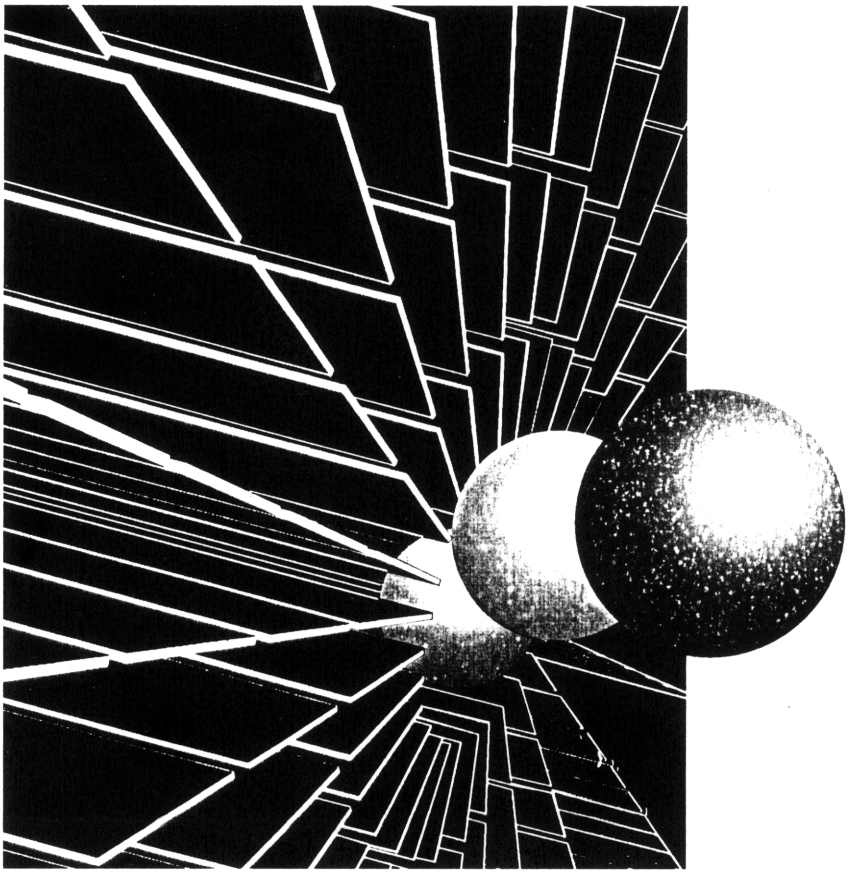
MoDOT

Research, Development and Technology

RDT 00-005

Evaluation of Diamond Grinding New PCCP
Route 60, Butler County

RI 96-025



July, 2000

TECHNICAL REPORT DOCUMENTATION PAGE

1. Report No. RDT00-005	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Evaluation of Diamond Grinding New PCCP Route 60, Butler County		5. Report Date May, 2000 6. Performing Organization Code MoDOT
7. Author(s) Dave Amos		8. Performing Organization Report No. RDT00-005/RI96-025
9. Performing Organization Name and Address Missouri Department of Transportation Research, Development and Technology P. O. Box 270-Jefferson City, MO 65102		10. Work Unit No. 11. Contract or Grant No.
12. Sponsoring Agency Name and Address Missouri Department of Transportation Research, Development and Technology P. O. Box 270-Jefferson City, MO 65102		13. Type of Report and Period Covered Final Report 14. Sponsoring Agency Code MoDOT
15. Supplementary Notes The investigation was conducted in cooperation with the U. S. Department of Transportation, Federal Highway Administration.		

16. Abstract

Two projects were selected for this investigation to provide a comparison between a diamond ground surface and a standard transverse tined surface. The two projects were located on Route 60, Butler County. The only difference was in the finishing technique: one was transversely tined while the other had a burlap drag finish with diamond grinding taking place within approximately a month of construction. The two projects are being monitored on a yearly basis by means of a visual distress survey, profilograph measurements using the 0.0 blanking band, the Automated Road Analyzer (ARAN) data, falling weight deflectometer (FWD), and friction properties.

The initial smoothness of the diamond ground pavement was smoother than the tined pavement with an average profile index of 6.3 inches per mile. The tined sections had an average profile index of 17.0 inches per mile, while the initial International Roughness Index (IRI) for the diamond ground sections averaged 62.4 and the tined sections averaged 91.8. After 2 years of service, the diamond ground pavement continues to maintain a lower profile index than the conventional tined pavement. The profile index after 2 years of service for the diamond ground sections is 6.7 inches per mile compared to 16.5 inches per mile for the tined sections. The diamond ground pavement sustains a higher serviceability rating than the tined, ranks higher in the state percentile, and has a comparable roughness index. Both pavements have favorable friction properties.

After two years of service, it can be stated that diamond grinding does produce a quieter and smoother ride than normally transverse tined pavement. This is an initial report containing the initial test data. It should be continued with yearly updates. It is recommended that diamond grinding as a finishing technique be used on other projects in the state for data comparison.

17. Key Words Diamond grinding, transverse tined, smoothness, profile index, profilograph, IRI, friction	18. Distribution Statement No restrictions. This document is available to the public through National Technical Information Center, Springfield, Virginia 22161

19. Security Classification (of this report) Unclassified	20. Security Classification (of this page) Unclassified	21. No. of Pages 11 w/o Appendices	22. Price

Form DOT F 1700.7 (06/98)

INITIAL REPORT

Research Investigation RI96-025

EVALUATION OF DIAMOND GRINDING NEW PCCP
ROUTE 60
BUTLER COUNTY

MISSOURI DEPARTMENT OF TRANSPORTATION
RESEARCH, DEVELOPMENT AND TECHNOLOGY DIVISION

Written By: Dave Amos, Intermediate Research and Development Assistant

Acknowledgement to:
Patty Brake Lemongelli, Director Research
Vernon Adams, Research and Development Assistant

JEFFERSON CITY, MISSOURI
DATE SUBMITTED: MAY, 2000

EXECUTIVE SUMMARY

In 1996, MoDOT began reviewing a proposal to use diamond grinding as a means to provide texture and a smooth profile in place of a transversely tined finish. It is believed that this method of construction would produce a smoother and more durable pavement at a comparable cost per mile. Diamond grinding can lower the profile index by 50% or more on newly constructed pavement and could produce a very smooth ride.

