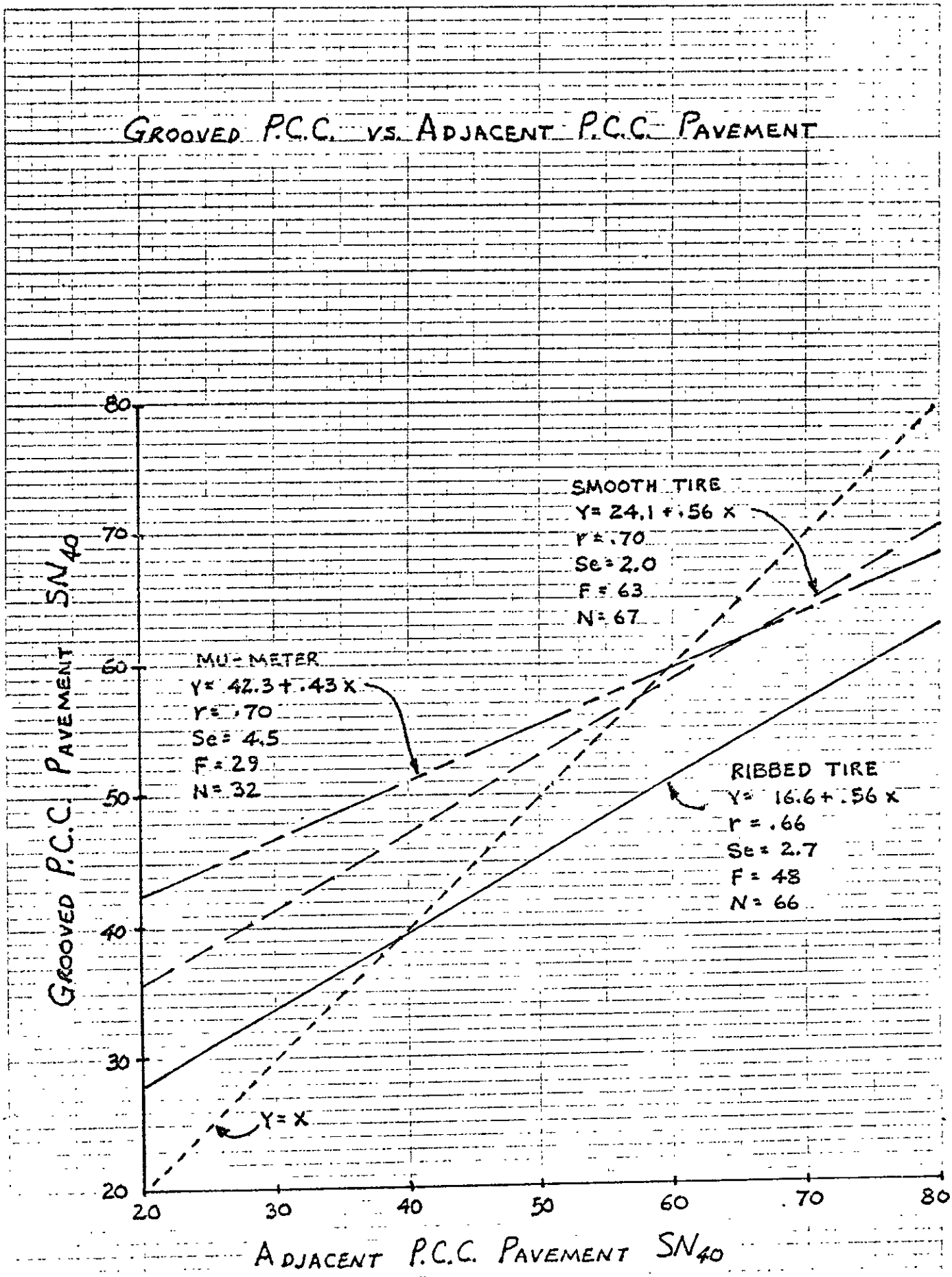

FIGURE 2

