Iowa State Highway Commission
Materials Department
Special Investigations

Correlation Studies

BPR Type Roughometer

vs.

PCA Type Road Meter

November 27, 1968

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Ames Laboratory

by

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1.0 INTRODUCTION

The BPR type Roughometer has been used by the Iowa State Highway Commission since 1955 for the evaluation of the relative roughness of the various Iowa road surfaces. Since the commencement of this program, standardized information about the roughness of the various Iowa roads with respect to their type, construction, location and usage has been obtained. The Roughometer has also served to improve the economics and quality of road construction by making the roughness results of various practices available to all who are interested.

In 1965, the Portland Cement Association developed a device known as the PCA Road Meter for measuring road roughness. Mounted in a regular passenger car, the Road Meter is a simple electromechanical device of durable construction which can perform consistently with extremely low maintenance. In 1967, the Iowa State Highway Commission's Laboratory constructed a P.C.A. type Road Meter in order to provide an efficient and reliable method for measuring the Present Serviceability Index for the state's highways. Another possibility was that after considerable testing the Road Meter might eventually replace the Roughometer.

Some advantages of the Road Meter over the Roughometer are:

(1) Road Meter tests are made by the automobile driver and one assistant without the need of traffic protection. The Roughometer has a crew of four men; two operating the roughometer and two driving safety vehicles.

(2) The Road Meter is able to do more miles of testing because of its faster testing speed and the fact that it is the only vehicle involved in the testing.

(3) Because of the faster testing speed, the Road Meter gives a better indication of how the road actually rides to the average highway traveler.

(4) The cost of operating a Road Meter is less than that of a Roughometer because of the fewer number of vehicles and men needed in testing.

2.0 PURPOSE

The purpose of this study was to determine if there is a meaningful correlation between the ISHC Road Meter and the ISHC Roughometer.

3.0 EQUIPMENT

The ISHC Roughometer, a trailer towed by a vehicle, was built according to a BPR standard design. (The towing vehicle used during this study was a 1962 International Travelall truck). When the roughness indicator is being towed, the roughness in the road causes vertical movement of the trailer wheel with respect to the trailer frame. These mechanical movements of the trailer wheel are converted into electric impulses which are transmitted to a control panel in the vehicle for convenience in recording. Roughness is recorded in the number of inches of one way vertical movement of the trailer wheel per mile of road tested.

The ISHC Road Meter was constructed to closely duplicate a unit developed by the Portland Cement Association. The unit makes

use of a simple electro-mechanical device, installed in a conventional passenger automobile. (The ISHC used a 1968 Ford Custom equipped with a 302 engine and air conditioning and referred to it as Road Meter #5).

The device consists of a flexible, nylon-covered, braided steel strand connected to the top center of the rear axle housing in the vehicle. The steel strand extends vertically through the trunk compartment and then through a small hole in the package deck just back of the rear seat. At this point, the strand passes over a transverse-mounted pulley, and is restrained by a tension spring attached to a small post on the package deck at a point near the right side of the body shell. Thus, vertical movement between the rear axle housing and the package deck is translated to horizontal movement of the strand.

Midway between the pulley and the tension spring, a roller micro-switch is attached to the metal strand. The switch is mounted in a small rectangular formica plate that slides in transverse guides.

The micro-switch roller impinges on a switch plate constructed so that transverse roller movements can be measured in 1/8 inch increments, either plus or minus from a reference standing position of the automobile. As the roller passes over each increment of the switch plate, it sends impulses to visual indicators and electric counters. The visual indicators are used to make sure the unit is operating correctly. The electric counters sum the number of impulses received from each of the segments of the switch plate, according to the magnitude relative to road-car deviations.

The information obtained from the counters is used to determine a Present Serviceability Index (PSI) for the road. The Present Serviceability Index concept was developed at the AASHO Road Test and is an unbiased indicator of the ability of a pavement to serve the motoring public. Because the PSI is determined by a different curve for AC and PCC roads, a unit of sum of the deviations divided by length of project tested was used for the correlation.

