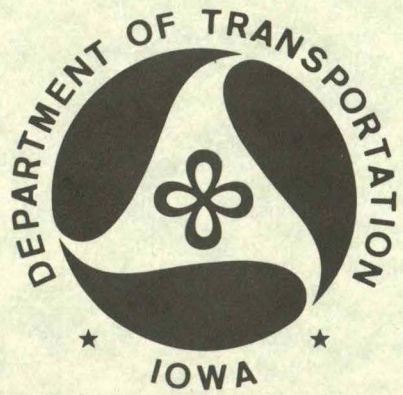
1980 PAVEMENT SMOOTHNESS MEASUREMENTS



HIGHWAY DIVISION
OFFICE OF MATERIALS

FEBRUARY 1981

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1980 PAVEMENT SMOOTHNESS MEASUREMENTS

By

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Highway Division

Office of Materials

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INTRODUCTION

The Special Investigations Section of the Office of Materials tested approximately seven hundred and seventy-six (776) miles of new paving and resurfacing for smoothness in 1980 on one hundred and eighty-two (182) individual projects. The Bureau of Public Roads (BPR) Roughometer and Iowa-Johannsen-Kirk (IJK) Roadmeter were used for 1980 smoothness testing, and test results are tabulated and summarized in this report.

PAVEMENT SMOOTHNESS MEASURING EQUIPMENT

Bureau of Public Roads (BPR) Roughometer:

The Roughometer was developed by the Bureau of Public Roads in 1941, and the Iowa State Highway Commission built its first Roughometer according to Bureau of Public Roads plans in 1953. The BPR Roughometer consists of a single-wheeled trailer towed behind a test van at 20 m.p.h. An integrator accumulates vertical movement in one direction only of the test wheel axle relative to the BPR trailer frame. When one inch of movement is accumulated, the integrator sends an electrical impulse to counters in the test van. The resulting Road Roughness Index (R.R.I.) is reported in Inches/Mile; lower BPR Roughometer numbers indicate smoother paving or resurfacing.

Figure 1
BPR Roughometer
Test Van

The integrator on the BPR Roughometer detects and accumulates short wavelength bumps up to 14 feet and minor surface deviations such as marks caused by screed settlement, straightedges, mops, vibratory rollers, stop-go movement of astro-turf drags, etc. The effect of longer wavelength bumps from 14 feet to 18 feet may be exaggerated, and long wavelength bumps over 22 feet are relatively ignored by the BPR Roughometer at 20 m.p.h. The BPR Roughometer is repeatable, rugged and reliable, but does not detect long wavelength bumps and can be affected by excessively deep or coarse transverse grooving on p.c.c. paving and sprinkle treatment on a.c. resurfacing.

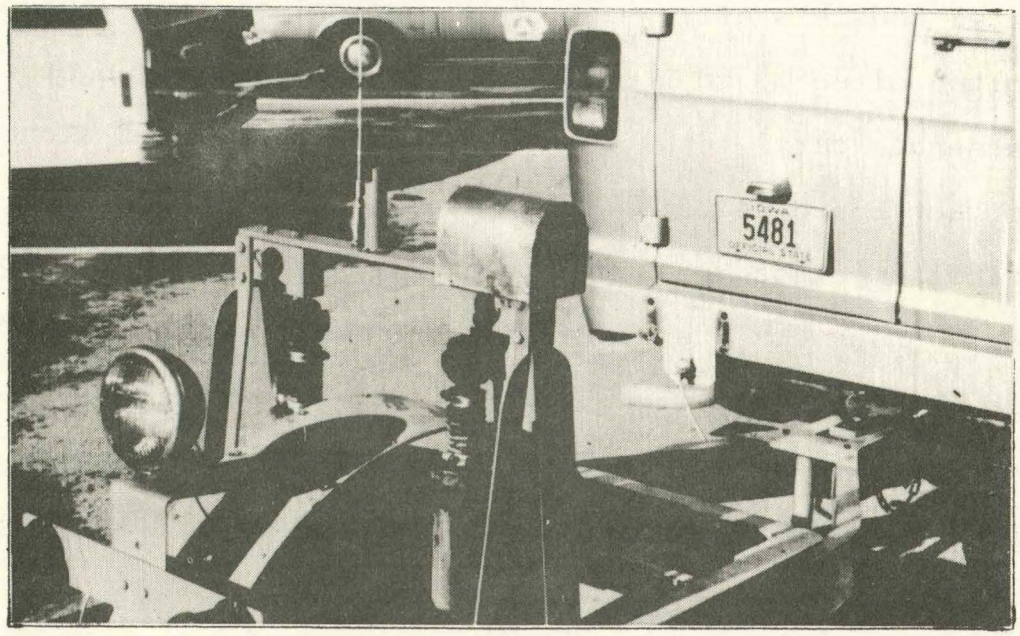


Figure 2

Closeup of BPR Roughometer

The Materials Department of the Iowa State Highway Commission began pavement smoothness testing with the BPR Roughometer in 1955 and performed this inventory of new construction yearly until 1972 when it was discontinued. Pavement smoothness testing of new construction with the BPR Roughometer resumed in 1978 and has been conducted yearly to date.

Iowa-Johannsen-Kirk (IJK) Roadmeter:

The IJK Roadmeter was developed in the Iowa State Highway Commission Materials Laboratory in 1971. It operates at 50 m.p.h. and replaces the old PCA type roadmeter which was sensitive to wind. The IJK Roadmeter consists of an electro-mechanical sensing device bolted directly to the differential housing of an ordinary passenger car. A cantilevered sprung mass moves along a contact board as bumps are encountered and sends electrical impulses to counter banks in the passenger compartment. Counters are numbered from one to ten and record the frequency and magnitude of bumps. The resulting sum/length value is converted to a Present Serviceability Index (PSI) for reporting purposes. Higher PSI's indicate smoother paving.

