IOWA STATE HIGHWAY COMMISSION

MATERIALS DEPARTMENT

CENTRAL LABORATORY

FINAL REPORT

R-250 and HR-152

MEASUREMENT OF PAVEMENT SURFACE VARIATIONS

JULY, 1974

Iowa
a place to grow

IOWA STATE HIGHWAY COMMISSION

MATERIALS DEPARTMENT
SPECIAL INVESTIGATIONS SECTION

Final Report of R-250

INVESTIGATING PAVEMENT SURFACE VARIATIONS

July, 1974

Materials Laboratory

By

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R-250

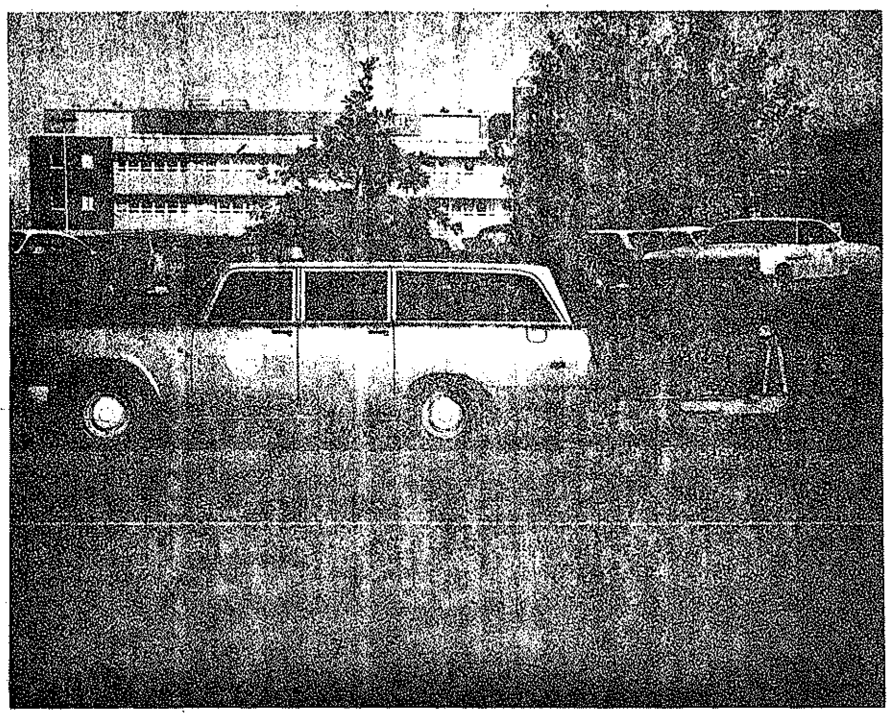
INVESTIGATING PAVEMENT SURFACE VARIATIONS

1.0 INTRODUCTION

The measurement of pavement roughness has been the concern of highway engineers for more than 70 years. This roughness is referred to as "riding quality" by the traveling public. Pavement roughness evaluating devices have attempted to place either a graphical or numerical value on the public's riding comfort or discomfort.

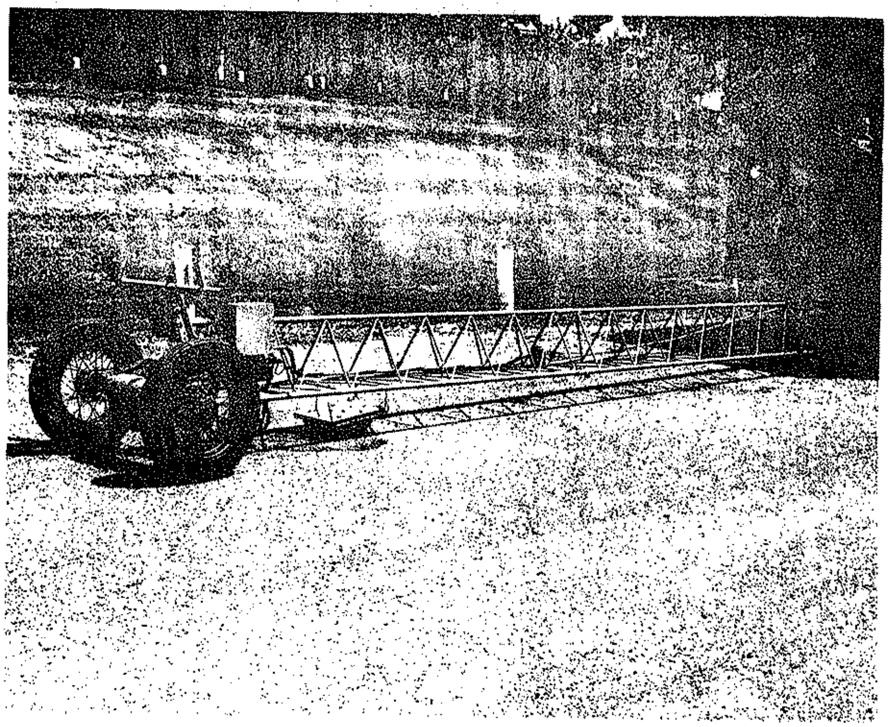
Early graphical roughness recorders had many different designs. In 1900 an instrument called the "Viagraph" was developed by an Irish engineer.[1] The "Viagraph" consisted of a twelve foot board with graphical recorder drawn over the pavement. The "Profilometer" built in Illinois in 1922 was much more impressive.[1] The instrument's recorder was mounted on a frame supported by 32 bicycle wheels mounted in tandem. Many other variations of profilometers with recorders were built but most were difficult to handle and could not secure uniformly reproducible results.

The Bureau of Public Roads (BPR) Road Roughness Indicator built in 1941 is the most widely used numerical roughness recorder.[1] The BPR Road Roughness Indicator consists of a trailer unit with carefully selected springs, means of dampening, and balanced wheel.



BPR Road Roughness Indicator

The 1962 AASHO Road Test produced a testing instrument called the AASHO Profilometer. This profilometer would produce a pavement rating which was correlated with a subjective rating assigned by experts in the highway field as well as the general motoring public. A similar device, the CHLOE profilometer was produced which was less costly and simplier in operation. The basic principle of both the AASHO and CHLOE profilometers is to measure the slope variance, which is by definition the variance of a set of slopes about a mean slope. The slope variance of a pavement section is directly related to the present serviceability index of that pavement[2].



