PCA ROAD METER MEASURING ROAD ROUGHNESS AT 50 MPH

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The roughness of highway pavements is of concern to highway users and to highway engineers. Usually, whenever a highway user travels over a stretch of highway he consciously or unconsciously rates the roughness of the ride and decides whether it is tolerable. Highway maintenance personnel will have done this also to appraise the serviceability of the road and to determine whether the road condition meets current acceptable standards.

There is usually a diversity of opinion on such matters as deciding how rough a road may be, and, because of this, highway engineers now measure road roughness in a quantitative or objective way. Several types of equipment are currently used for this purpose. Two machines have been in use for the past few years in Ontario: the roughometer (developed by the U. S. Bureau of Public Roads) and the profilometer (developed by the British Road Research Laboratory) (1).

The profilometer (Fig. 1) is a road roughness measuring machine that produces a profile of the pavement surface as well as a measurement of roughness. For reproducibility of results, however, it must not be operated at speeds greater than that of a slow walk—about 1 mph.

The roughometer (Fig. 2) produces a roughness measurement by integrating the upward vertical motion of a standard suspension system relative to the frame of a vehicle, as the vehicle travels over the pavement surface at 20 mph. This equipment (a towed trailer) simulates the interaction of a vehicle and the road surface, and, because of its standardized suspension system, the measurements obtained do not vary in the same manner as they would if produced by automobiles designed by different car manufacturers.

When operating the profilometer or the roughometer, traffic must be diverted from the lane being measured. In the case of the roughometer, however, it is only necessary for the trailer to be equipped with warning signs and lights, except in multilane high-volume situations where, for the purposes of traffic control, the trailer must be followed by a properly signed auxiliary vehicle. The roughometer is the more versatile of the 2 machines because of its operating speed (20 mph); it can be used to measure the roughness of municipal roads as easily as the roughness of major highways.

The capabilities of the profilometer, on the other hand, are quite limited because of its very low operating speed. There are few situations where it can be operated without seriously impeding traffic flow. It is extremely useful, however, for measuring the roughness of newly constructed pavement not opened to traffic and where speed-dependent instruments cannot be used (such as on bridge decks). In most traffic situations the profilometer must be followed by a control vehicle to divert traffic from the lane being measured, and flagmen using a 2-way radio must be employed.

Although these 2 instruments have served well in the measuring of road roughness, there has been an increasing need for equipment that will perform satisfactorily at normal traffic speeds. Such an instrument has now been introduced by the Portland

Figure 1. The Ontario Department of Highways profilometer.

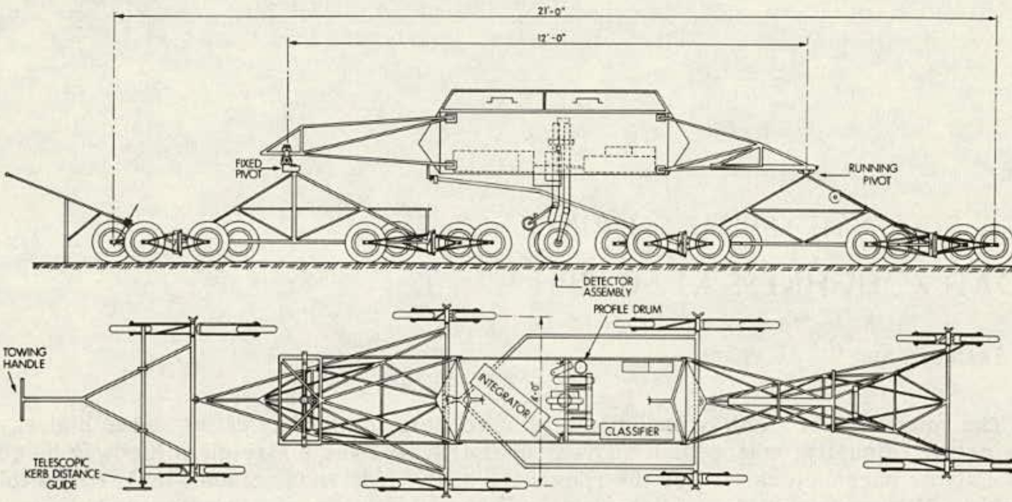


Figure 2. Roughometer trailer.

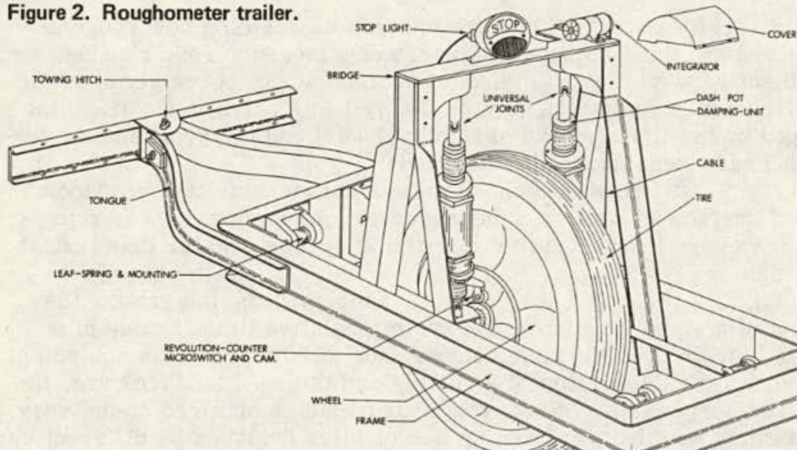
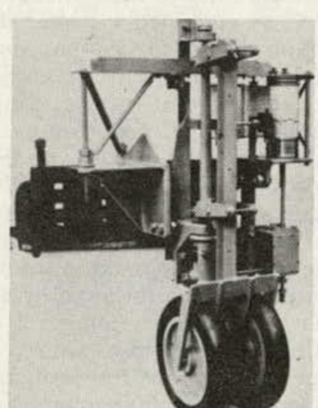


Figure 3. Profilometer recording wheel assembly.



Cement Association in its PCA road meter, which is fitted into an automobile (a normal passenger car) and is capable of measuring road roughness while being driven at 50 mph.

This report describes the PCA road meter and compares measurements obtained from its use with those of the roughometer and the profilometer.

METHOD OF EVALUATION

For evaluation purposes, 50 test sections were selected from both rigid and flexible pavements, and measurements of road roughness were carried out with all 3 measuring instruments.

The various measurements were not carried out on any one section at the same time because of the different speeds of operation but were arranged over a 6-week period during June and July of 1968.

The present performance ratings (PPR's) of the 50 test sections were determined by an individual rater; curves of PPR's were constructed for each instrument and correlation coefficients obtained.

