# HIGHWAY RESEARCH REPORT

# A STUDY OF THE PENNSYLVANIA STATE DRAG TESTER FOR MEASURING THE SKID RESISTANCE OF PAVEMENT SURFACES

67-11

STATE OF CALIFORNIA

TRANSPORTATION AGENCY

DEPARTMENT OF PUBLIC WORKS

DIVISION OF HIGHWAYS

MATERIALS AND RESEARCH DEPARTMENT

RESEARCH REPORT

NO. M& R 633251

Prepared in Cooperation with the U.S. Department of Transportation, Bureau of Public Roads May, 1967

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STATE OF CALIFORNIA
Department of Public Works
Division of Highways
Materials and Research Department

May 9, 1967

MR 633251
B-3-2

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Division of Highways
Sacramento, California

Dear Sir:

Submitted for your consideration is:

A

FINAL REPORT

ON

A STUDY OF THE PENNSYLVANIA STATE

DRAG TESTER FOR MEASURING THE

SKID RESISTANCE OF PAVEMENT SURFACES

Study made by . . . . . Pavement Section

Under general direction of. . . . . E. Zube

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## INTRODUCTION

A number of relatively simple devices have been developed for measuring the coefficient of friction of pavement surfaces. One of these is the Penn State Drag Tester which was developed by H. W. Kummer[1] in 1963 at the Pennsylvania State University.

The Penn State Drag Tester may be operated by one man and is light and easy to transport. The unit, Figure 1, consists of a two-wheeled cart which is pushed by an operator over a wetted pavement at uniform walking speed. In order to determine the friction value, a rubber slider of the same type as used on the British Portable Tester is pushed along the pavement. The slider's resistance to movement under a fixed load is measured through a hydraulic system. The pressure developed in this system is measured on a scale of a gage which may be viewed by the operator during the test. The operator wets the pavement for a distance of 15 to 20 feet and averages the varying reading on the dial when he pushes the tester over the pavement.

The unit appeared to be an ideal piece of equipment for use by District maintenance personnel and a tester was purchased from Die-A-Matic, Inc. of York, Pennsylvania.

In order to use the tester, it is necessary to correlate it with readings obtained with the California Skid tester in order to use a common figure for remedial action. Therefore, the objective of the initial project with the Drag Tester was to determine the degree of correlation with the California tester.

The purpose of this report is to present our findings on the project.

## CONCLUSIONS

A suitable correlation was not obtained between the Penn State Drag Tester and the California Skid Tester when different types of surfaces were compared. A significant correlation was attained when only PCC surfaces were used in the analysis. It is apparent that the speed effect mentioned in the papers by Kummer is of considerable importance in attempting to correlate low speed skid testers with those based on much higher speeds. This is especially true when there are definite differences in surface texture.

The rubber sliders wear at an excessively rapid rate and would require changing at rather frequent intervals. No further study is proposed on this project since the correlation between the two testers was not satisfactory.



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## TEST RESULTS AND DISCUSSION

All test results by both testers are shown in Table A and Figure 2. There is no evidence of a correlation. However, a significant correlation is attained if the results for different PCC pavements are compared as shown in Figure 3. When the results from the dense graded asphalt concrete surfaces are added to those of the PCC, Figure 4, the line of regression did not materially change but the coefficient of correlation fell to 0.37 which is only slightly significant at the five percent level.

The lack of correlation of the two units can best be explained by the fact that the Drag Tester cannot determine the skid number/speed gradient. According to Kummer[2] this begins to exert its influence when the test speed exceeds 35 mph. The number is also influenced by the type of surface, i.e., coarse or fine grained. Since the California skid tester is calibrated for a 50 mph speed, the skid number/speed gradient could materially affect the correlation. In the case of the PCC pavements, the surfaces are about the same in terms of texture, and the skid number/speed gradient would influence the result about the same and therefore a satisfactory correlation is possible.

Kummer, on pages 1 and 2 of reference 1, discusses this problem in some detail and states that a study underway at Penn State promises to provide a "drainage number" that is related to the pavement texture and thereby to the gradient of the skid resistance vs. speed curve. This may provide information for a more satisfactory correlation.

