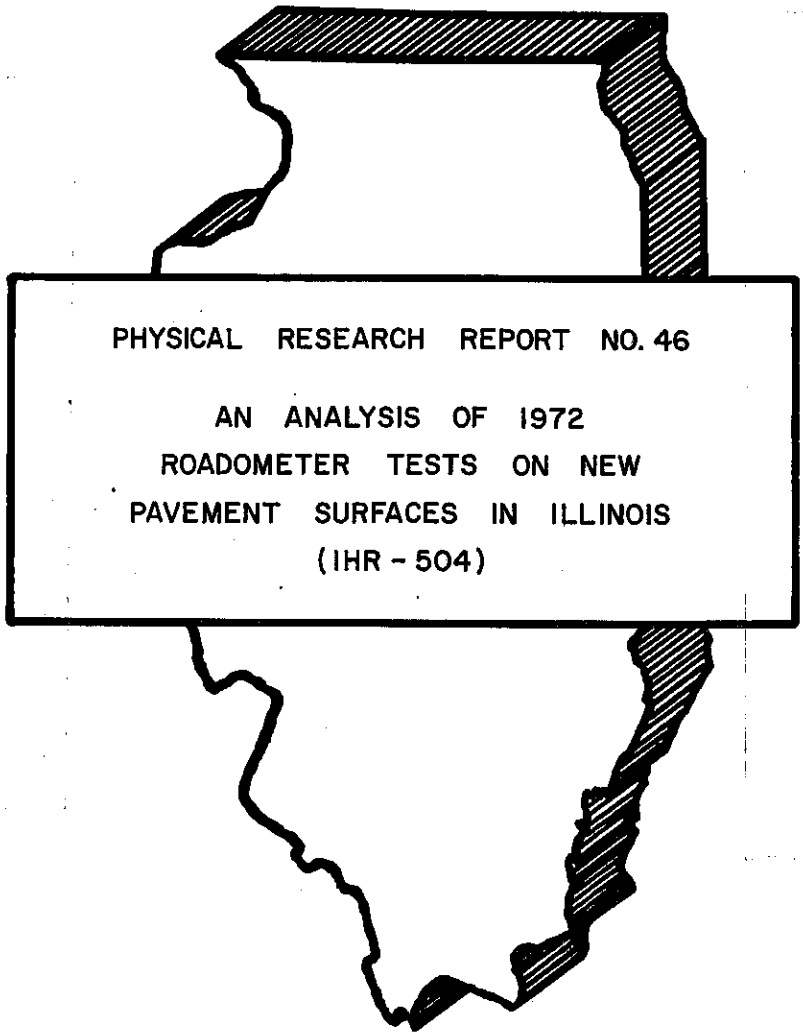
STATE OF ILLINOIS

DEPARTMENT OF TRANSPORTATION



PHYSICAL RESEARCH REPORT NO. 46

AN ANALYSIS OF 1972 ROADOMETER TESTS ON NEW PAVEMENT SURFACES IN ILLINOIS (IHR - 504)

SPRINGFIELD, ILLINOIS 62764 — MAY 1973

State of Illinois
DEPARTMENT OF TRANSPORTATION
Bureau of Materials and Physical Research

AN ANALYSIS OF 1972 ROADOMETER TESTS ON NEW PAVEMENT SURFACES IN ILLINOIS

By

John Edward LaCroix

Interim Report

IHR-504

Riding Quality of New Pavements

A Research Project Conducted by
Illinois Department of Transportation

May 1973

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16. Abstract

This report provides each district and region in Illinois with 1972 roadometer test results for their use in evaluating the riding quality of new pavements constructed within their district or region. A summary of past results based on statewide, district, and regional weighted averages is presented also which gives a yearly comparison of average RI values beginning with 1960.

The 1972 test results for bituminous concrete pavements show an increase in the statewide average Roughness Index (RI) from 73 in./mi in 1971 to 80 in./mi in 1972 which is now above the upper limit of 75 in./mi for smooth bituminous pavements. In regard to PCC pavements, the 1972 test results show an increase from 81 in./mi in 1971 to 88 in./mi which is now near the upper limit of 90 in./mi for smooth PCC pavements.

Since 1968 there has been a substantial increase in roughness of both new bituminous and PCC pavements, which suggest that more attention should be given to improving the riding quality of newly constructed pavements.

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SUMMARY

This report provides each district and region with 1972 road smoothness test results for their use in evaluating the riding quality of new pavements constructed within their district or region. A summary of past results based on statewide, district, and regional weighted averages is presented also, which gives a yearly comparison of average Roughness Index values beginning with 1960.

The 1972 test results for bituminous concrete pavements shows an increase in the statewide average RI from 73 in./mi in 1971 to 80 in./mi in 1972, which is now above the upper limit for smooth pavements. Previously, the yearly averages indicated a trend toward increased roughness from 1960 to 1966, followed by a marked reduction until 1968. The reduction in pavement roughness is believed attributable to a change in the specifications requiring bituminous paving machines to be equipped with a leveling device supported at points of bearing not less than 15 feet apart.

In regard to PCC pavements, the 1972 test results show an increase in the statewide average RI from 81 in./mi in 1971 to 88 in./mi in 1972, which is now near the upper limit for smooth pavements. From 1960, the annual averages were fairly constant until 1965 when a decrease in RI was apparent. This decrease which occurred from 1965-1968 is associated with the development of new equipment and construction procedures used in conjunction with slipform paving.

Since 1968 there has been a substantial increase in roughness of both new bituminous and PCC pavements, indicating that more attention needs to be given to those factors which affect the riding quality of newly constructed pavements.

Recommendations concerning some of the more important factors affecting the as-constructed riding quality of new pavement surfaces are:

(1) A special effort should be made to perform paving operations at a uniform rate. Start-and-stop operations produce rough riding pavements. Paver speeds should be maintained as uniform as possible and should be consistent with the delivery of material to the paver.

(2) Pavers equipped with electronic grade control devices will not necessarily guarantee a smooth surface unless they are properly used and controlled. Complete reliance on self-leveling devices alone to achieve a smooth surface can cause overworking of the devices beyond their capabilities, and result in a poor ride. Abrupt changes caused by soft or rough spots in the track lines will cause bumps to be formed in the finished surface.

(3) When travelling grade reference devices are used, the multi-foot ski or travelling string line should be as long as possible but not less than 30 feet. In matching joints in bituminous paving, the ski should not be less than 10 feet. The 6-inch joint-matching shoe should never be used for this purpose. It must be remembered that a 10-foot ski can only be expected to produce a surface as smooth as the one over which it is travelling, and the 6-inch shoe will produce a rougher surface than the one over which it is travelling.

(4) When preset stringlines are used as reference for automatic grade control devices on pavers, frequent checks should be made to insure that proper tension and vertical alignment are being maintained.

(5) Prior to commencing paving, the base or foundation over which the paver travels should be checked to insure that it is stable and reasonably smooth. Unstable or rough tracklines will result in rough-riding pavements, even with electronic controls.

Additional suggestions and recommendations pertaining specifically to PCC and to bituminous paving are included in the body of the report.

ILLUSTRATIONS

AN ANALYSIS OF 1972 ROADOMETER TESTS ON NEW PAVEMENT SURFACES IN ILLINOIS

INTRODUCTION

This report presents a summary of road smoothness tests conducted during 1972 on new pavements constructed in Illinois, and includes an analysis of previous tests based on annual statewide, district, and regional averages beginning with 1960. Since the beginning of field testing in 1960, over 1,900 new construction projects have been tested, which includes more than 8,700 equivalent two-lane miles of pavement surfaces. Of the total mileage tested, 75 percent were bituminous concrete pavements, and the remaining 25 percent were portland cement concrete (PCC) pavements.

The purpose of this report is to provide each district and region with past results of road smoothness measurements for their use in evaluating the riding quality of new pavements constructed within their district or region. This report also includes information and recommendations relating to construction equipment and procedures that produce smoother pavements.

In 1956, the study of road smoothness was undertaken in cooperation with the Federal Highway Administration, with the project identified as IHR-74, "An Investigation of the Road Smoothness Characteristics of Old and New Pavement Surfaces." The major objective of the study is to obtain quantitative knowledge regarding smoothness characteristics of old and new pavements for use in rating the structural adequacy of existing pavements. The study also provided for an evaluation of contractors, construction equipment, and construction procedures for improving the riding quality of newly constructed pavements. In September 1970, the work plan for IHR-74 was revised, with the evaluation of the as-constructed riding quality of new pavements now included as a new study, IHR-504, entitled

"Riding Quality of New Pavements." The study, IHR-504, which is non-Federal participating, provides a continuing service of evaluating the road smoothness of new pavements.

The results of the 1972 road smoothness measurements show a statewide average Roughness Index (RI) of 80 in./mi for bituminous concrete pavement and of 88 in./mi for PCC pavements. According to the adjective ratings, the average RI for bituminous concrete surfacings falls within the range of slightly rough pavements, and the average RI for PCC pavements is near the upper limit of 90 in./mi for smooth pavements. Comparisons of the statewide averages for 1972 with previous years has indicated a substantial increase in RI values since 1968 for both bituminous concrete and PCC pavements. The increase in RI values suggests that more attention should be given to improving the riding quality of newly constructed pavements.

In the following presentation, a summary of the 1972 road smoothness data is given, and comparisons are made with data previously obtained back to 1960. The results are presented in two separate parts: (1) bituminous concrete pavements, and (2) PCC pavements. Also included are a description of the test equipment and a tabulation of the RI values and corresponding adjective ratings used for evaluating the riding characteristics of pavement surfaces, and a discussion of construction equipment and practices that influence the smoothness of riding surfaces. Recommendations for improving the riding quality of newly constructed pavements are also presented.

BACKGROUND

The road roughness indicator used by the Illinois Department of Transportation is patterned after the device developed by the Bureau of Public Roads, and is commonly used for determining the surface smoothness or roughness of highway pavements.

Various names have been used to identify this piece of equipment, including road roughness indicator, roughometer, and roadometer. In Illinois, however, the device is most commonly referred to as the roadometer. An illustration showing the roadometer with an outrigger trailer is shown in Figure 1. The device has proven to be reasonably sturdy and easy to use. The reproducibility characteristics of the device have been very good.

The roadometer is basically a single-wheel trailer that is towed along the highway at a normal test speed of 20 mph. The wheel is mounted centrally within a steel frame, and the frame is weighted so that the center of percussion with respect to the hitch falls within the plane of the axle.

As the device is towed along the pavement, irregularities in the pavement surface cause a differential vertical movement of the wheel with respect to the frame. This movement is transmitted by a wire cable to a double-acting ball-clutch integrator which converts the upward vertical displacement to uni-directional rotary motion. The rotary motion is recorded for determining the riding quality of the pavement.

The total number of inches of upward displacement accumulated for a section of pavement is reduced to an average value per unit mile length which represents the average RI for the section of pavement tested. The tests are conducted in the wheelpaths of all lanes, and for the purpose of this report the results are based on the weighted average RI as determined from each project.

The Illinois Department of Transportation presently operates two roadometers. Fabrication of the first roadometer was started by Department staff in 1956. After numerous modifications in adapting the device for use in Illinois and after an extensive series of calibration tests, the device was made operational for recording the

smoothness of both new and old pavement surfaces in 1959. The second roadometer was purchased from the Illinois Toll Highway Commission in 1962 and was placed in regular service during the same year.

At the beginning of the study on road smoothness, a working relationship was established between roadometer measurements and highway user opinion. Mathematical expressions were developed taking into account the longitudinal profile of pavement surface, cracking, patching, and rutting. In the development of the mathematical expressions, which are based on the present serviceability concept, adjective descriptions of user opinion were applied to various ranges of the rating scale of 0 to 5. Equations were derived for both bituminous and PCC pavements. The factors consisting of cracking, patching, and rutting, are not present in new pavements, which permits a determination of the present Serviceability Index for new pavements based on roughness index alone. For the Illinois roadometers, this provided the group descriptions shown in Table 1.

BITUMINOUS CONCRETE PAVEMENTS

The bituminous concrete pavements tested in 1972 consisted of Class I surfacings on (1) existing PCC pavements, (2) existing I-11 surfacings on a PCC pavement base, and (3) flexible base. A total of 204 projects involving 1,148 equivalent two-lane miles of bituminous concrete pavements were tested, which includes projects constructed in either 1971 or 1972.

Table 2 contains a summary of 1972 roadometer results based on statewide weighted averages for bituminous pavements. The RI values and adjective ratings for the smoothest and roughest new construction projects tested during the year are shown also in the table.

The largest number of miles of bituminous pavements tested in 1972 consisted of first overlays or new bituminous surfacings on existing PCC pavement with 763

TABLE 1

GROUP DESCRIPTION VERSUS AASHO PRESENT SERVICEABILITY RATING FOR ILLINOIS ROADOMETER

AASHO Present Serviceability Rating		Illinois Roadometer Roughness Index		
Numerical	Adjective	Rigid Pavement (in./mi)	Flexible Pavement (in./mi)	Adjective Rating
5		45	35	-
4	Very good	75	60	Very smooth
	Good	90	75	Smooth
3		125	105	Slightly rough
	Fair	170	145	Rough
2		220	190	Very rough
1	Poor	375	330	Unsatisfactory
0	Very Poor			-

TABLE 2

SUMMARY OF 1972 ROADOMETER TESTS ON NEW BITUMINOUS CONCRETE PAVEMENTS

Pavement Type	Projects Tested	Equivalent Two-Lane Miles	Average RI in./mi	Adjective Rating
Class I Surface on:				
Existing PCC	139	763	80	Slightly Rough
Existing I-11	40	285	81	Slightly Rough
Flexible Base	25	100	84	Slightly Rough
1972 Weighted Average	204	1148	80	Slightly Rough
Smoothest Project	RC*	16.35	53	Very Smooth
Roughest Project	CMA*	0.34	145	Rough