The road meter was used to derive present serviceability indexes (PSI's) for each road section, using correlation data provided by the developers of the equipment. These derived PSI values were compared with the individual PPR values of the test sections, and regression analyses were performed to show how close the correlation was between the derived PSI and the PPR.

ROAD TEST SECTIONS

The test sections of highways were all within reasonable distance of Toronto. Each test section was ½ mile in length and was selected to provide uniform characteristics within its length.

Twenty-five of the sections were rigid pavement on Highway 401, between Highway 27 and Highway 6. The 25 flexible pavement sections were selected from 12 highways within 60 miles of Toronto; all of these pavements had been surfaced with a hot-mix asphalt.

Within each group of rigid and flexible pavement, the sections were chosen to provide a variety of roughnesses over the available range. The boundaries of the test locations were clearly identified by sketch maps and by painting start and finish marks on the sections of pavement concerned. This was done to ensure that the results obtained with the 3 instruments were from the same test sections.

PROFILOMETER

The profilometer is basically a 16-wheeled articulated carriage that supports a detecting and recording device at a constant height above the main level of the road surface. The 16 wheels and their axles support four 4-wheeled bogies that cover a total width of 4 ft and provide a 21-ft long wheel base. The design of the unit is such that only $1/16$ of the vertical movement of any single wheel is transmitted to the mounting of the detector wheels. The tires of the wheels are made of soft rubber and are inflated to a low pressure to ensure that very small irregularities in the road surface are not introduced into the measurement.

The detector assembly is located at the center of the chassis and consists of a detector wheel mounted centrally on a vertical detector shaft positioned in vertical guides (Fig. 3). Two trailing (flanking) wheels, mounted on elbows and pivoted on the detector shaft, ensure that the detector wheel "tracks" the line of travel properly. This results in a compensating forward movement of the profile pen, which keeps the plot of each vertical drop vertical.

The profilometer plots a profile of the road surface in a natural vertical scale and measures the number of bumps of different sizes by means of a classifier. In this unit, electrical counters record bumps of different sizes in intervals of 0.1 in.; other counters are included for each interval of 0.1 in., up to 1.5 in. The roughness value q, in inches per mile, is determined by the sum of all downward vertical motions in each interval (Fig. 4). This q-value automatically disregards any motion less than 0.1 in. and clas-

Figure 4. Profilometer data sheet.

DEPARTMENT OF HIGHWAYS, ONTARIO — SHEET 1 OF 3

PROFILOMETER DATA SHEET

DATE Sept. 7 19 67 HWY. NO. 401 PAVEMENT Concrete LANE WBDL OFFSET 6' off ℄

CONTRACT NO. 58 - 71 LOCATION Highway 27 Interchange to Etobicoke Creek

TIME OF TEST xxxx p.m. AIR TEMP. 25 °F. WEATHER sunny SURFACE CONDITION: Dry, Clean

PROFILE SCALE: 240 INTEGRATOR SCALE: ½ FOOTAGE/INDICATOR CORRECTION FACTOR: 1.005

FOOTAGE INDICATOR 1312 (ft.) CORRECTED TEST CELL LENGTH 1320 (ft.) FOOT-MILE RATIO (f) 4

$(\Delta a)_r = n_r \times \bar{b}_r$ WHERE: N = CUMULATIVE COUNTS; n'_r = NUMBER PER TEST LENGTH; $n_r = n'_r \times f$; $\bar{b}_r = b_r + 0.045$

$f = \frac{5280\ (ft.)}{L\ (ft.)}$ WHERE: L = CORRECTED TEST LENGTH

CELL (1) — Δp = 20.4 INCHES

b_r	N	n'_r	n_r	$\bar{b}_r$	$(\Delta a)_r$
.1	59	27	108	0.145	15.66
.2	32	18	72	0.245	17.64
.3	14	10	40	0.345	13.80
.4	4	1	4	0.445	1.78
.5	3	1	4	0.545	2.18
.6	2	1	4	0.645	2.58
.7	1	1	4	0.745	2.98
.8				0.845	
.9				0.945	
1.0				1.045	
1.1				1.145	
1.2				1.245	
1.3				1.345	
1.4				1.445	
1.5				1.545	
				TOTAL q =	56.62

q = CLASSIFIER INDEX 56.6 INCHES/MILE
p = INTEGRATOR INDEX 81.6 INCHES/MILE

CELL (2) — Δp = 20.3 INCHES

b_r	N	n'_r	n_r	$\bar{b}_r$	$(\Delta a)_r$
.1	61	31	124	0.145	17.98
.2	30	17	68	0.245	16.66
.3	13	8	32	0.345	11.04
.4	5	3	12	0.445	5.34
.5	2	0	0	0.545	0
.6	2	1	4	0.645	2.58
.7	1	0	0	0.745	0
.8	1	0	0	0.845	0
.9	1	0	0	0.945	0
1.0	1	1	4	1.045	4.18
1.1				1.145	
1.2				1.245	
1.3				1.345	
1.4				1.445	
1.5				1.545	
				TOTAL q =	57.78

q = CLASSIFIER INDEX 57.8 INCHES/MILE
p = INTEGRATOR INDEX 81.2 INCHES/MILE

CELL (3) — Δp = 20.4 INCHES

b_r	N	n'_r	n_r	$\bar{b}_r$	$(\Delta a)_r$
.1	61	36	144	0.145	20.88
.2	25	14	56	0.245	13.72
.3	11	8	32	0.345	11.04
.4	3	3	12	0.445	5.34
.5				0.545	
.6				0.645	
.7				0.745	
.8				0.845	
.9				0.945	
1.0				1.045	
1.1				1.145	
1.2				1.245	
1.3				1.345	
1.4				1.445	
1.5				1.545	
				TOTAL q =	50.98

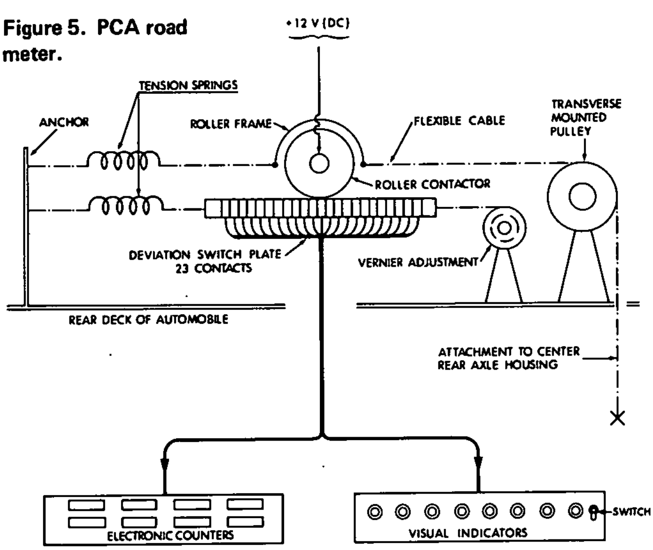
q = CLASSIFIER INDEX 51.0 INCHES/MILE
p = INTEGRATOR INDEX 81.6 INCHES/MILE

