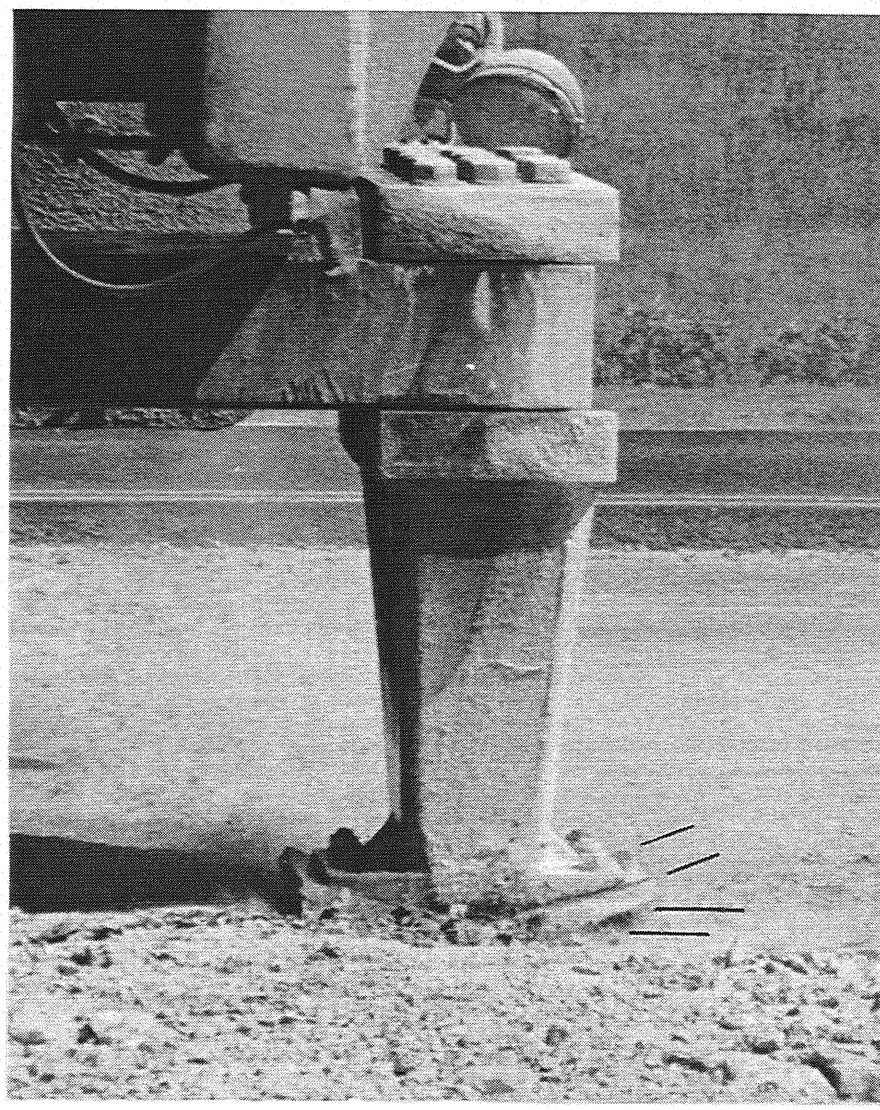
BREAKING AND SEATING FINAL REPORT

Wilson B. Brewer Jr.
Research Project Manager



Under the Supervision
of
Lawrence Senkowski, P.E.
Research & Development Asst. Engineer
Research & Development Division
Oklahoma Department of Transportation
200 N.E. 21st Street, Room 2A2
Oklahoma City, Oklahoma 73105

October, 1995

BREAKING AND SEATING
FINAL REPORT

Wilson B. Brewer Jr.
Research Project Manager

Under the Supervision
of
Lawrence Senkowski, P.E.
Research & Development Asst. Engineer
Research & Development Division
Oklahoma Department of Transportation
200 N.E. 21st Street, Room 2A2
Oklahoma City, Oklahoma 73105