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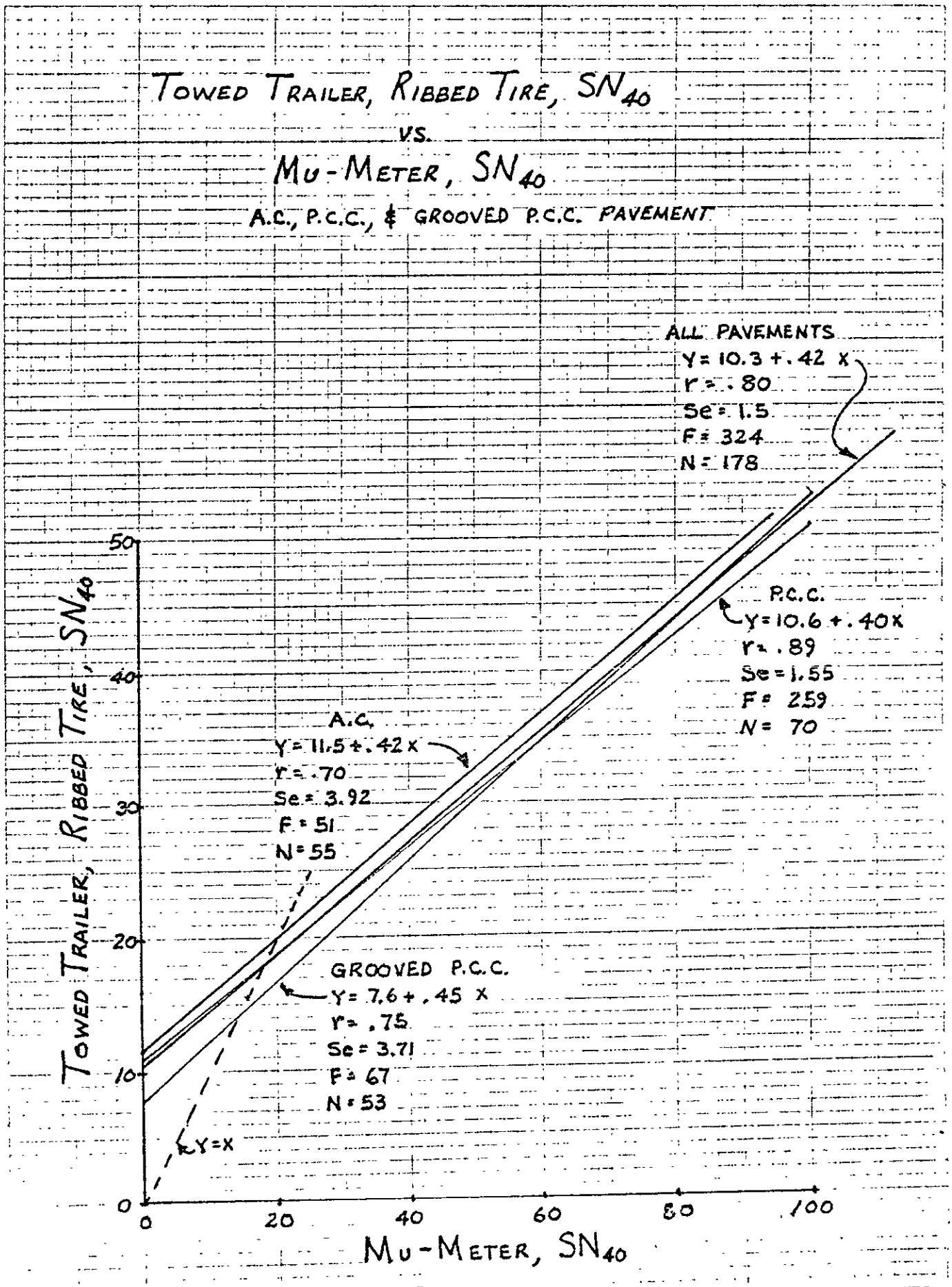