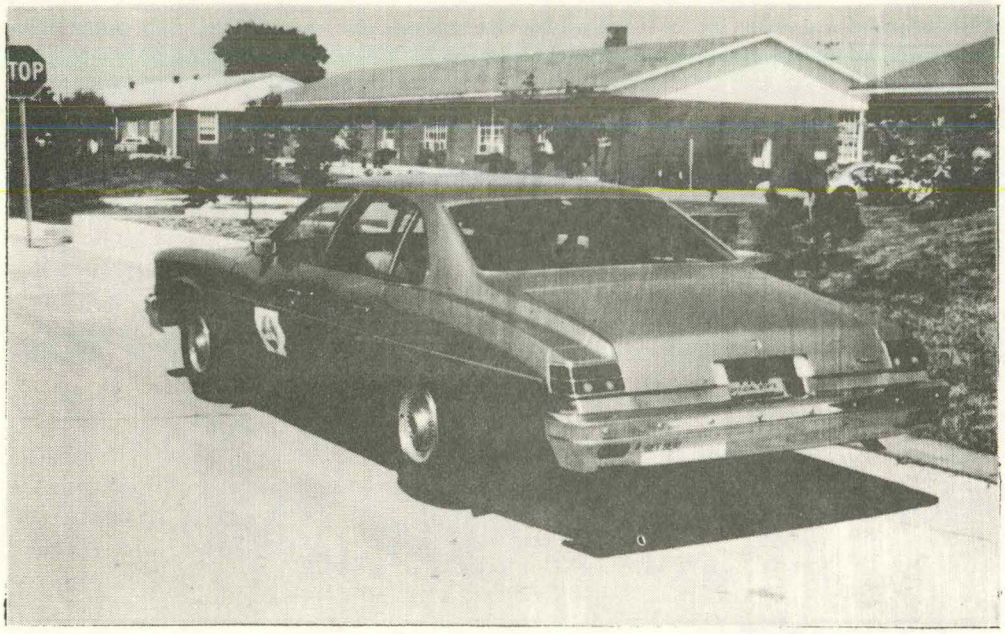


Figure 3

IJK Roadmeter Car

The IJK Roadmeter is more sensitive to long wavelength bumps than to short wavelength bumps and minor surface deviations. IJK Roadmeter data is fast and economical to obtain and simulates what the travelling public feels at 50 m.p.h. The problem with roadmeters has historically been poor repeatability. Trunk access to check the oil level in the IJK Roadmeter dampening mechanism several times daily has improved repeatability since 1979 to about $\pm$ 2% ($\pm$ 0.08 PSI) throughout the entire testing season.

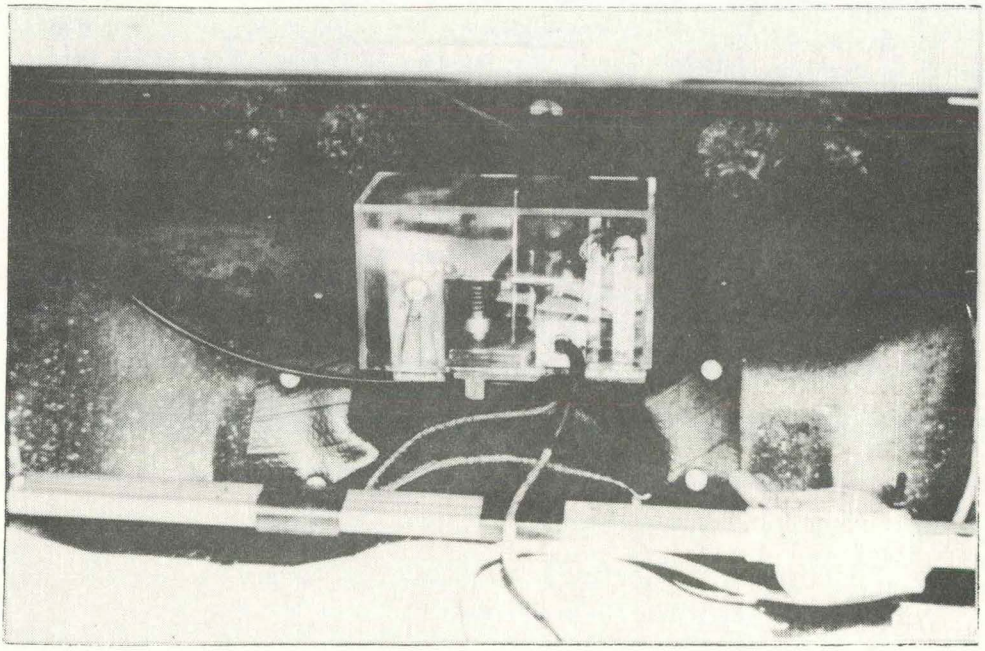


Figure 4

IJK Roadmeter Sensing Device

The IJK Roadmeter will read about 0.45 PSI lower on a.c. paving and resurfacing than on p.c.c. paving of comparable smoothness due to equations developed during the AASHO Road Test in the late 1950's.

The IJK Roadmeter is presently used to determine the Present Serviceability Index (PSI) of the primary road system on a three-year cycle and to test a.c. and p.c.c. pavement award candidates.

California Cox 25' Profilograph (Profilometer):

The Cox 25' Profilometer consists of a lightweight aluminum truss supported at the end points by six (6) averaging wheels and pushed at walking speed. A bicycle wheel measures deviations from a 25' reference plane and is connected to a graphical recording box. The resulting 25' Profilometer trace has a scale of 1 inch = 25 feet horizontally, and 1 inch = 1 inch or full scale vertically.

