PROSCAN AUTOMATED PROFILOGRAM REDUCTION SYSTEM

Final Report
for
MLR-94-7

November 1994

Project Development Division

Iowa Department of Transportation

ProScan Automated Profilogram Reduction System

Final Report
MLR-94-7

By
Barbara Andersen
Transportation Engineering Intern
Special Investigations - Office of Materials

and

Kevin Jones
Special Investigations Engineer
515-239-1232
Office of Materials
Project Development Division
Iowa Department of Transportation
Ames, Iowa 50010

November 1994

TECHNICAL REPORT TITLE PAGE

1. REPORT NO.	2. REPORT DATE
MLR-94-7	November 1994

3. TITLE AND SUBTITLE	4. TYPE OF REPORT & PERIOD COVERED
Evaluation of ProScan: The Computerized Profilogram Scanning Reduction System for Noncomputerized Profilographs	Final Report, 08-94 to 11-94

5. AUTHOR(S)	6. PERFORMING ORGANIZATION ADDRESS
Kevin Jones Special Investigations Engineer Barbara Andersen Transportation Engineering Intern	Iowa Department of Transportation Materials Office 800 Lincoln Way Ames, Iowa 50010

7. ACKNOWLEDGEMENT OF COOPERATING ORGANIZATIONS

8. ABSTRACT

Kansas State University, with funding from the Kansas Department of Transportation (KDOT), has developed a computerized reduction system for profilograms produced by mechanical profilographs. The commercial version of the system (ProScan™) is marketed by Devore Systems, Inc. The system consists of an IBM Compatible PC 486SX33 computer or better, Epson LQ-570 printer, a Logitech Scanman 32 hand scanner system, a paper transport unit, and the ProScan™ software. The Scanner is not adaptable to IBM computers with the micro channel architecture.

The Iowa DOT Transportation Centers could realize the following advantages by using ProScan:

1. Save about 5 to 8 staff hours of reduction and reporting time per Transportation Center per week for a Materials Technician 3 or 4. The time savings would come during the busiest part of the season.

2. Reduce errors in reduction, transfer, and typing of profile values.

3. Increase the accuracy of the monitor results.

4. Allow rapid evaluation of contractor traces when tolerance limits between monitor and certified results are exceeded.

9. KEY WORDS	10. NO. OF PAGES
profilograms filter settings	15

TABLE OF CONTENTS

INTRODUCTION

Kansas State University, with funding from the Kansas Department of Transportation (KDOT), has developed a computerized reduction system for profilograms produced by mechanical profilographs. The commercial version of the system (ProScan™) is marketed by Devore Systems, Inc. The system consists of an IBM Compatible PC 486SX33 computer or better, Epson LQ-570 printer, a Logitech Scanman 32 hand scanner system, a paper transport unit, and the ProScan™ software. The Scanner is not adaptable to IBM computers with the micro channel architecture.

The Iowa Department of Transportation (DOT) requires the use of a 25-foot California type mechanical profilograph to evaluate smoothness of most newly constructed pavement surfaces. Contractors are allowed to use either a computerized profilograph or a manual profilograph. The Iowa DOT Transportation Centers use manual profilographs and manual reduction procedures to reduce traces and locate bumps and dips eligble for grinding. The ProScan system can scan the same traces and automatically calculate the average profile roughness index (PRI) and identify the bump and dip locations for grinding.

This report will show the results of the ProScan system reductions compared to the results of the manual reductions and the filter setting chosen based on those results.

OBJECTIVES

The objectives of the evaluation were:

1. To compare manual reduction results to ProScan reduction results and determine an appropriate filter setting.
2. To determine the repeatability of the ProScan scanning process.
3. To compare project payment compensation for both manual and ProScan reduction of profilogram traces from recent construction projects.
4. To compute the effect of manual outlining on the ProScan results.
5. To evaluate the suitability of ProScan for use by the Department and the contractors on Iowa construction projects.

EVALUATION

A ProScan unit was purchased in August, 1994. The computer and printer were purchased separately and sent to Devore Systems, Inc. for installation of the scanner card and the software.

Manual Reduction Comparison

Four correlation traces were previously evaluated by 17 to 30 experienced Iowa DOT technicians. These results were used as a baseline to evaluate the ProScan results.

The four correlation traces were then run three times each through the scanner using two different filter settings. Filters 7 and 11 were recommended by the Devore Systems, Inc. for evaluation. Table 1 gives the results of the comparison of the ProScan and manual reduction results for the correlation traces as well as the comparison of the different filter settings.