CHLOE Profilometer

Unfortunately, all devices which measure the slope variance, and/or the present serviceability index of a pavement, are either (a) towed by or, (b) incorporated into a highway vehicle.

When used to measure the surface variation of a portland cement concrete pavement, these devices cannot be utilized until such time as the concrete has attained sufficient strength to assure no damage will occur. A period of seven days is normally specified to assure sufficient strength.[3] For this reason, the normal slope measuring devices are inappropriate for construction control of portland cement concrete paving projects.

Several states have adopted a specification for surface smoothness requiring the pavement surface to be tested by placing a straightedge on the surface, parallel to the centerline. Most agencies limit the surface deviations to 1/8" in a 10 foot span. Some agencies, Mississippi as an example, have adopted various other lengths up to 50 feet spans with 3/8" surface deviation limits.[4]

Presently the Iowa specification for surface tolerance is 1/8" in 10 feet.[3] This specification is no longer adequate to determine rideability of newly constructed pavements. Higher traffic speeds and the need for safety and comfort of the traveling public necessitate a testing machine which will detect the longer profile undulations.

2.0 OBJECTIVE

The long range objective of research on measurement of pavement surface variations is to provide a safer, smoother riding pavement for the traveling public.

3.0 PURPOSE

The purpose of this research project is to determine the feasibility and advisability of utilizing a mechanical device or other means to measure the surface deviations, in either a 25 foot or 50 foot span on a routine testing basis.

4.0 SCOPE

The project shall be concerned with:

A. DEVELOPMENT - Developing a prototype device capable of detecting surface deviations greater than 1/4 inch in a 25 foot span or greater than 1/2 inch in a 50 foot span, in either a continuous or static mode in lieu of the 50 foot stringline and

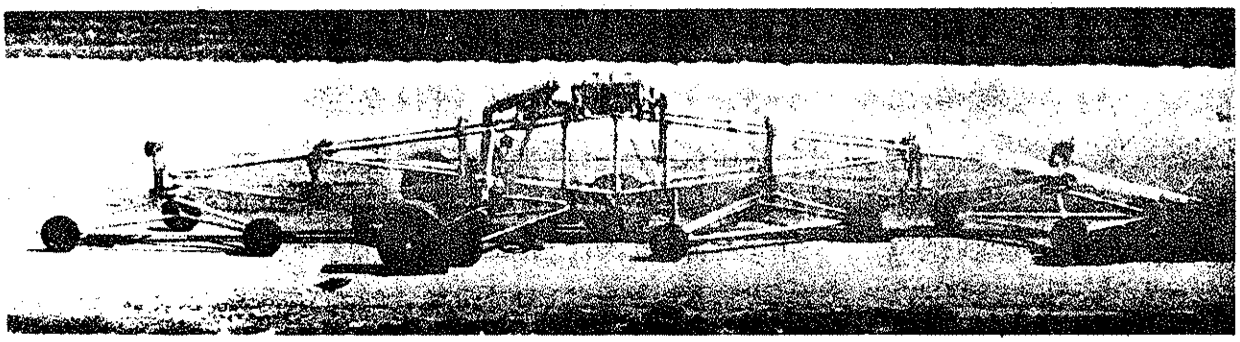
B. EVALUATION - Evaluating the profilograph selected in the development stage as a basis of construction control.

A. DEVELOPMENT

Many alternatives were considered for use as a device to record and evaluate pavement roughness. Two commercially available 25 foot profilometers were evaluated for mobility, ease of assembly, maintenance, type of record produced, and the possibility of adding extensions to the profilometer to extend the length to 50 feet. The two considered were:

<u>Rainhart Profilograph</u>

The Rainhart Catalog No. 860 Profilograph is designed, manufactured, and distributed by the Rainhart Company of Austin, Texas. The machine is 26 feet 10 inches long and weighs approximately 470 pounds.



Rainhart Profilograph

The structure is supported by 12-10 inch averaging wheels when in the testing position. The measuring wheel is located in the center below the recorder and is approximately 20 inches in diameter.

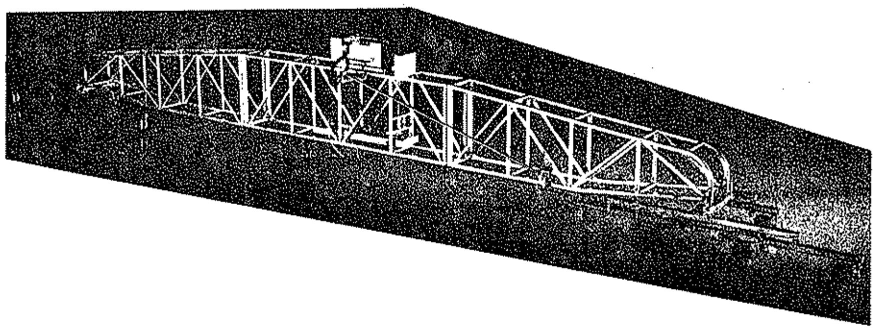
The machines averaging wheels establish a reference plane 44 inches wide and 24.75 feet long. The center measuring wheel draws the profile full scale vertically and either 10 ft. = 1 in. or 25 ft. = 1 in. horizontally.

The Rainhart Profilograph was not selected for use because of its limited use across the nation and the difficulty of adding extensions to extend the length to 50 feet. At the time of selection, only one other state agency was found who used this particular device.

25 Foot California Cox Profilometer

The California Cox Profilometer is manufactured and distributed by James Cox and Sons, Inc. of Colfax, California. The profilometer consists of a lightweight aluminum truss.

tubed structure. The structure divides easily into three segments by the use of four quick acting clamps. These three segments will fit into a 1/2 ton pickup and require less than ten minutes assembly time.