Two projects were selected for this investigation to provide a comparison between the diamond ground surface and the standard transverse tined surface. The two projects were located on Route 60, Butler County. The same contractor constructed the two projects during the summer of 1997, using the same equipment and material. The only difference was in the finishing technique: one was transversely tined while the other had a burlap drag finish with diamond grinding taking place within approximately a month of construction. The two projects are being monitored on a yearly basis by means of a visual distress survey, profilograph measurements using the 0.0 blanking band, the Automated Road Analyzer (ARAN) data, falling weight deflectometer (FWD), and friction properties.

The initial smoothness of the diamond ground pavement was smoother than the tined pavement with an average profile index of 6.3 inches per mile. The tined sections had an average profile index of 17.0 inches per mile, while the initial International Roughness Index (IRI) for the diamond ground sections averaged 62.4 and the tined sections averaged 91.8. After 2 years of service, the diamond ground pavement continues to maintain a lower profile index than the conventional tined pavement. The profile index after 2 years of service for the diamond ground sections is 6.7 inches per mile compared to 16.5 inches per mile for the tined sections. The IRI after 2 years of service for the diamond ground sections is 87.2 and for the tined sections is 82.0. Although the diamond ground sections indicate an increase in the IRI numbers, the pavement is still considered quite smooth. The diamond ground pavement sustains a higher serviceability rating than the tined, ranks higher in the state percentile, and has a comparable roughness index. Both pavements have favorable friction properties.

The project has been open to traffic for only two years, so final conclusions cannot be drawn at this time. However, after two years of service, it can be stated that diamond grinding does produce a quieter and smoother ride than normally transverse tined pavement. This is an initial report containing the initial test data. It should be continued with yearly updates. It is recommended that diamond grinding as a finishing technique be used on other projects in the state for data comparison.

TABLE OF CONTENTS

TABLE OF CONTENTS (cont'd)

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

Highway agencies in the United States spend billions of dollars annually on new pavement construction. Soaring traffic volumes and heavier truckloads are making it difficult to keep these newly constructed pavements riding smooth. Poor highway conditions can impair highway safety, damage vehicle tires and suspensions, and annoy motorists. Newly constructed smooth pavement that stays smoother longer is something that all highway agencies are searching for and the traveling public is hoping for. If this could be accomplished with possible savings to the taxpayers, a number of benefits are foreseen.

In 1996, MoDOT began reviewing a proposed concept to diamond grind, in lieu of conventional transverse tining, to provide the finished texture on newly constructed PCC pavement. The purpose of diamond grinding instead of tining would not only provide a finished texture, but would also provide a smoother and quieter ride than could be achieved through normal construction finishing techniques.

Research by ERES Consultants Inc. indicates that the smoother a pavement is initially, the better it is going to perform over time and the longer it's going to last (1). This provided the impetus to consider the diamond grinding concept. In addition, results from earlier rehabilitation projects that used diamond grinding operations to re-establish pavement ride and friction characteristics were favorable. As a result, a section in the eastbound lane of Route 60, Butler Co., scheduled for construction during the summer of 1997, was selected for diamond grinding. The Route 60 pavement design included 12-inch, non-reinforced PCC pavement and shoulders. Doweled joints were spaced at 15 feet. A similar project in the westbound lanes using the same pavement design was also scheduled for construction during the summer of 1997. This project would utilize conventional transverse tining methods and would allow a good comparison to the diamond grinding project.

Diamond grinding newly placed PCCP was proposed in order to introduce a number of benefits to concrete pavement construction and performance. The initial smoothness of the pavement should result in a pavement with improved performance over a longer service life. Increased production as a result of less stringent construction methods for finishing and tining may make up for the additional initial cost of the diamond grinding operation. Another possible benefit from diamond grinding may be improved concrete durability. Following placement, the pavement would immediately be given a uniformly roughened surface by a burlap drag then sprayed with a curing compound, as opposed to texturing using conventional transverse tining then followed with curing compound. This allows for a quicker cure application. Burlap drag finishes, uniform in appearance and free from rough or porous spots and irregularities also result in less surface area than tined finishes. Reducing the surface area of the pavement during the initial curing of the concrete may result in improved curing, in terms of better coverage, and in a more durable concrete.

Despite the appeal of burlap drag finishing, the use of transverse tining of PCC pavement was initiated in Missouri in the early 1970's. It was found that the transverse tining produced more desirable friction characteristics than the burlap drag (2). The friction characteristics produced by diamond grinding are anticipated to be comparable to those produced by transverse tining.

This project should also provide a better relationship between smoothness of the pavement before and after the diamond grinding operation and may help establish specifications on diamond grinding pavement smoothness requirements. Project efforts should help determine how smooth the pavement needs to be before the cost/benefit ratio for a smooth pavement, in terms of cost to achieve smoothness and benefits of long-term performance, is exceeded.

OBJECTIVE

The objective of this investigation is to determine if diamond grinding is a cost effective way to provide smoothness, texturing and improved long-term performance of newly constructed PCC pavement.

The scope of this report is to evaluate and report on construction methods, visual distress surveys, profilograph measurements, ARAN data, FWD data, and friction measurements. The study includes two projects let in combination, J0P0571 Route 60, Butler County for diamond grinding and J0P0572 Route 60, Butler County for conventional transverse wire comb finish, as a comparison.

DISCUSSION OF PRESENT CONDITIONS

Missouri's current method of texturing newly placed PCCP is transverse tining with a wire comb in accordance with MoDOT specification 502.3.5.1. As soon as practicable following placement, profilograph measurements are taken to evaluate pavement smoothness. Missouri has recently converted the profilograph measurements from the California 0.2 blanking band to the Kansas 0.0 blanking band. The 0.0 blanking band measures the micro-roughness that the 0.2 blanking band can not pick up, but still can be felt when driving over the pavement.

Diamond grinding the pavement in lieu of transverse tining should provide adequate texturing while improving the initial smoothness of the pavement. Studies have shown that initial pavement smoothness significantly affects future pavement smoothness. Initially smooth-riding concrete pavement will not only please the traveling public immediately after the highway is opened, but it is anticipated that it will remain smoother longer, extending the pavement's service life.