October, 1995

TECHNICAL REPORT STANDARD TITLE PAGE

1. REPORT NO. Ok 95(05)	2. GOVERNMENT ACCESSION NO.	3. RECIPIENT'S CATALOG NO.
4. TITLE AND SUBTITLE BREAKING AND SEATING FINAL REPORT		5. REPORT DATE October 1995
		6. PERFORMING ORGANIZATION CODE Item No. 2264
7. AUTHOR(S) Wilson Brewer, Jr. Project Manager		8. PERFORMING ORGANIZATION REPORT
9. PERFORMING ORGANIZATION ADDRESS Oklahoma Department of Transportation Research and Development Division 200 NE 21st Street, Room 2A2 Oklahoma City, Oklahoma 73105		10. WORK UNIT NO. OK 95(05)
		11. CONTRACT OR GRANT NO.
		13. TYPE OF REPORT AND PERIOD COVERED Final Report
12. SPONSORING AGENCY NAME AND ADDRESS Oklahoma Department of Transportation 200 N.E. 21st Street Oklahoma City, Ok 73105		14. SPONSORING AGENCY CODE
15. SUPPLEMENTARY NOTES		

16. ABSTRACT

A preliminary investigation of US 169 in Nowata county was completed in June 1988. The 9.9 km (6.2 mi) section of two-lane roadway is located 8.0 km (5.0 mi) north of the city of Nowata. The majority of the 4.5 m (15.0 ft) jointed Concrete Cement Pavement (PCCP) was spalling due to an advanced stage of D cracking.

"Rubblizing" was chosen as the method for rehabilitation of the roadway pavement. The construction steps were: 1) rubblizing PCCP with resonant breaker, 2) seat rubble, 3) place fabric over AC leveling course, 4) overlay roadway with dense graded AC mix.

After five years of evaluation the roadway had block and alligator cracking and a small amount of rutting. The reflection cracking of the joints were eliminated.

PCCP rubblizing prior to an asphalt overlay is a cost-effective treatment for minimizing reflective cracking. The majority of the distress found on the roadway after five years was raveling. It was due to asphalt degradation. While cracking at the north end of the project was a result of a weak rubblized area.

17. KEY WORDS Rubblizing, D cracking, rut depth, Benkelman beam, resonant breaker, crack map		18. DISTRIBUTION STATEMENT No restrictions. This publication is available from the Research and Development Division, Oklahoma DOT.	
19. SECURITY CLASSIF. (OF THIS REPORT) Unclassified	20. SECURITY CLASSIF. (OF THIS PAGE) Unclassified	21. NO. OF PAGES 26	22. PRICE

Table of Contents

List of Illustrations

List of Tables

EXECUTIVE SUMMARY

A preliminary evaluation of US 169 in Nowata County was completed in June of 1988. The section was located 8.0 km (5.0 mi) north of city of Nowata, Oklahoma and extended north for 9.9 km (6.2 mi). The majority of the 4.5 m (15.0 ft) jointed portland cement concrete pavement (PCCP) was spalling due to an advance stage of D cracking. The roadway had a extremely rough ride.

A breaking and seating process was chosen to "rubblize" the PCC. This was considered the best method for the reduction of slab movement. The rubblizing method for rehabilitation of the roadway required the following construction steps:

1) rubblizing the PCCP with a resonant breaker.
2) Seating the rubble.
3) Placing fabric over an asphalt concrete (AC) leveling course.
4) Overlay the roadway with 180 mm (7 in) of dense graded AC mix.

After five years of evaluation, the roadway showed block and alligator cracking with a small amount of rutting. The reflective cracking over joints was eliminated. Raveling was the major distress present on the roadway.

PCCP rubblizing prior to an asphalt overlay is a cost-effictive treatment for minimizing reflective cracking. After five years of services, raveling found on the roadway appeared to be due to asphalt mix degradation rather than rubblizing. The cracking noted on the north end of project is a result of a weak rubblized base.