FIGURE 3

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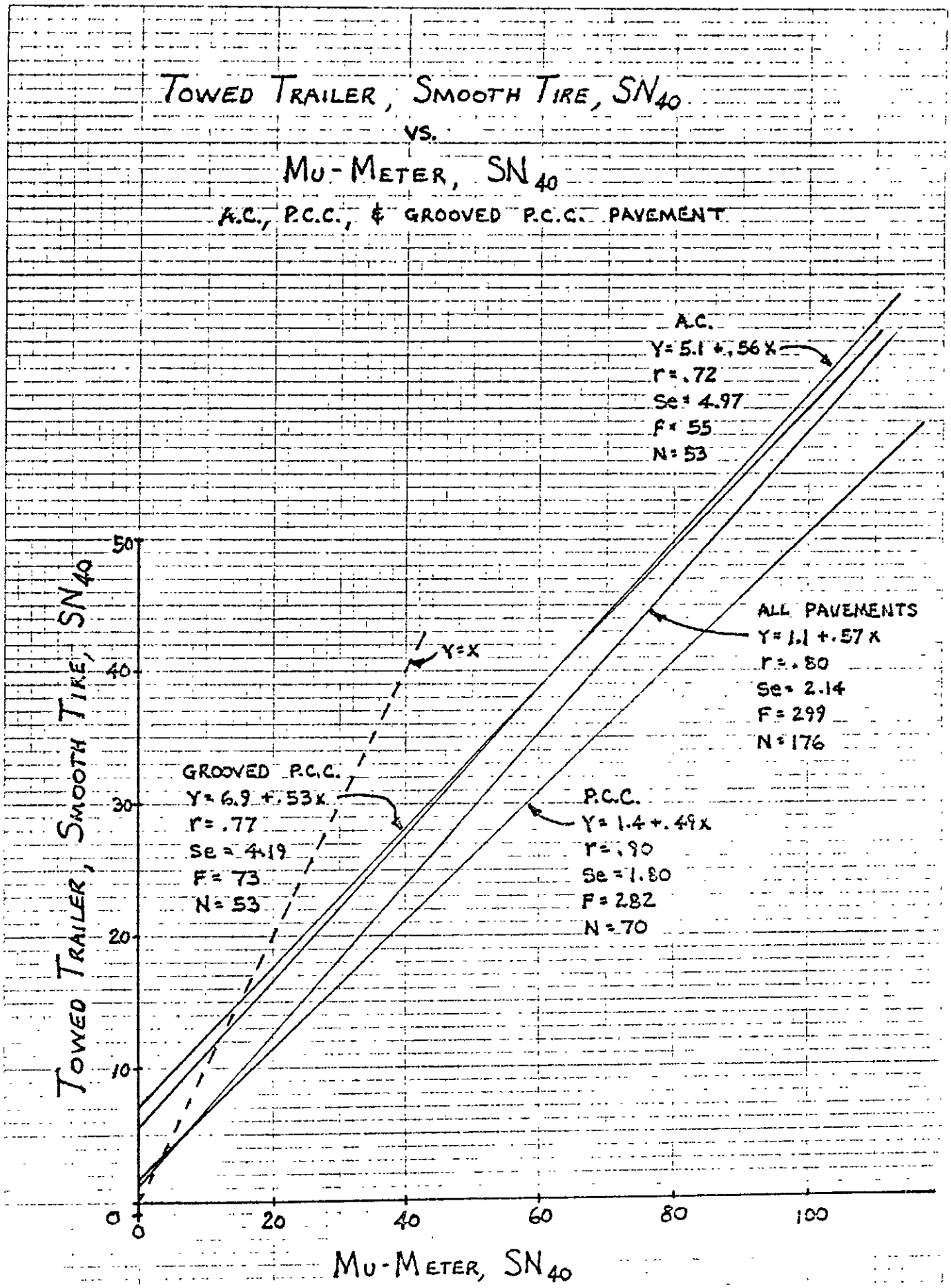

FIGURE 4

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Table 1

Regression Analysis

Surface Type	Equation*	Coefficient of Correlation, r	Standard Error of Estimate	F**	F.99;1,(n-2)	Number of Observations
AC	$Y_R=11.5+0.42X_M$	.70	3.92	51	7.14	55
	$Y_S=5.1+0.56X_M$	.72	4.97	55	7.16	53
	$Y_S=5.8+1.17X_R$	.90	2.76	266	7.05	66
PCC	$Y_R=10.6+0.40X_M$	.89	1.55	259	7.02	70
	$Y_S=1.4+0.49X_M$	.90	1.80	282	7.02	70
	$Y_S=-8.6+1.14X_R$	.95	1.56	660	6.98	78
Grooved PCC	$Y_R=7.6+0.45X_M$	.75	3.71	67	7.16	53
	$Y_S=6.9+0.53X_M$	.77	4.19	73	7.16	53
	$Y_S=3.3+1.04X_R$	.90	2.75	207	7.16	53
Combined	$Y_R=10.3+0.42X_M$	.80	1.51	324	6.78	178
	$Y_S=1.1+0.57X_M$	.80	2.14	299	5.78	176
	$Y_S=-7.5+1.2X_R$	.89	1.66	728	6.76	197