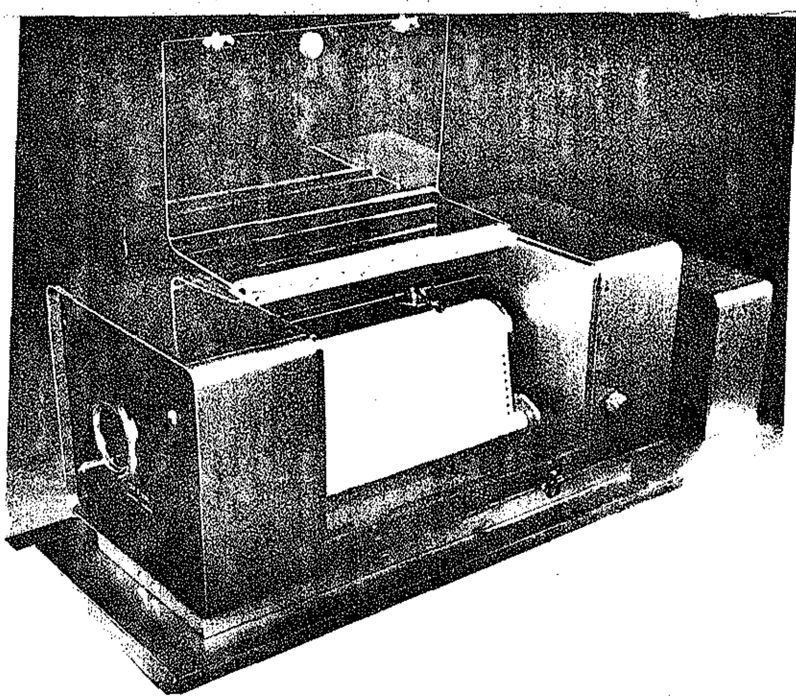


California Cox Profilometer

The structure is supported at the end points, 25 ft. apart, by a series of six averaging wheels. The wheels are cast aluminum hubs with cushioned rubber tires. The front wheels are steerable from the central steering wheel on the machine. The rear wheels can be manually adjusted to prevent rear end crabbing.

The measuring wheel is either a 24 or 26 inch diameter bicycle wheel depending on when the machine was built. This wheel measures vertical profile changes based on a straight line between the two end points. A metal cable connects the bicycle wheel frame to the recorder.

The profile is recorded on the recorder on a scale of one inch equal to 25 feet longitudinally and one inch equal to one inch, or full scale, vertically. The recorder also includes an event marker to note stationing for record keeping purposes.

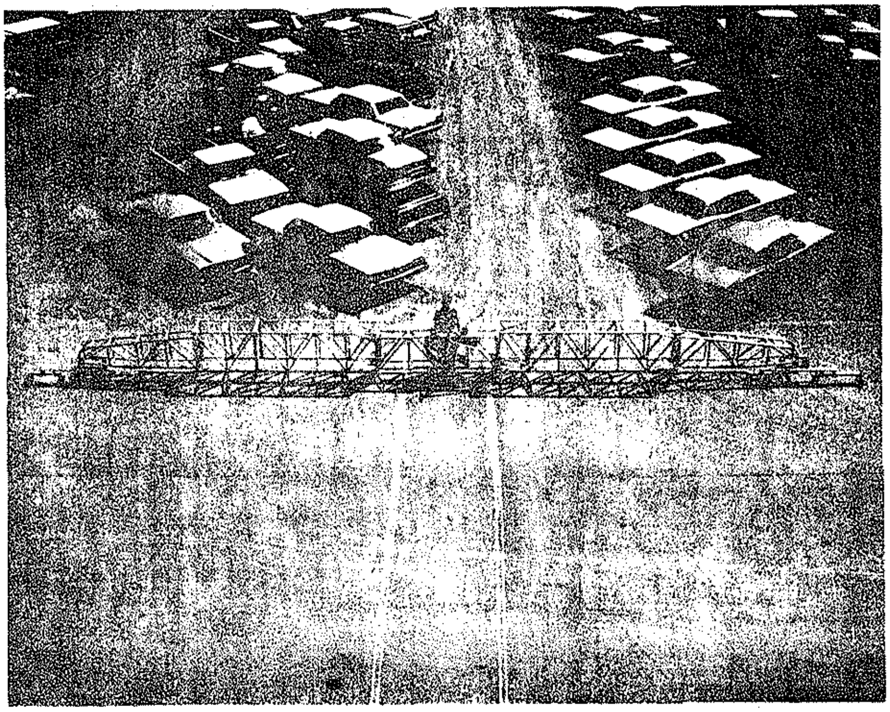


California Cox Profilometer Recorder

The Cox Profilometer was selected for use because of its wide use, ease of mobility, and the ease of extending the frame to a 50 ft. length. Upon our order, James Cox and Sons, Inc. delivered the profilometer in the summer of 1970.

50 Foot Profilometer

The California Cox Profilometer was extended to a 50 foot length in April, 1971. It was felt that objectionable pavement swales could be better detected with a 50 foot span versus the 25 foot length.



50 Foot Profilometer

To make the comparison between the 25 ft. length and the 50 ft. length, a section of U.S. 30 west of Boone, well known for its objectionable riding qualities, was selected. When evaluating and comparing the two graphs, the assumption that a 1/2 inch variation in 50 feet would be the controlling factor to determine an acceptable pavement was made. It was found that 81 percent of the locations within ± 20 ft. that exceeded the 1/2 inch variation in 50 ft. would also exceed a 0.30 inch variation in a 25 foot span.

The 50 ft. profilometer was quite cumbersome to operate. A minimum of 2 persons to manuever the machine, assemble and disassemble, and turn the machine around for measurements in the other lane was necessary.

Several other methods to detect surface deviations were studied. Among those considered were:

<u>Laserplane System</u>

The laserplane is a system for establishing a plane of laser light over an area. This plane is used to indicate elevations of points below it. Practical uses for this system have been found in the fields of surveying and construction for sewer pipes, tunnel boring, earth grading, field tile, etc.

The laser plane system did not offer a continuous method of test or a graphical trace of the profile. The high expense of the system was another reason the laserplane system was not selected.

<u>Mercury Pressure System</u>

The mercury pressure system measured differences in elevations by placing pressure modules at two points and reading the elevation difference. The system was limited by the length of tubing between the two points.