*Contractor coded by Bureau of Construction

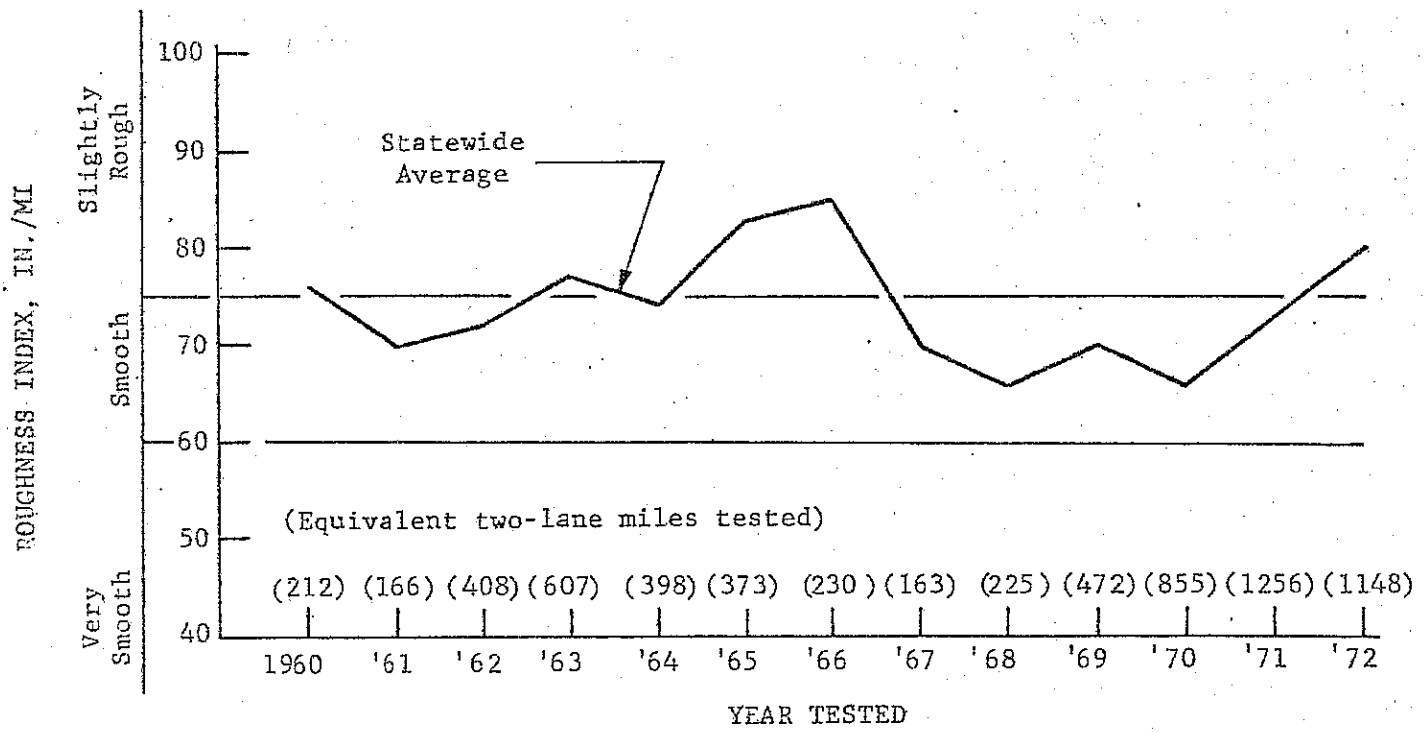

Figure 2. Graph showing average annual Roughness Index for new bituminous concrete pavements.

equivalent two-lane miles tested. The average RI for the first overlays was 80 in./mi (slightly rough). The second largest number of miles tested was second overlays or new surfacings on existing bituminous I-11 overlays on existing PCC base. A total of 285 equivalent miles of pavement surfaces with second overlays were tested which averaged 81 in./mi (slightly rough). The average RI for bituminous pavements with flexible base was 84 in./mi, based on 25 projects consisting of 100 equivalent two-lane miles of pavement tested. On the basis of a statewide average, all three types of bituminous pavements are considered slightly rough (80-84 in./mi), but the variation between average values is very small.

A plot of the annual weighted average RI values from 1960 to 1972 for new bituminous concrete pavements is shown in Figure 2. The graph indicates a trend toward increased average roughness until 1966, when a marked reduction occurred until 1968. This decrease in the average RI from 85 to 66 in./mi (slightly rough to smooth) is believed attributable to a change in the specifications requiring self-leveling devices for asphalt pavers. The minimum yearly level of average RI (66 in./mi) was obtained in 1968 and 1970. In 1971 and 1972, there was a continuous increase in the statewide average RI from 66 in./mi to 80 in./mi, which is now above the upper limit for smooth pavements.

A comparison of weighted average RI for bituminous concrete pavements by region and by district relative to the statewide averages for 1960-1972 are shown in Figures 3-13. In addition to the figures are Tables 3-13, which summarize the 1972 test results for new bituminous concrete pavements constructed in each district and the Northeast Region.

The annual average RI values for the Northeast Region shown in Figure 3 are given for the period beginning with 1960. From 1960 to 1969, the RI values plotted

TABLE 3

SUMMARY OF 1972 ROADOMETER TESTS ON NEW BITUMINOUS PAVEMENTS IN NORTHEAST REGION

Pavement Type	Projects Tested	Equivalent Two-Lane Miles	Average RI in./mi	Adjective Rating
Class I Surface on:				
Existing PCC	19	126	92	Slightly Rough
Existing I-11	13	48	77	Slightly Rough
Flexible Base	10	24	89	Slightly Rough
1972 Weighted Average	42	198	88	Slightly Rough
Smoothest Project	BA*	10.43	57	Very Smooth
Roughest Project	CMA*	0.34	145	Rough

*Contractor coded by Bureau of Construction

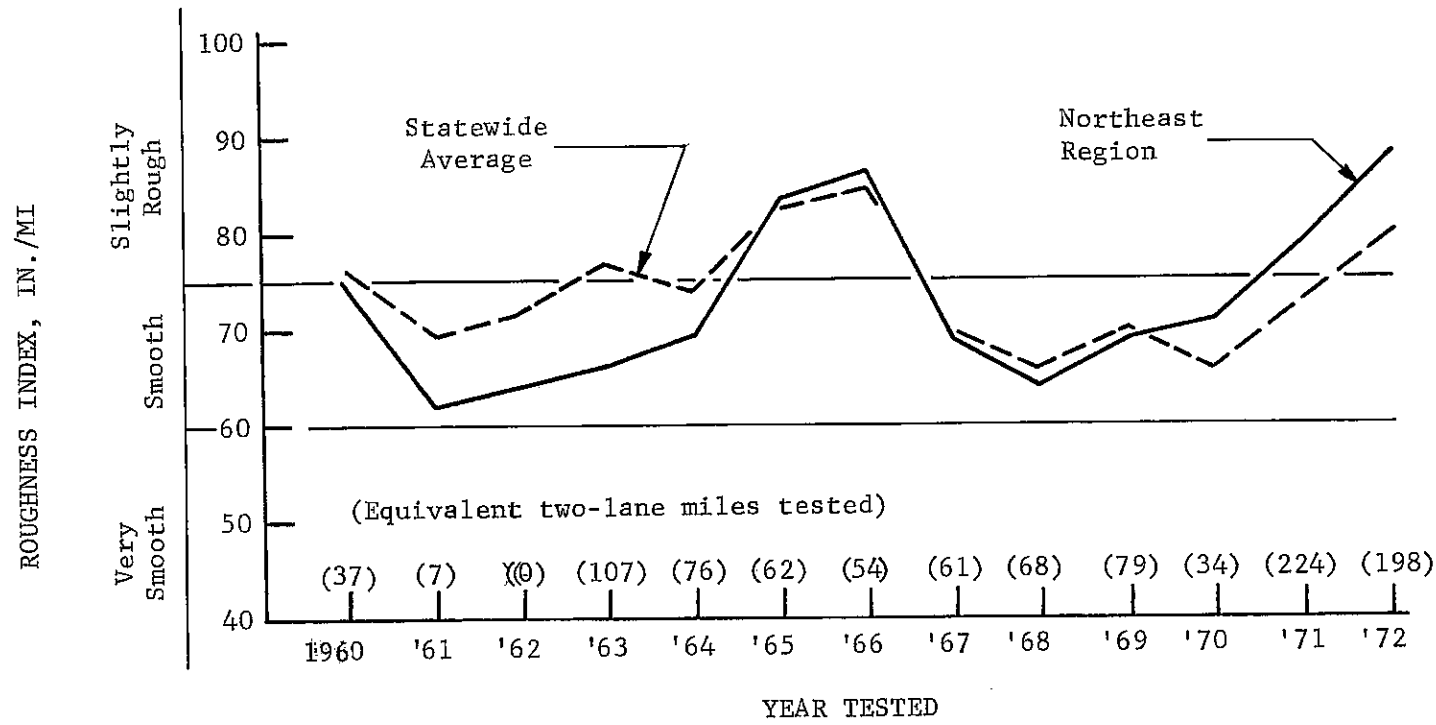

Figure 3. Graph showing average annual Roughness Index for new bituminous concrete pavements in Northeast Region.

TABLE 4

SUMMARY OF 1972 ROADOMETER TESTS ON NEW BITUMINOUS PAVEMENTS
IN NORTHEAST REGION EXCLUDING COOK COUNTY

Pavement Type	Projects Tested	Equivalent Two-Lane Miles	Average RI in./mi	Adjective Rating
Class I Surface on:				
Existing PCC	18	125	92	Slightly Rough
Existing I-11	13	48	77	Slightly Rough
Flexible Base	10	24	89	Slightly Rough
1972 Weighted Average	41	197	88	Slightly Rough
Smoothest Project	BA*	10.43	57	Very Smooth
Roughest Project	CMA*	0.34	145	Rough

*Contractor coded by Bureau of Construction

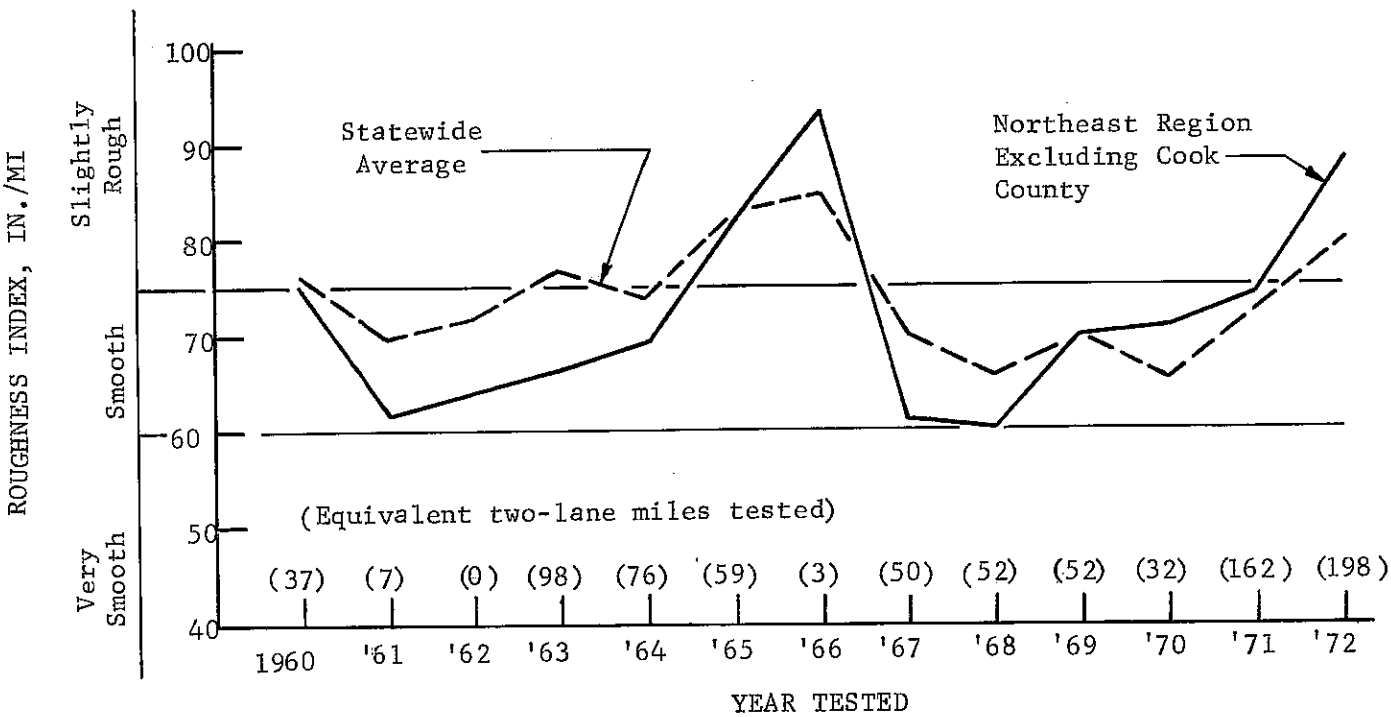

Figure 4. Graph showing average annual Roughness Index for new bituminous concrete pavements in Northeast Region excluding Cook County.

TABLE 5

SUMMARY OF 1972 ROADOMETER TESTS ON NEW BITUMINOUS PAVEMENTS IN COOK COUNTY

Pavement Type	Projects Tested	Equivalent Two-Lane Miles	Average RI in./mi	Adjective Rating
Class I Surface on:				
Existing PCC	1	1	103	Slightly Rough
Existing I-11	-	-	-	
Flexible Base	-	-	-	
1972 Weighted Average	1	1	103	Slightly Rough
Smoothest Project	-*	-	-	
Roughest Project	-*	-	-	

*Contractor coded by Bureau of Construction

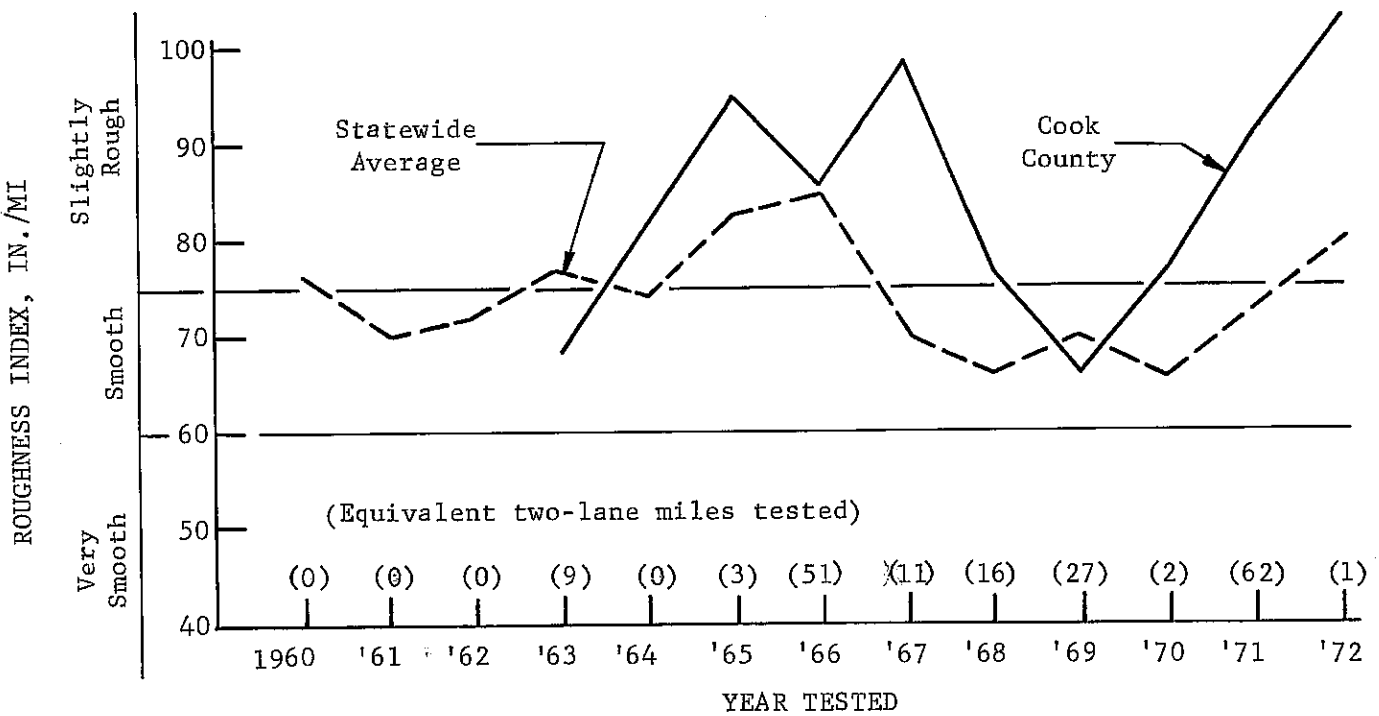

Figure 5. Graph showing average annual Roughness Index for new bituminous concrete pavements in Cook County.