*The equipment is devoted by subscript.
R = Towed trailer - ribbed tire
S = Towed trailer - smooth tire
M = Mu-meter

**If $F \geq F_{.99;1,n-2}$ there is linear regression.

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TABLE 2

Skid Resistance Data for AC Surfaces

Mu Meter	Ribbed Tire	Smooth Tire	Mu Meter	Ribbed Tire	Smooth Tire
60	40	42	28	22	23
62	40	45	26	21	17
73	40	41	26	21	17
74	42	44	64	32	27
73	43	45	39	25	23
63	43	52	36	22	18
68	42	48	64	43	49
67	41	45	62	39	45
61	40	46	81*	67	71
63	42	46	71*	40	45
68	42	--	77	47	52
67	41	--	79	52	51
61	40	--	66	42	48
63	42	46	70	41	40
64	43	47	80	45	52
51	41	42	81	43	44
58	33	36	80	44	47
63	41	51	40	28	17
66	39	47	83	52	52
79*	19	23	63	41	38
74*	21	17	62	36	36
84*	25	25	64	39	37
82*	26	27	69	41	40
64*	16	14	64	42	42
76	22	24	71	42	48
72	23	26	72	45	47
74	47	51	--	22	19
73	46	52	--	32	31
69	46	49	--	24	20
70	44	49	--	30	37
71	45	48	--	36	19
68	40	41	--	34	24
73	42	48	--	30	24
73	43	48	--	35	33
71*	44	45	--	30	22
75	--	42	--	37	23
--	16	20	--	25	19
73	23	28	70	45	48
--	22	21	--	46	31
			--	34	42

* Measurements of shoulder areas - not included in the regression analysis.

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TABLE 3

Skid Resistance Data For
PCC Surfaces

Mu Meter	Ribbed Tire	Smooth Tire	Mu Meter	Ribbed Tire	Smooth Tire
51	27	19	76	36	33
42	29	22	83	43	42
35	25	19	86	42	41
33	25	16	81	43	43
48	30	20	84	42	36
80	47	44	74	35	33
73	43	40	72	42	37
63	39	35	74	44	34
66	45	36	92	61	58
69	41	33	93	44	47
30	23	17	86	41	46
34	25	19	81	51	51
33	24	20	44	26	23
31	23	18	74	33	23
35	24	18	58	29	24
34	24	19	58	32	26
46	26	19	97	50	52
41	24	19	56	39	31
30	21	18	63	39	38
33	22	18	63	38	35
28	25	18	62	39	38
32	21	16	58	39	34
40	23	19	58	37	34
34	23	19	55	38	38
60	36	30	38	29	24
59	33	28	67	33	27
62	36	29	72	41	43
74	42	42	62	38	36
52	35	26	57	37	28
50	36	27	59	35	30
49	31	26	79	37	39
67	36	28	74	38	39
55	32	31	--	43	40
59	31	29	--	22	17
58	33	32	--	22	20
61	30	30	--	23	19
80	37	33	--	44	50
62	35	30	--	29	24
			--	31	27
			--	39	36

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TABLE 4

Skid Resistance Data
For Grooved PCC Surfaces

Mu Meter	Ribbed Tire	Smooth Tire	Mu Meter	Ribbed Tire	Smooth Tire
69	43	46	55	35	33
67	41	46	58	32	38
59	37	41	64	31	39
66	40	43	67	29	37
76	45	47	64	34	38
58	31	35	54	34	35
57	34	37	64	37	45
82	44	47	64	35	43
84	43	47	66	36	40
79	43	48	65	36	43
47	35	41	74	35	45
52	31	32	71	38	44
60	31	34	66	40	47
56	31	32	67	39	49
52	28	30	56	33	38
50	32	33	54	34	39
70	31	34	57	35	38
65	33	33	78	38	43
82	54	49	78	40	48
82	54	55	76	42	49
100	53	60	76	42	44
66	33	35	74	42	48
73	34	37	77	39	48
73	32	39	78	40	51
62	34	39	80	49	57
60	35	38	77	50	63
61	41	46			

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