Table 1. Correlation Traces At Different Filter Settings.
Avg. PRI (in/mi)

Correlation Traces	Manual	Filter 7	Filter 11
Trace 1	9.3	9.4	8.6
Trace 2	3.2	3.8	3.1
Trace 3	4.0	4.6	4.0
Trace 4	27.2	25.9	24.8

The purpose of the filter is to try to duplicate the manual outlining process through the profilogram trace. The ProScan reads 200 dots per inch. The filter setting is the number of scanned points in a running average used to smooth the trace. Therefore, the higher the filter number the more adjacent points used to smooth the scanned sample. A balance has to be met between smoother samples at higher filter number (with possible corresponding decrease in the calculated roughness) or a rougher sample with a lower filter number and greater chance of errors due to data noise. Filter setting 11 was chosen as the setting producing results closest to the manual results on the smooth traces.

Repeatability

Once the filter setting was decided, two of the correlation traces were each scanned six more times at the selected filter setting of 11 to determine the standard deviation and coefficient of variation of the PRIs for each trace. Table 2 shows the results of this evaluation.

TABLE 2.

	TRACE 1 (MANUAL)	TRACE 1 (PROSCAN)	TRACE 4 (MANUAL)	TRACE 4 (PROSCAN)
AVG. PRI. (IN.MI)	9.3	8.6	27.2	24.3
STANDARD DEVIATION	0.71	0.35	1.9	0.75
COEF. VAR.	7.6	4.1	7.0	3.0
NO. OF PEOPLE OR TRIALS	30	9	17	9

Pavement Compensation Comparison

Final payment for contractors is adjusted, based on profilogram results. Comparing the payment adjustment from manual and ProScan reductions of the same profilogram provides a measure of the sensitivity of the ProScan results with respect to manual reduction results. Five field traces were evaluated for payment adjustment based on Iowa DOT Supplemental Specification SS-5130. Tables 3a through 3c give the profile index results and associated pay adjustment comparison for new asphalt concrete surfaces.

TABLE 3a. P-133-0(6)--30-85
AVERAGE PRI (IN/MI)

SEGMENT(0.1MI)	MANUAL	FILTER 7 (AVERAGE OF 3 TRIALS)	FILTER 11 (AVERAGE OF 3 TRIALS)
1	15.5	16.3	15.0
2	5.5	4.0	4.0
3	8.5	8.2	7.5
AVERAGE PRI	9.8	8.7	8.0
INCENTIVE	NONE	NONE	NONE
REDUCTION	$100 AND ONE GRIND SECTION	$100 AND ONE GRIND SECTION	$100 AND ONE GRIND SECTION

TABLE 3b. STP-17-4((27)--22-99
AVERAGE PRI (IN/MI)

SEGMENT	MANUAL	FILTER 7 (AVG. OF 3 TRIALS)	FILTER 11 (AVG. OF 3 TRIALS)
1	4.0	4.0	3.5
2	2.5	1.5	1.5
3	0.5	0.5	0.5
4	0	0.5	0.5
5	0	0	0
6	0	0	0
7	0	0.5	0
8	0.5	0	0
9	0.5	0	0
10	0	0	0
11	0	0	0
12	0	0	0
13	0	0	0
14	0	0	0
AVERAGE PRI	0.5	0.5	0.4
INCENTIVE	$2825	$2875	$2875

TABLE 3c. STP-146-4(12)--2C-64
AVERAGE PRI (IN/MI)

SEGMENT	MANUAL	FILTER 7 (AVG. OF 3 TRIALS)	FILTER 11 (AVG. OF 3 TRIALS)
1	2.0	1.5	1.5
2	0	0	0
3	1.5	1.5	1.3
4	0.5	0	0
5	1.5	1.5	1.0
6	1.5	0	0
7	1.0	0.5	0.5
8	0.5	0	0
9	0	0	0
10	0	0	0
11	0	0	0
12	1.0	1.2	0.8
13	0.5	0.5	0.5
14	2.0	1.5	1.2
AVERAGE PRI	0.9	0.7	0.6
INCENTIVE	$2900	$2900	$3000

Tables 4a and 4b give the profile index results and associated pay adjustments comparison for new pc concrete surfaces.