TABLE 6

SUMMARY OF 1972 ROADOMETER TESTS ON NEW BITUMINOUS CONCRETE PAVEMENTS IN DISTRICT 2

Pavement Type	Projects Tested	Equivalent Two-Lane Miles	Average RI in./mi	Adjective Rating
Class I Surface on:				
Existing PCC	12	45	61	Smooth
Existing I-11	-	-	-	
Flexible Base	4	5	63	Smooth
1972 Weighted Average	16	50	61	Smooth
Smoothest Project	RC*	16.35	53	Very Smooth
Roughest Project	LBB*	0.14	139	Rough

*Contractor coded by Bureau of Construction

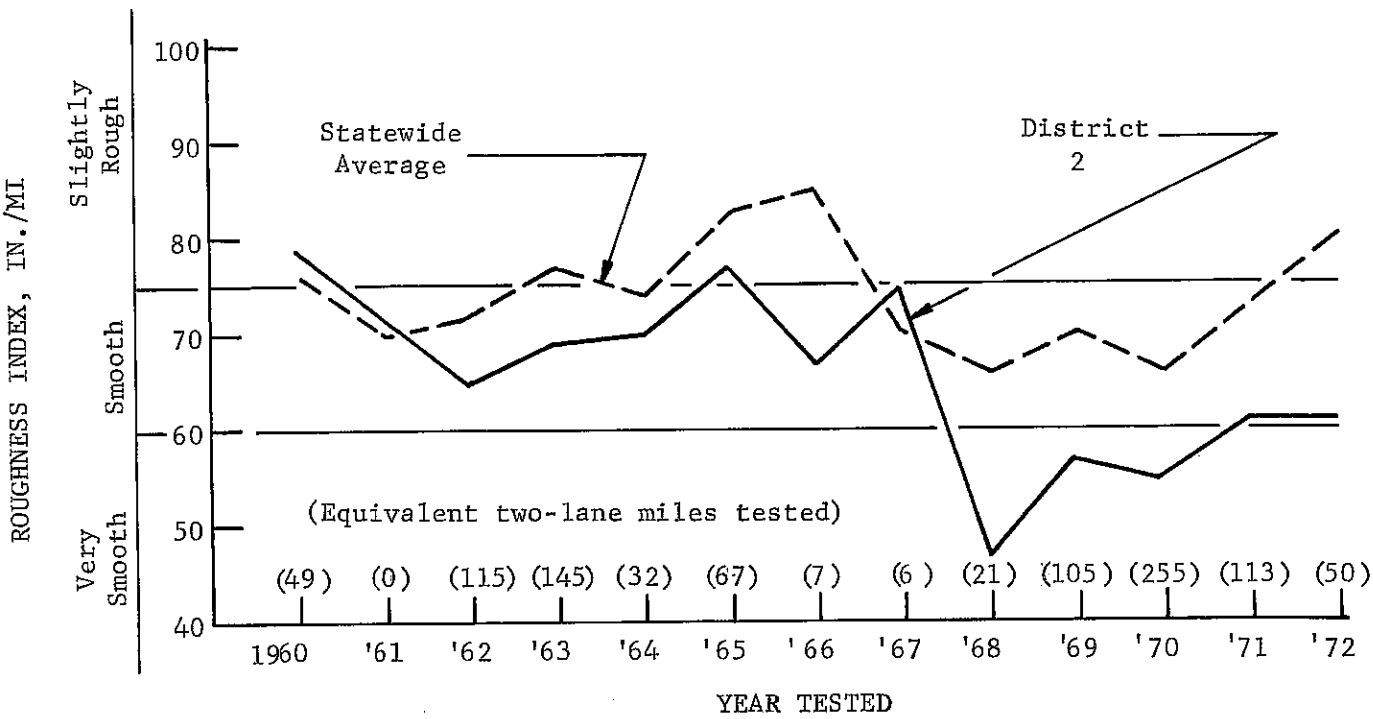

Figure 6. Graph showing average annual Roughness Index for new bituminous concrete pavements in District 2.

TABLE 7

SUMMARY OF 1972 ROADOMETER TESTS ON NEW BITUMINOUS CONCRETE PAVEMENTS IN DISTRICT 3

Pavement Type	Projects Tested	Equivalent Two-Lane Miles	Average RI in./mi	Adjective Rating
Class I Surface on:				
Existing PCC	17	156	70	Smooth
Existing I-11	5	34	78	Slightly Rough
Flexible Base	1	1	87	Slightly Rough
1972 Weighted Average	23	191	71	Smooth
Smoothest Project	AK*	4.72	60	Very Smooth
Roughest Project	WE*	3.22	93	Slightly Rough

*Contractor coded by Bureau of Construction

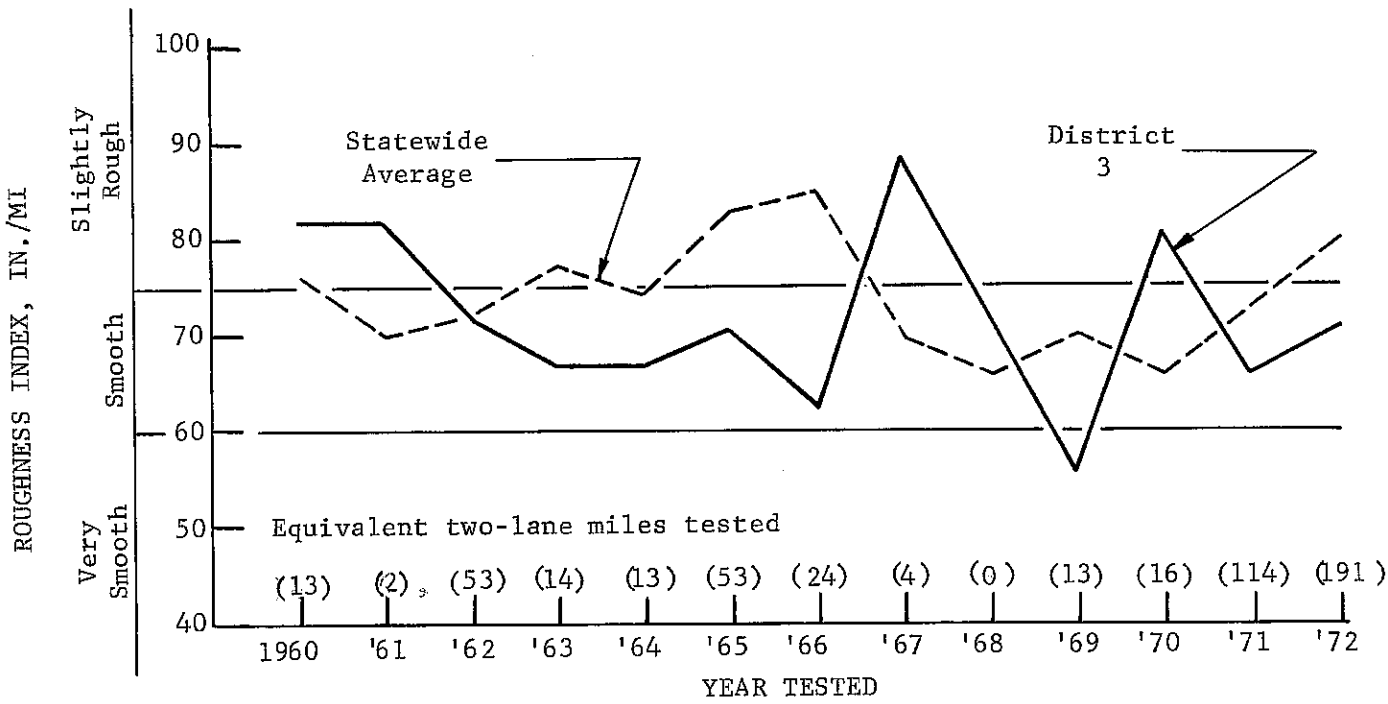

Figure 7. Graph showing average annual Roughness Index for new bituminous concrete pavements in District 3.

TABLE 8

SUMMARY OF 1972 ROADOMETER TESTS ON NEW BITUMINOUS CONCRETE PAVEMENTS IN DISTRICT 4

Pavement Type	Projects Tested	Equivalent Two-Lane Miles	Average RI in./mi	Adjective Rating
Class I Surface on:				
Existing PCC	12	43	70	Smooth
Existing I-11	-	-	-	
Flexible Base	-	-	-	
1972 Weighted Average	12	43	70	Smooth
Smoothest Project	CN*	10.98	55	Very Smooth
Roughest Project	SC*	.15	136	Rough

*Contractor coded by Bureau of Construction

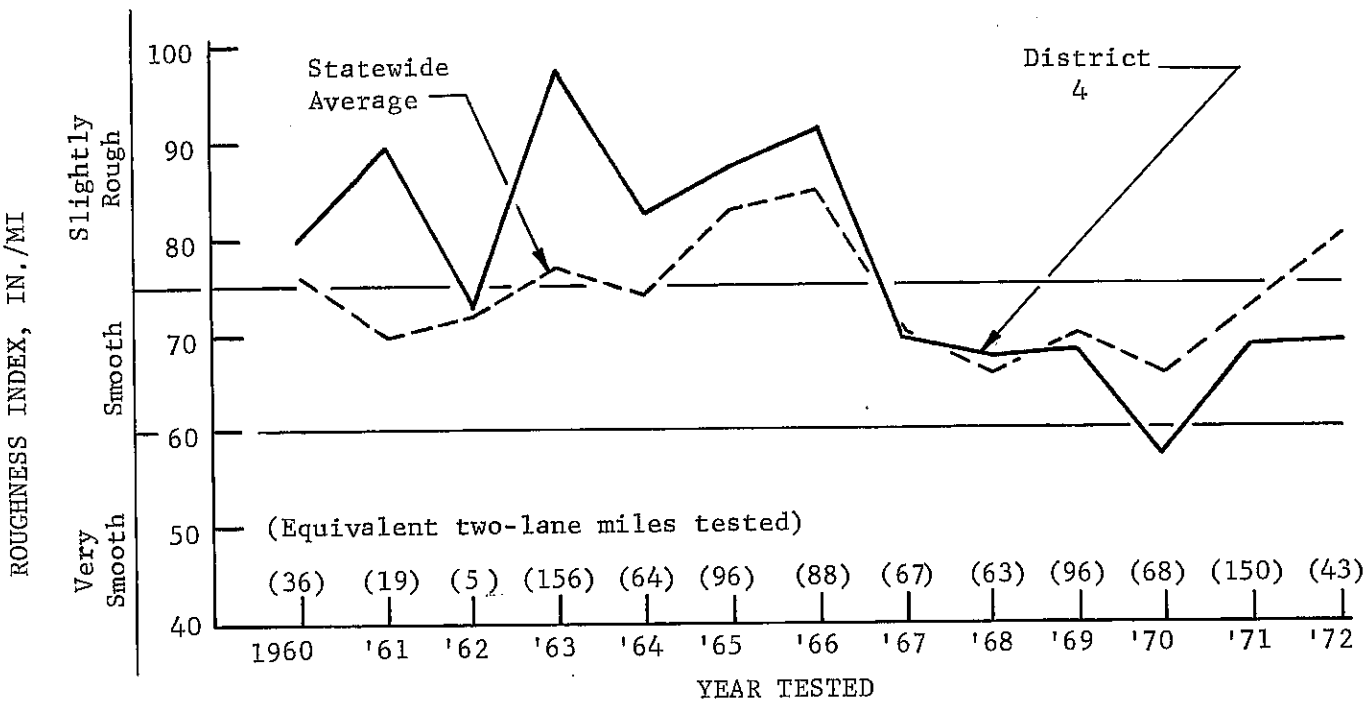

Figure 8. Graph showing average annual Roughness Index for new bituminous concrete pavements in District 4.

TABLE 9

SUMMARY OF 1972 ROADOMETER TESTS ON NEW BITUMINOUS CONCRETE PAVEMENTS IN DISTRICT 5

Pavement Type	Projects Tested	Equivalent Two-Lane Miles	Average RI in./mi	Adjective Rating
Class I Surface on:				
Existing PCC	22	49	84	Slightly Rough
Existing I-11	4	11	95	Slightly Rough
Flexible Base	-	-	-	
1972 Weighted Average	26	60	86	Slightly Rough
Smoothest Project	MV*	1.81	63	Smooth
Roughest Project	DA*	.31	121	Rough

*Contractor coded by Bureau of Construction

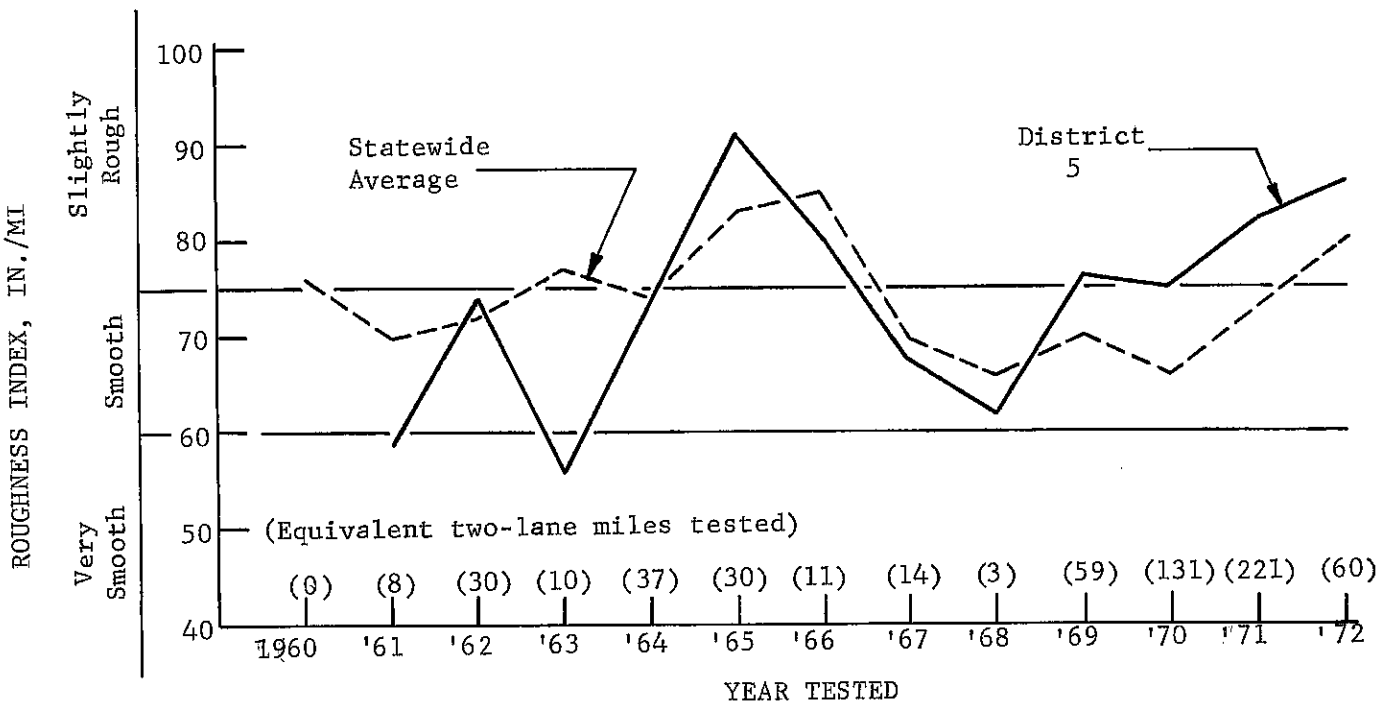

Figure 9. Graph showing average annual Roughness Index for new bituminous concrete pavements in District 5.