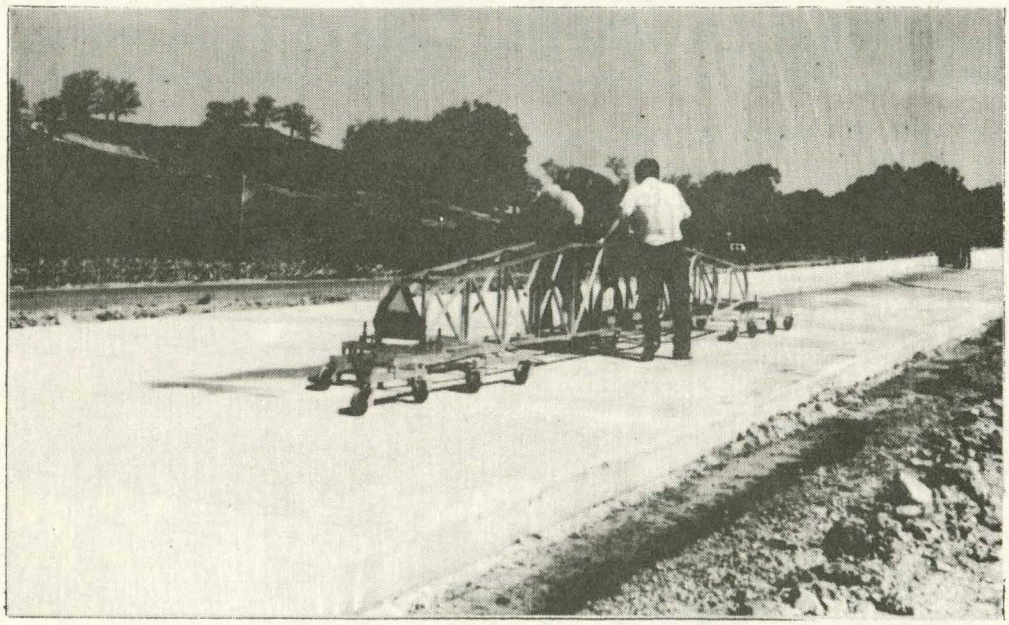


Figure 5

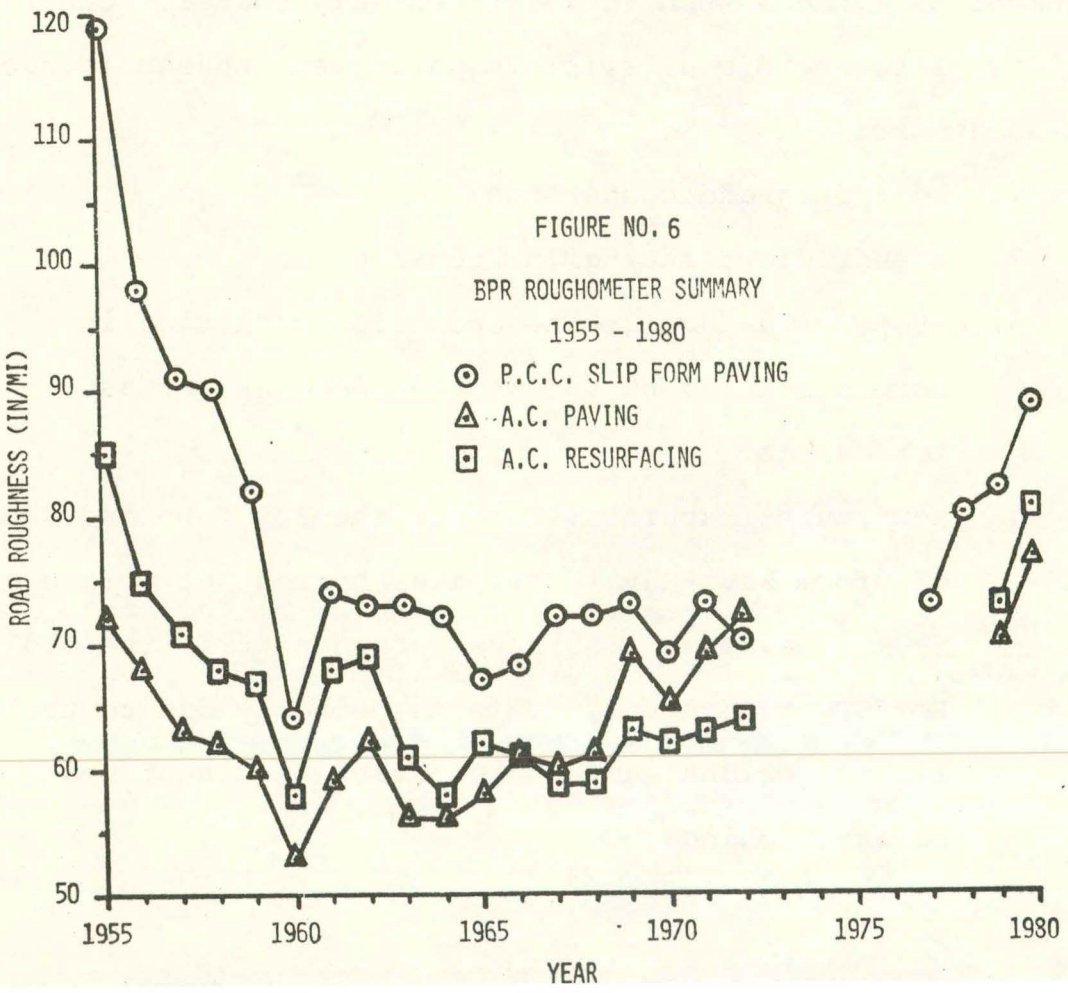
Cox 25' Profilometer

Minor deviations less than 0.20" are "blanked out" on the 25' Profilometer trace and discounted. 25' Profilometer results are reported in Inches/Mile; lower 25' Profilometer readings indicate smoother paving.

The 25' Profilometer is used to test new p.c.c. paving for smoothness the day after it is poured and to test new bridge deck overlays. The graphical output of the 25' Profilometer is good to use diagnostically on short sections of pavement, but is rather time-consuming and costly to obtain in large quantities.

1980 PAVEMENT SMOOTHNESS COMPARED TO PAST YEARS

Figure #6 illustrates pavement smoothness trends from 1955 to 1980 as measured by the BPR Roughometer for new portland cement concrete slipform paving, asphaltic concrete paving, and asphaltic concrete resurfacing. Portland cement concrete slipform paving has increased 19 inches/mile, asphaltic concrete paving has increased 5 inches/mile, and asphaltic concrete resurfacing has increased 17 inches/mile, respectively, since 1972. In addition, p.c.c. slipform paving, a.c. paving and a.c. resurfacing have all increased approximately 8 inches/mile in roughness between 1979 and 1980.



Increased roughness on new portland cement concrete slipform paving and primary asphaltic concrete resurfacing may be due in part to transverse grooving and sprinkle treatment, respectively. These texturing methods are specified for improved wet weather pavement frictional qualities. Although a study of 1977 and 1978 p.c.c. paving projects with and without transverse grooving indicated that transverse grooving has no apparent effect on pavement smoothness, increased roughness on new p.c.c. slipform paving in recent years has corresponded chronologically with the introduction of transverse grooving. One 1977 transversely grooved paving project tested as low as 46 inches/mile, and while the uniform texture of transverse grooving need not cause a problem, it can affect pavement smoothness when it is excessively coarse. Other factors affecting p.c.c. slipform paving smoothness in recent years may include:

1. Poor subgrade conditions.
2. Insufficient stringline tension.
3. Stop-go paving machine operation resulting in screed settlement and stop-go movement of astro-turf drags.
4. New paving machines, such as the Rex Town and Country and slipform Pave-Saver Citipave, having not worked as well from a pavement smoothness standpoint as the old Rex STR-type paver. This is probably due to the lighter weight and shorter track length of new paving machines.

5. Placing new p.c.c. paving over old a.c. pavement or over old broken concrete without using a track line cut by CMI fine-grading machine.

Sprinkle-treated primary rural asphaltic concrete resurfacing projects have averaged approximately 15 inches/mile rougher in 1979 and 1980 than nonsprinkle-treated projects. This is due to the random chip placement which is detected and integrated by the BPR Roughometer. Other factors affecting a.c. paving and resurfacing smoothness in recent years may include:

1. Vibratory roller use and especially improper use concerning frequency, amplitude and forward speed.
2. Increased density specification implemented in 1980 resulting in over-compactive effort and vibration at existing faulted and unstable joints.
3. New paving machines having not worked as well from a pavement smoothness standpoint as older machines, probably due to the type of screed vibration, oversensitivity of automatic paver controls, and nonsynchronization of asphaltic concrete delivery to the paver screed and forward paving speed.
4. Use and maintenance of the Bristowe chip spreader. This is the only chip spreader currently available to the industry, and it has certain smoothness limitations.

IOWA-JOHANNSEN-KIRK (IJK) ROADMETER COMPARED TO BUREAU OF PUBLIC ROADS (BPR) ROUGHOMETER ON 1980 PAVING AND RESURFACING

The relationship between the IJK Roadmeter and BPR Roughometer on 1980 p.c.c. slipform paving, 1980 a.c. paving, and 1980 a.c. resurfacing is illustrated in Figure Number 7, Figure Number 8, and Figure Number 9, respectively. The correlation coefficients were generally poor since these machines work on different operating principles, test at different operating speeds, and are sensitive to different types of roughness. Projects with the best pavement rideability are located at the lower right-hand corner of these figures.