TECHNICAL APPROACH

The diamond ground section was a 4 ½-mile section of eastbound Missouri Route 60 east of Poplar Bluff. Total width of the 12-inch, non-reinforced pavement, including shoulders, was 38 feet with doweled joints spaced at 15 feet. Following placement of the slip-formed pavement and finishing, the newly placed surface received initial texturing with a burlap drag. The burlap drag provided an interim textured surface following placement and prior to diamond grinding. Approximately a month following paving, only the center 24 feet of the travel lanes were diamond ground, leaving the shoulders with the burlap drag finish.

The diamond grinding finishing technique utilizes diamond-tipped blades in a large grinding wheel to smooth and cut longitudinal grooves into the concrete pavement. The prime contractor, Illinois Valley Paving Co., Winchester, Ill., subcontracted Concrete Textures Inc., Des Moines, Iowa, to do the grinding work. The diamond grinding machine is pictured in photo #1 (Appendix D). The difference between the burlap drag finish and the diamond ground finish can be seen in photo #2 (Appendix D).

The following is a summary of specifications for diamond grinding on this project. A complete copy of the contract special provision can be found in Appendix E.

- Use a burlap drag instead of transverse tining
- Seal joints so the sealant remains ¼" to ¾" below the pavement surface
- Require a 21-day cure and a minimum of 3500 psi compressive strength before diamond grinding
- Use a diamond grinding head of at least 3 feet wide, with 55 to 60 grooves per foot
- Allow an extra 0.2 inch for deficient pavement thickness because of diamond grinding
- Base deductions for roughness on the profile index before grinding and smoothness-incentive pay on the profile index after diamond grinding.

MoDOT also tightened the requirements for incentive pay by requiring an index of 10 inches per mile or less for a 5% bonus and 5 inches per mile or less for a 7% bonus.

Two bridges that fell within the 4½-mile section with the diamond grinding finish also were diamond ground at the same time as the pavement. However, due to concerns from the Bridge Division, the bridge surfaces were not ground quite as much as the pavement.

The same contractor built the adjacent 6 mile westbound section of 38 feet wide, 12-inch, non-reinforced pavement, with doweled joints spaced at 15 feet, using normal construction procedures including conventional transverse tining. This project will serve as a control for evaluating the diamond grinding concept. Both pavements were opened to traffic in August 1997. Monitoring will include a visual distress survey, profilograph measurements using the 0.0 blanking scale, Automated Road Analyzer (ARAN) data, falling weight deflectometer (FWD) data, and friction properties. Each section of pavement, diamond ground and transverse tined, will be monitored on an annual basis.

Three 600 feet test sections were set up within the diamond grinding section in the eastbound lanes, while two 600 feet test sections were set up within the transversely tined sections in the westbound lanes. The diamond grinding was performed in the travel lanes while the shoulders were left with the burlap drag finish as can be seen in photo #3 (Appendix D). The locations for the test sections are as follows:

Eastbound Diamond Grinding:
Test section #1 - Sta. 114+00 to 120+00
Test section #2 - Sta. 190+00 to 196+00
Test section #3 – Sta. 234+00 to 240+00

Westbound Tined:
Test section #4 - Sta. 590+00 to 584+00
Test section #5 - Sta. 570+00 to 564+00

RESULTS AND DISCUSSION

At this time, the project has been open to the traveling public for 2 1/2 years, and test results and observations have been favorable to date. Data and results collected since construction are discussed in the following:

Visual Distress Survey

Both the driving lane and the passing lane in all test sections were visually inspected two years after the pavement was opened to traffic. Of the 3600 lane feet surveyed in the diamond grinding test sections, only two 2 foot, light severity transverse cracks were found. There was no evidence of any joint problems, such as spalling. While driving through the diamond grinding section at the posted speed, the ride was smooth and quiet and there was no evidence of a tire-tracking problem. The only problem that was observed was that some of the joints had been overfilled with asphalt joint sealant during construction, giving the impression of a small bump at 15' intervals, as seen in photo #4 (Appendix D).

In the tined pavement, of the 2400 lane feet surveyed in the test sections, almost every 15 foot slab had very light block cracking present on the surface of the pavement. This is felt to be nothing more than minor shrinkage cracking and would have not been noticed except for the presence of additional moisture on the roadway surface, as seen in photo #5 (Appendix D). Cracks of this nature were not observed in the diamond ground pavement. This may also emphasize the improved curing of the smoother surface that diamond grinding provides versus a tined surface. The joint sealant in the tined section seemed to be below the surface of the pavement and there was no evidence of it affecting the ride quality. The ride throughout the tined sections is smooth and relatively quiet. There were no joint problems in the tined sections.

Profilograph measurements

Illinois Valley Paving's effort on the paving portion of the job produced an average profile index of 18.1, smooth enough for 100% pay, before diamond grinding. However, after the diamond grinding was performed, the average profile index dropped to 6.8, with one day's grinding at 5.0, earning a 7% bonus. The profile measurements were done using the zero blanking band and indicates some very smooth pavement. The tined pavement had an average profile index of 17.0 following construction, earning a 3% bonus. Average profilograph data collected for each test section is shown in Figure 1. It can be stated that after two years of service, the diamond ground pavement continues to maintain a lower profile index than the conventionally tined pavement. It should be noted that the data for Test Section #5 (transverse tined) indicates that the profile index at 2 years is a considerable decrease from the index recorded following construction. No explanation can be given at this time, but continued monitoring should provide further clarification of the results obtained. The test sections will continue to be monitored on a yearly basis.

Automated Road Analyzer Data

The Automated Road Analyzer (ARAN) provides information concerning the surface and ride condition of a pavement. Data from the ARAN is used to indicate a pavement's present serviceability rating (PSR), International Roughness Index (IRI), and state percentile ranking.

The ARAN Condition survey was first ran in the eastbound diamond ground section in August 1997, following construction and before the diamond grinding operation was performed. In November 1997, it was run again after the diamond grinding operation had taken place. At this time, a survey was also initially conducted in the westbound tined section. Data has since been collected on an annual basis. The ARAN data is contained in Appendix A.

The present serviceability rating (PSR) is determined by rating the joints, cracks, spalls, and patches from 0 to 5, with the combination of these measures then incorporated with the pavement's measured ride number. Pavements are rated on a scale of 0 to 40, with an increasing number indicating a pavement with a better surface condition and ride. According to the PSR values shown in Figure 2, the diamond ground pavement continues to maintain a higher PSR, currently 35.7, as compared to the tined pavement with a current PSR of 33.9.