Again the system did not offer a continuous method of test or a graphical trace of the profile. Also elevation differences would not measure deviations from the average profile.

Stretched Wire Straightedge

The use of a 25 ft. piano wire stretched between two points was considered for use as a reference plane. Elevations would then be read at various points along the wire. A plot of various profile points would indicate the profile changes.

This method proved to be slow and time consuming as different profiles were plotted. Also a continuous reference plane was not maintained. For these reasons the "stretched wire" method was not selected.

B. EVALUATION

During the 1972 and 1973 construction season, an effort was made to test all new paving by each contractor in Iowa. In 1972 the 25 ft. profilometer tested a 1/2 mile section in both lanes for every 5 miles of project length. In 1973 the profilometer was operated more closely with each contractor and his paving operation. Each previous day's paving was evaluated by stationing. Methods to improve the operation from a smoothness standpoint were incorporated into the next day's paving operation.

The profilometer results were evaluated per Materials I.M. 341, "Method of Evaluation of Pavement Profiles." This December 1972 I.M is included as Appendix A. The latest proposed specification applying to profilometer work is shown as Appendix B.

A summary of the 1972 and 1973 results are shown in Appendix C. The summary is divided into the portland cement concrete categories of primary and secondary work. These categories are further broken down by large and small amounts of paving difficulty based on pavement geometry, urban versus rural, and slip form versus fixed form. The adjustment bands refer to the mileage tested in each band based on the proposed specification.

A summary of each project's profile index by 0.1 mile sections was sent to the contractor. He was to use this information to determine reasons for the high profile index values, develop methods to improve the smoothness of his paving operation, and to study how the proposed specification would affect him.

5.0 SUMMARY

The 25 foot California Cox Profilometer proved to be the most reliable and productive from a testing standpoint of all the different testing methods considered. It offered a continuous, graphical profile of the surface variations. Ease of mobility, short assembly time, and low maintenance were other reasons the Cox Profilometer was selected in the development stage.

The evaluation of new paving during the 1972 and 1973 construction season showed profile index values ranging from a 2 inches/mile on asphaltic concrete pavement to 57 inches/ mile on portland cement concrete. Most work was in the 10 to 20 inch/mile range.

By working with the paving contractor and showing him the profile graph from the previous day's work, the contractor was able to reduce the profile index value. By improving his headers, tightening his stringline, and avoiding frequent stops and starts, the profile was much smoother.

The proposed specification for 25 foot profilometer work (Appendix B) was to be applied to a few particular projects in 1974. However, due to both budget and personnel shortages at the District Materials level, the profilometer has been scheduled for routine, information testing only in 1974, similar to 1972 and 1973 testing.

The proposed specification would not cause paving contract bids to increase once each contractor realized his capability of paving smooth pavement. Once the contractor establishes his capability of paving, his bid would reflect his ability to meet the specification requirements. Competitive contractor bidding plus penalty reimbursement to the state should make the proposed specification have little effect on contract price. Eventually only contractors capable of paving low penalty pavement would be able to afford to bid low contract prices. Therefore, the long range objective of providing a safer, smoother riding pavement would be the actual benefit of adopting the proposed specification.

6.0 RECOMMENDATION

Having worked with the California Cox Profilometer for approximately four years, we realize the capabilities and advantages of the use of the machine. Knowing these we recommend the adoption of the 25 ft. profilometer as the basis for determining pavement surface variations.

Secondly we recommend adopting the proposed specification as a basis for detecting unsatisfactory pavement. Modifications to the specification, such as changing the penalty ranges or applying the requirements to only certain types of pavement, may be necessary to meet future requirements. This specification would provide the backbone for obtaining our objective - to provide a safer, smoother riding pavement for the traveling public.

REFERENCES

(1) Hveem, F. N. "Devices for Recording and Evaluating Pavement Roughness", HRB Bulletin 264.

(2) Highway Research Board, "The AASHO Road Test, Report 5 - Pavement Research", HRB Special Report 61E.

(3) Iowa State Highway Commission, "Standard Specifications", Series of 1972.

(4) Mississippi State Highway Department, "Standard Specifications for Road and Bridge Construction", Series of 1967, p. 305.

IOWA STATE HIGHWAY COMMISSION

Materials Department Instructional Memorandum

METHOD OF EVALUATION OF PAVEMENT PROFILES

Scope:

This method describes the procedure used for determining the Profile Index from profilograms of pavements made with the California type Profilograph and also describes the procedure used to locate individual bumps when their reduction is required by specification.

The profilogram is recorded on a scale of one-inch equal to 25 ft. longitudinally and one-inch equal to one-inch, or full scale, vertically. The determination of the Profile Index involves measuring "scallops" that appear outside a "blanking" band. The determination of individual bumps involves the use of a special template.

Determination of the Profile Index

Procedure

A. Equipment

The only special equipment needed to determine the Profile Index is a plastic scale 1.70 inches wide and 21.12 inches long representing a pavement length of 528 feet or one-tenth of a mile at a scale of 1" = 25'. Near the center of the scale is an opaque band 0.2 inch wide extending the entire length of 21.12 inches. On either side of this band are scribed lines 0.1 inch apart, parallel to the opaque band. These lines serve as a convenient scale to measure deviations or excursions of the graph above or below the blanking band. These are called "scallops".

B. Method of Counting

Place the plastic scale over the profile in such a way as to "blank out" as much of the profile as possible. When this is done, scallops above and below the blanking band usually will be approximately balanced. See Figure I.

The profile trace will move from a generally horizontal position when going around superelevated curves making it impossible to blank out the central portion of the trace without shifting the scale. When such conditions occur the profile should be broken into short sections and the blanking band repositioned on each section while counting as shown in the upper part of Figure II.

Starting at the right end of the scale, measure and total the height of all the scallops appearing both above and below the blanking band, measuring each scallop to the nearest 0.05 inch (half a tenth). Write this total on the profile sheet near the left end of the scale together with a small mark to align the scale when moving to the next section. Short portions of the profile line may be visible outside the blanking band, but unless they project 0.03 inch or more and extend longitudinally for two feet (0.08" on the profilogram) or more, they are not included in the count. (See Figure I for illustration of these special conditions).