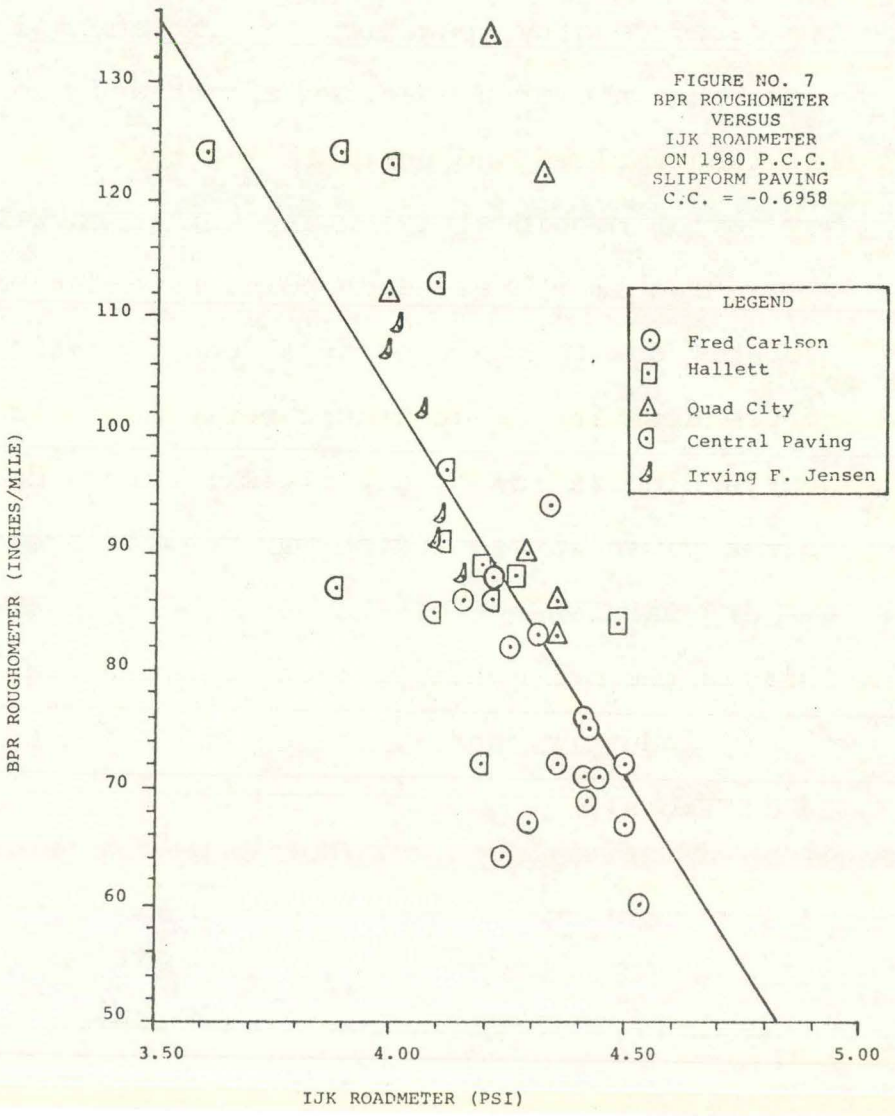
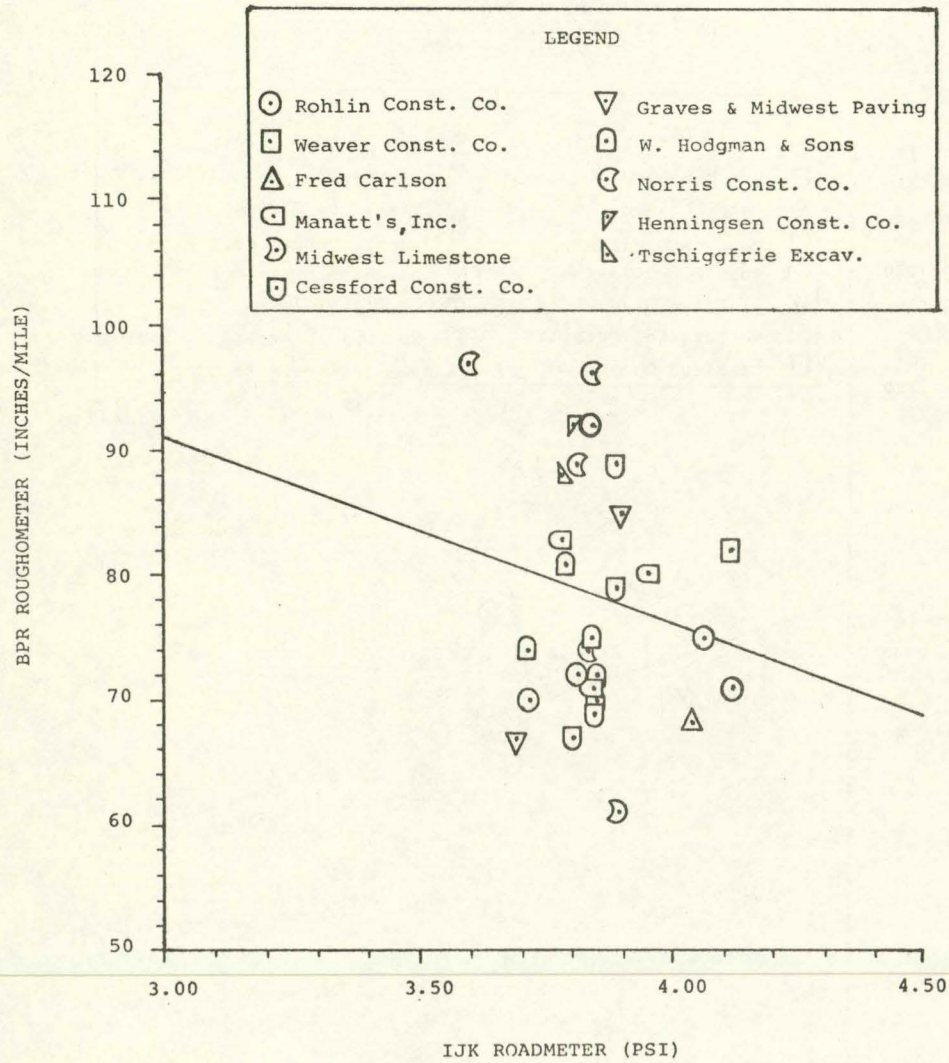


FIGURE NO. 7
BPR ROUGHOMETER
VERSUS
IJK ROADMETER
ON 1980 P.C.C.
SLIPFORM PAVING
C.C. = -0.6958

Since the IJK Roadmeter works on an inertia principle, operates at 50 m.p.h. and is sensitive to long wavelength bumps such as "dips" and "swells," it provides a better smoothness indication as felt by the travelling public than the BPR Roughometer, which operates at 20 m.p.h. and is sensitive to short wavelength bumps or "chatter."