Our operations indicate that about 75 tests of 15 feet in length may be performed with a rubber slider. We believe that the widespread use of the machine would require a fairly large expenditure for sliders. On the California machine, a tire may last for a number of years of extensive testing.

* * * * * * *

The opinions, findings, and conclusions expressed in this publication are those of the authors and not necessarily those of the U. S. Dept. of Transportation, Federal Hwy. Administration, Bureau of Public Roads.



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## REFERENCES


1. "The Penn State Drag Tester"
   H. W. Kummer
   Report No. 7, July, 1963. The Pennsylvania State University, University Park, Pennsylvania.

2. "Correlation Tests with the Penn State Drag Tester"
   H. W. Kummer
   Report No. 9, February, 1964. The Pennsylvania State University, University Park, Pennsylvania.




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TABLE A

TEST RESULTS - CORRELATION STUDY

| Location | Test Date | Type of Surface | Station or Mile Post | Coefficient of Friction | | | |
|---|---|---|---|---|---|---|---|
| | | | | Calif. Skid Tester | | Penn. State Drag Tester | |
| | | | | Wheel Track | Between Wh. Tr. | Wheel Track | Between Wh. Tr. |
| 03-Sac | 3/30/66 | PCC Pavement | Location A | .25 | .34 | 38 | 42 |
| -99, 50 | | " " | " B | .20 | .35 | 34 | 42 |
| | | " " | " C | .17 | .30 | 31 | 35 |
| | | Special Seal #1 (Note 1) | -- | .33 | .35 | 33 | 35 |
| | | Special Seal #2 | -- | .30 | .34 | 30 | 34 |
| | | Special Seal #3 | -- | .34 | .35 | 30 | 28 |
| | | Special Seal #4 | -- | .34 | .34 | 32 | 32 |
| | | Special Seal #5 | -- | .34 | .34 | 28 | 31 |
| | | Special Seal #6a | -- | .31 | .34 | 25 | 30 |
| | | Special Seal #6b | -- | .20 | .26 | 31 | 41 |
| | | Special Seal #7a | -- | .13 | .20 | 30 | 35 |
| | | Special Seal #7b | -- | .29 | .35 | 23 | 27 |
| | | Special seal #7c | -- | .28 | .33 | 28 | 34 |
| | | Special seal #7d | -- | .37 | .42 | 6 | 40 |

NOTE 1 - Special Seals - various special adhesives covered with fine rained material.

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TABLE A - Continued
TEST RESULTS - CORRELATION STUDY

| Location | Test Date | Type of Surface | Station or Mile Post | Coefficient of Friction | | | |
|---|---|---|---|---|---|---|---|
| | | | | Calif. Skid Tester | | Penn. State Drag Tester | |
| | | | | Wh. Tr. SB #2 | Wh. Tr. SB #1 | Wh. Tr. SB #2 | Wh. Tr. SB #1 |
| 04-Ala-017 | 1/17/67 | PCC Pavement | P.M. 11.92 | .13 | .26 | 30 | 34 |
| | | | " 11.915 | .14 | .24 | 30 | 35 |
| | | | " 11.91 | .14 | .25 | 30 | 35 |
| | | | " 11.905 | .14 | .28 | 31 | 36 |
| | | | " 11.90 | .14 | .28 | 31 | 36 |
| | | | " 11.895 | .14 | .29 | 31 | 36 |
| | | | " 11.89 | .15 | .24 | 31 | 36 |
| | | | Average | .14 | .26 | 31 | 35 |
| 04-Ala-017 | 1/18/67 | PCC Bridge Deck | P.M. 11.885 | .13 | .21 | 30 | 36 |
| | | | " 11.88 | .14 | .22 | 30 | 38 |
| | | | " 11.875 | .14 | .22 | 30 | 38 |
| | | | " 11.87 | .14 | .23 | 28 | 38 |
| | | | " 11.865 | .15 | .22 | 29 | 38 |
| | | | " 11.86 | .14 | .25 | 29 | 39 |
| | | | " 11.855 | .14 | .29 | 29 | 38 |
| | | | Average | .14 | .23 | .30 | .38 |
| | | | | Wh. Tr. NB #1 | Wh. Tr. NB #2 | Wh. Tr. NB #1 | Wh. Tr. NB #2 |
| 04-Mrn-101 | 2/7/67 | PCC Bridge Deck | P.M. 10.73 | .34 | .20 | 33 | 29 |
| | | | " 10.74 | .37 | .21 | 35 | 30 |
| | | | " 10.75 | .39 | .25 | 36 | 31 |
| | | | " 10.76 | .34 | .23 | 37 | 32 |
| | | | Average | .36 | .22 | 35 | 31 |