When scallops occurring in the first 0.1 mile are totaled, slide the scale to the left, aligning the right end of the scale with the small mark previously made, and proceed with the counting in the same manner. The last section counted may or may not be an even 0.1 mile. If not, its length should be scaled to determine its length in miles. An example follows:

	Section length Miles	Counts, tenth of an inch
	0.10	5.0
	0.10	4.0
	0.10	3.5
400' =	0.076	2.0
Total	0.376	14.5

The Profile Index is determined as "inches per mile in excess of the 0.2 inch blanking band" but is simply called the Profile Index. The procedure for converting counts of Profile Index is as follows:

Using the figures from the above example:

Length = 0.376 miles, total count = 14.5 tenths of an inch.

$$\text{Profile Index} = \frac{\text{1 mile}}{\text{Length of profiles in miles}} \times \text{total count in inches}$$

$$\text{PrI} = \frac{1}{0.376} \times 1.45 = 3.9$$

(Note that the formula uses the count in inches rather than tenths of an inch and is obtained by dividing the count by ten.)

The Profile Index is thus determined for the profile of any line called for in the specifications. Profile Indexes may be averaged for two or more profiles of the same section of road if the profiles are the same length.

Example:

	Section length, miles	Counts, tenths of an inch Left wheel track	Right wheel track
	0.10	5.0	4.5
	0.10	4.0	5.0
	0.10	3.5	3.0
400 =	0.076	2.0	1.5
Total	0.376	14.5	14.0
PrI (by formula)		3.9	3.7

$$\text{Average} = \frac{3.9 + 3.7}{2} = 3.8$$

The Profile Index will be computed at the midpoint of each driving lane unless this profile is not representative of the entire lane width.

C. Limitations of Count in 0.1 Mile Sections

When the specification limits the amount of roughness in successive 1/10 mile lots, the scale is moved along the profile in successive 1/10 mile sections and counts are made to determine specification compliance. The limits of the sections are noted on the profile and can be later located on the pavement if corrections are needed.

D. Limits of Counts - Joints

When counting profiles, a day's paving is considered to include the last portion of the previous day's work which includes the daily joint. The last 15 to 30 feet of a day's paving cannot usually be obtained until the following day. In general the paving contractor is responsible for the smoothness of joints if he places the concrete pavement on both sides of the joint. On the other hand, the contractor is responsible only for the pavement placed by him if the work abuts a bridge or a pavement placed under another contract. Profilograph readings when approaching such joints should be taken in conformance with current specifications.

E. Average Profile Index For the Whole Job

When averaging Profile Indexes to obtain an average for the job, the average for each day must be "weighted" according to its length. This is most easily done by totaling the counts for the 0.1 mile sections of a given line or lines and using the total length of the line in computation for the determining the Profile Index.

 December 1972

Determination of Bumps in Excess of the Specification

Procedure

A. Equipment

The only special equipment needed is a plastic template having a line one-inch long scribed on one face with a small hole or scribed mark at either end, and a slot a distance equal to the maximum bump specified, from and parallel to the scribed line. See Figure II. (The one-inch line corresponds to a horizontal distance of 25 feet on the horizontal scale of the profilogram.)

B. Locating Bumps in Excess of the Specification

At each prominent bump or high point on the profile trace, place the template so that the small holes or scribe marks at each end of the scribed line intersect the profile trace to form a chord across the base of the peak or indicated bump. The line on the template need not be horizontal. With a sharp pencil draw a line using the narrow slot in the template as a guide. Any portion of the trace extending above this line will indicate the approximate length and height of the bump in excess of the specification.

There may be instances where the distance between easily recognizable low points is less than one-inch (25 feet). In such cases a shorter chord length shall be used in making the scribed line on the template tangent to the trace at the low points. It is the intent however, of this requirement that the baseline for measuring the height of bumps will be as nearly 25 feet (1-inch) as possible, but in no case to exceed this value. When the distance between prominent low points is greater than 25 feet (1-inch) make the ends of the scribed line intersect the profile trace when the template is in a nearly horizontal position. A few examples of the procedure are shown in the lower portion of Figure II.

