CORRELATION OF THE ROUGHOMETER TO THE HIGH-SPEED LASER PROFILER

Final Report
For
MLR-97-7

NOVEMBER 1997

Project Development Division

Iowa Department of Transportation

Correlation of the Roughometer to the High-Speed Laser Profiler

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November 1997

TECHNICAL REPORT TITLE PAGE

1. REPORT NO.	2. REPORT DATE
MLR-97-7	November 1997

3. TITLE AND SUBTITLE	4. TYPE OF REPORT & PERIOD COVERED
Correlation of the Roughometer to the High-Speed Laser Profiler	Final report, 5-97 to 11-97

5. AUTHOR(S)	6. PERFORMING ORGANIZATION ADDRESS
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7. ACKNOWLEDGEMENT OF COOPERATING ORGANIZATIONS

8. ABSTRACT

The Iowa Department of Transportation has been using the Bureau of Public Roads (BPR) Roughometer as part of its detour analysis process for more than 20 years. Advances in technology have made the BPR Roughometer obsolete for ride quality testing. High-speed profilers that can collect the profile of the road at highway speeds are the standard ride instruments for determining ride quality on pavements. The objective of the project was to develop a correlation between the BPR Roughometer and the high-speed laser South Dakota type Profiler (SD Profiler).

Nineteen pavement sections were chosen to represent the range of types and conditions for detours. Three computer simulation models were tested on the profiler profiles. The first model is the International Ride Index (IRI) which is considered the standard index for reporting ride quality in the United States. The second model is the Ride Number (RN) developed by the University of Michigan Transportation Research Institute and the third model used is a quarter-car simulation of the BPR Roughometer (ASTM E-1170) which should match the speed and range of roadway features experienced by Iowa's BPR Roughometer unit.

The BPR Roughometer quarter-car model provided the best overall correlation with Iowa's BPR Roughometer. Correlation coefficients and standard error estimates were:

	R^2	Std. Error (Inches/Mile)
ACC Surfaced Pavements	0.94	10.7
PCC Surfaced Pavements	0.93	12.6
Combined	0.94	11.8

The correlation equation developed from this work will allow use of the high-speed laser profiler to predict the BPR Roughometer value.

9. KEY WORDS	10. NO. OF PAGES
BPR Roughometer South Dakota type Profiler	6

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DISCLAIMER

INTRODUCTION

The Iowa Department of Transportation has been using the Bureau of Public Roads (BPR) Roughometer as part of its detour analysis process for more than 20 years. The BPR Roughometer is a response-type ride meter developed around 1940. It travels at a speed of 32 kilometers per hour. Advances in technology have made the BPR Roughometer obsolete for ride quality testing. High-speed profilers that can collect the profile of the road at highway speeds are the standard ride instruments for determining ride quality on pavements. A second benefit of the high-speed profiler is the ability to collect the transverse profile of the road at the same time the longitudinal profile is being collected. In the current detour procedure, the transverse profile is collected manually.

The most important reason for moving from the BPR Roughometer to the high-speed profiler is to reduce the risk to the personnel doing the testing and to the other traffic. Not being on the road collecting transverse profile and testing at highway speed will reduce potential conflicts with traffic.

OBJECTIVE

The objective of the project was to develop a correlation between the BPR Roughometer and the high-speed laser South Dakota type Profiler (SD Profiler). The correlation would allow the use of the SD Profiler on construction detour analysis.

TESTING AND ANALYSIS

Nineteen pavement sections were chosen to represent the range of types and conditions for detours. Each section was 804 meters long. The outside wheel path of each direction was used for all testing. Three runs were made with each test unit each direction. The BPR Roughometer was operated at 32 kilometers per hour and the SD Profiler was operated at the speed limit for the section.