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TABLE A - Continued

| Location | Test Date | Type of Surface | Station or Mile Post | Coefficient of Friction: Calif. Skid Test, Wheel Track | Calif. Skid Test, Between Wh. Tr. | Penn State Drag Tester, Wheel Track | Penn State Drag Tester, Between Wh. Tr. |
|---|---|---|---|---|---|---|---|
| 03-Pla-80 | 5/4/66 | PCC Pavement | EB #2 | .19 | .30 | 33 | 35 |
| | | " " | EB #1 | .23 | .19 | 37 | 39 |
| | | Special Seal A* | -- | .25 | .20 | 39 | 37 |
| | | " " B | -- | .22 | .23 | 35 | 37 |
| | | " " C | -- | .27 | .26 | 45 | 42 |
| * Special Seals - Various special adhesives covered with fine grained materials. | | | | | | | |
| 01-Hum-299 | 4/12/66 | Dense Graded Asphalt Conc. | WB #2 PM 21.12 | .23 | .18 | 41 | 43 |
| | | | WB #1 PM 21.12 | .23 | .18 | 47 | 43 |
| | | | WB #1 PM 21.89 | .32 | .32 | 45 | 45 |
| | | | EB PM 22.87 | .25 | .19 | 46 | 44 |
| | | | WB PM 23.33 | .24 | .16 | 40 | 42 |
| | | | Average | .25 | .21 | 45 | 44 |
| 10-SJ-99 | 11/22/66 | Dense Graded Asphalt Conc. | SB #3 PM 20.33 | .29 | .28 | 34 | 33 |
| | | | " " " 20.32 | .29 | .27 | 34 | 34 |
| | | | " " " 20.31 | .32 | .29 | 34 | 33 |
| | | | " " " 20.30 | .33 | .31 | 34 | 34 |
| | | | " " " 20.29 | .28 | .30 | 34 | 34 |
| | | | Average | .30 | .29 | 34 | 34 |
| 03-Pla-80 | 1/4/67 | Dense Graded Asphalt Conc. Test Sect. #1 | EB #2 Sta 297+00 | .37 | — | 44 | — |
| | | | " " " 297+25 | .38 | — | 41 | — |
| | | | " " " 297+50 | .38 | — | 43 | — |
| | | | " " " 297+75 | .37 | — | 41 | — |
| | | | " " " 298+00 | .38 | — | 42 | — |
| | | | Average | .38 | — | 42 | — |

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TABLE A - Continued

| Location | Test Date | Type of Surface | Station or Mile Post | Coefficient of Friction: Calif. Skid Test, Wheel Track | Calif. Skid Test, Between Wh. Tr. | Penn State Drag Tester, Wheel Track | Penn State Drag Tester, Between Wh. Tr. |
|---|---|---|---|---|---|---|---|
| 03-Pla-80 | 1/4/67 | Dense Graded Asphalt Conc. Test Sect. 2 | EB #2 Sta. 309+00 | .33 | — | 41 | — |
| | | | " " " 309+25 | .33 | — | 41 | — |
| | | | " " " 309+50 | .32 | — | 41 | — |
| | | | " " " 309+75 | .32 | — | 41 | — |
| | | | " " " 310+00 | .33 | — | 42 | — |
| | | | Average | .33 | — | 41 | — |
| 03-Pla-80 | 1/4/67 | Dense Graded Asphalt Conc. Test Sect. 3 | EB #2 Sta. 316+00 | .33 | — | 41 | — |
| | | | " " " 316+25 | .32 | — | 41 | — |
| | | | " " " 316+50 | .32 | — | 40 | — |
| | | | " " " 316+75 | .30 | — | 39 | — |
| | | | " " " 317+00 | .30 | — | 40 | — |
| | | | Average | .31 | — | 40 | — |
| 03-Pla-80 | 1/4/67 | Dense Graded Asphalt Conc. Test Sect. 4 | WB #2 Sta. 244+25 | .36 | — | 36 | — |
| | | | " " " 244+00 | .31 | — | 38 | — |
| | | | " " " 243+75 | .27 | — | 36 | — |
| | | | " " " 243+50 | .29 | — | 36 | — |
| | | | " " " 243+25 | .26 | — | 36 | — |
| | | | Average | .30 | — | 37 | — |
| 03-Pla-80 | 1/6/67 | Dense Graded Asphalt Conc. | WB #2 Sta. 237+00 | .28 | — | 37 | — |
| | | | " " " 236+75 | .26 | — | 38 | — |
| | | | " " " 236+50 | .27 | — | 38 | — |
| | | | " " " 236+25 | .27 | — | 37 | — |
| | | | " " " 236+00 | .27 | — | 37 | — |
| | | | Average | .27 | — | 37 | — |