CELL (4) — Δp = 22.35 INCHES

b_r	N	n'_r	n_r	$\bar{b}_r$	$(\Delta a)_r$
.1	65	30	120	0.145	17.40
.2	35	17	68	0.245	16.66
.3	18	14	56	0.345	19.32
.4	4	1	4	0.445	1.78
.5	3	2	8	0.545	4.36
.6	1	0	0	0.645	0
.7	1	0	0	0.745	0
.8	1	1	4	0.845	3.38
.9				0.945	
1.0				1.045	
1.1				1.145	
1.2				1.245	
1.3				1.345	
1.4				1.445	
1.5				1.545	
				TOTAL q =	62.90

q = CLASSIFIER INDEX 62.9 INCHES/MILE
p = INTEGRATOR INDEX 90.4 INCHES/MILE

Figure 5. PCA road meter.



sifies all motion between 0.1 in. and 0.199 in. as 0.1 in.; it does the same for each class interval. There is, therefore, inherent in the q-value, a disregard for small fluctuations that might be caused by surface texture.

ROUGHOMETER

The roughometer is a single-wheeled trailer having a recording wheel located centrally in a frame that represents the top of a suspension system; it is comprised of 2 standard leaf-springs and 2 standard hydraulic dashpot dampers. An integrator capable of moving in both directions (but which is arranged to integrate only in one direction) is coupled to an electric counter that is calibrated to record inches of vertical movement. The integrator that is fixed to the framework attached to the suspension system is connected to the axle of the recording wheel by a steel cable.

The recording system thus measures the inches of vertical movement of the axle relative to the top of the suspension system. A second counter records the revolutions of the recording wheel so that between the 2 counters the roughness of any length of road may be recorded.

The Federal Highway Administration specifies a standard operational speed of 20 mph to ensure that the conditions of the test are exactly repeatable.

PCA ROAD METER

The PCA road meter also measures pavement roughness at the top of the suspension system of a vehicle. It is a simple electromechanical device that is installed in a standard passenger car to measure the number and magnitude of vertical deviations between the body of the automobile and the center of the rear-axle housing (2).

The instrument consists of a nylon-covered flexible steel cable connected to the top center of the rear-axle housing in the carrier vehicle (which should be in good condition and have a mechanically sound suspension system and good tires). The cable is brought vertically through the floor of the car to a package deck just behind the rear seat. At this point the cable is passed over a transverse-mounted pulley and 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. Consequently, any vertical movement between the rear-axle housing and the package deck is translated into a horizontal movement of the steel cable and a corresponding movement to the recorder.

Halfway between the pulley and the tension spring, a roller type microswitch is attached to the steel cable. The switch, which is mounted on a small rectangular plate (that slides in transverse metal guides), is forced by its own internal compression spring onto a copper switch plate. The switch, therefore, is always in a partially compressed state, and electrical impulses are conducted through the roller and not by the microswitch contacts. A roller-type microswitch is used solely because its physical size and compression spring are well suited to the application, not because of any requirement for the special characteristics of a microswitch.

The switch plate is divided into 23 segments ⅛ in. long so that any transverse roller movements derived through the action of the steel cable are measured in ⅛-in. increments of vertical motion, which are either plus or minus from a reference standing position of the automobile. The transverse reference position of the switch plate can be adjusted beneath the roller to accommodate different static loads in the automobile. This adjustment is accomplished by a separate tension spring attachment and a vernier control.

The 12-volt electrical power of the automobile is applied to the roller and switch-plate circuit. Output is fed to the visual indicators of the road-car deviations and also connected to 8 high-speed electric counters capable of recording electrical impulses having a "make" time of 0.03 sec. The counters sum the impulses received from the segments of the switch plate, according to the magnitude of the impulses relative to the road-car deviations. Individual counters are connected to switch-plate segments, which correspond to road-car deviations of ± ⅛, ¼, ⅜, ½, ⅝, ¾, ⅞, and 1 in. The center segment, which is used for the initial zero reference, has no electrical connection.

Figure 6. Switch assembly in operating position.

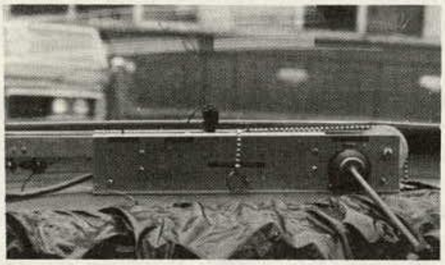


Figure 7. Switch plate and roller contactor.

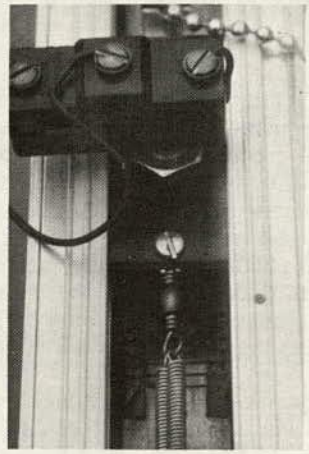


Figure 8. Electrical counters.

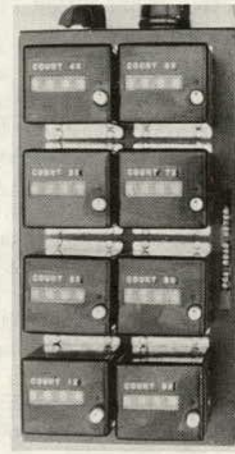


Figure 9. Visual indicators and control switch.

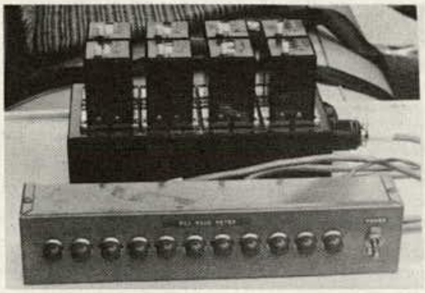


Figure 10. Road meter data sheet.