EXAMPLE SHOWING METHOD OF DERIVING PROFILE INDEX FROM PROFILOGRAMS

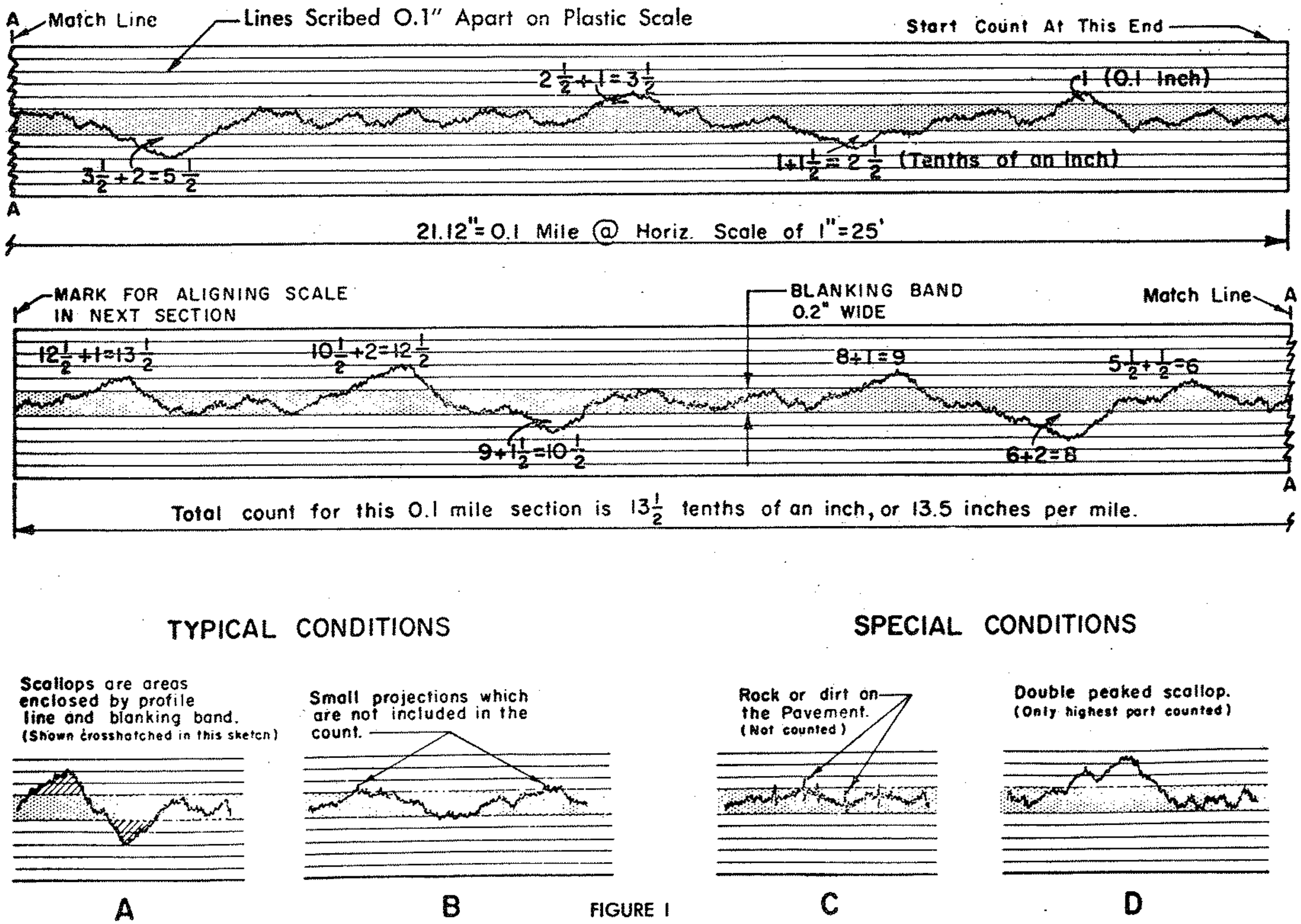


FIGURE 1

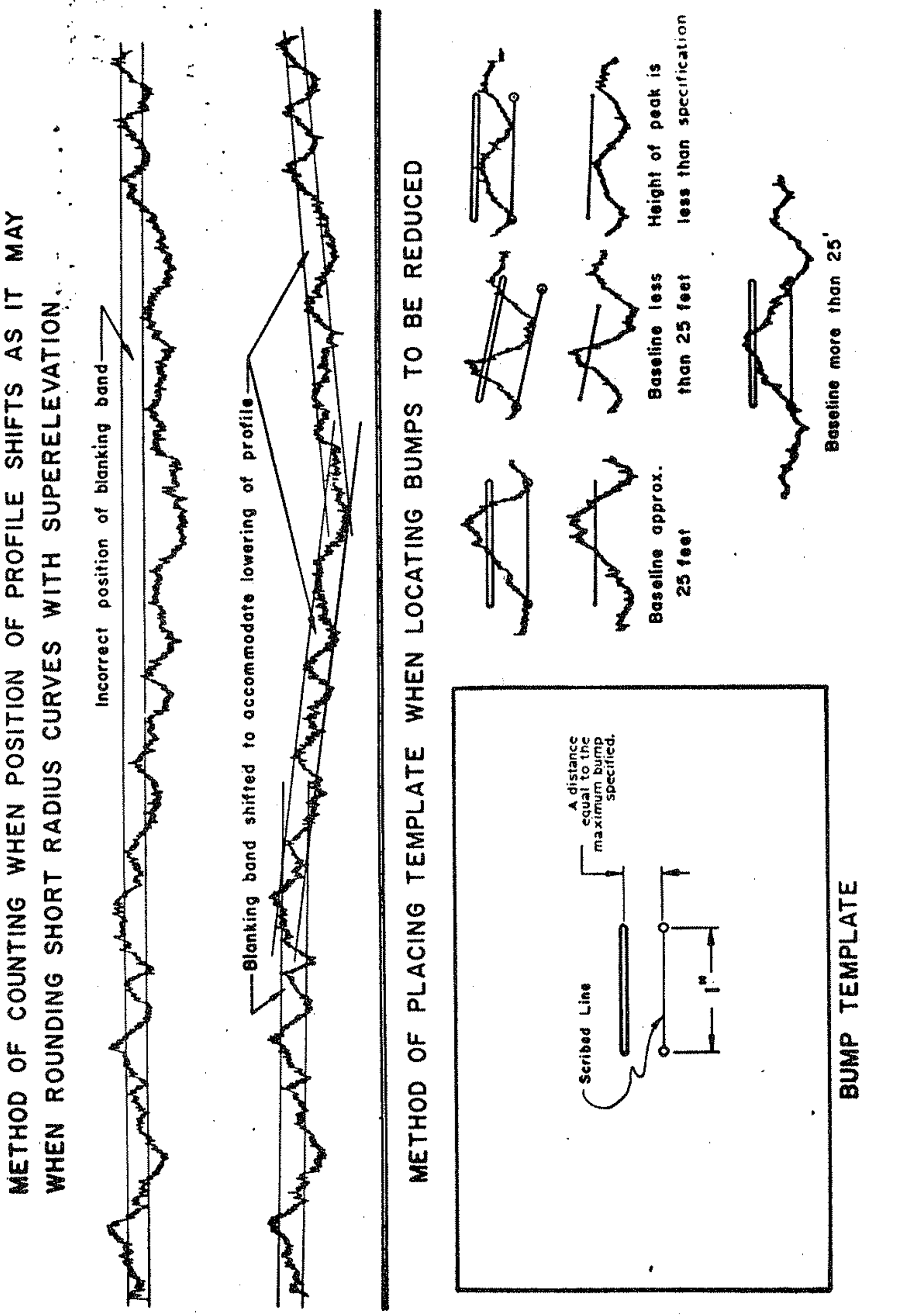

METHOD OF COUNTING WHEN POSITION OF PROFILE SHIFTS AS IT MAY
WHEN ROUNDING SHORT RADIUS CURVES WITH SUPERELEVATION.
Incorrect position of blanking band
Blanking band shifted to accommodate lowering of profile
METHOD OF PLACING TEMPLATE WHEN LOCATING BUMPS TO BE REDUCED
Baseline approx. 25 feet
Baseline less than 25 feet
Height of peak is less than specification
Baseline more than 25'
Scribed Line
A distance equal to the maximum bump specified.
1"
BUMP TEMPLATE