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TABLE A - Continued

| Location | Test Date | Type of Surface | Station or Mile Post | Coefficient of Friction: Calif. Skid Tester, Wheel Track | Calif. Skid Tester, Between Wh. Tr. | Penn State Drag Tester, Wheel Track | Penn State Drag Tester, Between Wh. Tr. |
|---|---|---|---|---|---|---|---|
| 03-Pla-80 | 1/6/67 | Dense Graded Asphalt Conc. | WB #2 Sta. 231+75 | .30 | — | 35 | — |
| | | | " " " 231+50 | .29 | — | 36 | — |
| | | | " " " 231+25 | .28 | — | 36 | — |
| | | | " " " 231+00 | .29 | — | 35 | — |
| | | | " " " 230+75 | .30 | — | 36 | — |
| | | | Average | .29 | — | 36 | — |
| 03-Pla-80 | 1/6/67 | Dense Graded Asphalt Conc. | WB #2 Sta. 226+00 | .28 | — | 34 | — |
| | | | " " " 225+75 | .29 | — | 34 | — |
| | | | " " " 225+50 | .28 | — | 35 | — |
| | | | " " " 225+25 | .29 | — | 33 | — |
| | | | " " " 225+00 | .29 | — | 33 | — |
| | | | Average | .29 | — | 34 | — |
| 04-SM-101 | 1/18/67 | Dense Graded Asphalt Conc. | NB #4 Sta. 409+00 | .24 | — | 31 | — |
| | | | " " " 409+50 | .21 | — | 31 | — |
| | | | " " " 410+00 | .22 | — | 31 | — |
| | | | " " " 410+50 | .21 | — | 32 | — |
| | | | " " " 411+00 | .23 | — | 32 | — |
| | | | " " " 411+50 | .20 | — | 31 | — |
| | | | " " " 412+00 | .20 | — | 30 | — |
| | | | Average | .22 | — | 31 | — |
| 04-SM-101 | 1/19/67 | Dense Graded Asphalt Conc. | NB #3 PM 23.06 | .27 | — | 30 | — |
| | | | " " " 23.07 | .23 | — | 29 | — |
| | | | " " " 23.08 | .22 | — | 30 | — |
| | | | " " " 23.09 | .27 | — | 30 | — |
| | | | " " " 23.10 | .26 | — | 27 | — |
| | | | " " " 23.11 | .28 | — | 26 | — |
| | | Average | | .26 | — | 28 | — |