PCA ROAD METER SURVEY

DATE *May 17* COUNTY ______ ROUTE *401* PROJECT ______ SECTION *10* TYPE *PCC*

FROM *Streetsville Road* TO *Highway 10* LANE *EBDL*

SURVEY BEGINS *2.0 Miles East Streetsville Road* ODOMETER ______

SURVEY ENDS *3.0 Miles East Streetsville Road* ODOMETER ______

TIME ______ TEMPERATURE *60°F* WIND *Light* CLOUDS ______

DATA FOR SECTIONS TESTED

BO: ______ EO: ______

L = *1.0* MILES

1X *360*	= *360*	*360*	= *360*
2X *317*	= *634*	*331*	= *662*
3X *186*	= *558*	*201*	= *603*
4X *78*	= *312*	*79*	= *316*
5X *32*	= *160*	*29*	= *145*
6X *14*	= *84*	*16*	= *96*
7X *4*	= *28*	*6*	= *42*
8X *1*	= *8*		*2224*
SUM	= *2144*	REPEAT ENTRIES	

SUM/L = ______

PSI (RIDE) = *3.16*

C + P = *–*

RUTTING = *–*

FINAL PSI = ______

NOTES : SPEED = *50 MPH*

Figure 5 shows some of the mechanical and electrical details of the road meter, and Figures 6, 7, 8, and 9 show the switch assembly, switch plate and roller contactor, visual indicators and control switches, and the electric counters.

The method of data reduction is straightforward. Each counter accumulates the number of impulses equal to, or greater than, its segment number. For example, a maximum road-car deviation of ½ in. will be recorded twice on the ⅛-, ¼-, and ⅜-in. counters and only once on the ½-in. counter because under most circumstances the roller will move away from the reference point and then return to it for each impulse. Each counter will therefore record the road-car deviation each time the roller passes over the individual segments of the switch plate up to the magnitude of the impulse. However, because the number of counters is limited to 8, the maximum deviation readable is 1 in., and all deviations greater than 1 in. will be recorded on the 1-in. counter and all other counters as the roller passes the segments.

Figure 10 shows a sample of a data record and its reduction. The summation of counts (Σ-counts) is obtained by reading off the number accumulated on each counter and then multiplying these numbers by the factor of 1, 2, 3, 4, 5, 6, 7, and 8. The total is the Σ-counts for a preestablished length of pavement, usually 1 mile. The PSI is derived from the Σ-counts that have been correlated with the CHLOE slope variance. The chart used to obtain these PSI values is shown in Figure 11.

PRESENT PERFORMANCE RATING

The Canadian Good Roads Association's PPR procedure was used to obtain a subjective ridability rating, for each test section, for correlation purposes with the roughness measurements from the instruments.

The PPR is the condition of the pavement at any time as determined by a rater, or a rating panel, who judges the present ability of the pavement to serve comfortably and conveniently, high-speed, high-volume, mixed automobile and truck traffic (1, 3).

The rating form is shown in Figure 12. The rater drives, or is driven, over the pavement section in a passenger vehicle at the assigned speed limit. On completion, the rater decides in which of the 5 categories he will rate the ridability. He then subdivides his rating in a given category by drawing a line upward or downward on the 2-unit scale within the category. The PPR value is then read off from the 0-to-10 rating scale.

The rater also answers the question, Is pavement of acceptable quality? by deciding whether the road ridability (in his opinion) is adequate for the class of traffic being served.

CORRELATION OF THE RESULTS

The results of all the measurements of the 50 test sections obtained with the 3 instruments are given in Tables 1 and 2. The PPR values and the PSI values derived from the PCA road meter measurements are also shown in these tables.

The results for rigid and flexible pavements have been separated because it was found that better correlations could be obtained in this way than from the combined data.

Regression analyses were carried out on all of the data, and the results of these analyses are given in Table 3 and shown in Figures 13 through 26.

The correlation coefficients (Table 3) are all of a high order, which shows that the performance of the instruments and the consistency of the raters' judgment were both good.

SURFACE TREATMENTS

A subsequent series of PPR and road meter evaluations were made in 1970 on 45 half-mile sections of surface-treated roads from the secondary and municipal road networks. The Wisconsin road meter used was installed in a 1970 Ford Sedan. The PPR was carried out in this same vehicle by the rater. The correlation shown in Figure 27 is of high order, and the regression equation is $PPR = 21.7239 - 5.3976 \log \Sigma$.

Correlations were made on the same surface-treated sections for the profilometer and the roughometer. No correlations were found for the PPR and the profilometer and the roughometer.

Table 1. Roughness measurements for flexible pavements.

Section Number	Highway	Profilometer (q)	Roughometer (R)	Subjective Rating (PPR)	Road Meter Σ-counts	Road Meter PSI
1	2	51.1	100.6	6.5	1,752	2.83
2	2	38.8	93.4	7.0	1,070	3.28
3	7	10.1	51.4	8.0	184	4.80
4	7	17.2	57.4	8.3	270	4.46
5	7	29.9	69.4	7.7	892	3.42
6	7	10.9	51.0	7.2	316	4.33
7	7	52.8	88.6	4.5	4,420	2.04
8	7	64.1	104.0	3.0	5,880	1.81
9	8	17.6	56.6	7.8	404	4.10
10	10	19.3	64.6	7.3	526	3.86
11	10	14.4	64.6	8.0	522	3.86
12	24	38.0	80.6	5.8	1,086	3.25
13	24	13.4	59.4	7.0	386	4.14
14	24	10.1	58.0	7.0	282	4.44
15	25	7.9	52.0	7.8	174	4.86
16	25	9.3	50.0	7.7	364	4.20
17	27	45.7	104.6	6.0	1,116	3.22
18	50	68.2	120.6	4.4	2,720	2.47
19	50	69.7	123.0	4.0	2,838	2.42
20	50	35.1	113.0	4.9	1,518	2.97
21	50	51.2	110.0	4.0	2,850	2.44
22	Cty.	52.8	126.6	4.2	3,280	2.32
23	Cty.	89.9	161.4	3.2	3,568	2.22
24	48	12.7	58.0	8.6	470	3.96
25	90	15.9	57.4	7.9	396	4.12

Table 2. Roughness measurements for rigid pavements.

Section Number	Highway	Profilometer (q)	Roughometer (R)	Subjective Rating (PPR)	Road Meter Σ-counts	Road Meter PSI
1	401	55.3	92.0	5.2	1,204	3.65
2	401	43.7	86.0	5.9	942	3.83
3	401	42.0	70.0	6.9	714	4.17
4	401	55.5	90.0	5.8	1,232	3.64
5	401	63.9	102.0	5.2	936	3.83
6	401	52.3	80.0	7.3	538	4.30
7	401	41.4	84.0	7.3	792	3.99
8	401	32.8	86.0	8.0	652	4.15
9	401	24.0	72.0	7.6	546	4.30
10	401	29.5	64.0	7.8	416	4.52
11	401	21.9	58.0	8.3	388	4.58
12	401	29.7	68.0	7.7	472	4.42
13	401	27.2	74.0	8.0	442	4.48
14	401	29.7	70.0	8.0	372	4.60
15	401	25.3	76.0	7.5	492	4.37
16	401	32.6	66.0	7.7	746	4.03
17	401	89.8	100.0	4.3	1,342	3.57
18	401	81.2	100.0	5.0	1,166	3.68
19	401	85.2	98.0	4.4	1,400	3.54
20	401	79.8	102.0	4.1	970	3.83
21	401	103.4	104.0	3.8	1,936	3.28
22	401	73.1	98.0	4.2	1,328	3.59
23	401	13.0	54.0	8.7	308	4.77
24	401	16.2	60.0	8.8	338	4.70
25	401	14.0	58.0	8.5	290	4.81

Table 3. Regression analysis of results.