The state percentile compares pavement from this project to other pavements throughout the state. For example, if a pavement has a state percentile of 90%, that means it is ranked better than 90% of the other pavements ranked in the state. The diamond ground section currently ranks at 93.2%, while the tined section currently ranks at 87.9%, when compared to other pavements in the state.

The International Roughness Index (IRI) is a nationally based number to measure pavement smoothness and compares the pavement to other pavements throughout the United States. The scale for the IRI ranges from 0 to 300. Lower values indicate improved smoothness or better ride as compared to higher IRI values. Below lists the ranges of IRI and how they've been found to correspond to roughness. (3)

Approximate IRI, inches/mile	Roughness classification
0-95	Smooth
95-133	Moderately rough
>133	Rough

The IRI values for Route 60 are shown in Figure 3, according to the driving and passing lanes for both pavements. After 2 years of service the IRI values for both the diamond ground and tined sections have maintained well below 100, except for the eastbound diamond ground passing lane. However, despite the noted increase in the IRI number, the pavement is considered to ride smoothly.

Falling Weight Deflectometer

The Falling Weight Deflectometer (FWD) testing was initially performed in October 1997. Post construction PCCP material properties can be found in Table 1. The analysis of the FWD data to date indicates that all the pavement components are structurally sound for both the diamond ground and the tined sections. The average joint load transfers, located in Table 2, were all above 70%, the standard recommended for adequate load transfer, with most at or above 80%. Table 3 contains the maximum average deflections for the test sections. The deflections are minimal, in the range of 2 – 3 mils. FWD data will continue to be collected at three-year intervals.

Friction Properties

In an effort to address concerns that some have concerning the friction properties of diamond ground pavements versus transverse tined pavements, annual collection of friction data will be conducted as part of this study. Intentions were to collect initial friction data on this project following construction in 1997. Unfortunately, data was collected; however, it was inadvertently collected in the wrong locations. As a result, the first annual friction tests were performed in the fall of 1998, with the westbound tined section recording an average 56.3 and the eastbound diamond ground section recording an average of 52.2. Both averages are representative of good pavement friction. The 4.1 difference in average is relatively small. Data collected in the fall of 1999 indicate that the friction numbers for both the diamond ground and the transverse tined pavements have actually slightly increased, at approximately the same rate. To date, it is observed that the diamond ground pavement provides adequate friction properties and is comparable to the friction properties of the conventionally transverse tined pavement.

Research conducted by the Wisconsin Department of Transportation and published in 1998 (4) regarding highway crashes on continuously ground PCC pavements concluded that "longitudinally ground PCC pavements were found to have better overall crash rates than transversely tined PCC pavements". This research indicates that ground PCC pavements should maintain sufficient friction properties over time.

PROJECT COSTS

Project costs can be found in Table 4. The concrete for both the diamond ground and the conventional tined sections had a unit cost of $23.47 per square yard for the 38-foot wide roadway. The diamond ground texture cost an additional $1.53 per square yard for the 24-foot travel lanes. The 38-foot wide pavement initially cost $523,224.45 per mile, but the additional $21,542.40 per mile for diamond grinding brought the total cost for the diamond grinding sections to $544,766.85 per mile. Despite the increased initial cost of the diamond grinding procedure, it is anticipated that the improved performance and longer service life will make the increased initial cost well worth paying.

In addition, it is expected that if diamond grinding is approved as an acceptable texturing procedure, money could be saved on the initial placement of the concrete because of less stringent requirements on concrete smoothness and fewer personnel needed to finish the pavement before diamond grinding takes place.

CONCLUSIONS

- Visually, both pavements, diamond ground and tined, show only minor pavement distress and no joint problems. Both pavements ride smooth. Diamond grinding to date maintains a smoother ride than the tined pavement.

- The profilograph data indicates that after 2 years of service, the diamond ground pavement continues to maintain a lower profile index than the conventional tined pavement.

- The ARAN data implies that the diamond ground pavement sustains a higher PSR than the tined pavement, the diamond ground pavement currently ranks higher than the tined pavement in the state percentile, and the IRI rankings are comparable.

- The friction numbers are representative of good pavement friction and show an increase after two years of service, in both the diamond ground and the tined texture. To date, the diamond ground pavement provides adequate friction properties.

- Diamond grinding is a viable alternative to surface smoothness and texture.

- At this time, it appears that both test sections (diamond ground and tined) are doing well in regards to performance.

RECOMMENDATIONS

- Continue the yearly monitoring of the test sections. The continued comparison of the data from the two test areas could prove to be highly beneficial.

- The diamond grinding of newly constructed PCC pavement should be used on other projects within the state. It could prove to be advantageous to monitor other sites in the state and compare the data collected.

- On future projects with diamond grinding, the friction characteristics of the burlap drag finish, prior to diamond grinding, should be compared to the friction characteristics of the longitudinal diamond ground finish.