INTRODUCTION

The breaking and seating process that was used on the project is called, "Rubblizing". Breaking and seating is the process of cracking the pavement to create concrete pieces that are small enough to reduce slab movement due to traffic action and to a point where reflective cracking will be greatly reduced(1). It is the complete destruction of the concrete slab and the elimination of all of the concrete slab movement(2). Rubblizing reduces the PCCP to sand and gravel particles in the top 50 mm (2 in). The rubble size got larger toward the bottom of the pavement. At the bottom of slab, the rubblized PCCP pieces measured as large as 180 mm (7 in) across.(3).

The major steps used in the construction of the breaking and seating project were:

1) Rubblizing of the existing PCC slabs. A resonant breaker was used in rubblizing.
2) Seating of the rubblized material. A 45 Mg (50 ton) roller made several passes.
3) Special treatments. A prefabricated "fin" type pavement edge drain was placed between the shoulder and roadway. A full width paving fabric was placed over the leveling course.
4) An AC overlay. A leveling course of Type D mix, Type B binder course and Type B surface course (ODOT 1988 Specification section 708) were all placed over the rubblized PCCP.

BACKGROUND

D cracking is a progressive deterioration of portland cement concrete pavement (PCCP) that occurs as a result of freeze-thaw damage of poor quality aggregates(4). The major factors which influence the likelihood that a pavement will develop D cracking are the following:

* The availablity of moisture.
* The occurrence of freeze-thaw cycles.
* Coarse aggregate composition (sedimentary rocks such as limestone are generally most susceptible).
* Pore size distribution within the coarse aggregate.
* Maximum aggregate size(5).

This pavement was a 4.5 m (15 ft) jointed PCCP, 200 mm (8.0 in) thick, over a 100 mm (4 in) fine aggregate bituminous base with a clay subgrade. The terrain here is nearly level to gently rolling. It was constructed in 1972, using coarse aggregates from the Lenapah limestone.

A preliminary investigation in June 1988 showed that the majority of the joints were spalling due to an advanced stage of D cracking. Cracking covered over 50 percent of the pavement surface. The joints were spalling 13 mm (1/2 in) to 38 mm (1 1/2 in) in depth and 50 mm (2.0 in) to 76 mm (3 in) on each side. The spalling was so severe, that loose aggregate was present at the bottom of the slabs in the joints(3).

LOCATION

This was the first large scale rubblizing project for the Oklahoma Department of Transportation (ODOT). Its location is on US 169 in Nowata County, Oklahoma, about 8.0 km (5.0 mi) north of the city of Nowata. The treatment began 0.3 km (0.2 mi) south of SH 28 and extended north for 9.9 km (6.2 mi) to the junction SH 10 at Lenapah. See Figure 1 for Location Map.