Type of Pavement	Independent Variable	Dependent Variable	Figure Number	Regression Formula	Correlation Coefficient
Rigid	Profilometer, q	Roughometer, R	13	$\log R = 0.3241 \log q + 1.3793$	0.9313
	Profilometer, q	Road meter, Σ-counts	14	$\log \Sigma = 0.8516 \log q + 1.4810$	0.9286
	Roughometer, R	Road meter, Σ-counts	15	$\log \Sigma = 2.3890 \log R - 1.6907$	0.9037
	Profilometer, q	PPR	16	$PPR = 16.2037 - 5.9878 \log q$	0.9341
	Roughometer, R	PPR	17	$PPR = 38.1211 - 16.5961 \log R$	0.9012
	Road meter, Σ-counts	PPR	18	$PPR = 25.0720 - 6.4873 \log \Sigma$	0.9276
	PPR	PSI (derived from Σ-counts)	19	$PSI_{(D)} = 0.2484\ PPR + 2.4555$	0.9276
Flexible	Profilometer, q	Roughometer, R	20	$\log R = 0.4496 \log q + 1.2581$	0.9566
	Profilometer, q	Road meter, Σ-counts	21	$\log \Sigma = 1.3265 \log q + 1.0671$	0.9461
	Roughometer, R	Road meter, Σ-counts	22	$\log \Sigma = 2.7160 \log R - 2.1929$	0.9068
	Profilometer, q	PPR	23	$PPR = 12.7288 - 4.5291 \log q$	0.8519
	Roughometer, R	PPR	24	$PPR = 25.2519 - 10.0093 \log R$	0.8813
	Road meter, Σ-counts	PPR	25	$PPR = 16.4401 - 3.4377 \log \Sigma$	0.9066
	PPR	PSI (derived from Σ-counts)	26	$PSI_{(D)} = 0.4733\ PPR + 0.4454$	0.9030

Figure 11. Relation of AASHO PSI to road meter Σ-counts.

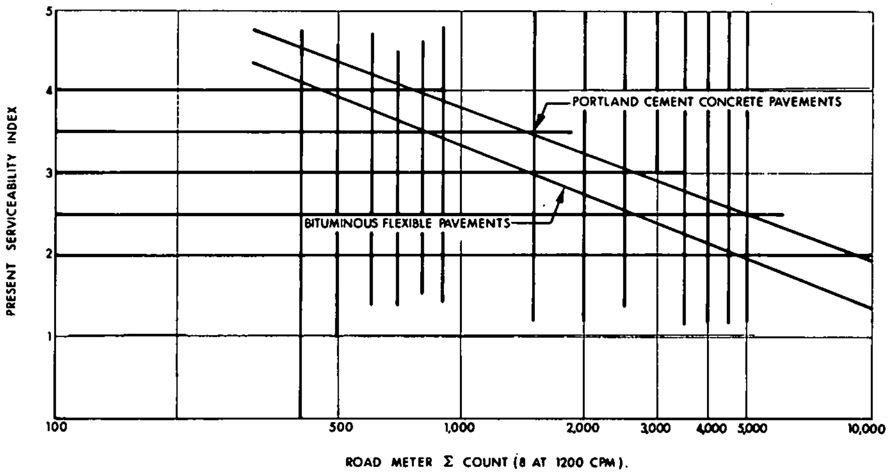


Figure 12. PPR form.

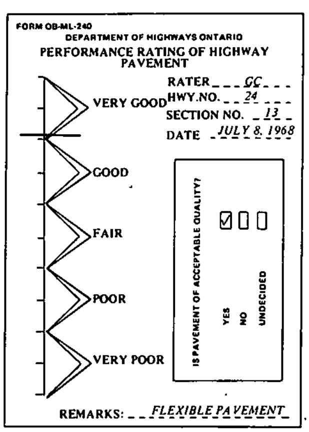

FORM OB-ML-240
DEPARTMENT OF HIGHWAYS ONTARIO
PERFORMANCE RATING OF HIGHWAY PAVEMENT
RATER GC
HWY.NO. 24
SECTION NO. 13
DATE JULY 8, 1968
VERY GOOD
GOOD
FAIR
POOR
VERY POOR
IS PAVEMENT OF ACCEPTABLE QUALITY?
YES
NO
UNDECIDED
REMARKS: FLEXIBLE PAVEMENT

Figure 13. Correlation of profilometer and roughometer for rigid pavements.

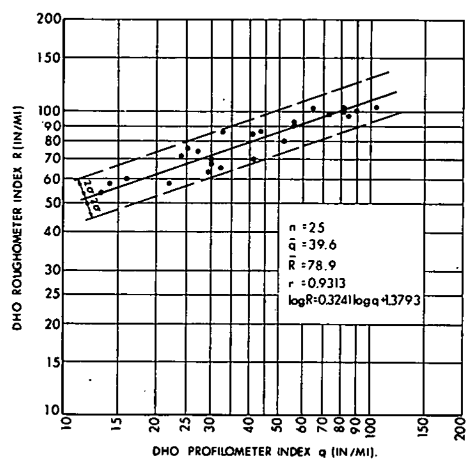


Figure 14. Correlation of profilometer and road meter for rigid pavements.

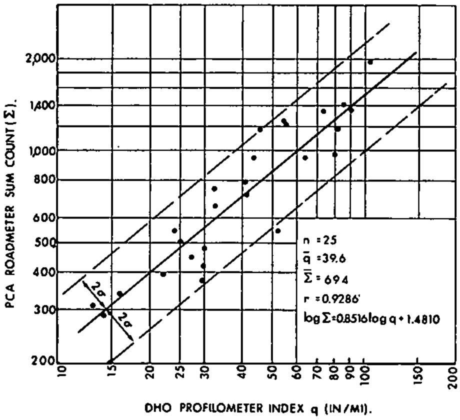


Figure 15. Correlation of roughometer and road meter for concrete pavements.