TABLE 10

SUMMARY OF 1972 ROADOMETER TESTS ON NEW BITUMINOUS CONCRETE PAVEMENTS IN DISTRICT 6

Pavement Type	Projects Tested	Equivalent Two-Lane Miles	Average RI in./mi	Adjective Rating
Class I Surface on:				
Existing PCC	12	28	91	Slightly Rough
Existing I-11	7	85	73	Smooth
Flexible Base	-	-	-	
1972 Weighted Average	19	113	78	Slightly Rough
Smoothest Project	DD*	18.15	61	Smooth
Roughest Project	SA & SB*	.88	107	Rough

*Contractor coded by Bureau of Construction

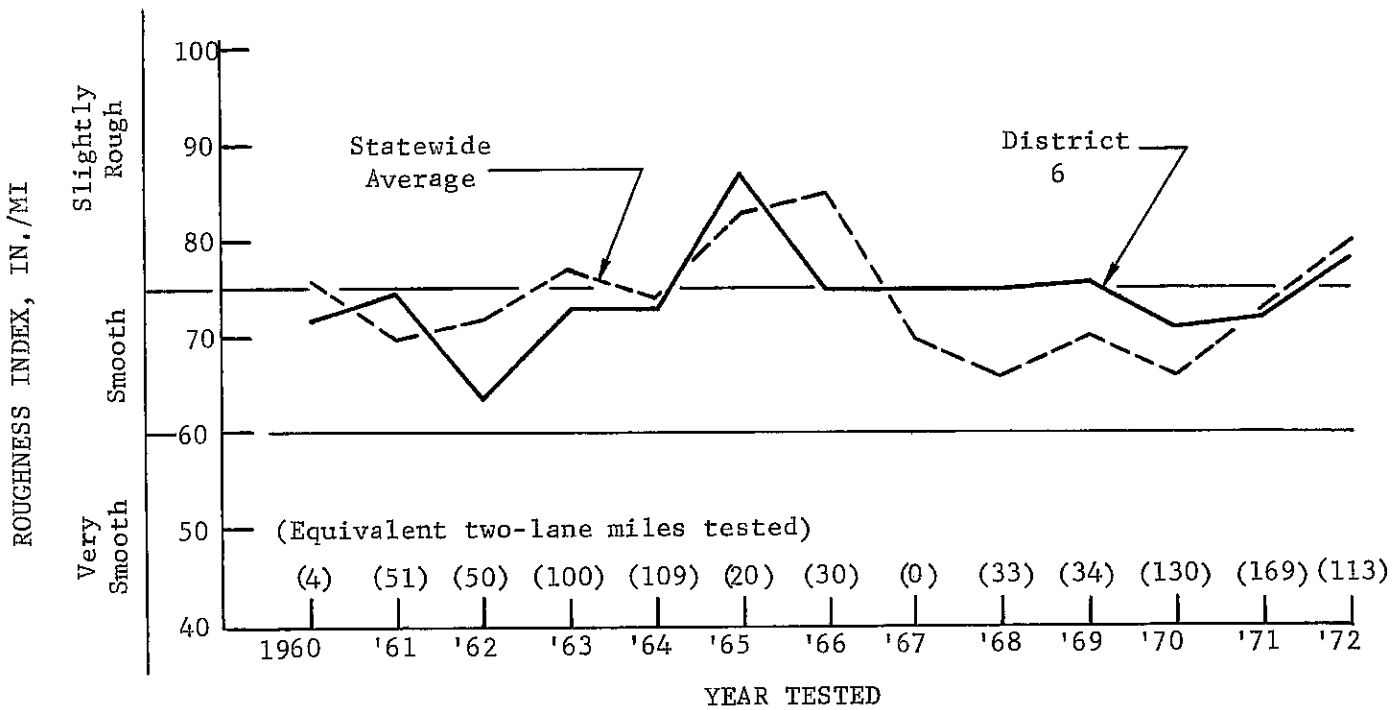

Figure 10. Graph showing average annual Roughness Index for new bituminous concrete pavements in District 6.

TABLE 11

SUMMARY OF 1972 ROADOMETER TESTS ON NEW BITUMINOUS CONCRETE PAVEMENTS IN DISTRICT 7

Pavement Type	Projects Tested	Equivalent Two-Lane Miles	Average RI in./mi	Adjective Rating
Class I Surface on:				
Existing PCC	5	48	86	Slightly Rough
Existing I-11	3	27	95	Slightly Rough
Flexible Base	2	36	78	Slightly Rough
1972 Weighted Average	10	111	85	Slightly Rough
Smoothest Project	RC*	17.58	70	Smooth
Roughest Project	HG*	.54	103	Slightly Rough

*Contractor coded by Bureau of Construction

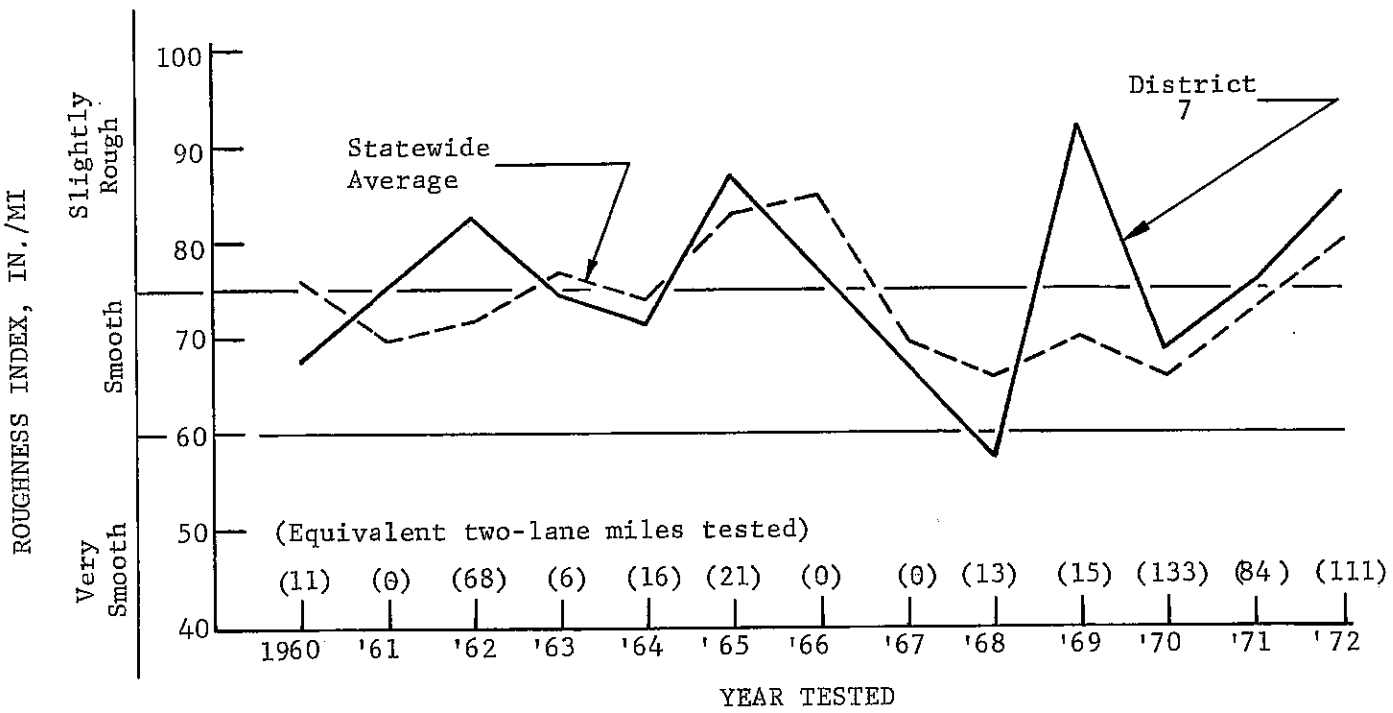

Figure 11. Graph showing average annual Roughness Index for new bituminous concrete pavements in District 7.

TABLE 12

SUMMARY OF 1972 ROADOMETER TESTS ON NEW BITUMINOUS CONCRETE PAVEMENTS IN DISTRICT 8

Pavement Type	Projects Tested	Equivalent Two-Lane Miles	Average RI in./mi	Adjective Rating
Class I Surface on:				
Existing PCC	17	147	82	Slightly Rough
Existing I-11	2	14	82	Slightly Rough
Flexible Base	4	21	93	Slightly Rough
1972 Weighted Average	23	182	83	Slightly Rough
Smoothest Project	TA & LE*	1.00	55	Very Smooth
Roughest Project	LE*	6.97	101	Slightly Rough

*Contractor coded by Bureau of Construction

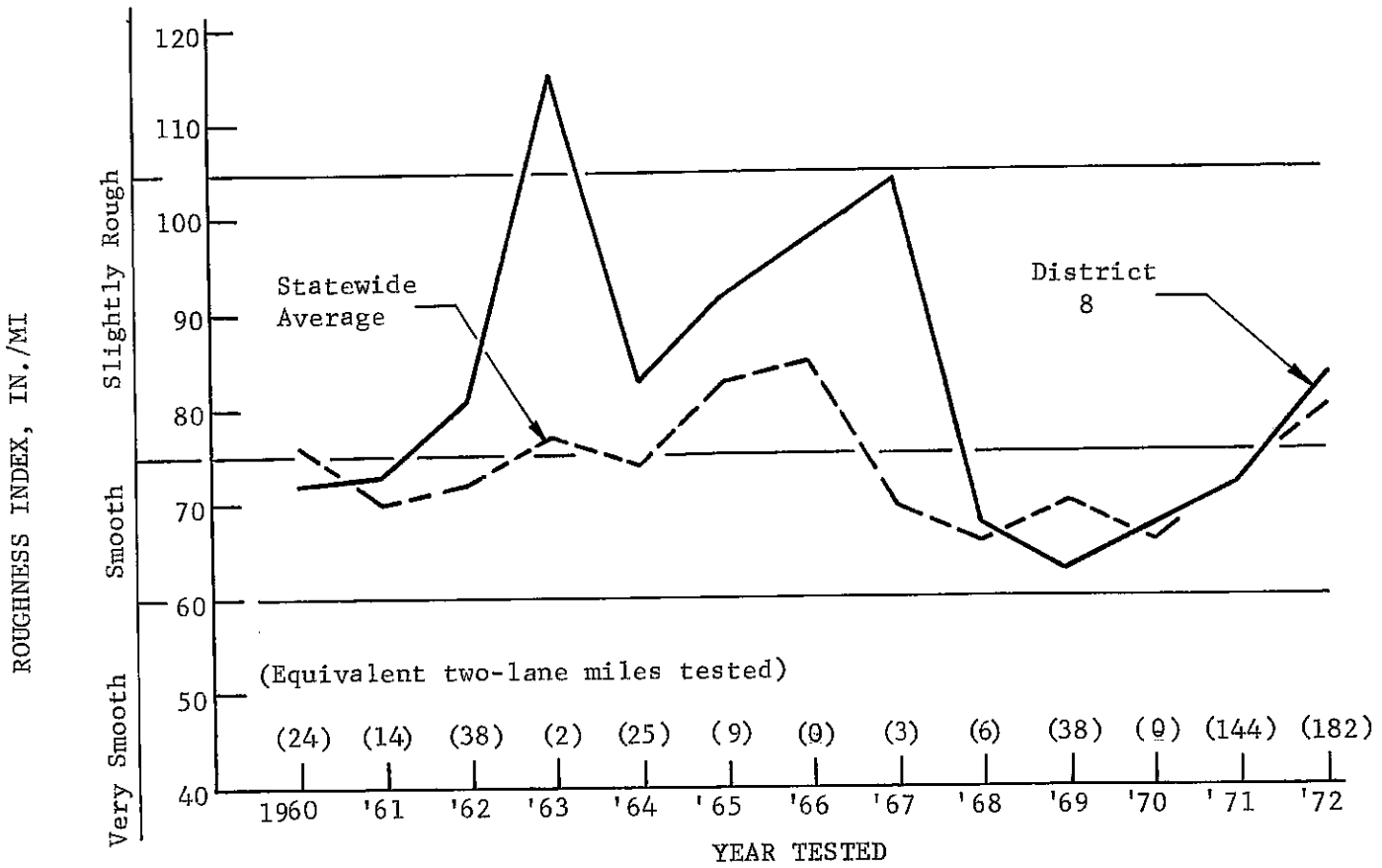

Figure 12. Graph showing average annual Roughness Index for new bituminous concrete pavements in District 8.

TABLE 13

SUMMARY OF 1972 ROADOMETER TESTS ON NEW BITUMINOUS CONCRETE PAVEMENTS IN DISTRICT 9

Pavement Type	Projects Tested	Equivalent Two-Lane Miles	Average RI in./mi	Adjective Rating
Class I Surface on:				
Existing PCC	23	121	80	Slightly Rough
Existing I-11	6	66	87	Slightly Rough
Flexible Base	4	13	85	Slightly Rough
1972 Weighted Average	33	200	83	Slightly Rough
Smoothest Project	JD & JE*	17.24	73	Smooth
Roughest Project	KG*	1.02	125	Rough

*Contractor coded by Bureau of Construction

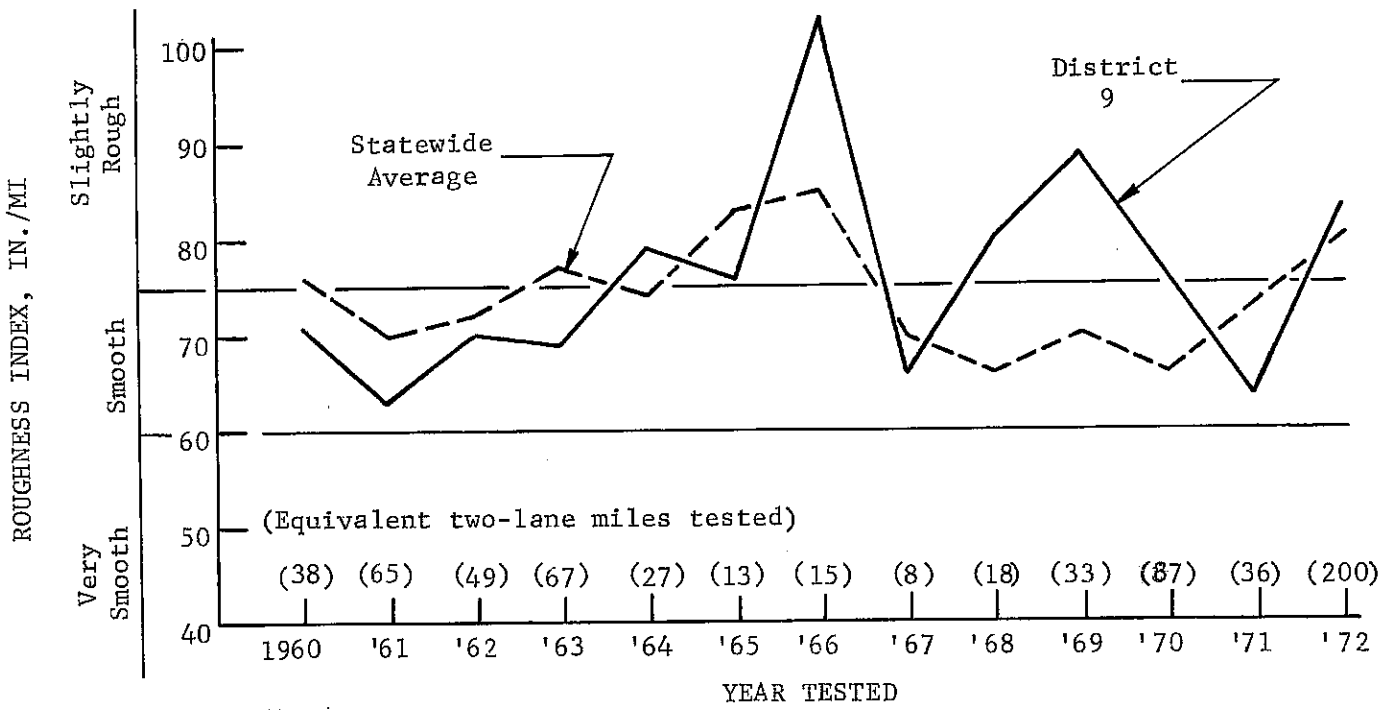

Figure 13. Graph showing average annual Roughness Index for new bituminous concrete pavements in District 9.

in the figure represents the combined weighted average for former District 1 and 10. Curves representing the Northeast Region, excluding Cook County (former District 1), and Cook County (former District 10), are presented in figures 4 and 5, respectively.