4.0 TEST SECTIONS

A total of 237 projects were used to determine the correlation. This consisted of 117 A.C. pavement and 120 PCC pavement projects of 1967 and 1968 construction. The projects were not tested on the same day by both units, but were tested during the period from June, 1968, through September, 1968. The projects were located throughout the state.

5.0 TESTING PROCEDURE

The method of determining the road roughness with the roughometer is quite simple. The roughometer is pulled behind the towing vehicle at a rate of 20 MPH. The roughness is recorded in quarter, half or one mile segments. This is done for each lane. When completed, a weighted average is determined for each lane in inches of roughness per mile.

Before starting a project with the Road Meter, the microswitch roller and switch plate must be referenced to a zero reading. This is done by turning on the power to the unit and turning the vernier until the visual indicator corresponding to zero is lit. The vernier dial is turned clockwise until the 0 and 1 visual indicators are lit simultaneously and a vernier reading is

taken. The vernier dial is then turned counterclockwise until the 0 and 1 visual indicators are again lit simultaneously. Another vernier reading is observed, added to the first, and the sum is divided by two. The vernier is then set to the obtained value, the power is turned off and the electric counters are set to zero.

The Road Meter is driven over each lane of the test section at 50-MPH with the electrical counters and visual indicators on. When each lane of the project is completed, the counter readings are recorded, multiplied by the corresponding magnitudes relative to road-car deviations, and summed. This sum is then divided by the length of the project tested to obtain the necessary unit used in the study.

After all the projects were tested by both the ISHC Road Meter and ISHC Roughometer, the results were compared by plotting them on a graph (See Figure 1). The results were plotted according to their type of surface (See Legend). The paired numbers were also sent to Data Processing where a coefficient of correlation was determined.

6.0 INTERPRETATION OF RESULTS

The coefficient of correlation for the projects tested was determined to be 0.7948. This means that there is a relationship between the Roughometer and Road Meter. Now that a correlation has been determined, it must be examined to see if it is meaningful for the study. "A meaningful correlation" for this study was defined by the Special Investigations Department of the ISHC as being one in which given the sum/length from a Road Meter test, the Roughometer road roughness within $\pm$ 10 inches