APPENDIX A

Figure 1

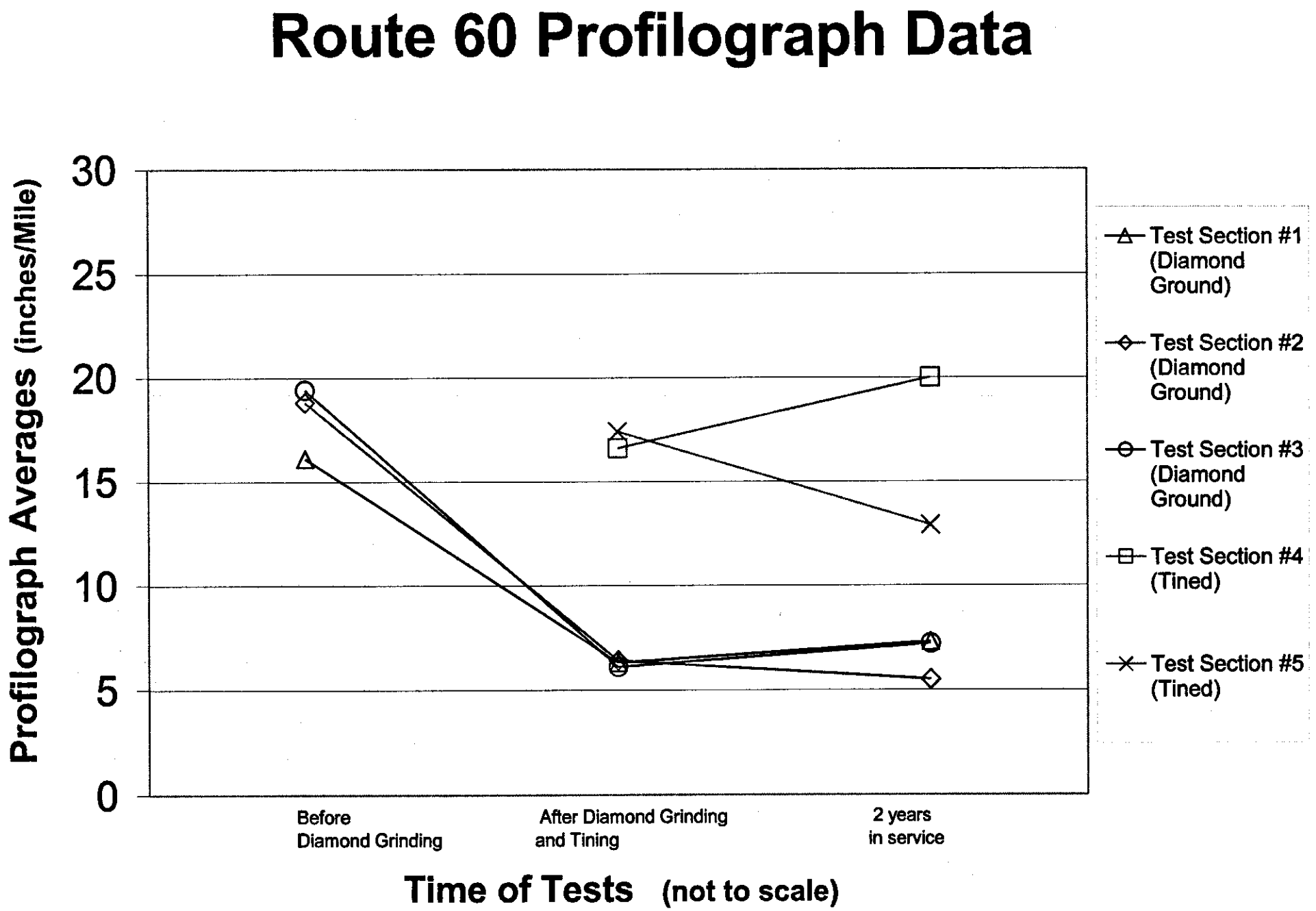

Route 60 Profilograph Data
Profilograph Averages (inches/Mile)
30
25
20
15
10
5
0
Before Diamond Grinding
After Diamond Grinding and Tining
2 years in service
Time of Tests (not to scale)
Test Section #1 (Diamond Ground)
Test Section #2 (Diamond Ground)
Test Section #3 (Diamond Ground)
Test Section #4 (Tined)
Test Section #5 (Tined)

Figure 2

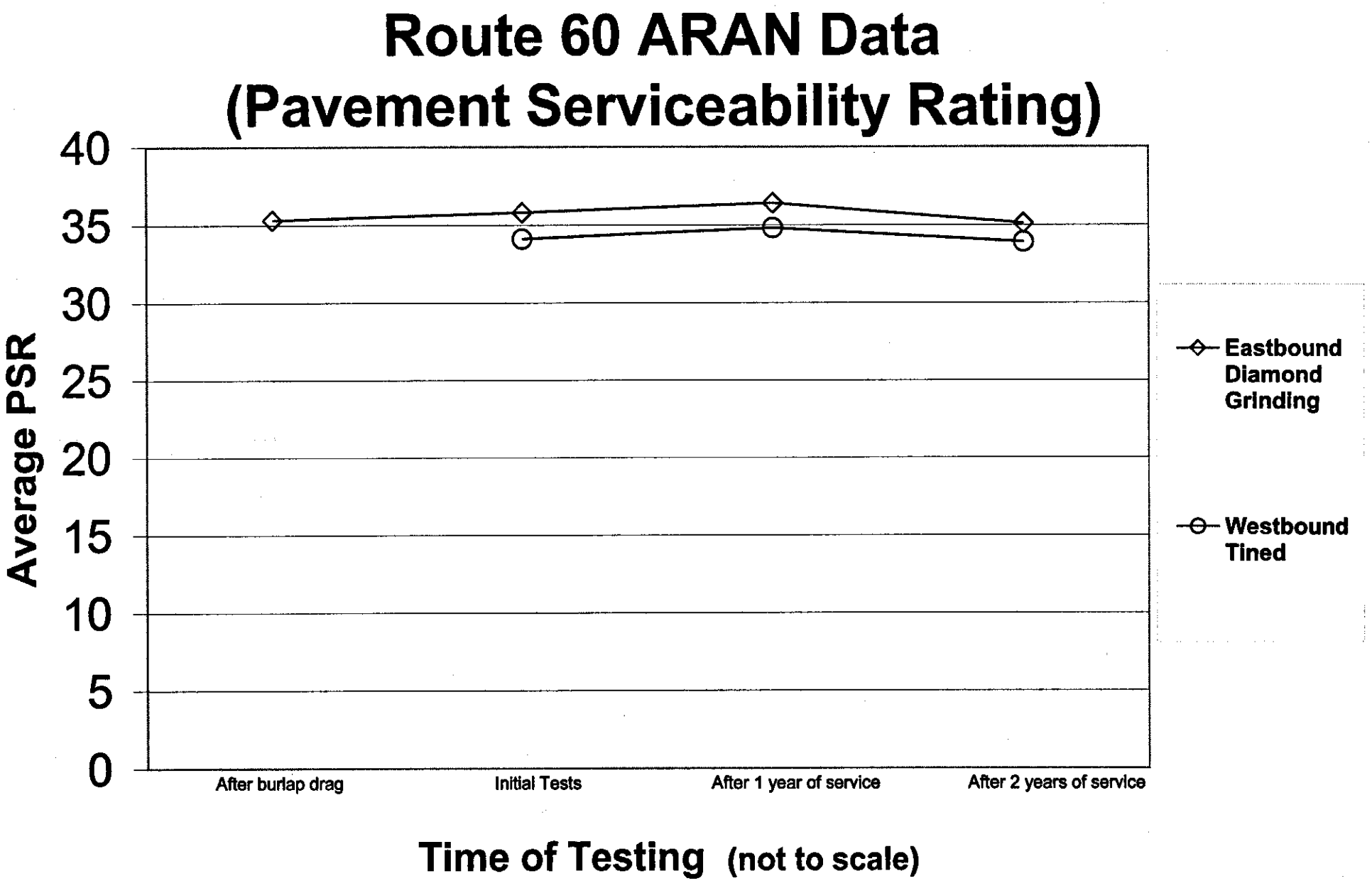

Route 60 ARAN Data
(Pavement Serviceability Rating)
Average PSR
40
35
30
25
20
15
10
5
0
After burlap drag
Initial Tests
After 1 year of service
After 2 years of service
Time of Testing (not to scale)
Eastbound Diamond Grinding
Westbound Tined