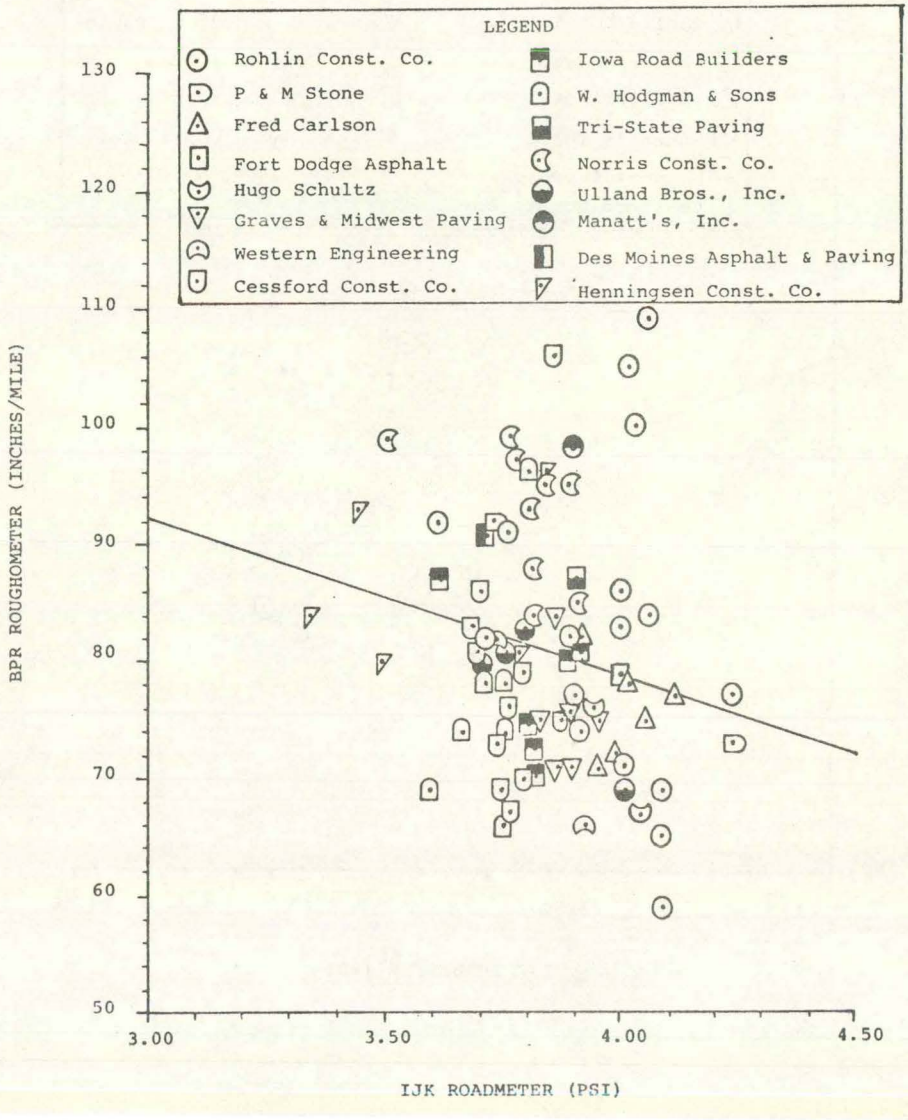
FIGURE NO. 8
BPR ROUGHOMETER VERSUS IJK ROADMETER
ON 1980 ASPHALTIC CONCRETE PAVING
C.C. = -0.1839



IJK Roadmeter testing costs about $6 per two-lane mile, requires two people and utilizes an ordinary passenger car. BPR Roughometer testing costs about $40 per two-lane mile, requires four people and utilizes a test van and two safety vehicles.

The IJK Roadmeter may be substituted for the BPR Roughometer in future years to test new construction for pavement smoothness. This will provide an initial PSI for pavement management purposes and also result in a substantial savings to the Iowa DOT in testing costs.

FIGURE NO. 9
BPR ROUGHOMETER VERSUS IJK ROADMETER
ON 1980 ASPHALTIC CONCRETE RESURFACING
C.C. = -0.2095



Projects and contractors are listed in descending order in the following tabulations as ranked by the IJK Roadmeter. When projects or contractors have identical smoothness as measured by the IJK Roadmeter, they are ranked by the BPR Roughometer.

All projects could not be tested with the IJK Roadmeter due to speed zones or their extremely short lengths. These projects were inserted in tabulations by inspection based on BPR Roughometer readings.

AVERAGE PAVEMENT SMOOTHNESS BY CLASS AND TYPE OF CONSTRUCTION

Class of Construction	Type of Pavement	No. of Projects	Length (Miles)	BPR Roughometer Wtd. Avg. R.R.I. (In/Mi)	IJK Roadmeter Wtd. Avg. (PSI)
Primary Rural	P.C.C. Slip Form	8	51.95	99	4.24
Primary Urban & Urban	P.C.C. Slip Form	4	4.91	126	-
Primary Urban & Urban	P.C.C. Fixed Form	4	4.12	108	-
Secondary	P.C.C. Slip Form	34	141.56	86	4.24
Primary Rural	A.C. Paving	6	23.57	70	3.84
Primary Rural	A.C. Re-surfacing	13	102.55	80	3.86
Primary Urban & Urban	A.C. Re-surfacing	6	7.81	97	-
Secondary	A.C. Paving	30	88.25	79	3.84
Secondary	A.C. Re-surfacing	77	351.31	81	3.85
		182	776.03		

P.C.C. - Portland Cement Concrete

A.C. - Asphaltic Concrete

AVERAGE PAVEMENT SMOOTHNESS BY CONTRACTOR FOR EACH CLASS AND TYPE OF CONSTRUCTION

PRIMARY RURAL PORTLAND CEMENT CONCRETE SLIPFORM PAVING

Contractor	Number of Projects	Length (Miles)	BPR Roughometer Wtd. Avg. R.R.I. (In/Mi)	IJK Roadmeter Wtd. Avg. (PSI)
Fred Carlson	2	10.96	71	4.40
Hallett	2	14.91	88	4.24
Quad City	3	17.28	125	4.20
Central Paving	1	8.80	98	4.12
	8	51.95	99	4.24

PRIMARY URBAN & URBAN PORTLAND CEMENT CONCRETE SLIPFORM PAVING

Irving F. Jensen	1	2.12	107	-
Hallett	1	0.89	132	-
Peterson	1	1.44	138	-
McAninch Corp. Iowa Road Builders	1	0.46	166	-
	4	4.91	126	

PRIMARY URBAN & URBAN PORTLAND CEMENT CONCRETE FIXED FORM PAVING

Metro Pavers, Inc.	1	1.57	95	-
Cedar Valley	1	1.26	104	-
Iowa Road Builders	1	0.81	119	-
Manatt-Carter	1	0.48	141	-
	4	4.12	108	

SECONDARY PORTLAND CEMENT CONCRETE SLIPFORM PAVING

Contractor	Number of Projects	Length (Miles)	BPR Roughometer Wtd. Avg. R.R.I. (In/Mi)	IJK Roadmeter Wtd. Avg. (PSI)
Hallett	1	4.45	84	4.48
Fred Carlson	14	58.89	77	4.35
Quad City	3	21.88	87	4.32
Central Paving	10	31.58	93	4.07
Irving F. Jensen	6	24.76	99	4.07
	34	141.56	86	4.24