The purpose of the project was to develop a historical tie to the existing detour models and analysis while utilizing the current technology. A strong correlation is possible because the SD Profiler collects the profile of the road. Ride indexes are then computed by simulating in the computer various models over the profiles. Three models were tested. The first model is the International Ride Index (IRI) which is considered the standard index for reporting ride quality in the United States. The second model is the Ride Number (RN) developed by the University of Michigan Transportation Research Institute (UMTRI) which is designed to correlate well with the perceived ride quality in a passenger car.(1) The third model used is a quarter-car simulation of the BPR Roughometer (BPR-Sim) (ASTM E-1170) which should match the speed and range of roadway features experienced by Iowa's BPR Roughometer unit.(2)

Table 1 is a summary of the data collected and calculated for each section. The IRI was calculated using three different long-wavelength filters (91 meters, 15 meters, and 8 meters). The 91- meter filter is the normal filter length used for IRI reporting. Software developed by UMTRI was used to compute the Ride Number and the BPR simulation.(1)

TABLE 1. Summary of Test Data Collection

Section Number	Section Location	Pavement Type	BPR In/Mi	IRI91 M/KM	IRI15 M/KM	IRI8 M/KM	RN	BPR-SIM In/Mi
17-1e	IA 17 MP 19.5 to MP 21.5	COMP	98	2.05	1.71	1.47	2.97	164
17-2w		COMP	110	1.99	1.71	1.44	3.04	186
210-1s	IA 210 in Woodward	COMP	185	3.59	3.03	2.64	1.85	383
210-2n		COMP	207	4.11	3.55	3.11	1.56	453
11e	E23 N side Sec 10, 85N, 24W	ACC	74	0.97	0.86	0.72	3.92	111
11w		ACC	72	0.85	0.70	0.59	4.02	97
210-3e	IA 210 MP 2.0 to MP 4.5	ACC	123	2.55	2.12	1.84	2.63	245
210-4w		ACC	109	2.27	2.00	1.75	2.77	211
2e	13th St. Ames From I-35 East	ACC	116	2.47	2.13	1.85	3.09	192
2w		ACC	132	2.72	2.38	2.11	2.88	237
3e	E41 N side Sec 9 84N, 23W	ACC	153	2.49	2.26	2.04	2.18	321
3w		ACC	139	2.38	2.15	1.95	2.12	336
5n	S14 From E29 South	ACC	131	3.02	2.70	2.38	1.94	326
5s		ACC	125	2.85	2.60	2.34	2.02	286
6n	S14 From E29 North	ACC	172	2.39	2.26	2.18	1.87	358
6s		ACC	194	2.54	2.45	2.21	1.64	410
8e	E29 From R77 East	ACC	181	3.99	3.80	3.42	1.69	446
8w		ACC	209	3.65	3.42	3.14	1.67	444
9e	E29 From I-35 West	ACC	80	1.36	1.18	1.01	3.51	128
ONT-E	Ontario St. Ames From North Dakota east	ACC	174	4.58	4.05	3.47	1.74	370
ONT-W		ACC	178	4.01	3.53	3.08	2.09	416
10e	Co. Rd. N side Sec 25 84N 24W	PCC	89	1.48	1.27	1.10	3.67	129
10w		PCC	107	1.56	1.39	1.23	3.49	159
12n	R38 From E26 South	PCC	84	1.47	1.33	1.17	3.67	134
12s		PCC	77	1.24	1.10	0.96	3.79	114
1e	13th St. Ames From Dayton Ave. West	PCC	230	5.24	4.62	4.04	1.37	492
1w		PCC	218	4.77	4.05	3.48	1.62	491
24E	24th ST. Ames From Stange East	PCC	128	3.02	2.44	1.98	2.5	270
24W		PCC	155	3.58	2.92	2.39	1.89	332
4n	Airport Rd. Nevada From E41 South	PCC	182	2.77	2.56	2.33	2.53	300
4s		PCC	141	2.50	2.24	2.00	3.24	240
50N	R50 South From E26	PCC	132	2.40	2.14	1.90	2.23	276
50S		PCC	124	2.29	2.05	1.82	2.12	260
7n	R77 From E29 North	PCC	95	2.02	1.61	1.33	3.17	184
7s		PCC	104	2.28	1.86	1.53	2.48	181
210-5w	IA 210 MP 4.5 to MP 5.5	PCC	127	2.60	2.28	1.92	N/A	206
210-6e		PCC	121	2.54	2.16	1.80	N/A	197