FIGURE II

PROPOSED 25' PROFILOMETER SPECIFICATION

1. Apply to rural primary and interstate projects on which mainline pavement exceeds 14,000 sq. yds.

2. Adjust the contract price paid for 1/10 mile pavement lots according to the following schedule:

Profile Index (Inches/Mile)	Band	Price Adjustment (% Downward)	Percent of Unit Contract Price Allowed
15 or less	1R	No Adjustment	100
18 to 15.01	2R	2	98
21 to 18.01	3R	5	95
24 to 21.01	4R	10	90
Above 24.01	5R	Correct Roughness	

The contractor may elect to correct any roughness in lieu of the above price adjustments.

3. Bumps exceeding 0.5 inches high measured with the 25' profilometer will not be permitted.

APPENDIX C

SUMMARY OF 1972 AND 1973 PROFILOMETER TESTING

Table	Type of Construction	
IA	PC Primary-Slip Form	(Jobs with a small amount of difficulty)
IB	PC Primary	(Jobs with a large amount of difficulty)
IIA	PC Secondary-Slip Form	(Jobs with a small amount of difficulty)
IIB	PC Secondary	(Jobs with a large amount of difficulty)
III	AC Pavement	

TABLE IA

PC PRIMARY SLIP FORM - JOBS WITH SMALL AMOUNT OF DIFFICULTY

Project Number Code	Contractor Letter Code	Miles Tested	Profile Index	Adjustment Bands 1R 15	2R 15-18	3R 18-21	*4R & 5R 21	Year Tested
1	A	2.10	9.01	1.90	.20	0	0	1972**
2	B	5.12	18.90	2.88	.86	.32	1.06	"
3	B	2.39	14.22	1.53	.36	.10	.40	"
4	C	.52	7.05	.52	0	0	0	"
5	C	1.03	10.31	.93	0	0	.10	"
6	C	2.10	11.25	1.57	.30	.20	.03	"
7	D	6.26	11.26	4.53	1.06	.12	.55	"
8	D	5.60	6.01	5.06	.16	.20	.18	"
9	D	4.73	8.09	3.82	.40	.30	.21	"
10	E	1.86	12.80	1.30	.30	0	.26	"
11	F	3.39	8.70	2.89	.30	.20	0	"
12	F	3.11	8.87	2.81	.20	0	.10	"
13	G	3.15	9.49	2.89	.10	0	.16	"
14	H	3.13	13.61	2.01	.30	.42	.40	"
15	H	2.27	5.28	2.27	0	0	0	"
16	I	2.97	11.50	2.27	.30	.20	.20	"

TABLE IA

PC PRIMARY SLIP FORM - JOBS WITH SMALL AMOUNT OF DIFFICULTY (cont.)

Project Number Code	Contractor Letter Code	Miles Tested	Profile Index	Adjustment Bands 1R 15	2R 15-18	3R 18-21	*4R & 5R 21	Year Tested
17	I	3.11	7.61	3.01	.10	0	0	1972**
18	I	1.82	16.71	1.02	.20	0	.60	"
19	J	3.16	8.37	2.18	.32	.30	.36	"
20	B	5.569	10.14	4.659	.734	.141	.035	1973
21	B	2.859	12.85	1.922	.500	.100	.337	"
22	H	11.360	8.09	10.54	.413	.231	.176	"
23	H	11.24	10.19	9.30	.740	.300	.900	"
24	H	11.015	11.28	8.871	.400	.800	.944	"
25	H	10.793	17.40	4.762	1.531	1.027	3.473	"
26	K	.934	11.88	.734	.200	0	0	"
27	K	8.033	8.18	7.418	.539	0	.076	"
28	K	4.061	9.91	3.361	.300	0	.400	"
		123.684	10.83	96.957 78.4%	10.817 8.7%	4.959 4%	10.951 8.9%	

*Information not available for P.I. 21.01 to 24.00

**In 1972 only random portions of projects were tested

CONTRACTOR TOTALS FROM TABLE I A

Contractor	Total Miles Tested	Average Profile Index	Adjustment Bands 1R	2R	3R	4R & 5R
F	6.50	8.78	5.700 88%	.500 8%	.200 3%	.100 1%
B	15.938	14.05	10.991 69%	2.454 15%	.661 4%	1.832 12%
H	49.808	11.50	37.753 76%	3.384 7%	2.778 6%	5.893 11%
J	16.188	8.86	13.69 85%	1.36 8%	.30 2%	.84 5%
C	3.65	10.39	3.02 83%	.30 8%	.20 5%	.13 4%
E	1.86	12.80	1.30 70%	.30 16%	0	.26 14%
D	16.59	8.58	13.41 81%	1.62 10%	.62 4%	.94 5%
I	7.90	11.17	6.30 80%	.60 8%	.20 2%	.80 10%
A	2.10	9.01	1.90 90%	.20 10%	0 0%	0 0%

TABLE IB

PC PRIMARY - JOBS WITH A LARGE AMOUNT OF DIFFICULTY

Project Number Code	Contractor Letter Code	Miles Tested	Profile Index	Adjustment Bands 1R 15	2R 15-18	3R 18-21	*4R & 5R 21	Year Built	Difficulty
29	L	1.920	31.17	0	0	.060	1.860	1972**	Fixed Form
30	L	1.004	35.38	0	0	0	1.004	"	Fixed Form
31	L	0.514	36.90	0	0	0	.514	"	Fixed Form
32	M	2.153	48.37	0	0	0	2.153	"	Fixed Form
33	I	0.757	31.04	0	.100	.200	.457	"	Urban Fixed Form
34	C	3.830	49.50	.015	.200	.200	3.415	"	Urban Fixed Form
35	N	1.291	17.82	.363	.628	.100	.200	"	Urban
36	L	1.442	56.54	0	0	0	1.442	1973	Fixed Form
37	C	2.609	24.07	.459	.300	.261	1.589	"	Intersection Curves etc.
38	B	1.141	28.73	.139	.160	.088	.754	"	Fixed Form
39	O	1.93	22.08	.590	.18	.78	.38	1972**	Urban
40	H	2.84	16.44	.92	.54	.54	.86	"	Part in 2 towns Hilly
41	I	0.75	10.31	.20	0	0	.55	"	Urban
42	F	1.941	8.91	1.741	.100	0	.100	"	T Intersection

TABLE IB

PC PRIMARY - JOBS WITH A LARGE AMOUNT OF DIFFICULTY(Cont.)