PRIMARY RURAL ASPHALTIC CONCRETE PAVING

Rohlin	2	1.71	72	4.10
Manatt's, Inc.	1	8.89	71	3.84
Cessford	2	12.07	68	3.82
Norris	1	0.90	97	3.60
	6	23.57	70	3.84

PRIMARY RURAL ASPHALTIC CONCRETE RESURFACING

Contractor	Number of Projects	Length (Miles)	BPR Roughometer Wtd. Avg. R.R.I. (In/Mi)	IJK Roadmeter Wtd. Avg. (PSI)
Rohlin	1	8.72	59	4.09
Graves Const.	1	8.93	75	3.95
Manatt's, Inc.	1	1.08	98	3.88
Western Engineering	2	17.91	70	3.87
Iowa Road Builders	2	7.61	78	3.87
Cessford	1	4.25	106	3.85
Midwest Paving	1	16.95	75	3.83
Norris	2	13.47	95	3.83
Henningsen	2	23.63	87	3.77
	13	102.55	80	3.86

PRIMARY URBAN & URBAN ASPHALTIC CONCRETE RESURFACING

Des Moines Asphalt & Paving Company	2	2.16	86	-
Everds Bros.	1	2.07	97	-
Weaver Const.	1	2.07	98	-
Norris	1	0.71	112	-
Iowa Road Builders	1	0.80	113	-
	6	7.81	97	

SECONDARY ASPHALTIC CONCRETE PAVING

Contractor	Number of Projects	Length (Miles)	BPR Roughometer Wtd. Avg. R.R.I. (In/Mi)	IJK Roadmeter Wtd. Avg. (PSI)
Weaver Const.	1	2.04	82	4.12
Fred Carlson	1	4.07	68	4.04
Midwest Limestone	1	3.94	61	3.89
Des Moines Asphalt & Paving Co.	1	3.40	78	-
Cessford	4	5.77	96	3.88
Graves & Midwest Paving	3	7.52	83	3.87
Manatt's, Inc.	2	6.05	82	3.86
Norris	4	17.24	83	3.83
Henningsen	1	3.05	92	3.82
W. Hodgman & Sons	6	19.92	74	3.81
Tschiggfrie Excav.	1	3.27	88	3.78
Rohlin	4	10.62	73	3.75
Iowa Road Builders	1	1.36	104	-
	30	88.25	79	3.84

SECONDARY ASPHALTIC CONCRETE RESURFACING

Contractor	Number of Projects	Length (Miles)	BPR Roughometer Wtd. Avg. R.R.I. (In/Mi)	IJK Roadmeter Wtd. Avg. (PSI)
Fred Carlson	7	41.98	76	4.02
Hugo Schultz, Inc.	2	9.35	70	4.00
Fort Dodge Asphalt	4	7.69	79	4.00
P & M Stone	2	11.48	82	4.00
Rohlin	16	87.35	85	3.94
Tri-State Paving	1	1.55	87	3.90
Graves & Midwest Paving	4	27.64	75	3.88
Ulland Bros., Inc.	4	12.03	75	3.88
Cessford	12	48.42	75	3.76
Iowa Road Builders	4	6.29	80	3.74
W. Hodgman & Sons	7	36.19	78	3.73
Des Moines Asphalt & Paving	3	8.91	88	3.72
Norris	7	37.64	94	3.72
Henningsen	4	14.79	87	3.42
	77	351.31	81	3.85

PAVEMENT SMOOTHNESS BY INDIVIDUAL PROJECT FOR EACH CLASS AND TYPE OF CONSTRUCTION

PRIMARY RURAL PORTLAND CEMENT CONCRETE SLIPFORM PAVING

Project No.	County	Length (Miles)	Contractor	BPR Roughometer R.R.I. (In/Mi)	IJK Roadmeter (PSI)
P-333-0(12)	Page	8.90	Fred Carlson	71	4.41
F-21-4(13)	Benton	6.84	Quad City	122	4.32
F-TQF-17-2(8)	Boone	11.13	Hallett	88	4.26
DP-17-3(20)	Hamilton	3.78	Hallett	89	4.19
F-21-4(11)	Benton	7.29	Quad City	134	4.18
P-333-0(14)	Page	2.06	Fred Carlson	72	4.35
		8.00	Central Paving	97	4.12
BRF-44-3(17)	Audubon	0.80	Central Paving	103	-
F-175-7(13)	Hamilton	3.15	Quad City	112	3.99
		51.95		99	4.24

PRIMARY URBAN & URBAN PORTLAND CEMENT CONCRETE SLIPFORM PAVING

Project No.	County	Length (Miles)	Contractor	BPR Roughometer R.R.I. (In/Mi)	IJK Roadmeter (PSI)
M-6500(2)	Black Hawk	2.12	Irving F. Jensen	107	-
M-0246(1)	Polk	0.89	Hallett	132	-
M-2810(1)	Polk	1.44	Peterson	138	-
F-100-1(1)	Linn	0.46	McAninch Corp. Iowa Road Builders	166	-
		4.91		126	

PRIMARY URBAN & URBAN PORTLAND CEMENT CONCRETE FIXED FORM PAVING

UST-M-4051(1)	Johnson	1.57	Metro Pavers, Inc.	95	-
M-0761(2)	Linn	1.26	Cedar Valley	104	-
I-IG-380-6(124)	Linn	0.81	Iowa Road Builders	119	-
M-5428(1)	Wapello	0.48	Manatt-Carter	141	-
		4.12		108	

SECONDARY PORTLAND CEMENT CONCRETE
SLIPFORM PAVING

Project No.	County	Length (Miles)	Contractor	BPR Roughometer R.R.I. (In/Mi)	IJK Roadmeter (PSI)
FM-33(14)	Fayette	3.00	Fred Carlson	60	4.53
FM-71(7)	O'Brien	4.44	Fred Carlson	67	4.50
FM-74(14)	Palo Alto	1.67	Fred Carlson	72	4.50
FM-37(7)	Greene	4.45	Hallett	84	4.48
FM-21(6)	Clay	1.25	Fred Carlson	71	4.44
FM-74(13)	Palo Alto	2.83	Fred Carlson	69	4.42
RS-1692(1)	Fayette	5.12	Fred Carlson	75	4.42
SN-3540(1)	Story	9.86	Fred Carlson	76	4.41
RS-4850(4)	Linn	6.00	Quad City	83	4.35
FM-23(2)	Clinton	6.04	Quad City	86	4.35
SN-1679(2)	Clayton	3.85	Fred Carlson	94	4.33
GRS-1792(1)	Clayton	7.51	Fred Carlson	83	4.31
RS-7956(4)	Lee	2.84	Fred Carlson	67	4.29
RS-4798(1)	Buchanan	9.84	Quad City	90	4.28
GRS-1802(4)	Allamakee	3.00	Fred Carlson	82	4.25
RS-7916(4)	Lee	2.49	Fred Carlson	64	4.23
L-2886(2)	Warren	4.54	Central Paving	86	4.22
RS-4741(1)	Jackson	6.14	Fred Carlson	88	4.22
SOS-FM-17(2)	Cerro Gordo	5.77	Central Paving	72	4.19
SN-1683(1)	Clayton	4.89	Fred Carlson	86	4.15
FM-81(7)	Sac	2.92	Irving F. Jensen	88	4.15
SN-7718(3)	Mahaska	5.57	Central Paving	91	4.11
FM-81(9)	Sac	2.98	Irving F. Jensen	93	4.11