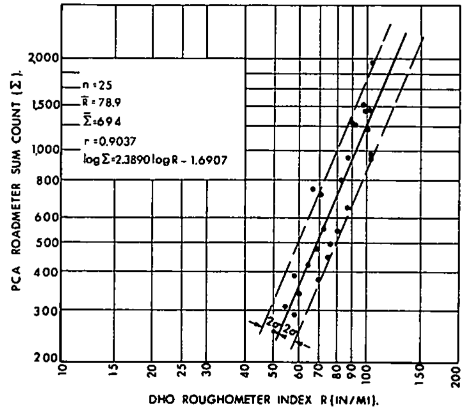


Figure 16. Correlation of profilometer index q and PPR for rigid pavements.

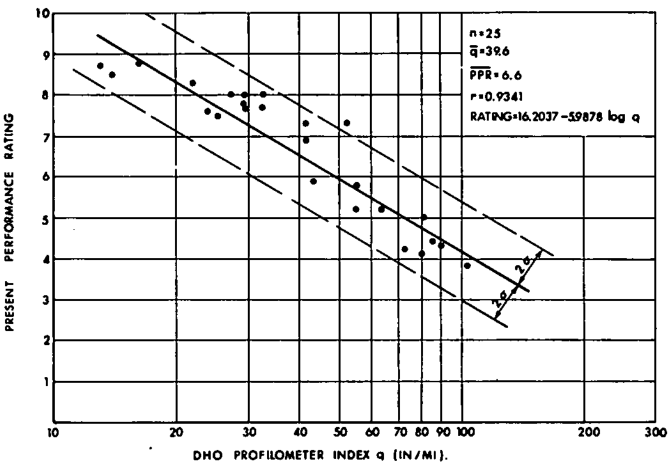


Figure 17. Correlation of roughometer index R and PPR for rigid pavements.

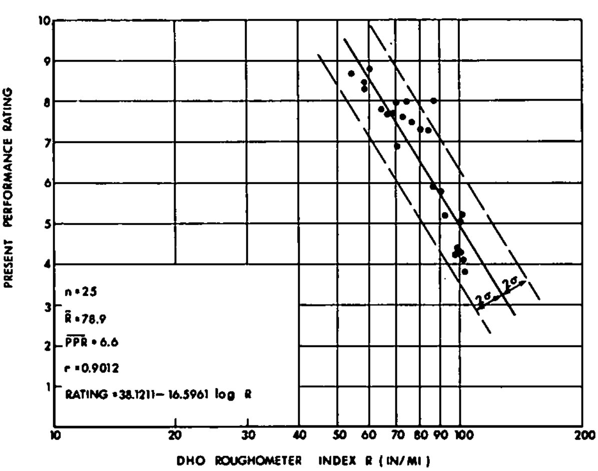


Figure 18. Correlation of road meter Σ-counts and PPR for concrete pavements.

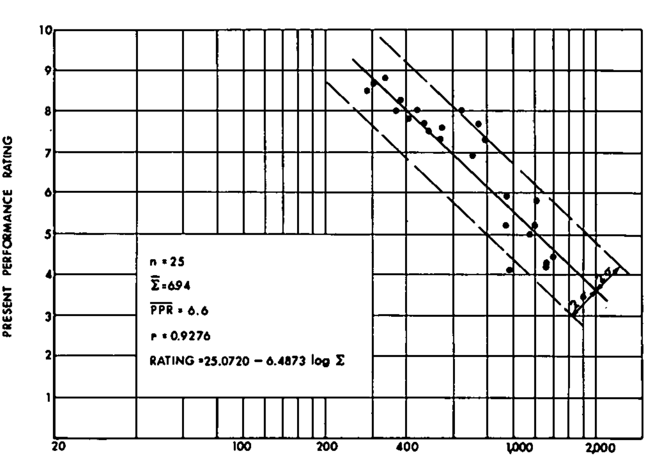


Figure 19. Correlation of PPR and PSI based on road meter Σ-counts for rigid pavements.

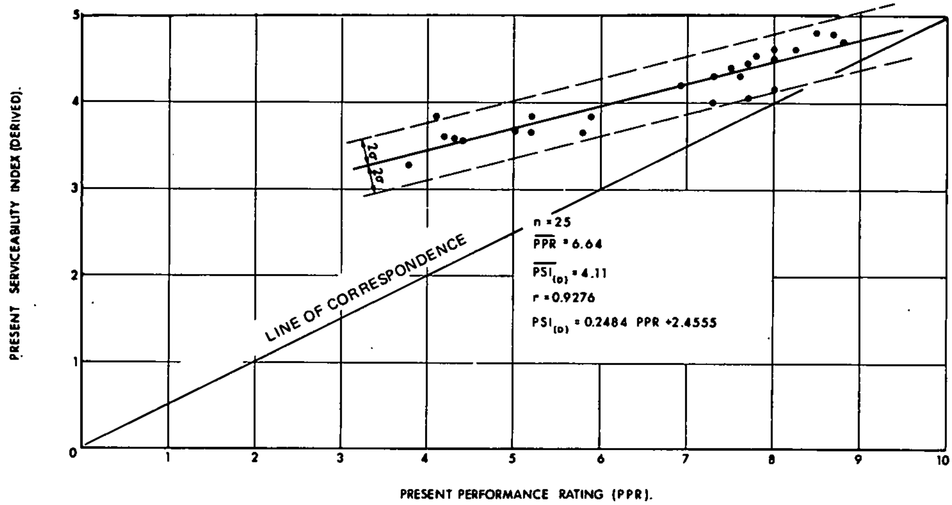


Figure 20. Correlation of profilometer and roughometer for flexible pavements.

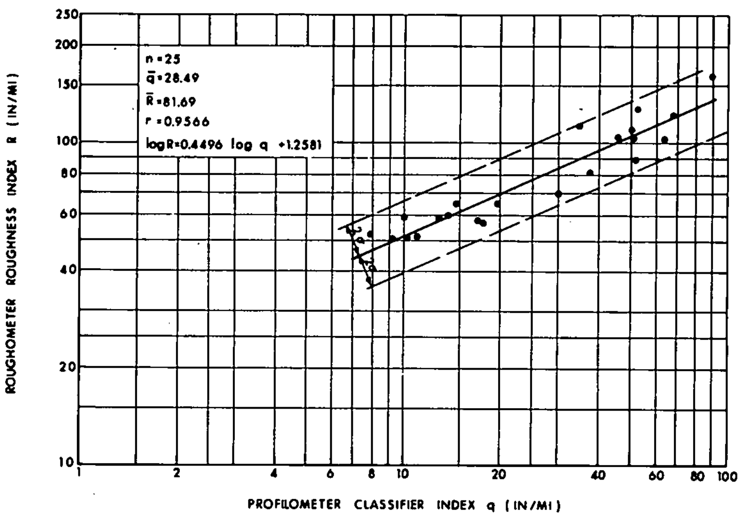


Figure 21. Correlation of profilometer and road meter for flexible pavements.