Figure 3

Route 60 ARAN Data (International Roughness Index)

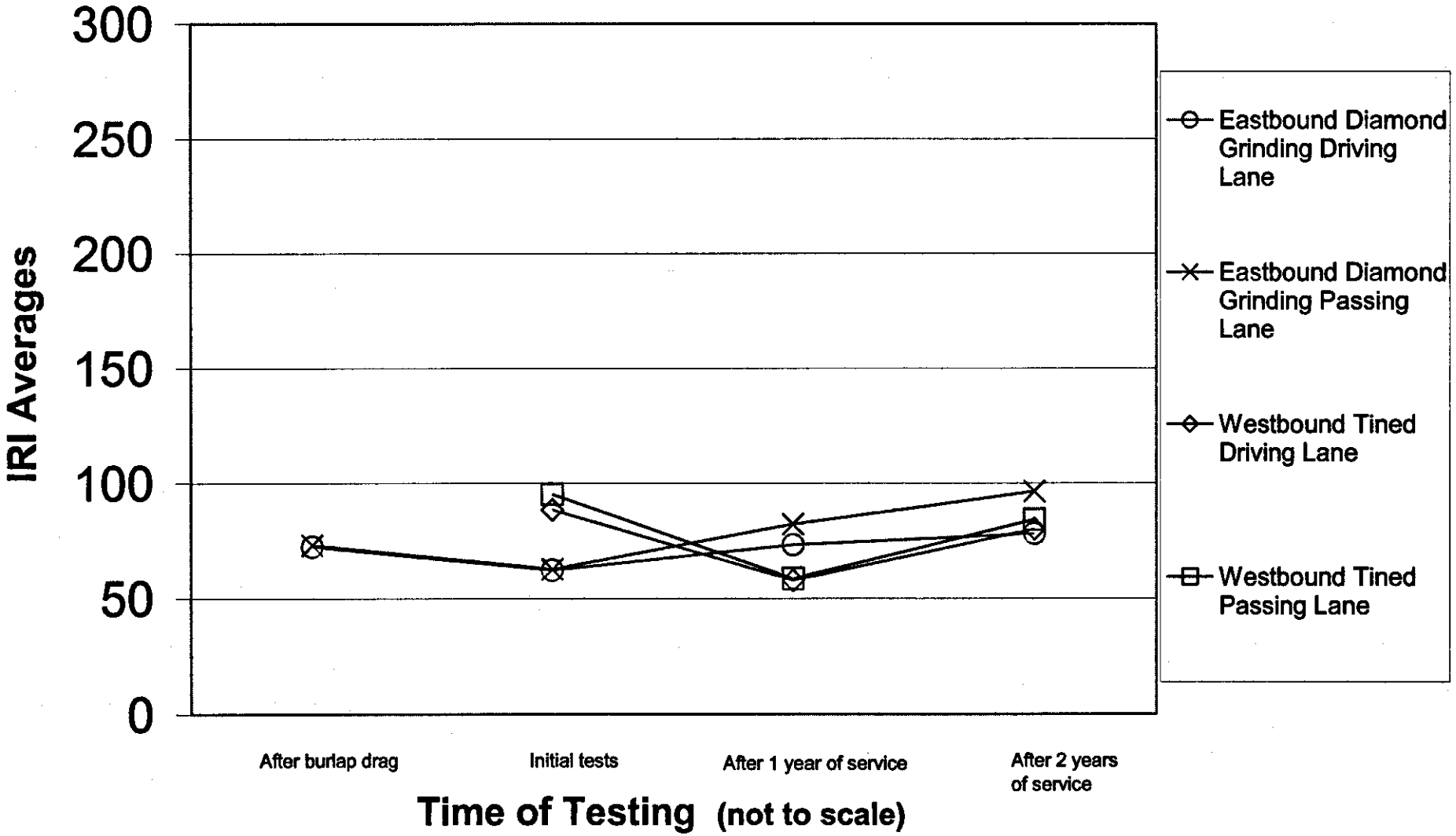
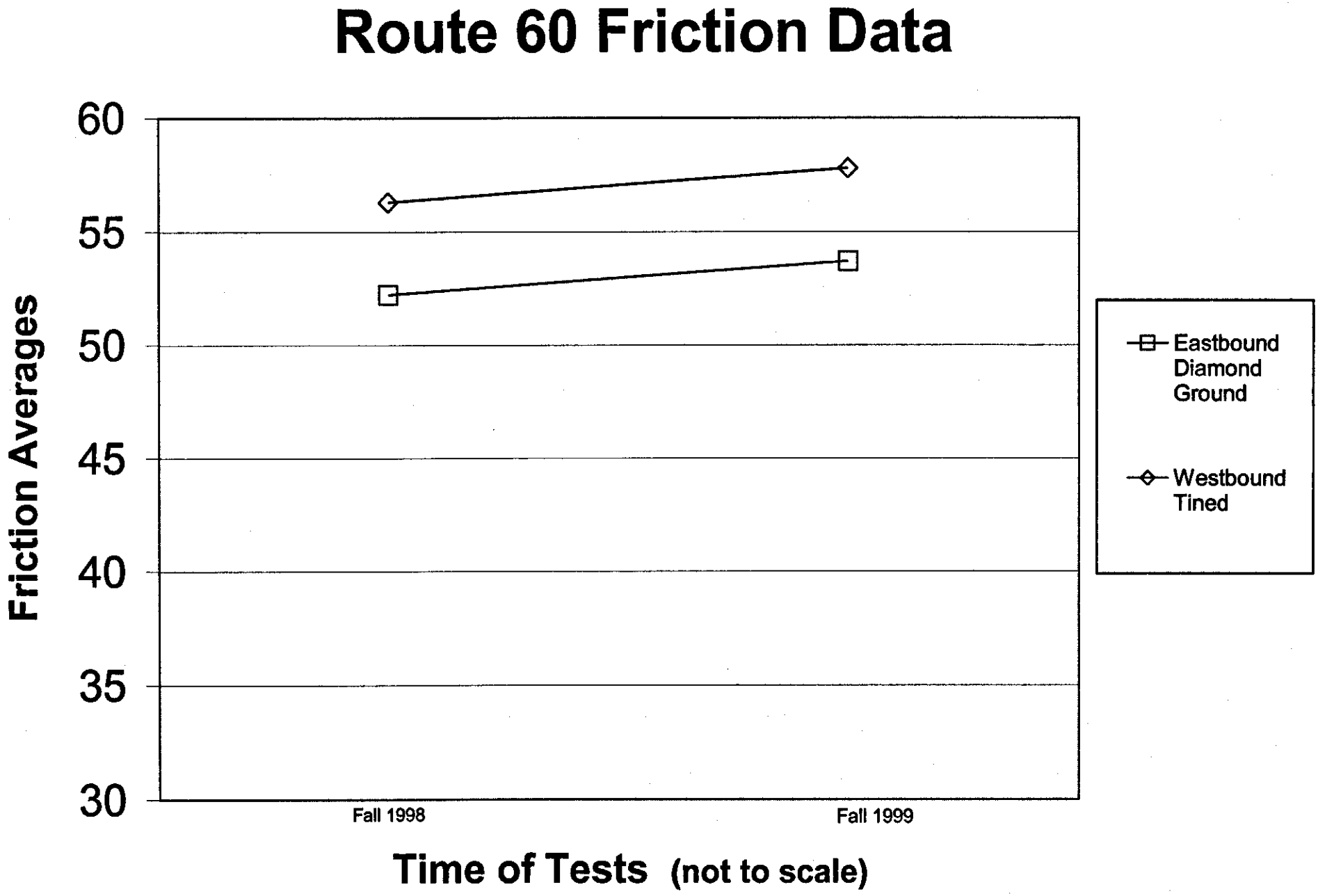