TABLE 4a. SN-3265(9)--51-37
AVERAGE PRI (IN/MI)

SEGMENT	MANUAL	FILTER 7 (AVG. OF 3 TRIALS)	FILTER 11 (AVG. OF 3 TRIALS)
1	4.0	5.8	5.7
2	4.0	4.8	4.5
3	4.0	4.5	4.5
4	13.0	9.5	9.5
5	18.0	19.5	19.5
6	21.5	23.0	23.0
7	3.5	4.5	4.5
8	7.5	10.7	9.0
AVERAGE PRI	9.5	10.4	10.1
INCENTIVES	NONE	NONE	NONE
REDUCTION	$100 AND 3 GRIND SECTIONS	$100 AND 3 GRIND SECTIONS	$200 AND 2 GRIND SECTIONS

TABLE 4b. F-30-5(80)--20-85
AVERAGE PRI (IN/MI)

SEGMENT	MANUAL	FILTER 7 (AVG. OF 3 TRIALS)	FILTER 11 (AVG. OF 3 TRIALS)
1	1.0	0.7	0.5
2	1.5	0.5	0.5
3	1.0	1.0	1.0
4	0	0	0.0
5	1.0	1.3	1.0
6	1.0	1.2	1.0
AVERAGE PRI	0.9	0.8	0.6
INCENTIVE	$4450	$4400	$4500

Manual Outlining

Manual outlining of a trace is done to remove some of the spikes and minor deviations caused by rocks, texturing, or transverse grooving. To find the effect of manual outlining on the scanning process, a section was scanned before and after an experienced technician outlined the trace. Table 5 gives the results of each scan.

Table 5.
AVG. PRI (IN/MI)

SEGMENT (0.1MI.)	FILTER 7: BEFORE OUTLINED	FILTER 7: AFTER OUTLINED	FILTER 11:BEFORE OUTLINED	FILTER 11:AFTER OUTLINED
1	6.8	8.7	6.3	6.8
2	3.2	2.8	2.5	2.5
3	2.0	1.8	1.8	2.0
4	4.3	4.0	4.0	4.0
5	0.5	0.5	0.5	0.5
6	2.5	2.5	2.5	2.5
7	3.2	3.0	3.0	2.7
8	3.7	2.3	2.7	2.5
9	10.0	9.2	9.2	8.3
10	2.3	2.0	2.0	1.5
11	1.2	1.4	1.0	1.0
AVG. PRI	3.6	3.5	3.2	3.1

DISCUSSION OF RESULTS

ProScan was able to satisfactorily and accurately scan the profilograms evaluated in this study into the computer. The computer system uses a different blanking band placement method than is specified by the Iowa DOT. ProScan allows the vertical placement of each successive blanking band placement to be independent of the last. The Iowa DOT method requires the trailing end of the blanking band to be at the same vertical point as the leading edge of the preceding blanking band placement. From the traces in this study, it appears that the larger the profile index, the larger the difference in the results from the two methods.

The standard deviations of the four correlation traces were determined to find the repeatability of the ProScan system. As shown in Table 2, the standard deviations and the coefficient of variation values were reduced by about one-half from the manual results to the ProScan results, meaning that the ProScan system is more accurate and consistent in its results.

At both filters 7 and 11 the payment adjustment results for the field traces were within 1% of the manual results. The payment schedule used by the Iowa DOT isn't sensitive to small biases in the profile index values.

ProScan will likely be used to evaluate contractor traces that were previously manually reduced and manually outlined. Manual outlining on the trace analyzed decreased the average PRI by 0.1 inch per mile.

SUITABILITY FOR PROJECT USE

The ProScan system is suitable for use by the Transportation Centers to analyze monitor traces for smoothness. The issue of the blanking band placement methods needs to be resolved in the Materials Instruction Memorandum I.M. 341. The computer profilographs also allow the blanking band placement to be independent of the last placement. This year 13 out of the 41 profilographs calibrated in Iowa were computerized. A small bias toward a smaller than actual profile index may be encountered.

The available test report formats for ProScan are not appropriate for use in Iowa by the contractors. The Appendix contains an example of the ProScan test report. A test report format consistent with the current Iowa form could be requested from the vendor.

The ProScan system has the capability of plotting the scanned trace with the blanking band placement and grind locations shown. The Appendix contains an example of a plotted trace. This provides for verification of the scan, if necessary. The vendor indicates that the ProScan can process and report profilograms at

the rate of 15 miles per hour versus a manual rate of about 1.5 miles per hour.

ProScan is an alternative to manual reduction or to one of the three types of computerized profilographs. ProScan is being marketed at $7,500. A computerized upgrade to a manual profilograph would cost about $15,000. The advantage to the computerized profilographs is that the profile index is available immediately after testing. The disadvantage is needing a generator for power.

The Iowa DOT Transportation Centers could realize the following advantages by using ProScan:

1. Save about 5 to 8 staff hours of paving and reporting time per Transportation Center per week for a Materials Technician 3 or 4. The time savings would come during the busiest part of the season.
2. Reduce errors in reduction, transfer, and typing of profile values.
3. Increase the accuracy of the monitor results.
4. Allow rapid evaluation of contractor traces when tolerance limits between monitor and certified results are exceeded.