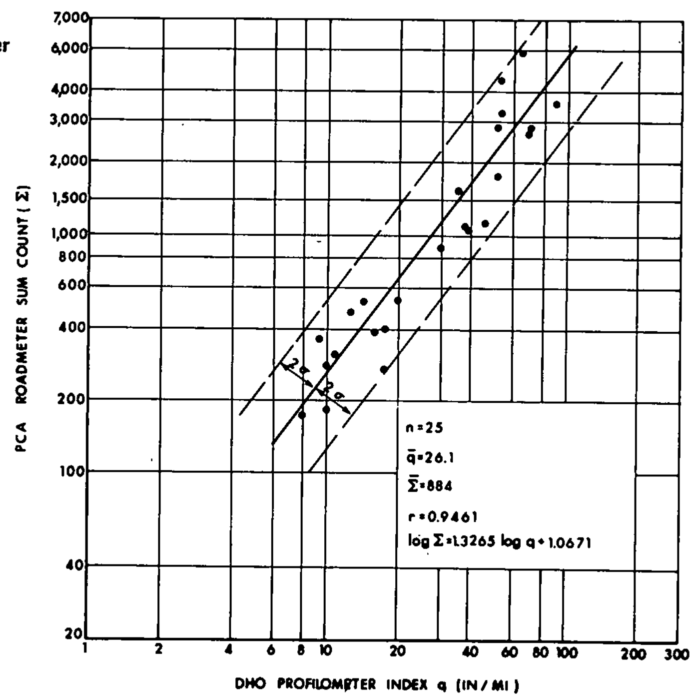


Figure 22. Correlation of roughometer and road meter for flexible pavements.

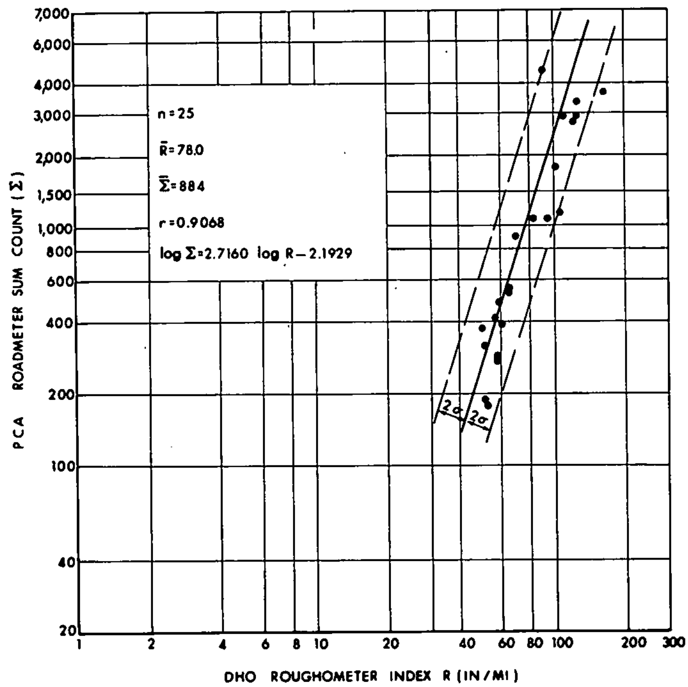


Figure 23. Correlation of profilometer index q and PPR for flexible pavements.

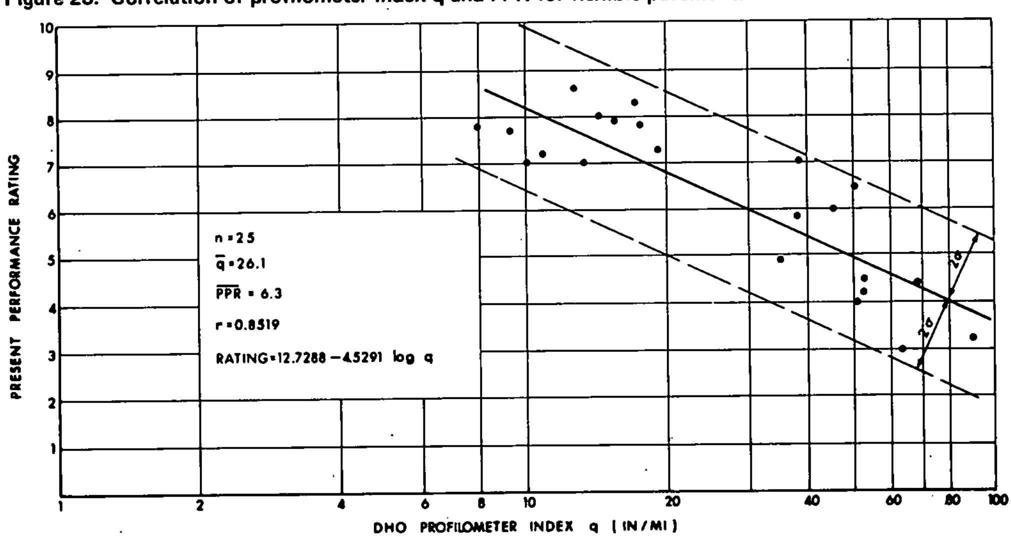


Figure 24. Correlation of roughometer index R and PPR for flexible pavements.

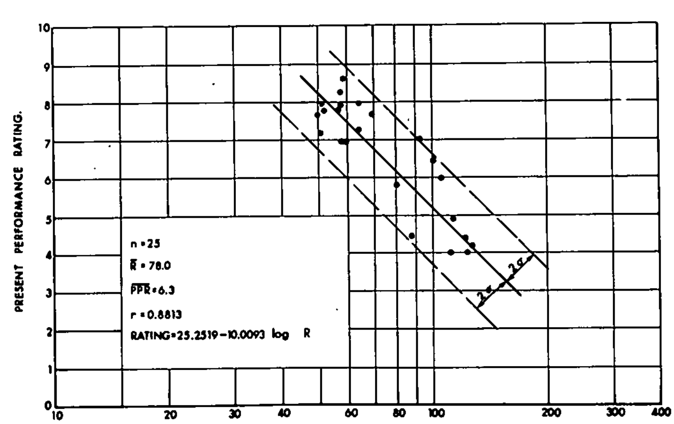


Figure 25. Correlation of road meter Σ-counts and PPR for flexible pavements.