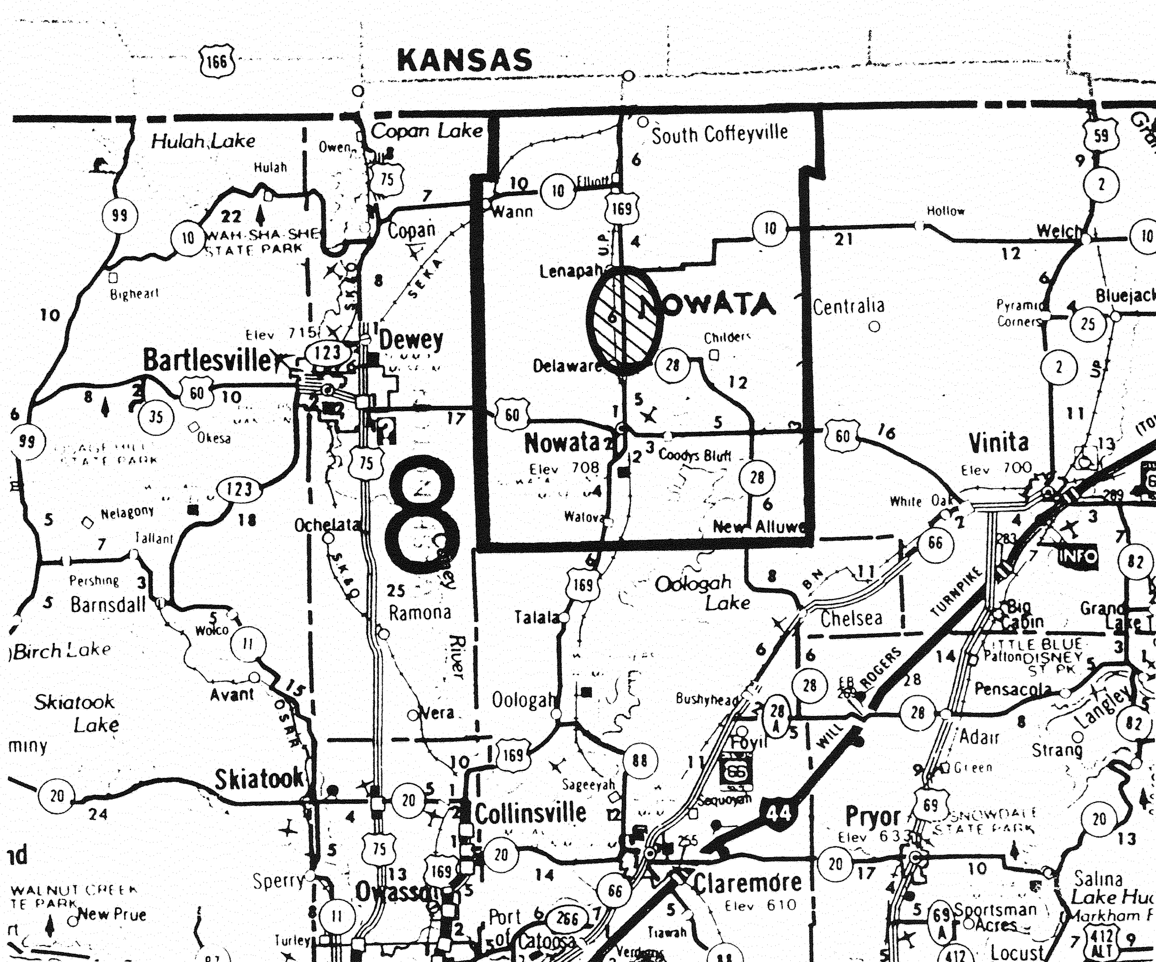


Figure 1. Location Map

FINAL EVALUATION

Five years of evaluation were concluded in August 1994. The field investigation consisted of the following:

1) Condition rating survey of flexible pavements.
2) Crack mapping.
3) Profilograph survey.
4) Deflection data.
5) Rut depth measurements.

The condition rating for the entire section of roadway was 'average'. Raveling was the major distress occurring on the roadway surface. Small patches of bleeding that formed in the first year of the pavement service life slowly hardened. Due to the exposure to the environment, oxidation caused these patches not be a significant distress. Cracking was not visible in the first year evaluation. However, it slowly increased each year thereafter. The cracking was not a reflection of the PCCP joints. This pavement developed fatigue cracking. Ruts had an average depth of 5 mm (0.2 in). A total of 668 square meters (7,200 square feet) of patching was placed on the 9.9 km (6.2 mi) roadway. That was considered a very small amount.

The crack mapping sections showed a large amount of cracking had developed on the northern most end of the project. Crack mapped Section One is located on the south end of the project. About 10 percent of the section showed longitudinal cracking. This was fatigue cracking in the in the wheel path. Section Two is located 4 miles north of Section One. Here cracking increased greatly. Thirty percent of the Section showed longitudinal and random cracking. Section Three was final crack map section and it is located on the north end of the project. It showed greater than 50 percent cracking. This Section had block and alligator cracking. See Figure 2 for Crack Map Locations. See Figures 3 through 5, for Crack Diagrams of the Three Sections.