From the 1972 test results, 5 of the 9 district or regional areas within the State had average RI values above the statewide average and the remaining 4 were below the statewide average.

PCC PAVEMENTS

A total of 278 equivalent two-lane miles of newly constructed PCC pavement were tested in 1972. The summary is shown in Table 14. Included in the table are the number of construction projects, the equivalent two-lane miles tested, the statewide weighted average RI, the adjective ratings, and the smoothest and the roughest construction projects that were tested in 1972. The data are presented for both conventional jointed PCC and continuously reinforced concrete (CRC) pavements using both slipform and side form paving.

The CRC pavements placed with a slipform paver, which consist of 210 equivalent two-lane miles, accounted for most of the concrete pavements tested during 1972. The statewide average RI for the slipform CRC pavements was 83 in./mi, which corresponds to a smooth rating. On the basis of weighted averages, CRC pavements placed with a slipform paver were the smoothest PCC pavements tested.

Except for the one project consisting of a CRC pavement constructed with side forms, the jointed PCC pavements constructed with side forms had the highest average RI of 107 in./mi, which is equivalent to a slightly rough rating. There was, however, only a slight difference of 2 in./mi less in the average RI value for the jointed PCC pavements using slipform paving.

TABLE 14

SUMMARY OF 1972 ROADOMETER TESTS ON NEW PCC PAVEMENTS

Pavement Type	Projects Tested	Equivalent Two-Lane Miles	Average RI in./mi	Adjective Rating
PCC - Side Forms	21	23	107	Slightly Rough
PCC - Slipform	15	40	105	Slightly Rough
CRC - Side Forms	1	5	112	Slightly Rough
CRC - Slipform	21	210	83	Smooth
1972 Weighted Average	58	278	89	Smooth
Smoothest Project	AH*	10.08	64	Very Smooth
Roughest Project	LBB*	1.28	163	Rough

*Contractor coded by Bureau of Construction

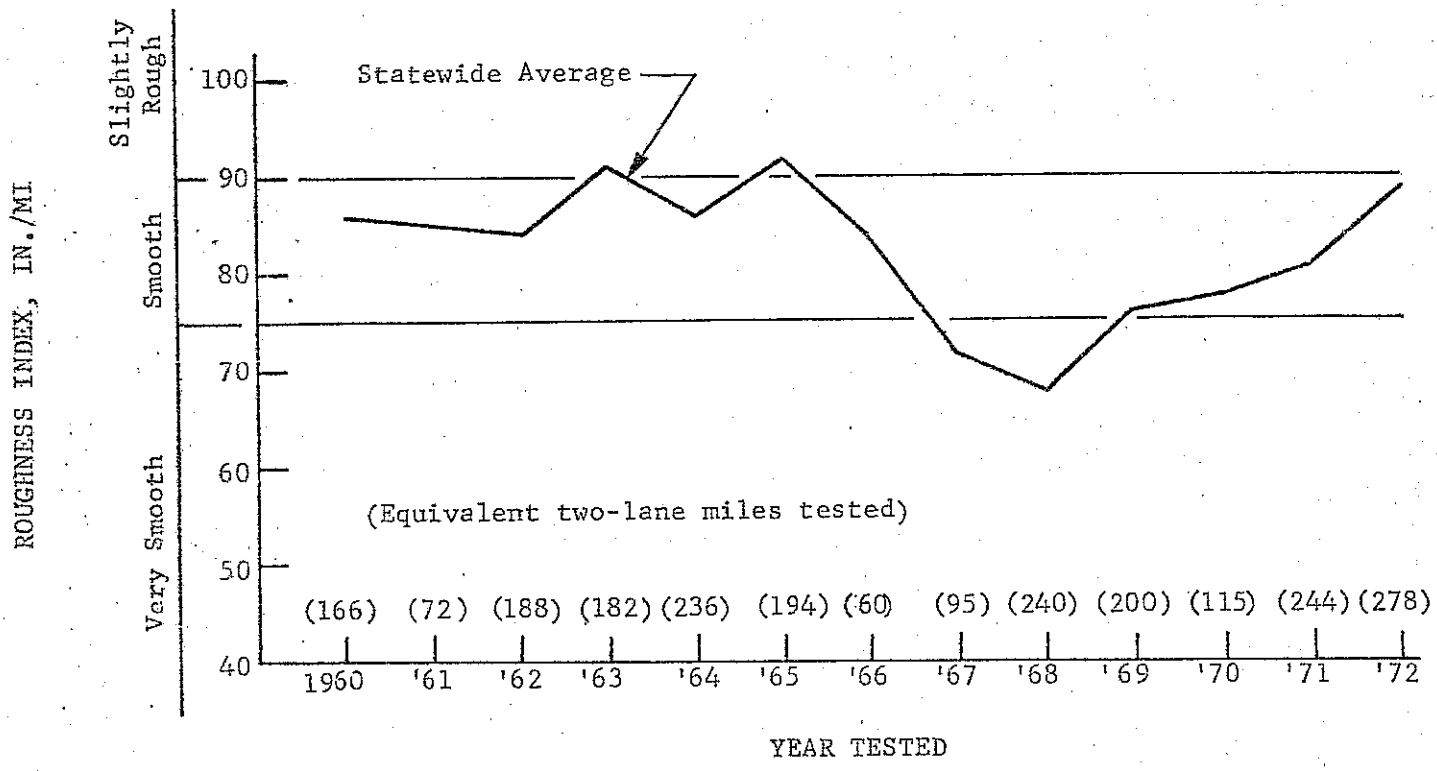

Figure 14. Graph showing average annual Roughness Index for new PCC pavements.

A comparison of statewide RI weighted averages for all PCC pavements tested between 1960 and 1972 is shown in Figure 14. Between 1960 and 1966, the yearly statewide weighted averages appear relatively uniform, with a weighted average RI of about 87 in./mi. From 1966 to 1968, a marked reduction in RI is apparent which is associated with an increased use of the slipform paver. The data indicate an increase in average roughness from very smooth in 1968 to smooth in 1969. This increase in roughness is believed partially attributable to a change in the specifications requiring two separate burlap drags for final finishing. The revision to the specifications was made in August 1968 to improve the skid resistance characteristics of PCC pavement surfaces.

Since 1969, there has been a statewide trend indicating an increase in roughness of newly constructed PCC pavements. On the basis of a statewide average, slightly rough pavements will result should the same trend continue.

A comparison of weighted average RI for PCC pavements by region or by district in relation to the statewide averages for 1960-1972 are shown in Figures 15-25. A summary of the 1972 test results for PCC pavement is presented also for each district or region in Tables 15-25. The results shown that 3 of the 9 districts or regional areas were above the statewide average and 5 were below the average. No tests were conducted in 1972 on new PCC pavements constructed in District 3.

The annual average RI for the Northeast Region shown in Figure 15 is given for the period beginning with 1960. From 1960 to 1969, the RI values plotted in the figure represents the combined weighted average for former Districts 1 and 10. Curves are also presented in Figures 16 and 17 for the Northeast Region, excluding Cook County (former District 1) and for Cook County (former District 10), respectively.

TABLE 15

SUMMARY OF 1972 ROADOMETER TESTS ON NEW PCC PAVEMENTS IN NORTHEAST REGION

Pavement Type	Projects Tested	Equivalent Two-Lane Miles	Average RI in./mi	Adjective Rating
PCC - Side Forms	1	1	106	Slightly Rough
PCC - Slipform	5	22	110	Slightly Rough
CRC - Side Forms	1	5	112	Slightly Rough
CRC - Slipform	-	-	-	
1972 Weighted Average	7	28	110	Slightly Rough
Smoothest Project	RE*	5.18	102	Slightly Rough
Roughest Project	RE*	3.34	121	Slightly Rough

*Contractor coded by Bureau of Construction

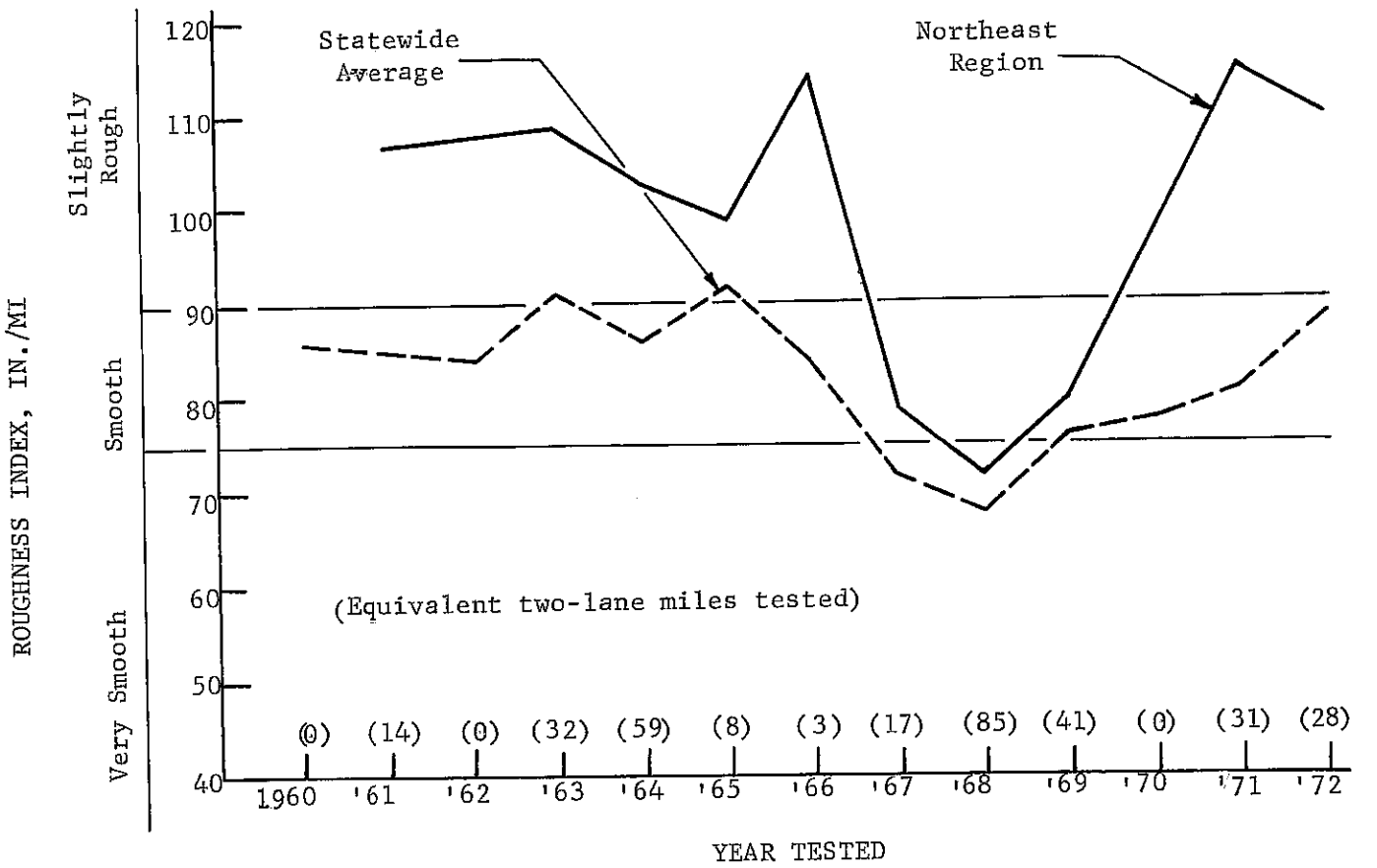

Figure 15. Graph showing average annual Roughness Index for new PCC pavements in Northeast Region.