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TABLE A - Contined

| Location | Test Date | Type of Surface | Station or Mile Post | Coefficient of Friction: Calif. Skid Tester, Wheel Track | Calif. Skid Tester, Between Wh. Tr. | Penn State Drag Tester, Wheel Track | Penn State Drag Tester, Between Wh. Tr. |
|---|---|---|---|---|---|---|---|
| 04-SM-101 | 1/19/67 | Dense Graded Asphalt Conc. | NB #3 PM 23.39 | .22 | — | 28 | — |
| | | | " " " 23.40 | .24 | — | 28 | — |
| | | | " " " 23.41 | .20 | — | 26 | — |
| | | | " " " 23.42 | .25 | — | 26 | — |
| | | | Average | .23 | — | 27 | — |
| 04-Mon-101 | 2/7/67 | Dense Graded Asphalt Conc. | NB #1 PM 10.70 | .34 | — | 37 | — |
| | | | " " " 10.71 | .31 | — | 35 | — |
| | | | " " " 10.72 | .29 | — | 39 | — |
| | | | Average | .31 | — | 37 | — |
| 04-Mon-101 | 2/7/67 | Dense Graded Asphalt Conc. | NB #3 PM 13.15 | .22-.24 | — | 29-28 | — |
| | | | " " " 13.16 | .25-.22 | — | 27-28 | — |
| | | | " " " 13.17 | .25-.25 | — | 27-29 | — |
| | | | " " " 13.18 | .22-.29 | — | 27-29 | — |
| | | | Average | .24 | — | 28-29 | — |
| 04-Son-101 | 2/8/67 | Dense Graded Asphalt Conc. | SB #2 PM 1.44 | .23 | — | 38 | — |
| | | | " " " 1.43 | .18 | — | 36 | — |
| | | | " " " 1.42 | .24 | — | 34 | — |
| | | | " " " 1.41 | .22 | — | 34 | — |
| | | | Average | .22 | — | 36 | — |
| 04-Mrn-101 | 2/8/67 | Dense Graded Asphalt Conc. | SB #2 PM 25.35 | .21 | — | 42 | — |
| | | | " " " 25.33 | .23 | — | 42 | — |
| | | | " " " 25.03 | .22 | — | 41 | — |
| | | | " " " 25.00 | .23 | — | 42 | — |
| | | | Average | .22 | — | 42 | — |

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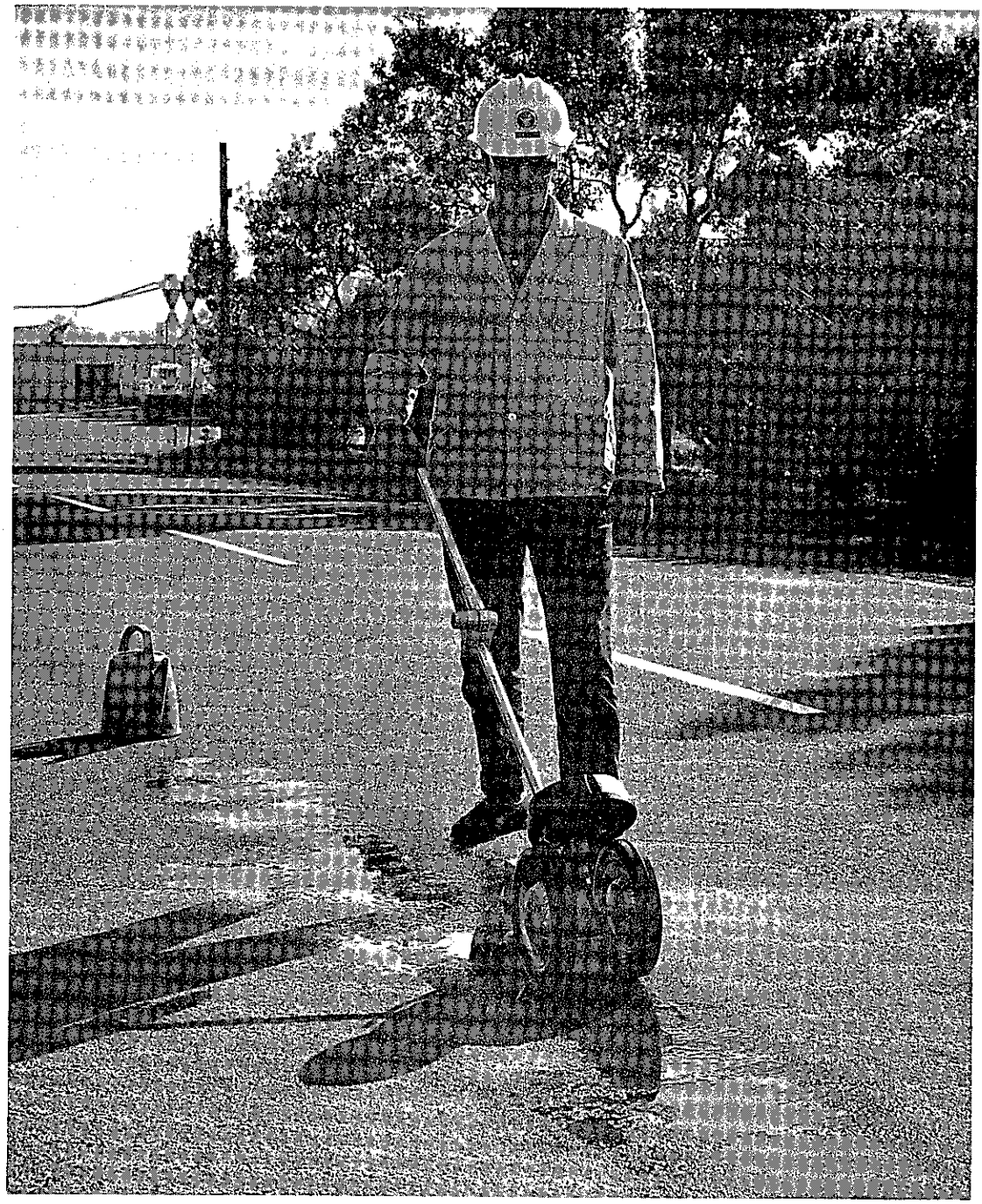
Figure 1