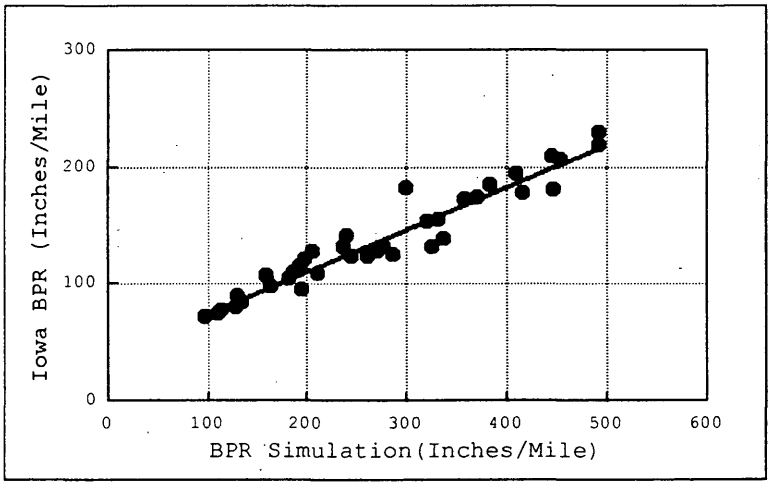
Table 2 contains the summary of the correlations. The IRI value was looked at first because it is the standard index used and reported in Iowa. Unfortunately, the correlation was not as good as desired. The IRI simulates travel at a speed of 80 kilometers per hour and is affected greatest by profile deviations in the 1.2 -meter to 30.5-meter range.(1) The BPR Roughometer travels at 32 kilometers per hour and is affected greatest by profile deviations in the 0.6-meter to 7.6-meter range.(3) The Ride Number analysis also did not provide satisfactory correlations.

Table 2. Summary of Correlations

Model	Section Surface	R^2	Std.. Err.	A*	B*
IRI91	ACC Surfaced	0.71	24.0	44.1	35.8
	PCC Surfaced	0.88	16.0	34.0	37.6
	Combined	0.78	20.5	39.1	36.8
IRI15	ACC Surfaced	0.75	22.1	43.5	40.5
	PCC Surfaced	0.93	12.6	31.1	44.9
	Combined	0.83	18.3	37.5	42.6
IRI8	ACC Surfaced	0.78	20.4	42.4	46.3
	PCC Surfaced	0.95	10.2	30.5	52.5
	Combined	0.86	16.6	37.0	48.9
RN	ACC Surfaced	0.84	17.8	266.7	-51.5
	PCC Surfaced	0.69	28.0	266.8	-49.5
	Combined	0.77	21.8	265.3	-50.1
BPR-Sim	ACC Surfaced	0.94	10.7	36.6	0.36
	PCC Surfaced	0.93	12.6	37.8	0.38
	Combined	0.93	11.8	38.5	0.36
*Equation	BPR=A+B(X)				

The Quarter Car simulation using the BPR Roughometer parameters listed in the ASTM E-1170 and a simulation speed of 32 kilometers per hour produced the best correlations for the ACC surfaced sections and for the combination of all the sections. Figure 1 shows graphically the correlation achieved. Detour analyses are done before and after the detour is used. Small deviations from a perfect correlation are not considered critical because the deviation should be constant for both the before and after test on a detour segment when the same unit is used.

Figure 1. Correlation Plot for Iowa BPR and BPR Simulation- All Sections



RECOMMENDATIONS

Based on the study the following recommendations can be made:

1. The laser South Dakota Type Profiler should be used on all detour testing starting in 1998.
2. The simulated BPR Roughometer model in ASTM E-1170 should be used to calculate the ride index used in the detour analysis.

3. The 5-sensor transverse profile values from the profiler should be used in the detour analysis in place of the manual method values.

4. The International Roughness Index should also be calculated and provided to the Department and local agency personnel involved in the detour agreement. The IRI value is used in the pavement management system for both the department and local agencies and may be more understandable and meaningful than the seldom encountered BPR Roughometer value.

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