TABLE 16

SUMMARY OF 1972 ROADOMETER TESTS ON NEW PCC PAVEMENTS IN NORTHEAST REGION EXCLUDING COOK COUNTY

Pavement Type	Projects Tested	Equivalent Two-Lane Miles	Average RI in./mi	Adjective Rating
PCC - Side Forms	1	1	106	Slightly Rough
PCC - Slipform	-	-	-	
CRC - Side Forms	1	5	112	Slightly Rough
CRC - Slipform	-	-	-	
1972 Weighted Average	2	6	111	Slightly Rough
Smoothest Project	BG*	1.22	106	Slightly Rough
Roughest Project	BG*	5.20	112	Slightly Rough

*Contractor coded by Bureau of Construction

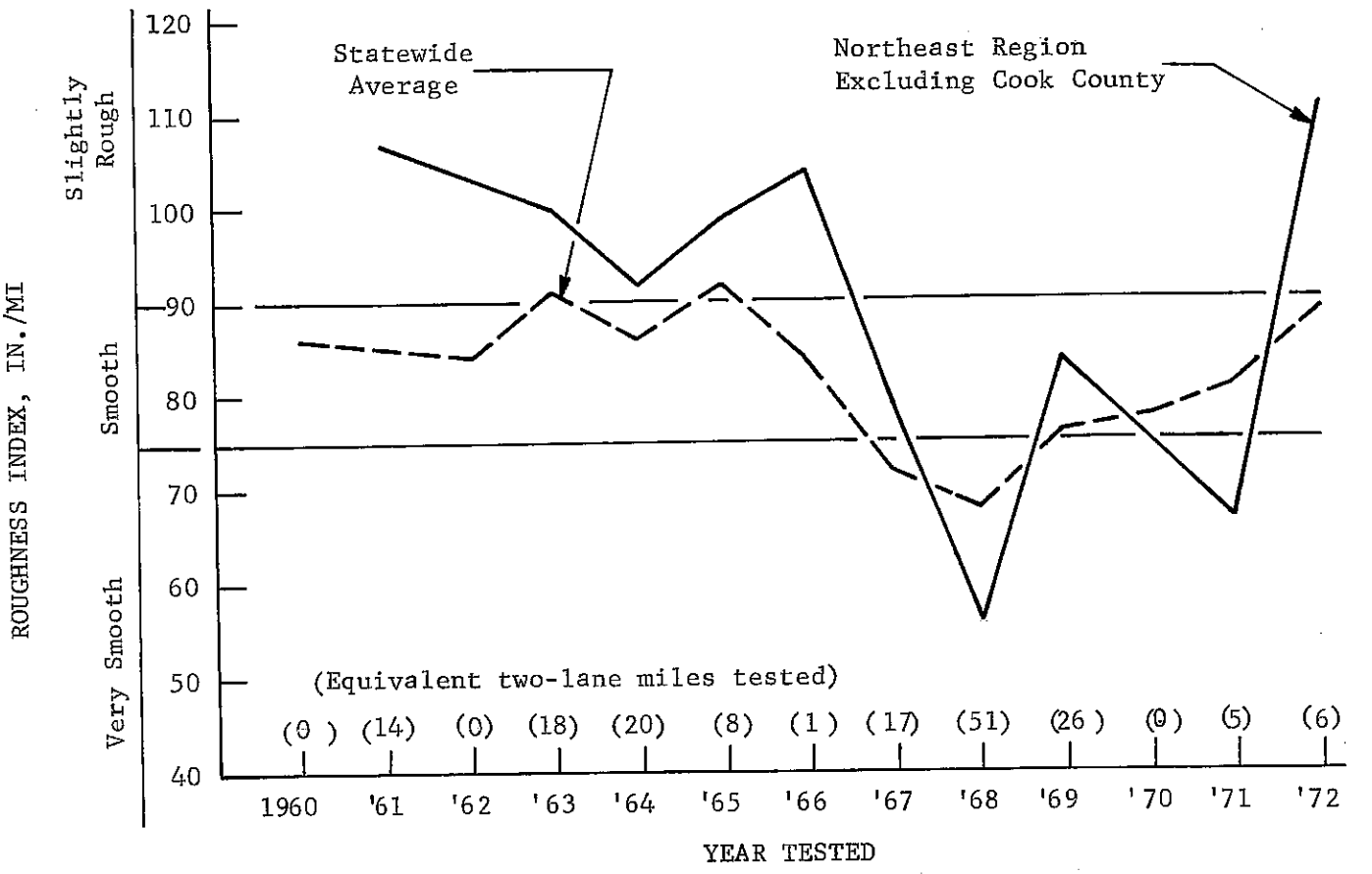

Figure 16. Graph showing average annual Roughness Index for new PCC pavements in Northeast Region excluding Cook County.

TABLE 17

SUMMARY OF 1972 ROADOMETER TESTS ON NEW PCC PAVEMENTS IN COOK COUNTY

Pavement Type	Projects Tested	Equivalent Two-Lane Miles	Average RI in./mi	Adjective Rating
PCC - Side Forms	-	-	-	
PCC - Slipform	5	22	110	Slightly Rough
CRC - Side Forms	-	-	-	
CRC - Slipform	-	-	-	
1972 Weighted Average	5	22	110	Slightly Rough
Smoothest Project	RE*	5.18	102	Slightly Rough
Roughest Project	RE*	3.34	121	Slightly Rough

*Contractor coded by Bureau of Construction

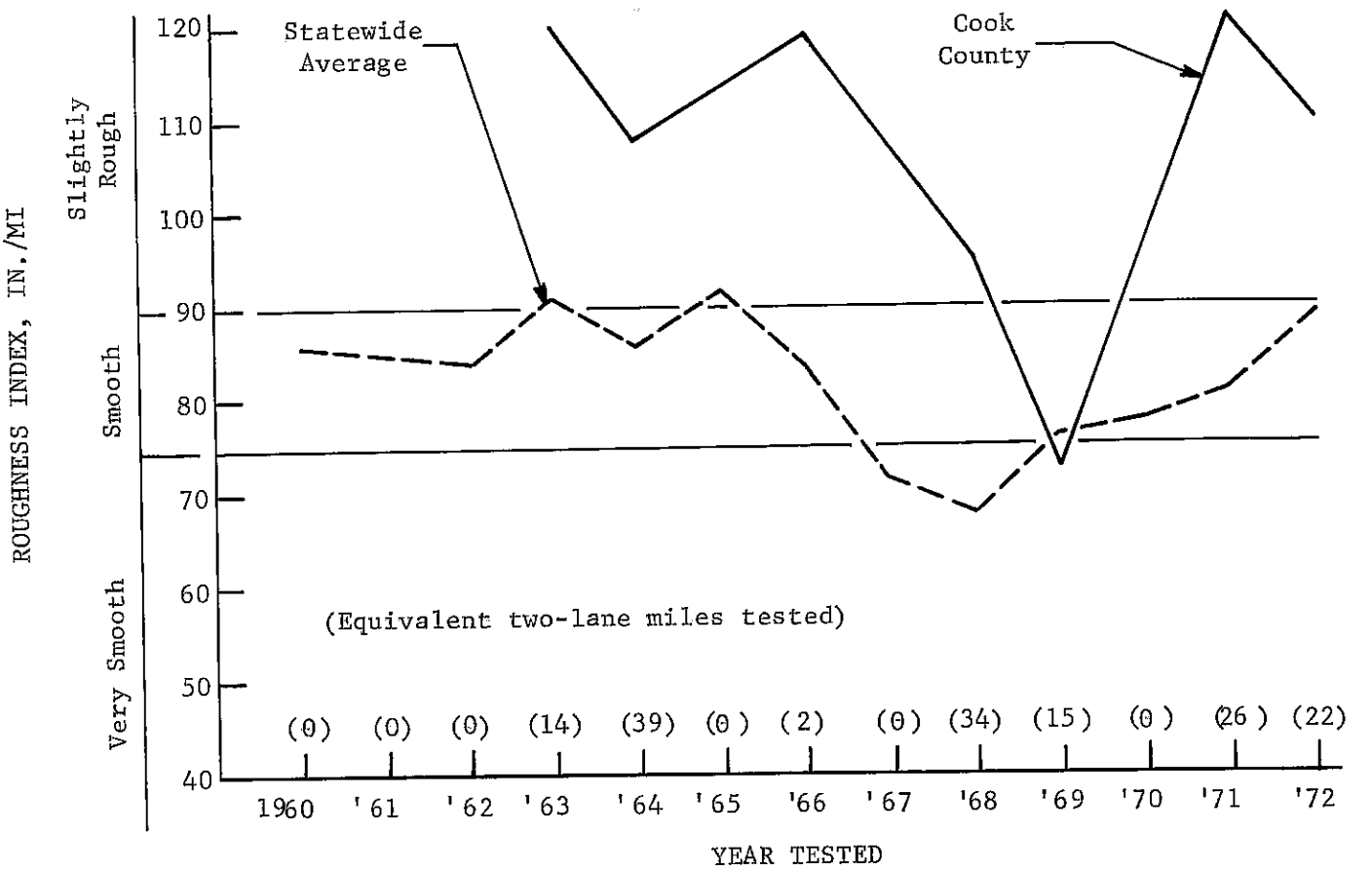

Figure 17. Graph showing average annual Roughness Index for new PCC pavements in Cook County.

TABLE 18

SUMMARY OF 1972 ROADOMETER TESTS ON NEW PCC PAVEMENTS IN DISTRICT 2

Pavement Type	Projects Tested	Equivalent Two-Lane Miles	Average RI in./mi	Adjective Rating
PCC - Side Forms	4	4	117	Slightly Rough
PCC - Slipform	-	-	-	
CRC - Side Forms	-	-	-	
CRC - Slipform	4	16	79	Smooth
1972 Weighted Average	8	20	87	Smooth
Smoothest Project	IC*	3.90	71	Very Smooth
Roughest Project	LBB*	1.28	163	Rough

*Contractor coded by Bureau of Construction

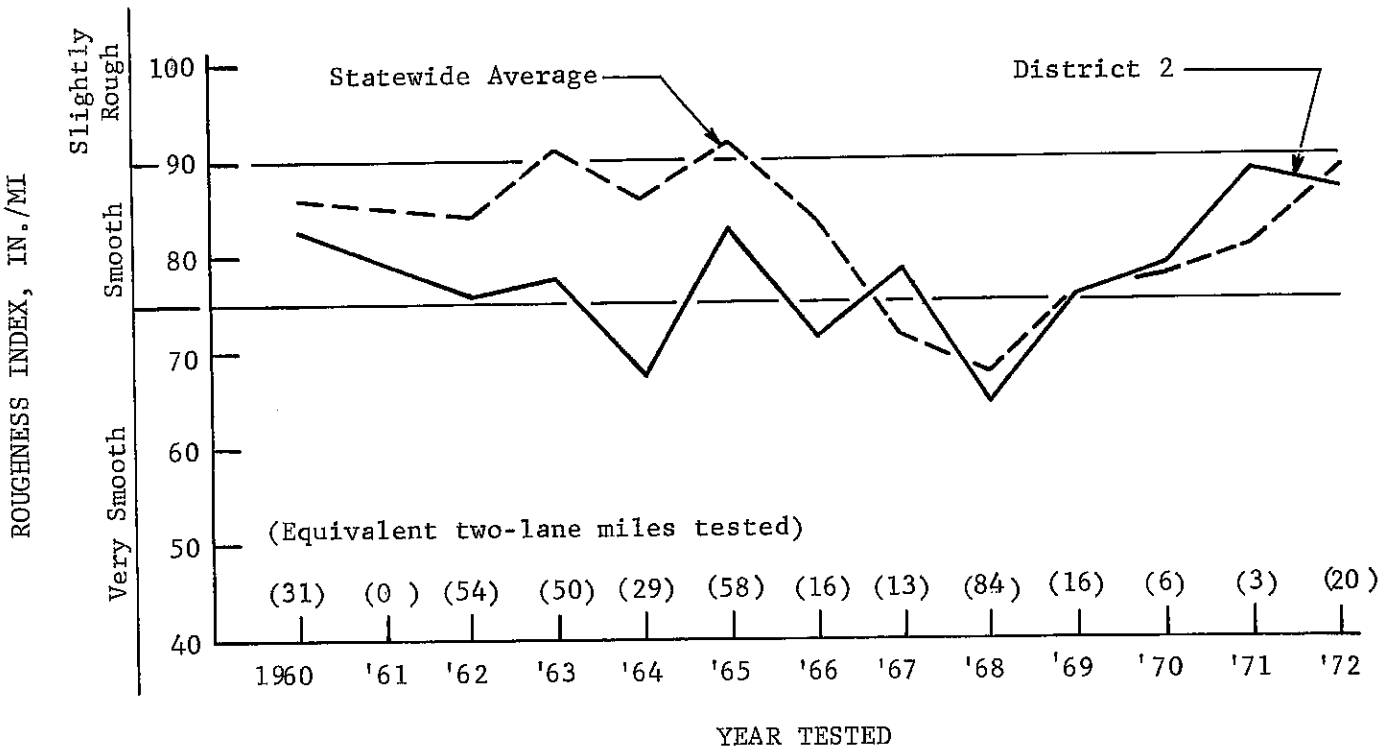

Figure 18. Graph showing average annual Roughness Index for new PCC pavements in District 2.

TABLE 19

SUMMARY OF 1972 ROADOMETER TESTS ON NEW PCC PAVEMENTS IN DISTRICT 3

Pavement Type	Projects Tested	Equivalent Two-Lane Miles	Average RI in./mi	Adjective Rating
PCC - Side Forms				
PCC - Slipform				
CRC - Side Forms				
CRC - Slipform				
		(NO TESTS TAKEN IN 1972)		
1972 Weighted Average				
Smoothest Project	*			
Roughest Project	*			

*Contractor coded by Bureau of Construction

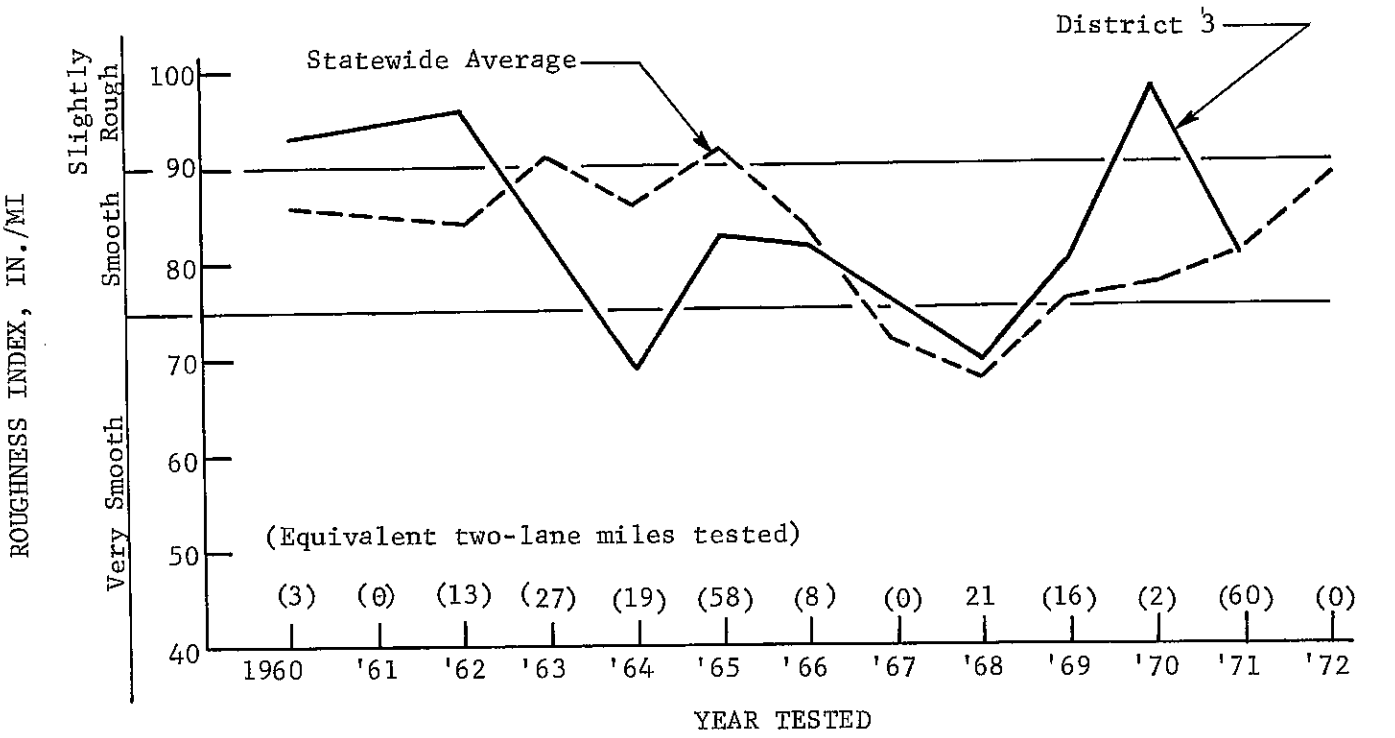

Figure 19. Graph showing average annual Roughness Index for new PCC pavements in District 3.