SECONDARY PORTLAND CEMENT CONCRETE (CONT'D)
SLIPFORM PAVING

Project No.	County	Length (Miles)	Contractor	BPR Roughometer R.R.I. (In/Mi)	IJK Roadmeter (PSI)	
FM-81(8)	Sac	4.94	Irving F. Jensen	91	4.10	
FM-40(3)	Hamilton	5.01	Central Paving	85	4.09	
SN-6258(1)	Adair	2.99	Central Paving	113	4.09	(1)
FM-18(10)	Cherokee	6.97	Irving F. Jensen	102	4.06	
FM-40(2)	Hamilton	0.75	Central Paving	107	-	
RS-3090(2)	Monona	3.97	Irving F. Jensen	109	4.01	
SN-7661(1)	Marion	1.54	Central Paving	123	3.99	
L-37-2	Monona	2.98	Irving F. Jensen	107	3.98	
GH-6	Dallas	2.42	Central Paving	87	3.88	(2)
SN-6258(3)	Union	0.97	Central Paving	124	3.88	(1)
SN-6113(4)	Union	2.02	Central Paving	124	3.60	(1)
		141.56		86	4.24	

(1) These projects consisted of 7" p.c.c. placed over old concrete broken in place.

(2) This project consisted of 4" p.c.c. placed over old a.c. resurfacing.

PRIMARY RURAL ASPHALTIC CONCRETE PAVING

RRF-9-1(24)	Lyon	1.14	Rohlin	71	4.12
HES-9-1(17)	Lyon	0.57	Rohlin	75	4.06
F-64-1(11)	Jones	5.13	Cessford	69	3.84
F-181-1(5)	Marion	8.89	Manatt's, Inc.	71	3.84
F-64-1(12)	Jones	6.94	Cessford	67	3.80
F-61-3(20)	Louisa	0.90	Norris	97	3.60
		23.57		70	3.84

PRIMARY RURAL ASPHALTIC CONCRETE RESURFACING

Project No.	County	Length (Miles)	Contractor	BPR Roughometer R.R.I. (In/Mi)	IJK Roadmeter (PSI)
MP-3038	Dickinson	8.72	Rohlin	59	4.09
MP-3042	Sac-Buena Vista	8.93	Graves Const.	75	3.95
P-83-0(8)	Pottawattamie	13.05	Western Engr.	66	3.92
IR-80-2(88)	Dallas	5.61	Iowa Road Builders	81	3.89
F-218-1(25)	Lee	1.05	Norris	95	3.88
P-365-0(1)	Marion	1.08	Manatt's, Inc.	98	3.88
FR-218-9(33)	Floyd	4.25	Cessford	106	3.85 (S)
EACF-3-2(5) EACF-3-2(8)	Cherokee	16.95	Midwest Paving	75	3.83
FR-78-1(6)	Keokuk	12.42	Norris	95	3.83 (S)
P-930-0(15)	Story	2.00	Iowa Road Builders	70	3.81
FR-61-6(17)	Clinton	9.36	Henningsen	96	3.79 (S)
FR-44-4(26)	Guthrie	14.27	Henningsen	81	3.76
I-EAC-IR-1(127)	Cass	4.86	Western Engr.	82	3.72
		102.55		80	3.86

(S) Sprinkle treatment on these projects.

PRIMARY URBAN & URBAN ASPHALTIC CONCRETE RESURFACING

M-2808(3)	Polk	1.24	Des Moines Asphalt & Paving Company	80	-
M-2808(2)	Polk	0.92	Des Moines Asphalt & Paving Company	94	-
TJ-106-0(11)	Cerro Gordo	2.07	Everds Bros.	97	-
UST-20-WC-1	Hamilton	2.07	Weaver Const.	98	-
MAS-869-0(1)	Wapello	0.71	Norris	112	-
FN-25-4(14)	Guthrie	0.80	Iowa Road Builders	113	-
		7.81		97	

SECONDARY ASPHALTIC CONCRETE PAVING

Project No.	County	Length (Miles)	Contractor	BPR Roughometer R.R.I. (In/Mi)	IJK Roadmeter (PSI)
LB-80-1	Humboldt	2.04	Weaver	82	4.12
LC-280	Allamakee	4.07	Fred Carlson	68	4.04
L-4890-80	Delaware	2.68	Manatt's, Inc.	80	3.95
FM-11(4)	Buena Vista	6.02	Graves & Midwest Paving	85	3.90
FM-32(1)	Emmet	3.94	Midwest Limestone	61	3.89
C-578(1)	Jones	0.88	Cessford	79	3.89
L-770-80	Delaware	2.00	Cessford	89	3.88
SN-4774(1)	Benton	5.32	W. Hodgman & Sons	72	3.85
SN-4774(2)	Benton	6.71	W. Hodgman & Sons	70	3.84
FM-6(5)	Benton	1.00	W. Hodgman & Sons	75	3.84
SN-45(6)	Dickinson	0.70	Rohlin	92	3.84
RS-7768(6)	Davis	3.91	Norris	96	3.84
SN-7984(1)	Des Moines	9.00	Norris	74	3.83
FM-98(6)	Worth	2.00	Rohlin	72	3.82
SN-7674(1)	Appanoose	3.63	Norris	89	3.82
RS-6097(5)	Mills	3.05	Henningsen	92	3.82
FM-6(6)	Benton	2.52	W. Hodgman & Sons	81	3.78
SN-7733(1)	Monroe	3.37	Manatt's, Inc.	83	3.78
SN-4657(3)	Dubuque	3.27	Tschiggfrie Excav.	88	3.78
FM-98(5)	Worth	7.01	Rohlin	70	3.72
SN-4758(1)	Benton	3.93	W. Hodgman & Sons	74	3.72
L-BV-2-80	Buena Vista	1.00	Graves & Midwest Paving	67	3.69

SECONDARY ASPHALTIC CONCRETE PAVING (CONT'D)

Project No.	County	Length (Miles)	Contractor	BPR Roughometer R.R.I. (In/Mi)	IJK Roadmeter (PSI)
L-RS-1-80	Polk	3.40	Des Moines Asphalt And Paving	78	-
L-B119-8	Marshall	0.49	Cessford	84	-
L-14-1	Appanoose	0.70	Norris	86	-
L-1-79(2)	Sioux	0.50	Graves & Midwest Pav.	86	-
L-A39-80	Mitchell	0.91	Rohlin	87	-
L-1(6)79	Montgomery	0.44	W. Hodgman & Sons	98	-
SP-677-0(1)	Polk	1.36	Iowa Road Builders	104	-
SN-7725(3)	Des Moines	2.40	Cessford	111	-
		88.25		79	3.84