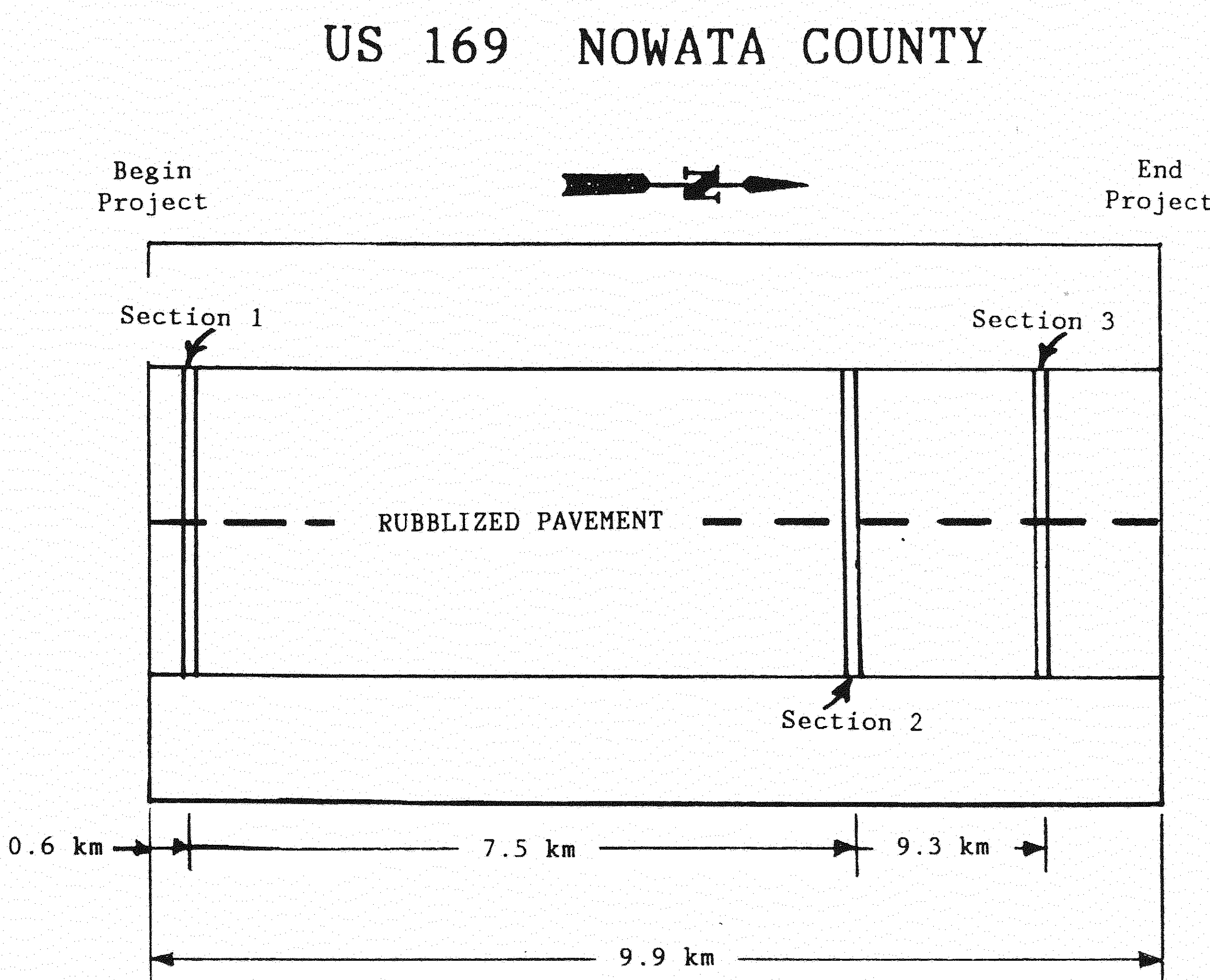