TABLE 20

SUMMARY OF 1972 ROADOMETER TESTS ON NEW PCC PAVEMENTS IN DISTRICT 4

Pavement Type	Projects Tested	Equivalent Two-Lane Miles	Average RI in./mi	Adjective Rating
PCC - Side Forms	-	-	-	
PCC - Slipform	3	1	120	Slightly Rough
CRC - Side Forms	-	-	-	
CRC - Slipform	2	13	72	Very Smooth
1972 Weighted Average	5	14	77	Smooth
Smoothest Project	AH*	10.08	64	Very Smooth
Roughest Project	SD & AH*	.63	123	Slightly Rough

*Contractor coded by Bureau of Construction

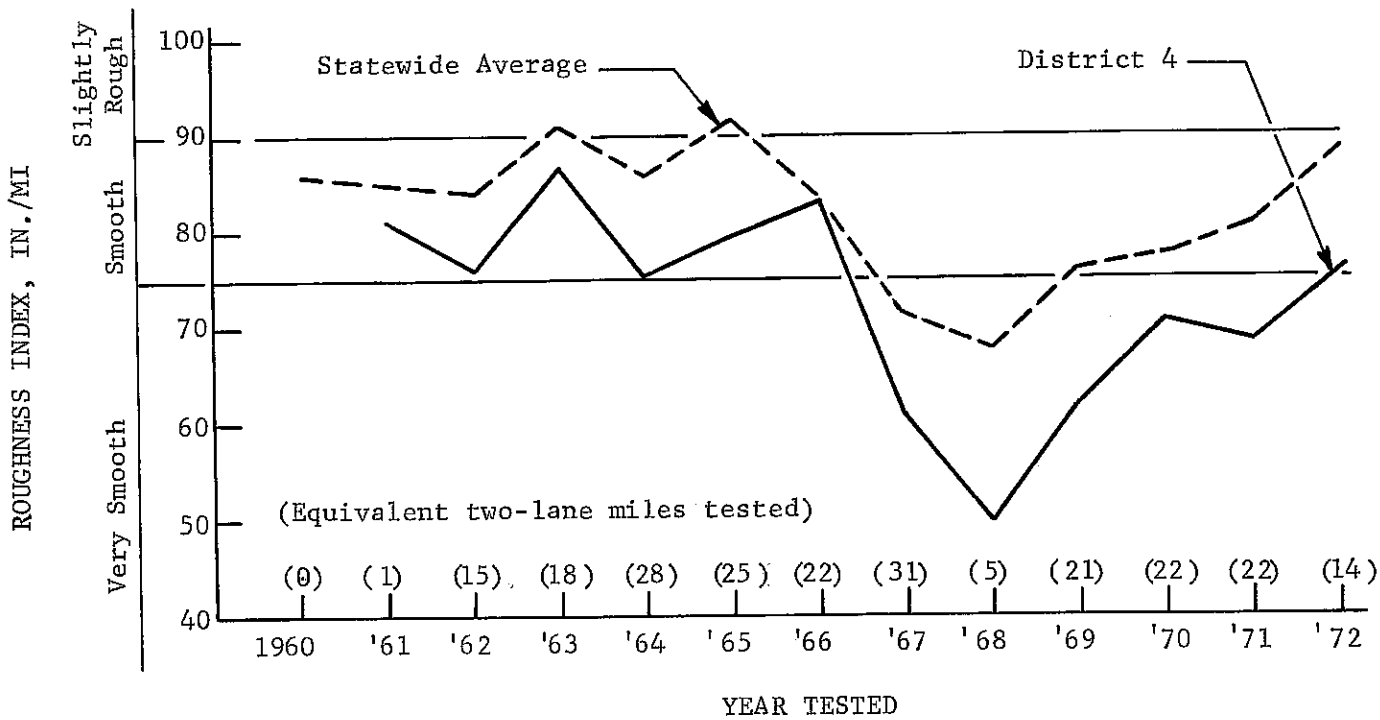

Figure 20. Graph showing average annual Roughness Index for new PCC pavements in District 4.

TABLE 21

SUMMARY OF 1972 ROADOMETER TESTS ON NEW PCC PAVEMENTS IN DISTRICT 5

Pavement Type	Projects Tested	Equivalent Two-Lane Miles	Average RI in./mi	Adjective Rating
PCC - Side Forms	6	6	99	Slightly Rough
PCC - Slipform	4	8	108	Slightly Rough
CRC - Side Forms	-	-	-	
CRC - Slipform	2	52	83	Smooth
1972 Weighted Average	12	66	88	Smooth
Smoothest Project	HG & HH*	1.72	70	Very Smooth
Roughest Project	GB*	.26	132	Rough

*Contractor coded by Bureau of Construction

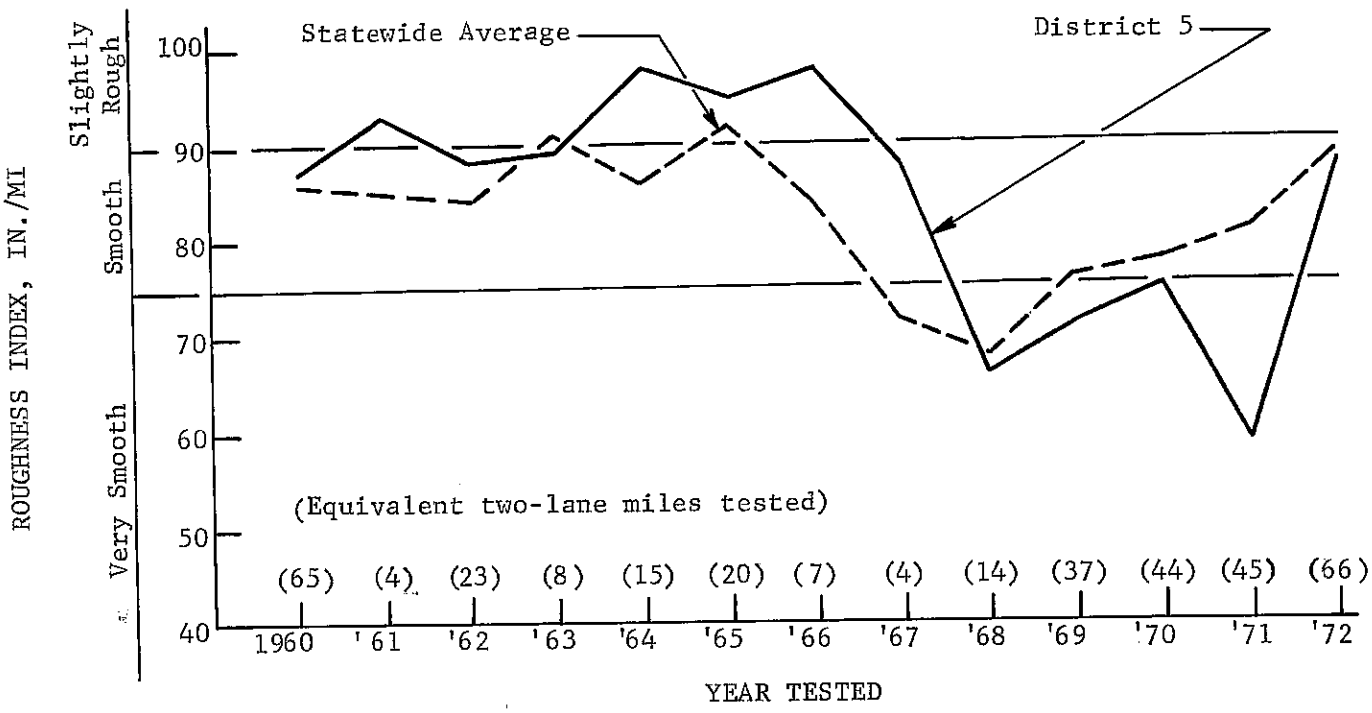

Figure 21. Graph showing average annual Roughness Index for new PCC pavements in District 5.

TABLE 22

SUMMARY OF 1972 ROADOMETER TESTS ON NEW PCC PAVEMENTS IN DISTRICT 6

Pavement Type	Projects Tested	Equivalent Two-Lane Miles	Average RI in./mi	Adjective Rating
PCC - Side Forms	3	5	101	Slightly Rough
PCC - Slipform	-	-	-	
CRC - Side Forms	-	-	-	
CRC - Slipform	6	53	91	Slightly Rough
1972 Weighted Average	9	58	92	Slightly Rough
Smoothest Project	SA & GH*	4.99	84	Smooth
Roughest Project	LBB*	.60	117	Slightly Rough

*Contractor coded by Bureau of Construction

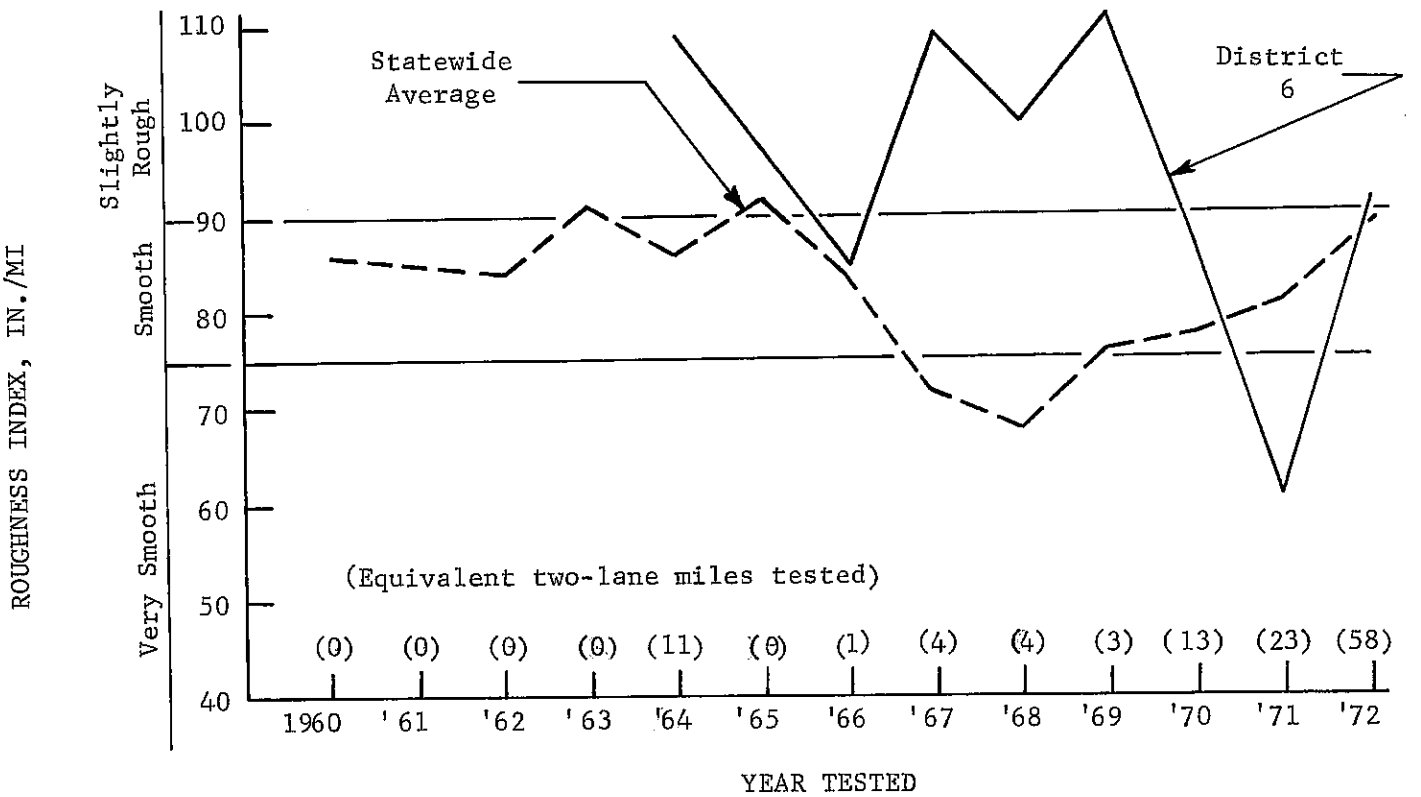

Figure 22. Graph showing average annual Roughness Index for new PCC pavements in District 6.

TABLE 23

SUMMARY OF 1972 ROADOMETER TESTS ON NEW PCC PAVEMENTS IN DISTRICT 7

Pavement Type	Projects Tested	Equivalent Two-Lane Miles	Average RI in./mi	Adjective Rating
PCC - Side Forms	-	-	-	
PCC - Slipform	2	6	97	Slightly Rough
CRC - Side Forms	-	-	-	
CRC - Slipform	-	-	-	
1972 Weighted Average	2	6	97	Slightly Rough
Smoothest Project	SJ*	.45	87	Smooth
Roughest Project	GB*	5.47	98	Slightly Rough

*Contractor coded by Bureau of Construction

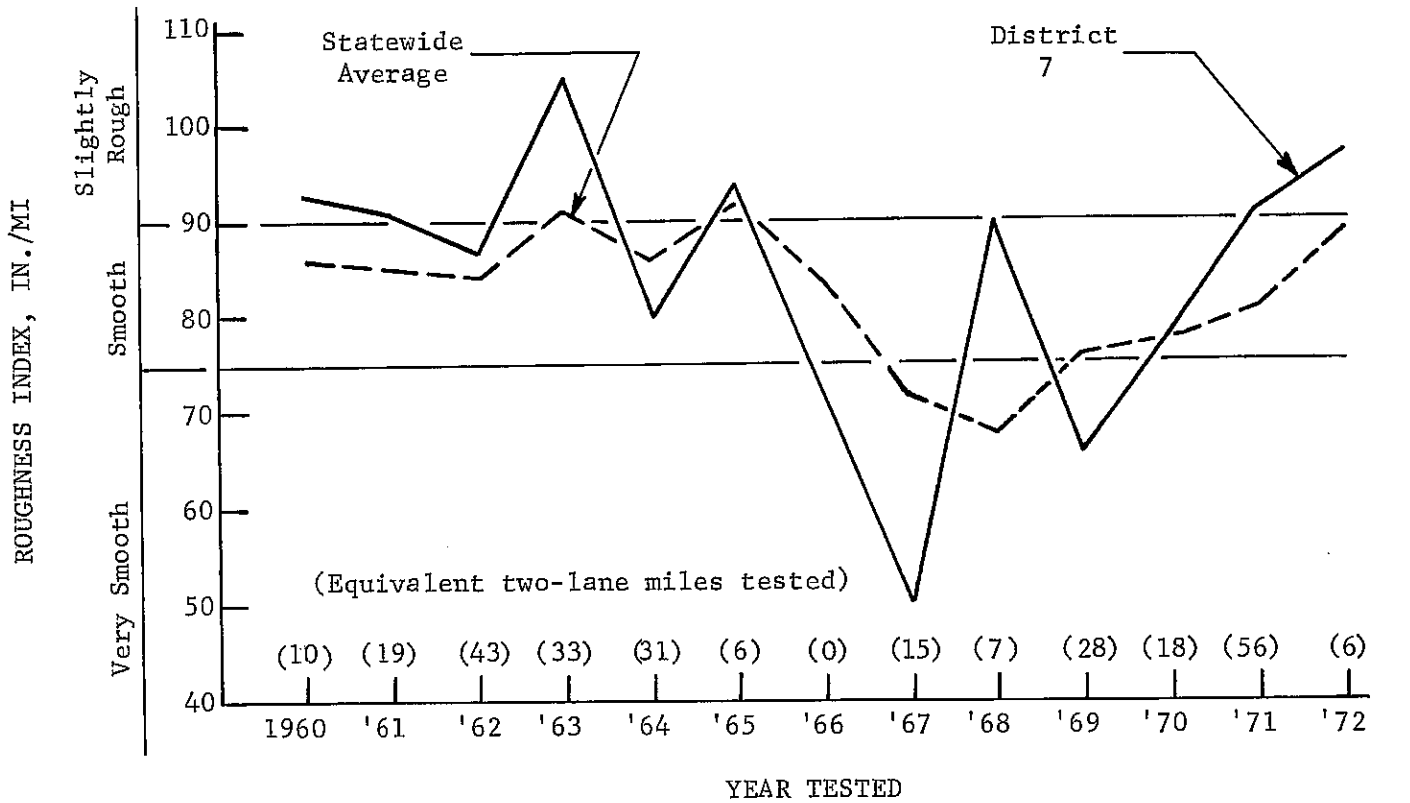

Figure 23. Graph showing average annual Roughness Index for new PCC pavements in District 7.