PENNSYLVANIA STATE DRAG TESTER

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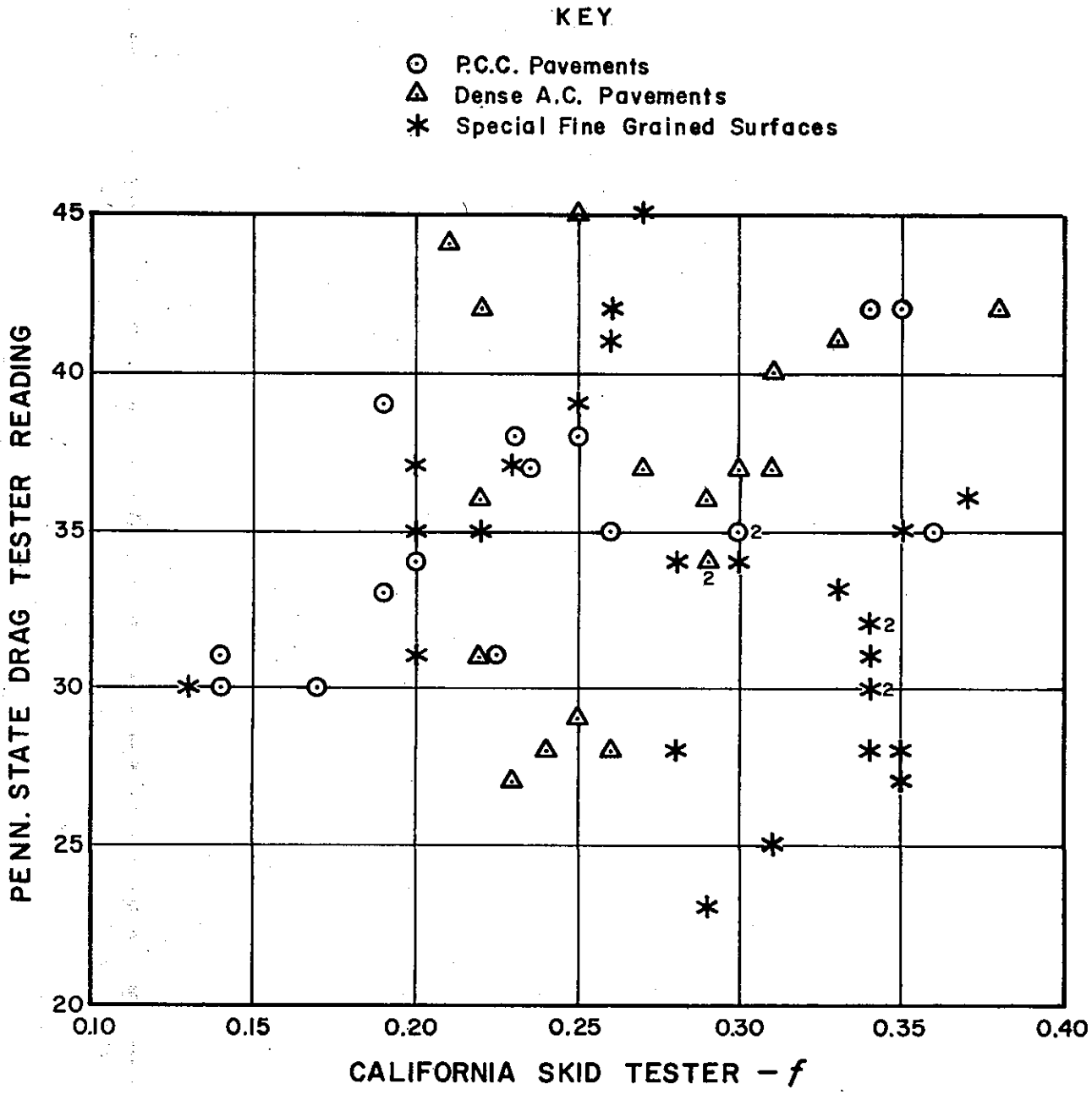
Figure 2