Figure 4


Route 60 Friction Data
60
55
50
45
40
35
30
Friction Averages
Fall 1998
Fall 1999
Time of Tests (not to scale)
Eastbound Diamond Ground
Westbound Tined

APPENDIX B

Table 1
Post-Construction PCCP Material Properties*
(1997)

Section	*Average PCC Modulus (psi)***	*Average PCC Modulus of Rupture (psi)*
Test #1	5,146,000	712
Test #2	5,812,000	741
Test #3	7,518,000	816
Control #1	6,814,000	785
Control #2	6,209,000	759

* Data backcalculated from FWD test files using DARWin software program

Table 2
Average Joint Load Transfer (%)

Section	1997	1998	1999
Test #1	73.6	84.4	84.1
Test #2	80.7	77.5	84.8
Test #3	85.3	79.1	84.4
Control #1	92.4	84.8	83.7
Control #2	79.8	77.6	80.2

Table 3
Average Maximum Deflection (mils)

Section	1997	1998	1999
Test #1	1.87	2.14	2.80
Test #2	2.07	2.01	2.57
Test #3	2.47	2.46	2.91
Control #1	2.67	2.76	3.12
Control #2	2.99	2.92	3.33

APPENDIX C

Table 4

COST COMPARISON OF TINED FINISH AND DIAMOND GRINDING

Section	Paving sq. yds./ mile	Paving cost / sq. yd.	Paving cost / mile	Diamond Grinding sq. yds.	Diamond Grinding/ cost / sq. yd.	Diamond Grinding/ cost / mile	Total / cost mile
	38' width		38' width	24' width		24' width	
1	22,293.33	$23.47	$523,224.45	14,080	$1.53	$21,542.40	$544,766.85
2	22,293.33	$23.47	$523,224.45	14,080	$1.53	$21,542.40	$544,766.85
3	22,293.33	$23.47	$523,224.45	14,080	$1.53	$21,542.40	$544,766.85
4	22,293.33	$23.47	$523,224.45	n/a	n/a	n/a	$523,224.45
5	22,293.33	$23.47	$523,224.45	n/a	n/a	n/a	$523,224.45

APPENDIX D

Photo #1 Machine used for Diamond Grinding

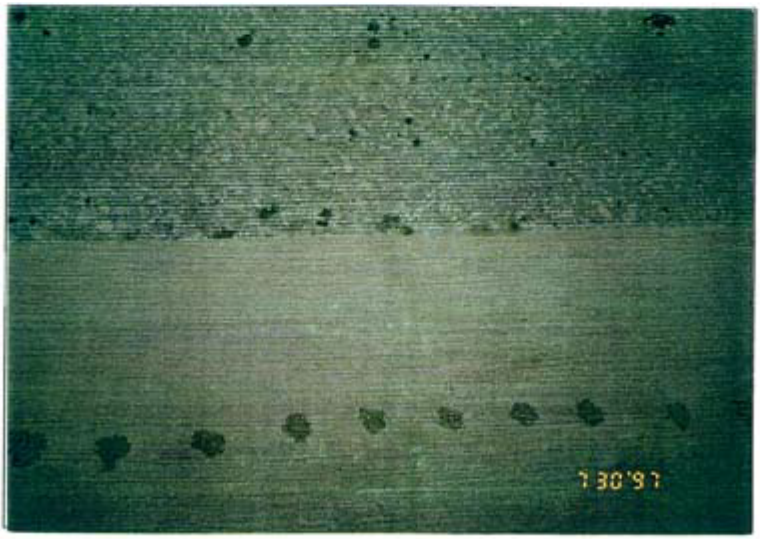


Photo #2 View of the difference between diamond grinding and the burlap drag finishes