TABLE 24

SUMMARY OF 1972 ROADOMETER TESTS ON NEW PCC PAVEMENTS IN DISTRICT 8

Pavement Type	Projects Tested	Equivalent Two-Lane Miles	Average RI in./mi	Adjective Rating
PCC - Side Forms	-	-	-	
PCC - Slipform	-	-	-	
CRC - Side Forms	-	-	-	
CRC - Slipform	4	47	81	Smooth
1972 Weighted Average	4	47	81	Smooth
Smoothest Project	HE*	8.12	77	Smooth
	HE*	7.32	77	Smooth
Roughest Project	HE*	8.94	86	Smooth

*Contractor coded by Bureau of Construction

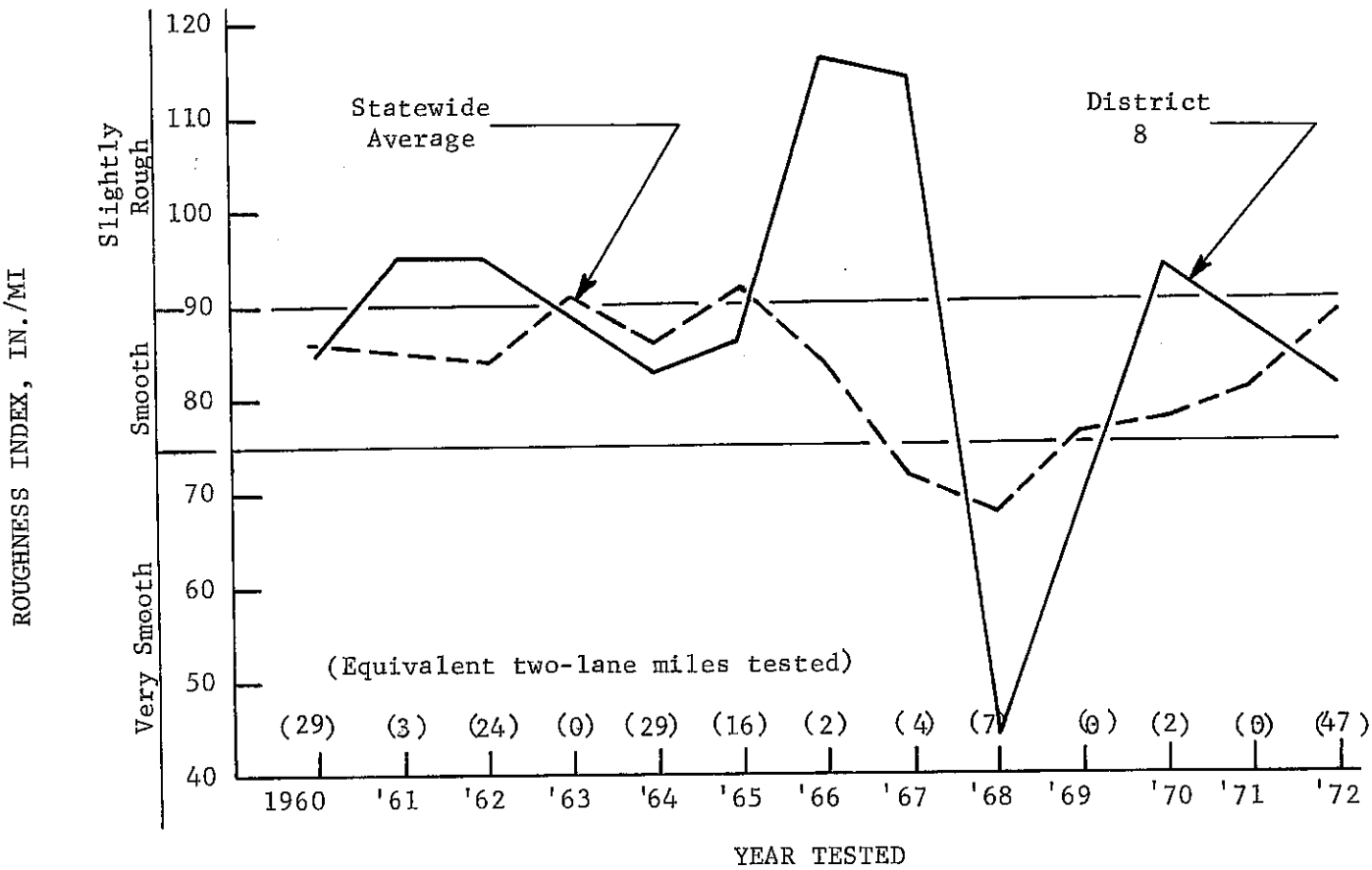

Figure 24. Graph showing average annual Roughness Index for new PCC pavements in District 8.

TABLE 25

SUMMARY OF 1972 ROADOMETER TESTS ON NEW PCC PAVEMENTS IN DISTRICT 9

Pavement Type	Projects Tested	Equivalent Two-Lane Miles	Average RI in./mi	Adjective Rating
PCC - Side Forms	7	7	113	Slightly Rough
PCC - Slipform	1	3	77	Smooth
CRC - Side Forms	-	-	-	
CRC - Slipform	3	29	79	Smooth
1972 Weighted Average	11	39	85	Smooth
Smoothest Project	PB & JD*	11.00	68	Very Smooth
	SF*	3.60	68	Very Smooth
Roughest Project	HG & FD*	0.16	151	Rough

*Contractor coded by Bureau of Construction

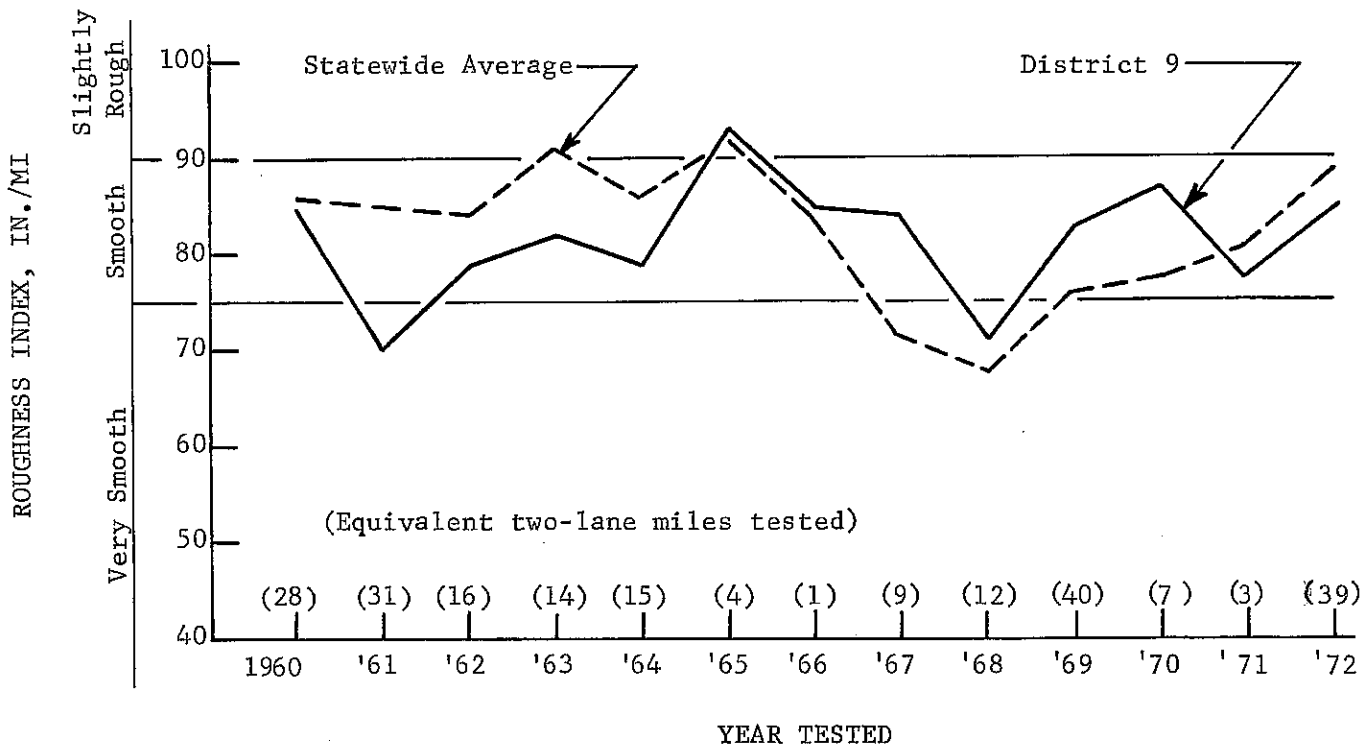

Figure 25. Graph showing average annual Roughness Index for new PCC pavements in District 9.

DISCUSSION

Experience and other research sources indicate that the riding quality of new pavement depends on many factors including, but not limited to, workmanship, construction equipment, and construction procedures. At the start of the past two decades, several contractors were beginning to use leveling devices on bituminous pavers for improving the road smoothness characteristics of bituminous surfacings. In February 1963, supplemental specifications were adopted requiring the use of a leveling device for placing bituminous concrete binder courses. Its use also was extended for placing surface courses as required by the supplemental specifications adopted in January 1966. The specifications require a supporting device having points of bearing not less than 15 feet apart, with an adjustable screed located midway between the bearing points. Back bearing points of smooth, steel wheels not less than 20 inches wide nor less than 30 inches in diameter that ride on the surface of the mixture being placed were also part of the requirement. In lieu of this device, the standard specifications, adopted August 1, 1968, permit the use of an automatic grade control device meeting the approval of the engineer.

In 1965, a special study was made of three different grade reference devices used in conjunction with an automatic grade control for the screed on bituminous pavers. The types investigated included 10-foot and 30-foot multi-foot skis, and a 6-inch joint-matching shoe. The results of the study indicate: (1) the 30-foot multi-foot ski was most effective in producing a smooth riding surface, (2) the 10-foot multi-foot ski produced a riding surface equal to the reference surface, and (3) the 6-inch joint-matching shoe produced a riding surface substantially rougher than the reference surface.

In regard to PCC pavements, the development of new equipment and construction procedures has influenced the smoothness characteristics of newly constructed

pavements as measured by the roadometers. The increased use of the slipform paving in conjunction with CRC pavement construction has shown a definite statewide improvement in the riding quality of new pavements. However, final finishing with two separate burlap drags may have resulted in part of the increase in roughness. The use of two burlap drags as currently specified became necessary to improve the skid resistance characteristics of PCC pavement surfaces.

Other factors that influence the smoothness of newly constructed pavements are: (1) stability of the subgrade or subbase supporting the paver, (2) smoothness of the surface that supports the paver, (3) accuracy in setting the grade reference line used for automatic leveling devices, and (4) consistency of the concrete mixture.

Irregular interruptions resulting in frequent stopping and starting of the paver is another factor which affects the riding quality of the pavement. Although the use of automatic screed control devices generally produces a smooth pavement, roughness can be induced every time the paver stops. Therefore, paving should be steady and continuous with no interruptions. Also, the paving speed should be consistent with the amount of concrete being delivered to the paver.

SUGGESTIONS AND RECOMMENDATIONS

Since 1968, there have been statewide trends in roadometer measurements that indicate an increase in the average roughness of newly constructed pavements. Should this trend continue, a majority of the pavements constructed in Illinois will be classified as slightly rough according to the adjective ratings established for the RI values obtained from the roadometer. In order to alleviate this problem, more attention needs to be given to those factors that influence the smoothness of as-built pavements.

One important factor in attaining smooth surfaces for both bituminous and concrete pavements is the placement of the paving materials at a uniform and uninterrupted rate. Start-and-stop operations produce rough-riding pavements. Paver speeds should be maintained as uniform as possible and should be coordinated with plant production and mix delivery.

The fact that a paver is equipped with automatic grade control is no guarantee that a smooth surface will be obtained. Complete reliance on self-leveling devices alone to achieve a smooth surface can cause overworking of the devices beyond their capabilities and result in a rough ride. Abrupt changes caused by soft or rough spots in the track lines will cause bumps to be formed in the finished surface.

When traveling grade reference devices are used, the milti-foot ski or traveling stringline should be as long as possible and not less than 30 feet. The use of shorter devices will produce poorer riding quality. In joint matching, the ski should be not less than 10 feet long, and a 6-inch joint-matching shoe should never be used. It should be noted that a 10-foot ski cannot be expected to produce a surface any smoother than the one it is tracing. A 6-inch joint-matching shoe will produce a rougher surface than the one it is tracing.

When preset stringlines are used as reference for grade control, frequent checks should be made to be sure that proper tension and correct vertical alignment are being maintained at all times.

Prior to commencing paving each day, the base or foundation over which the paver will travel should be checked to be sure that it is stable and reasonably smooth and true to grade. Yielding or rough bases will result in rough-riding pavements, even with pavers equipped with electronic grade controls.

In addition to the above, the following suggestions and recommendations are offered as possible means of improving the riding quality of new bituminous and PCC surfaces, respectively.

Bituminous Surfaces

(1) The amount of material in front of the screed and in the hopper of the paver should be maintained reasonably uniform. Permitting the amount of material in front of the screed to vary appreciably will result in a rough ride. Running the hopper dry prior to starting to unload the next truck should be discouraged.

(2) Succeeding trucks should be positioned ahead of the paver and picked up by the paver for unloading. Backing trucks into the paver usually requires stopping the paver and can jolt the machine, both of which can produce bumps in the surface being laid.

(3) Stringlining the existing pavement on resurfacing contracts and correcting major pavement variations prior to starting resurfacing operations will improve the riding quality of the new surface.

PCC Surfaces

(1) Care should be exercised to maintain a constant and proper head of concrete in front of the paver at all times. Permitting the head of concrete in front of the paver to vary appreciably during paving will adversely affect the smoothness of the surface as well as the structural quality of the pavement.

(2) Constant adjusting of paver thickness screws should be discouraged. This can result in a rough pavement.

(3) When forms are used, they should not only be checked at grade stakes but also should be checked by sighting down the form line and correcting

any irregularities between stakes. These irregularities, if not corrected, will show up in the pavement surface.

(4) Improper and excessive hand finishing of the concrete will produce a poor riding surface. Hand floating should be kept to a minimum and should always be performed prior to straightedging. Long-handled floats should never be used behind the straightedging operation.

REFERENCES

1. Foster, Charles R., "Pavement Smoothness," National Asphalt Pavement Association, November 1972.

2. Halm, Harold J., "Concrete Paving Construction Innovations--Two Miles Per Day," ASCE National Meeting on Transportation Engineering, Preprint 926, July 1969.