SUMMARY AND CONCLUSIONS

ProScan is economically feasible. It will save staff time of experienced technicians in reducing profilogram traces and producing test reports. It is more accurate than manual reduction for profile indexes less than 10 inches per mile. The

precision is higher for all profile indexes tested. Filter 11 gives the best reduction results compared to the manual results. Finally, the project payment adjustment is not significantly affected by the switch to the ProScan system.

There are some disadvantages. The test report currently printed out does not meet the requirements of the Iowa DOT and will have to be developed by the vendor.

RECOMMENDATIONS

1. Purchase at least six systems, one for each Transportation Center.
2. Request the vendor to provide an Iowa DOT test report format in ProScan.
3. Allow the use of ProScan by contractors with the modified test report format.
4. Review the Materials Instructional Memorandum I.M. 341 and modify the blanking band placement procedures for the computerized method.

Appendix

PROSCAN - PROFILOGRAPH REPORT OF PAVEMENT SMOOTHNESS

Project No. STP-17-4(27)--22-99 County

Contractor FRED CARLSON Pavement Type ACC

Station 0+00.0 to station 76+13.5 Traffic Direction

No. of Lanes Direction of Paving

Date [Placed/Corrected] Date Tested 9-6-94

Tested by (Evaluated by ProScan) BARB ROTH

Paving Action Special Prov.

	Track 1			Track 2			Track 3			
			Meas'd			Meas'd			Meas'd	Avg
Seg	Leng (mi)	Rough (in)	PRI (in/mi)	Seg	Leng (mi)	Rough (in)	PRI (in/mi)	Seg	Leng (mi)	Rough (in)	PRI (in/mi)	PRI (in/mi)
1	.100	0.35	3.5									3.5
2	.100	0.15	1.5									1.5
3	.100	0.05	0.5									0.5
4	.100	0.05	0.5									0.5
5	.100	0.00	0.0									0.0
6	.100	0.00	0.0									0.0
7	.100	0.00	0.0									0.0
8	.100	0.00	0.0									0.0
9	.100	0.00	0.0									0.0
10	.100	0.00	0.0									0.0
11	.100	0.00	0.0									0.0
12	.100	0.00	0.0									0.0
13	.100	0.00	0.0									0.0
14	.100	0.00	0.0									0.0
15	.042	0.00	0.0									0.0
Total/Avg												
	1.442	0.60	0.4									0.4

There were no defects located in these segments.

Scallop (Filter 11)
- min height .030 in
- min width .08 in
- resolution .05 in

Blanking band .20 in

Defect template .50 in

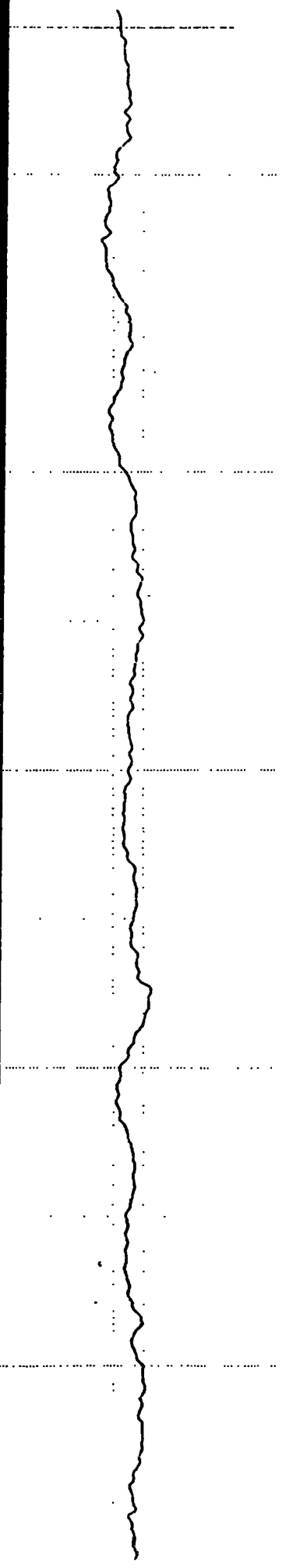
Certified by:

Title:

Organization:

File FCTEST11

Substitute IA-DOT Form



PROSCAN - PROFILOGRAM SCANNING SYSTEM
VERSION V3.00 - DEVORE SYSTEMS, INC.

File FILTER72
Track 1 Segment 1

Station 50+00.0 to 55+28.0
Segment length 21.12in (528ft, .100mi)

Up is to the right

Scallop (Filter 07)

minimum height	.030	in
minimum width (300:1)	.08	in
resolution	.05	in
Blanking band	.20	in
Defect template height	.50	in

Profile Roughness Index 2.5 in/mi
No bumps or dips found!