Project Number Code	Contractor Letter Code	Miles Tested	Profile Index	Adjustment Bands 1R 15	2R 15-18	3R 18-21	*4R & 5R 21	Year Built	Difficulty
43	I	12.497	15.39	6.920	1.899	1.148	2.530	Urban	
		36.619	25.62	11.347 31%	4.107 11%	3.377 9%	17.808 49%		

*Information not available for P.I. 21.01 to 24.00

**In 1972 only random portions of projects were tested.

TABLE IIA
PC SECONDARY SLIP FORM - JOBS WITH SMALL AMOUNT OF DIFFICULTY

Project Number Code	Contractor Letter Code	Miles Tested	Profile Index	Adjustment Bands 1R 15	2R 15-18	3R 18-21	*4R & 5R 21	Year Tested
44	B	3.179	11.72	2.655	.300	.100	.124	1972**
45	B	2.051	16.28	.841	.267	.600	.343	"
46	A	2.075	7.23	1.954	.121	0	0	"
47	A	2.110	5.47	2.110	0	0	0	"
48	E	2.859	10.16	2.319	.200	.100	.240	"
49	E	3.092	5.87	2.992	.100	0	0	"
50	E	2.172	10.70	1.700	.300	.100	.072	"
51	E	2.134	5.69	1.934	.200	0	0	"
52	J	1.957	6.52	1.757	.100	0	.100	"
53	J	2.070	8.14	1.751	.100	.100	.114	"
54	F	2.080	5.53	1.980	0	.100	0	"
55	H	1.921	5.93	1.921	0	0	0	"
56	C	5.103	12.76	3.703	.600	.300	.500	1973
57	C	6.340	8.98	5.201	.500	.300	.339	"
58	K	18.324	6.59	18.061	.100	.100	.063	"
59	H	12.424	8.47	11.480	.200	.332	.412	"

TABLE IIA

PC SECONDARY SLIP FORM - JOBS WITH SMALL AMOUNT OF DIFFICULTY (Cont.)

Project Number Code	Contractor Letter Code	Miles Tested	Profile Index	Adjustment Bands 1R 15	2R 15-18	3R 18-21	*4R & 5R 21	Year Tested
60	E	11.845	11.73	8.233	1.596	1.237	.779	1973
61	E	14.921	13.54	9.472	1.750	1.834	1.865	"
62	F	6.759	5.04	6.671	.088	0	0	"
63	F	9.810	8.77	8.270	.700	.340	.500	"
		113.226	9.20	95.005 83.9%	7.210 6.4%	5.532 4.9%	5.451 4.8%	

*Information not available for P.I. 21.01 to 24.00

**In 1972 only random portions of projects were tested

***Less difficulty in portion tested

CONTRACTOR TOTALS FROM TABLE IIA

Contractor	Total Miles Tested	Average Profile Index	1R	2R	3R	4R & 5R
F	2.080	5.53	1.98 95%	0 0%	.100 5%	0 0%
B	5.230	13.51	3.496 67%	.567 11%	.700 13%	.467 9%
H	14.345	8.13	13.401 93%	.200 1%	.332 2%	.412 4%
J	4.027	7.35	3.508 87%	.200 5%	.100 2%	.214 6%
K	18.324	6.59	18.061 99%	.100 .4%	.100 .4%	.063 .2%
C	11.443	10.67	8.904 79%	1.100 10%	.600 5%	.839 6%
E	37.023	11.44	26.65 72%	4.146 11%	3.271 9%	2.965 8%
A	4.185	6.34	4.064 97%	.121 3%	0 0%	0 0%

TABLE IIB

PC SECONDARY - JOBS WITH LARGE AMOUNT OF DIFFICULTY

Project Number Code	Contractor Letter Code	Miles Tested	Profile Index	Adjustment Bands 1R 15	2R 15-18	3R 18-21	4R & 5R 21	Year Tested
64	L	.976	43.95	0	0	.100 10%	.876 90%	1973

TABLE III
AC PAVEMENT

Project Number Code	Contractor Letter Code	Miles Tested	Profile Index	Adjustment Bands 1R 15	2R 15-18	3R 18-21	*4R & 5R 21	Year Built
			PRIMARY					
65	P	2.815	9.93	2.315	.300	.200	0	1972**
66	P	2.077	6.88	2.077	0	0	0	"
67	P	1.844	8.81	1.644	.200	0	0	"
68	P	2.105	5.46	2.005	.100	0	0	"
69	Q	4.331	1.59	4.331	0	0	0	"
70	Q	.769	3.32	.769	0	0	0	Urban 1973
71	Q	6.00	1.92	6.00	0	0	0	1973
72	P	7.04	1.97	7.04	0	0	0	"
73	P	2.09	8.47	1.69	.300	0	.100	"
			SECONDARY					
74	R	1.085	9.03	1.085	0	0	0	1972**
75	S	3.095	5.46	3.095	0	0	0	"
76	T	4.549	6.86	4.249	.200	.100	0	1973
77	S	1.103	12.83	.703	.300	0	.100	"
78	S	3.579	10.02	3.140	.100	.100	.239	"
		42.482	5.43	40.143 94.5%	1.500 3.5%	.400 1%	.439 1%	

*Information not available for P.I. 21.01 to 24.00
**In 1972 only random portions of projects were tested