# CORRELATION OF CALIFORNIA SKID TESTER AND PENNSYLVANIA STATE DRAG SKID TESTER

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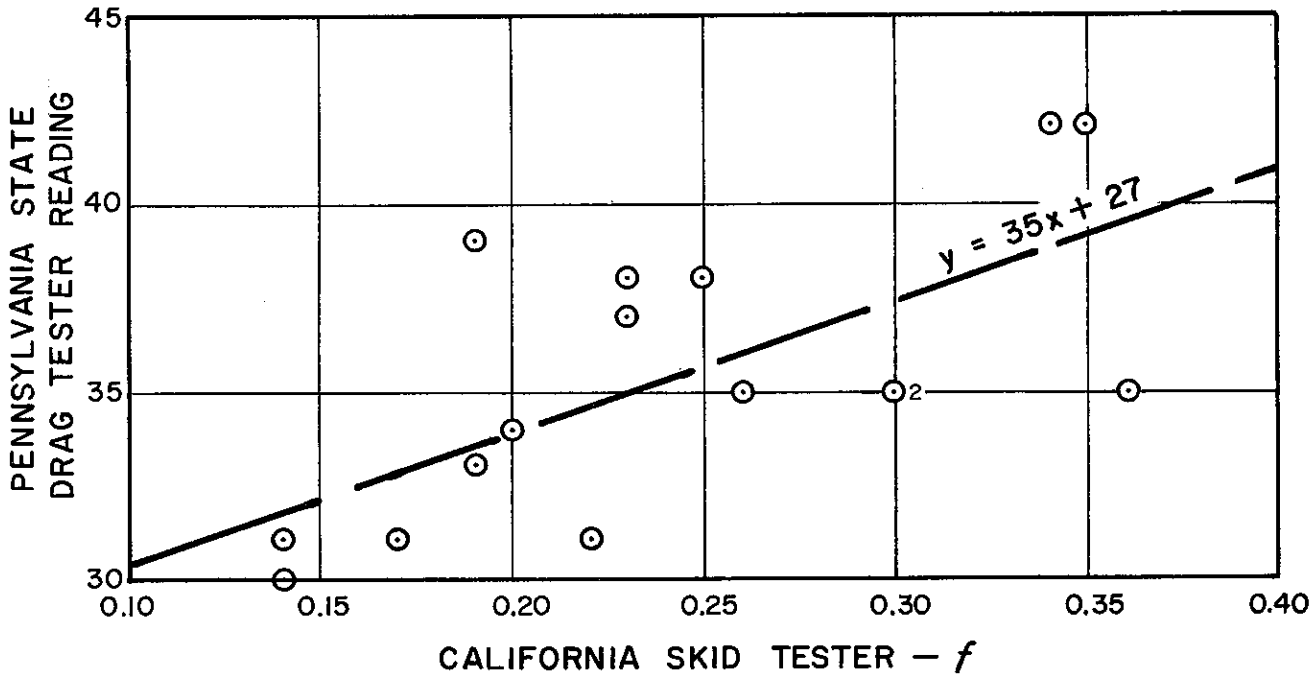
# CORRELATION OF CALIFORNIA SKID TESTER AND PENNSYLVANIA STATE DRAG SKID TESTER