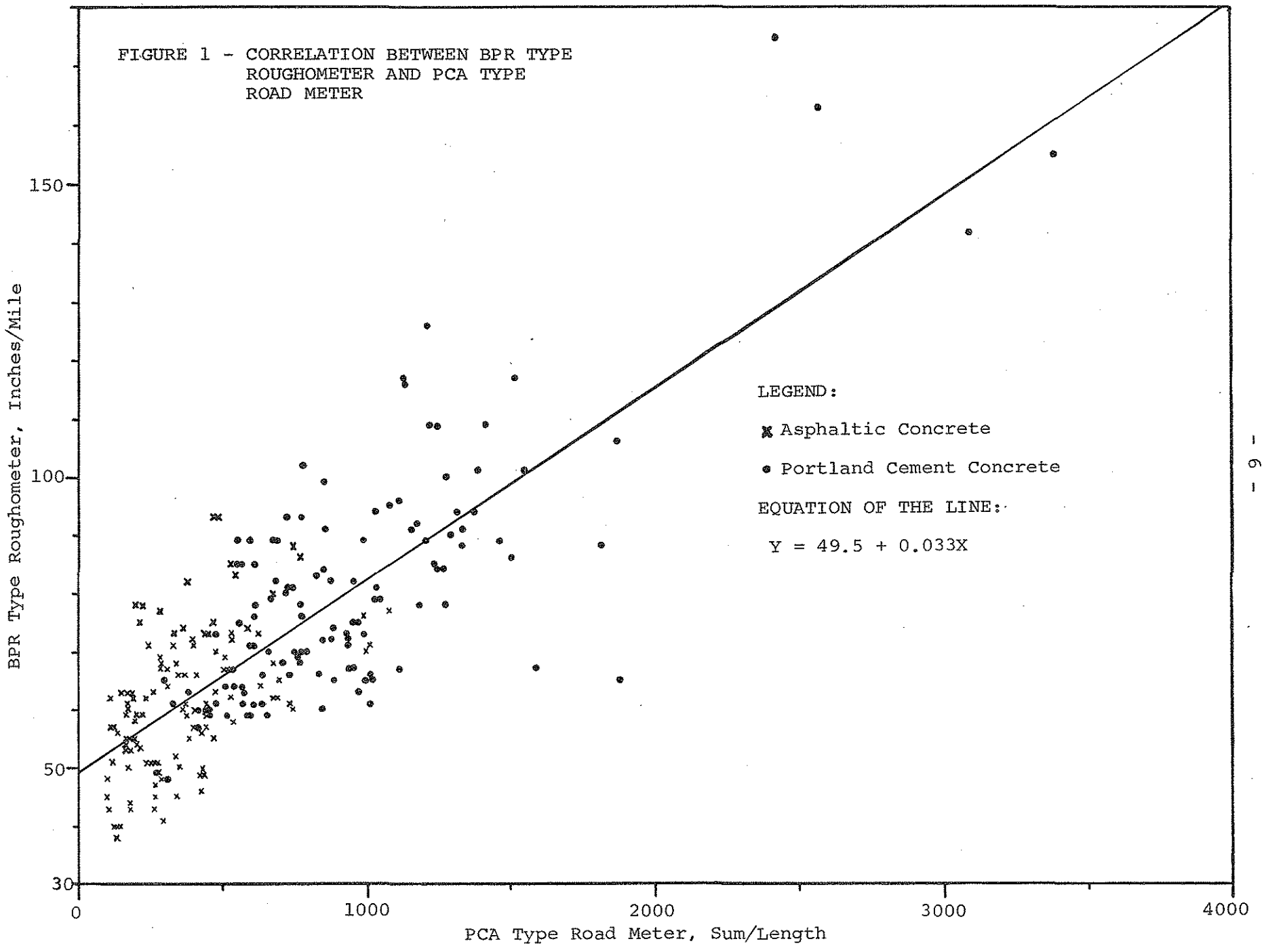
FIGURE 1 - CORRELATION BETWEEN BPR TYPE ROUGHOMETER AND PCA TYPE ROAD METER
BPR Type Roughometer, Inches/Mile
150
100
50
30
0
1000
2000
3000
4000
PCA Type Road Meter, Sum/Length
LEGEND:
Asphaltic Concrete
Portland Cement Concrete
EQUATION OF THE LINE:
Y = 49.5 + 0.033X

could be estimated 95% of the time. Statistical analysis is necessary to determine if the coefficient of correlation obtained is meaningful.

The standard error of estimate is calculated as being 11.9. Statistical methods show that given a Road Meter sum/length, it can be used to correctly estimate a Roughometer count within ±24 inches 95% of the time. Comparing this with the standards set, it is evident that the correlation is not meaningful.

The graph shows that both Asphaltic Concrete and Portland Cement Concrete types of surface had nearly the same variation. Both types of surface appear to give even distribution above and below the regression line, with the Asphaltic Concrete showing a tendency to be smoother.

7.0 SUMMARY

In summary, it is evident that:

(1) Although a correlation exists between the ISHC Roughometer and ISHC Road Meter, it is not one of sufficient meaning to warrant any definite comparisons between the two units.

(2) If the results of a Road Meter project are given, it is possible to determine the expected Roughometer results to within ±24 inches 95% of the time.

(3) Both Asphaltic Concrete and Portland Cement Concrete yield approximately the same variation from the regression line.

8.0 REFERENCES

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