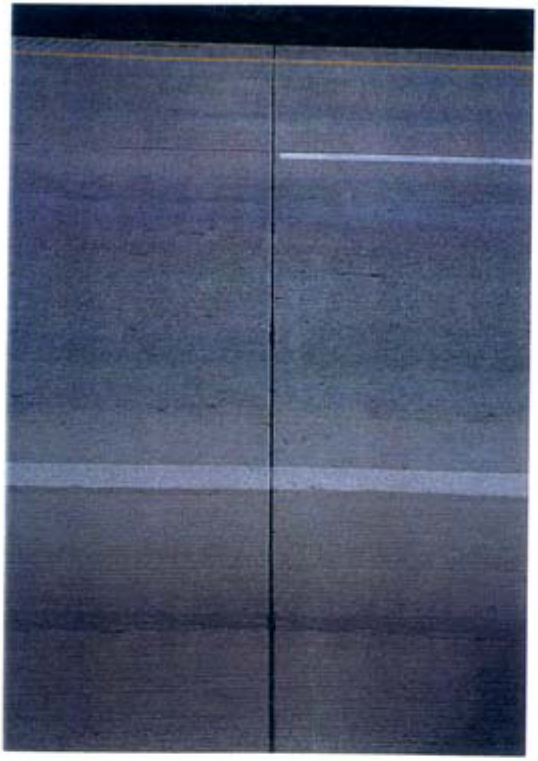


Photo #3 Diamond ground travel lanes and the burlap drag shoulder

Photo #4 Overfilled joints in the eastbound lanes of the diamond ground sections

Photo #5 Very light block cracking in the westbound tined sections

Photo #6 Route 60, Butler Co.

APPENDIX E

PCCP DIAMOND GRIND TEXTURING MSP-96-19B

1.0 DESCRIPTION OF MSP-96-19B. This specification covers diamond grinding the roadway surface of new PCCP in lieu of a wire comb surface finish.

1.1 Unless otherwise stated, specification section references are from the English version, in effect at the time of this contract, of the Missouri Standard Specifications for Highway Construction and its supplements.

2.0 Construction Requirements. All concrete paving on this job shall be in accordance with the standard specifications except as noted herein.

2.1 Paving.

2.1.1 Surface Finish. A wire comb surface finish shall not be provided for the specified mainline or adjacent shoulders. Instead, a burlap drag finish shall be provided for, in accordance with the following. After surface irregularities have been removed and while the concrete is still plastic, the concrete shall be given a uniformly roughened surface of gritty texture by use of a seamless burlap fabric drag. The damp fabric shall be dragged in a longitudinal direction. The dragging shall be completed before the concrete is in a condition that it will be torn or unduly roughened and before the concrete has attained its initial set. The fabric shall be maintained clean and free of encrusted mortar. It shall be replaced as often as necessary to obtain the required surface texture. Upon completion of dragging, the surface of the pavement shall be uniform in appearance and shall be free from surplus water, rough or porous spots, irregularities, depressions and other objectionable features.

2.1.2 Joint Sealing. All PCCP joint sealing shall be completed, prior to any adjacent surface being diamond ground. It is mandatory that all joints in diamond ground areas have the sealant recessed 1/4 - 3/8 inch below the surface so that the grinding process does not encounter the joint material. Adjoining areas with joints filled at the same time, such as the shoulders, may also be filled to those limits. Any remaining joints filled at separate times shall be filled according to the plans.

2.1.3 Diamond Grinding. Following curing of the PCCP, all traffic lanes shall also be diamond ground as specified herein for the 12 foot lane width. Diamond grinding shall be in accordance with Sec 622.30 except as follows.

2.1.3.1 No diamond grinding shall be done until the pavement has attained strength sufficient to be opened to all types of traffic, and no sooner than 21 days after being placed. All diamond grinding shall be completed, on any section, prior to opening that section to other than construction traffic.

2.1.3.2 The grinding head shall be a minimum of 3 feet wide and provide 55 to 60 evenly spaced grooves per foot.

2.1.3.3 All grooves and adjacent passes shall be parallel to each other and the roadway, with no variation. Adjacent passes shall completely lap with no unground surface between, however they shall not overlap more than 1 1/2 inches. Adjacent passes shall be within 1/8 inch of the same height as measured with a 3-foot straightedge. Not less than 98 percent of the specified surface shall be textured by

grinding. It is preferable that all specified surface be textured. There shall be no ridge between lanes. Any remaining ridges on the outside edge next to the shoulder greater than 1/8 inch in height shall be feathered out to the satisfaction of the engineer in a separate operation.

2.1.3.4 Grinding operations will be limited only by other contractor operations and the remainder of the contract, and not restricted to daytime closures.

2.1.3.5 Any deficiencies in the final surface due to improper contractor operations and/or equipment shall be corrected by the contractor at no additional expense to the department. This includes, but is not limited to: a) corrugation of the pavement due to "out of round" wheels or improper cutting operations, b) depressions created due to improper starting or stopping operations, or c) unground ridges due to defective blades. All corrections shall be parallel to, and match, existing operations.

3.0 Basis of Payment.

3.1 Pavement Thickness. Pavement thickness determination will be made after all diamond grinding has been completed. The following table applies to adjacent PCCP shoulder as well as the diamond ground traffic lanes. The table in Sec 502.19.1 shall be modified as follows:

	Deductions
Deficiency in Thickness	Percent of Contract Unit Price
0 inch to 4/10 inch	None
Over 4/10 inch and not over 6/10 inch	15
Over 6/10 inch and not over 8/10 inch	60
Over 8/10 inch	100

Pavement deficient in thickness by more than 8/10 inch will be considered under Sec 502.19.2.

3.2 Profile.

3.2.1 Initial Profile. Based on profilograph measurements made prior to diamond grinding operations, the contract price for square yard of PCCP paid will be reduced by 7 percent for sections of pavement having measurements of 45.1 or greater, prior to bump correction. Any subsequent bump correction in order to improve the final profile is at the option of the contractor.

3.2.2 Final Profile. Delete the table in Sec 502.19.5 and replace with the following table, which applies to the diamond ground surface in addition to any initial profile payment deductions.

Final Profile Index	Percent of
Inches Per Mile	Contract Price for SY PCCP
5.0 or less	107
5.1 - 10.0	105
10.1 - 15.0	103
15.1 - 30.0	100
30.1 - 45.0	100*
45.1 or greater	93*

* Correction required.

3.2.3 The contract price for PCCP (SY) will be considered as compensation for all defined paving operations except the diamond grinding. Diamond grinding (SY) will be paid for at a separate unit price.

3.3 Any adjustments in payment as a result of the profilograph index or pavement thickness deficiency will be made to the unit contract price for the PCCP price per square yard (including materials and placement), or when bid separately, for concrete pavement material quantity and concrete pavement placement prices combined.