## P.C.C. PAVEMENTS




Coefficient of Correlation
r = 0.66

Significant Correlation

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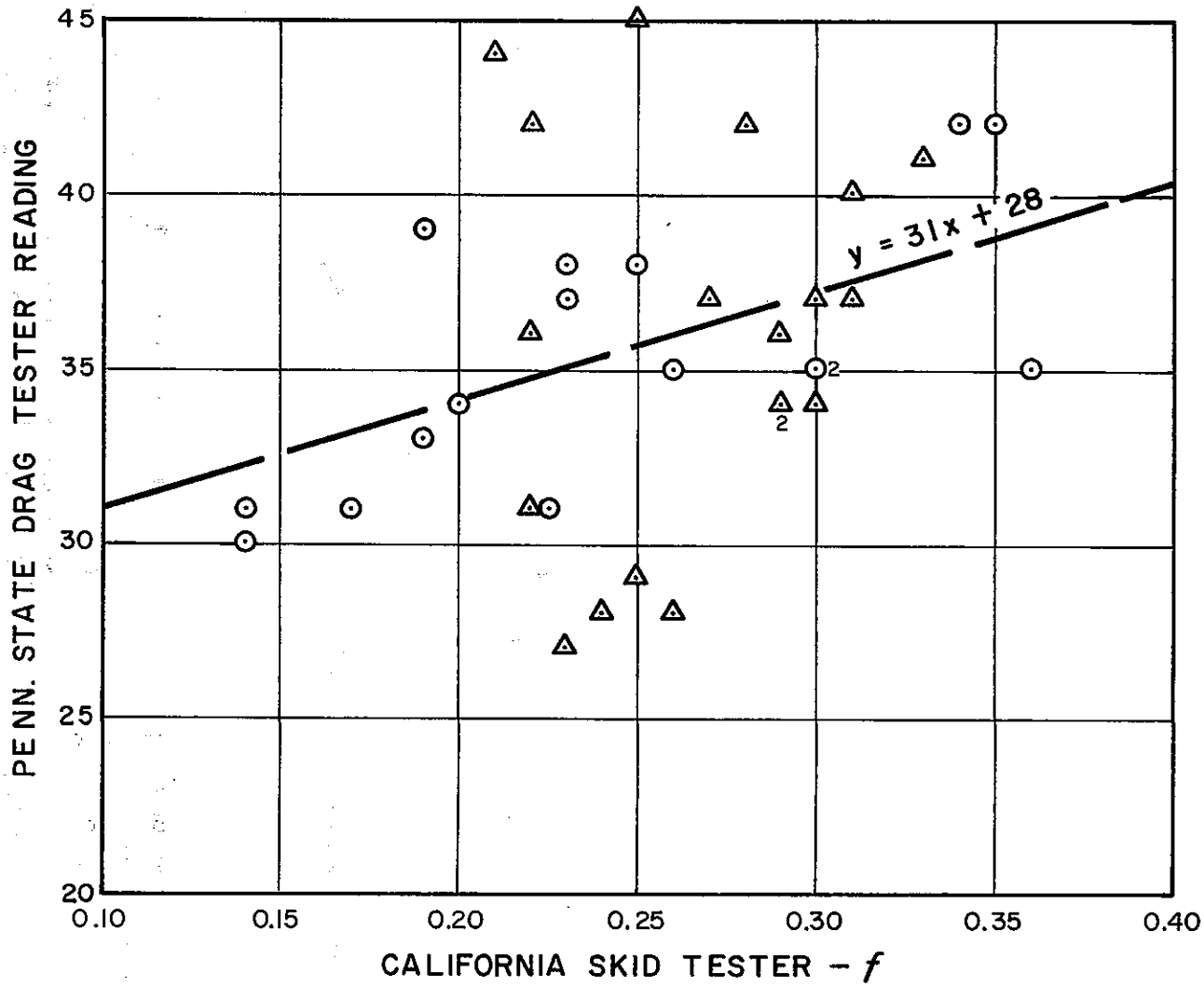
Figure 4

# CORRELATION OF CALIFORNIA SKID TESTER AND PENNSYLVANIA STATE DRAG SKID TESTER P.C.C. AND DENSE GRADED A.C. PAVEMENTS

KEY

⊙ P.C.C. Pavements

△ Dense Graded A.C. Pavements




Coefficient of Correlation
r = 0.37

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