SECONDARY ASPHALTIC CONCRETE RESURFACING

Project No.	County	Length (Miles)	Contractor	BPR Roughometer R.R.I. (In/Mi)	IJK Roadmeter (PSI)
FM-46(5)	Humboldt	6.02	P & M Stone	73	4.24
SN-45(4)	Dickinson	5.86	Rohlin	77	4.24
SR-1620(1)	Howard	9.33	Fred Carlson	77	4.12
SN-4669(2)	Black Hawk	7.16	Rohlin	65	4.09
SN-4673(1)	Black Hawk	4.97	Rohlin	69	4.09
FM-32(2)	Emmet	7.79	Rohlin	84	4.06
SR-1632(2)	Chickasaw	4.05	Rohlin	109	4.06
SN-1572(1)	Floyd	10.36	Fred Carlson	75	4.05
FM-72(5)	Osceola	5.93	Hugo Schultz, Inc.	67	4.04
FM-19(2)	Chickasaw	3.53	Rohlin	100	4.03
L-1612-80	Mitchell	8.47	Fred Carlson	78	4.02
SR-1628(1)	Chickasaw	6.89	Rohlin	105	4.02
SN-1513(1)	Allamakee	6.33	Ulland Bros., Inc.	69	4.01
FM-7(3)	Black Hawk	1.75	Rohlin	71	4.01
SN-3400(1)	Webster	5.32	Fort Dodge Asphalt	79	4.00
SN-45(5)	Dickinson	3.00	Rohlin	83	4.00
L-1540-80	Mitchell	8.84	Rohlin	86	4.00
SR-1636(2)	Howard	2.12	Fred Carlson	72	3.99
SR-1563(1)	Howard	5.93	Fred Carlson	71	3.95
FM-72(6)	Osceola	3.42	Hugo Schultz, Inc.	76	3.94
SR-230(2)	Emmet	3.03	Rohlin	74	3.92
FM-41(7)	Hancock	6.54	Rohlin	77	3.90
LS-1602(9)	Jackson	1.55	Tri-State Paving	87	3.90

SECONDARY ASPHALTIC CONCRETE RESURFACING (CONT'D)

Project No.	County	Length (Miles)	Contractor	BPR Roughometer R.R.I. (In/Mi)	IJK Roadmeter (PSI)
FR-58(1)	Sioux	12.10	Graves Const. & Midwest Paving	71	3.89
SR-50(1)	Sioux	5.95	Graves Const. & Midwest Paving	76	3.89
F-39	Fayette	4.57	Fred Carlson	82	3.89
L-FM-380	Emmet	1.00	Rohlin	82	3.89
SN-7841(2)	Van Buren	1.72	Norris	85	3.89
SR-4690(8)	Grundy	4.01	Cessford	75	3.88
L-WA-180	Story	1.04	Iowa Road Builders	80	3.88
L-BV-1-80	Buena Vista	3.67	Graves Const. & Midwest Paving	71	3.86
LFM80-S-1	Webster	0.95	Fort Dodge Asphalt	71	-
L-5-80	Sioux	5.92	Graves Const. & Midwest Paving	84	3.86
3-80	Boone	1.02	Iowa Road Builders	73	3.81
F-38	Fayette	1.20	Fred Carlson	84	-
SN-7873(2)	Van Buren	3.34	Norris	84	3.81
SN-7880(1)	Van Buren	6.31	Norris	88	3.81
SN-7789(3)	Van Buren	5.48	Norris	93	3.80
SR-4958(4)	Cedar	7.17	W. Hodgman & Sons	96	3.80
SR-7900(1)	Henry	7.01	Cessford	70	3.79
L-N-180	Story	1.83	Iowa Road Builders	75	3.79
SN-4664(1)	Marshall	1.14	Cessford	75	-
SR-4690(9)	Grundy	2.49	Cessford	79	3.79
SN-4701(1)	Tama	0.51	Cessford	79	-
SR-37(3)	Winnebago	1.77	Ulland Bros., Inc.	83	3.79
SN-7844(1)	Van Buren	3.99	Norris	97	3.78
SN-1663(2)	Butler	4.86	Cessford	67	3.76

SECONDARY ASPHALTIC CONCRETE RESURFACING (CONT'D)

Project No.	County	Length (Miles)	Contractor	BPR Roughometer R.R.I. (In/Mi)	IJK Roadmeter (PSI)
SR-4677(2)	Hardin	10.28	Cessford	76	3.76
TC1-80	Carroll	3.12	Rohlin	91	3.76
SN-7778(2)	Wapello	7.42	Norris	99	3.76
L-RS-1-80	Polk	3.45	Des Moines Asphalt & Paving	78	-
SN-10(3)	Plymouth	6.97	W. Hodgman & Sons	66	3.75
L-ACR-180	Plymouth	3.47	W. Hodgman & Sons	74	3.75
FM-75(4)	Plymouth	1.52	W. Hodgman & Sons	78	3.75
SR-1(4)	Winnebago	1.94	Ulland Bros., Inc.	81	3.75
SN-1556(1)	Butler	3.74	Cessford	69	3.74
SN-1665(1)	Butler	6.07	Cessford	73	3.73
L-B-80-2	Humboldt	5.46	P & M Stone	92	3.73
PGA-79	Mahaska	6.52	Rohlin	82	3.72
SN-7578(2)	Polk	3.70	Des Moines Asphalt & Paving	91	3.72
FM-75(5)	Plymouth	12.06	W. Hodgman & Sons	78	3.71
FM-95(4)	Winnebago	1.99	Ulland Bros., Inc.	80	3.70
SR-4621(1)	Hardin	3.49	Cessford	86	3.70
SN-4801(2)	Marshall	1.44	Cessford	81	3.69
SR-7789(4)	Henry	3.38	Cessford	83	3.68
SN-3025(7)	Plymouth	0.50	W. Hodgman & Sons	74	3.66
L80-S-3	Webster	0.48	Ft. Dodge Asphalt	86	-
L-F-180	Story	2.40	Iowa Road Builders	87	3.62
L80-S-1	Webster	0.94	Ft. Dodge Asphalt	87	-

SECONDARY ASPHALTIC CONCRETE RESURFACING (CONT'D)

Project No.	County	Length (Miles)	Contractor	BPR Roughometer R.R.I. (In/Mi)	IJK Roadmeter (PSI)
JE-A-79	Mahaska	13.30	Rohlin	92	3.62
SN-6166(2)	Montgomery	4.50	W. Hodgman & Sons	69	3.59
SN-7837(3)	Davis	9.38	Norris	99	3.50
L-FM-280	Cass	4.65	Henningsen	82	3.49
SR-6015(1)	Cass	3.45	Henningsen	93	3.44
L-FM-480	Cass	5.69	Henningsen	84	3.34
L-RS-573	Polk	1.76	Des Moines Asphalt & Paving	99	-
L-J-32-AC	Adair	1.00	Henningsen	104	-
		351.31		81	3.85