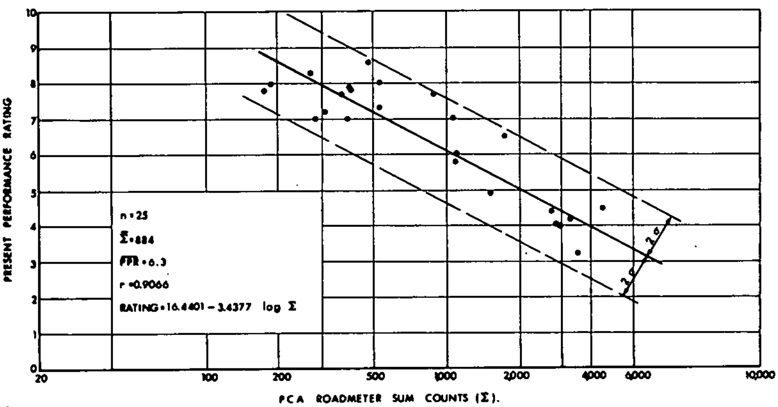


Figure 26. Correlation of PPR and PSI based on road meter Σ-counts for flexible pavements.

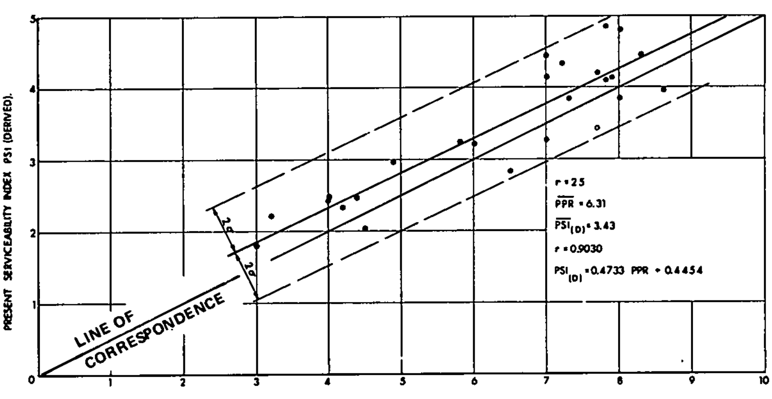
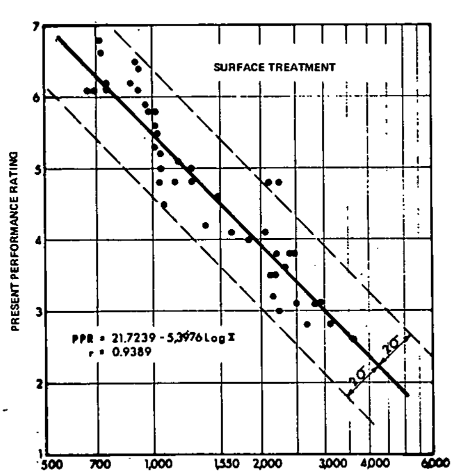


Figure 27. Correlation of PPR and road meter Σ-counts for surface-treated pavements.



IMPORTANT POINTS IN OPERATING THE PCA ROAD METER

The PCA road meter must be maintained in proper order at all times so that good repeatability is ensured. To maintain it in proper condition, the designer suggests a number of important points to observe in its operation in addition to the normal maintenance procedures.

Condition of Automobile

To achieve repeatable sum-count measurements, the automobile in which the road meter is used must be in good mechanical condition, particularly the suspension components. Shock absorbers must be removed every 10,000 miles of operation and inspected for wear along the piston sides; the working action must be compared with new shock absorbers.

Good front- and rear-wheel balance and front-end alignment must be maintained because improper alignment results in uneven tire wear, which will affect meter counts.

Tire pressures must be maintained at 24 to 26 psi (static pressure when cold); if the vehicle is equipped with rear snow tires, they should be kept between 22 and 24 psi.

The gasoline tank must be at least one-quarter full at all times. No extra weight must be carried by the vehicle, nor should the weight be redistributed after calibration.

Operating Speed

The best results are obtained with the road meter when the operating speed is maintained at 48 to 52 mph; if the speed falls below, or exceeds, these limits, correction should be made quickly—but in a manner that will not cause an increased count rate due to sudden acceleration or deceleration.

Special Conditions

The road meter should be switched off just before crossing railroad tracks to avoid damage from sudden jarring of the instrument.

The road meter should be operated only when the air temperature is above 10 F because the characteristics of the automobile's suspension system will likely change at lower temperatures.

To avoid unnecessary jarring, the road meter should be disconnected by removing the steel cable from the roller contactor and carefully sliding the contactor to the "switch stop" position when traveling between projects that are 20 or more miles apart.

Zero Balance

A valid Σ-counts of vertical motion is achieved only when the road meter is properly balanced to produce minimal deviation when the car is stopped on the pavement. Changes in crossfall, superelevations, and even pavement rutting affect the zero position of the vernier while the car is in motion; consequently the results obtained are an average of plus or minus variations from the actual zero position on any point in the test section.

It is advisable to check the road meter operation periodically on a known stretch of roadway whose roughness does not change extremely through seasonal or normal deterioration of the roadbed. An independent means of assessing the road meter's performance with the profilometer or roughometer is also advisable. It is suggested that long, exposed concrete bridge decks offer the best areas for this periodic check.

CONCLUSIONS

This comparative study of the 3 roughness measuring instruments has resulted in the important finding that little difference exists among the 3 instruments in predicting serviceability of a pavement. Therefore, the choice of instrument to use on any particular project depends on the nature of the data desired, instrument and operating costs, ease of data reduction, and efficiency of operation.

Of similar importance is the finding that the PCA road meter has a number of advantages over the other 2 instruments, which makes it more desirable for certain types of roughness measuring applications such as mass inventory of the road roughness of existing highway systems and seasonal serviceability surveys. The instrument is advantageous in many respects. Because of its simplicity, initial costs are low; the instrument can be manufactured and installed at a cost of less than $1,000, and the only other equipment required is a standard passenger car. No special outfitting of the carrier automobile, other than the mounting of the unit, is necessary. The data obtained are immediately usable because no calculations are involved. PSI's are derived directly from a prepared chart by using only the total sum counts obtained for each pavement section. Its efficiency is good because of the high operating speed (50 mph) at which it can be used. An additional benefit from the high operating speed is the relative safety with which the test vehicle can merge with normal traffic flow.

However, if large-scale use of the PCA road meter is envisaged because of these advantages, it is essential that the test vehicle be kept in good operating condition at all times and the specified standard speed be adhered to. It is also important to make frequent check runs on standard pavement sections and to use an independent method of rating the standard pavement section with a profilometer or roughometer.

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4. Scott, W. J. O. Roads and Their Riding Qualities. The Institute of Civil Engineers, 1947.