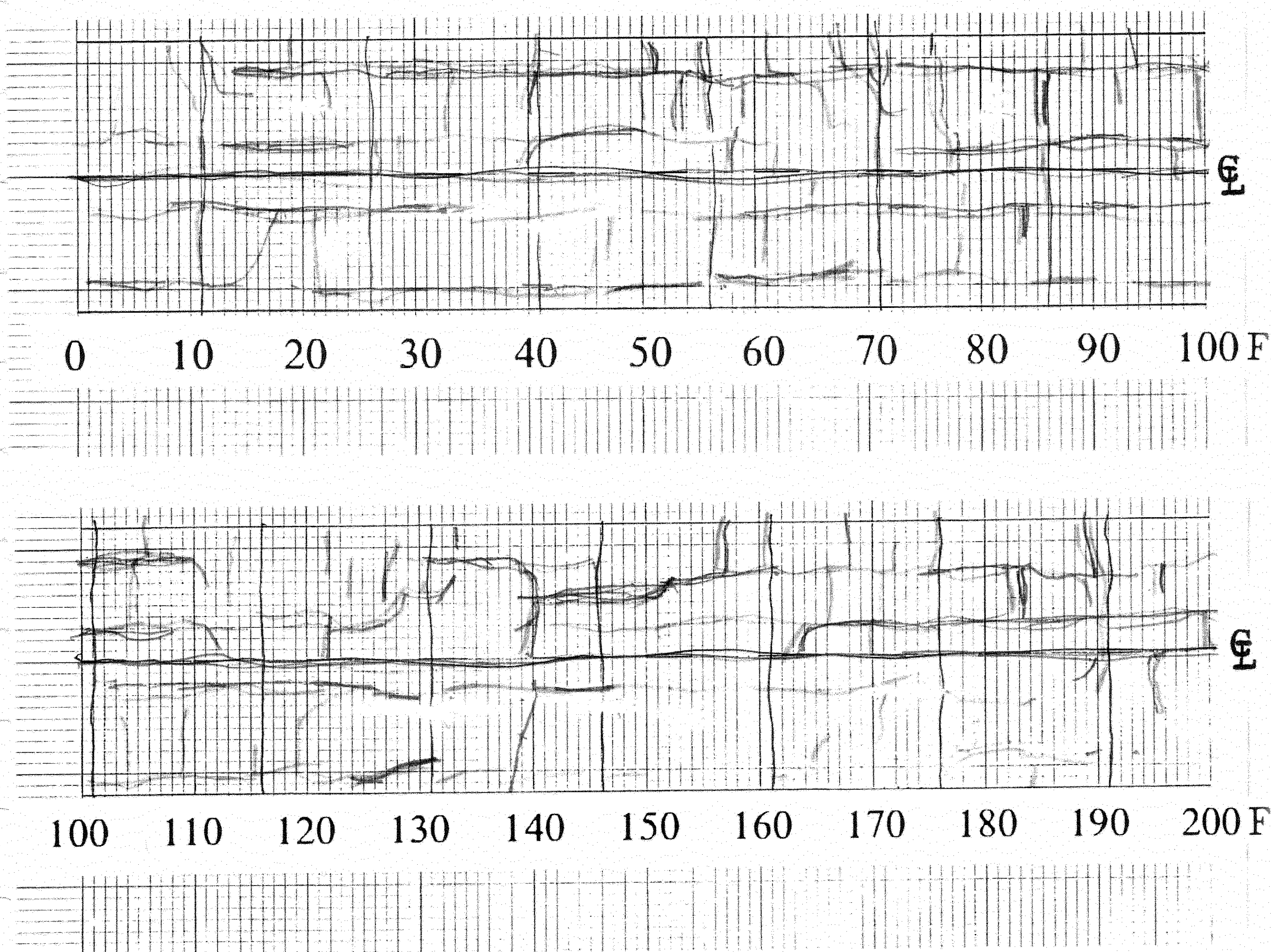


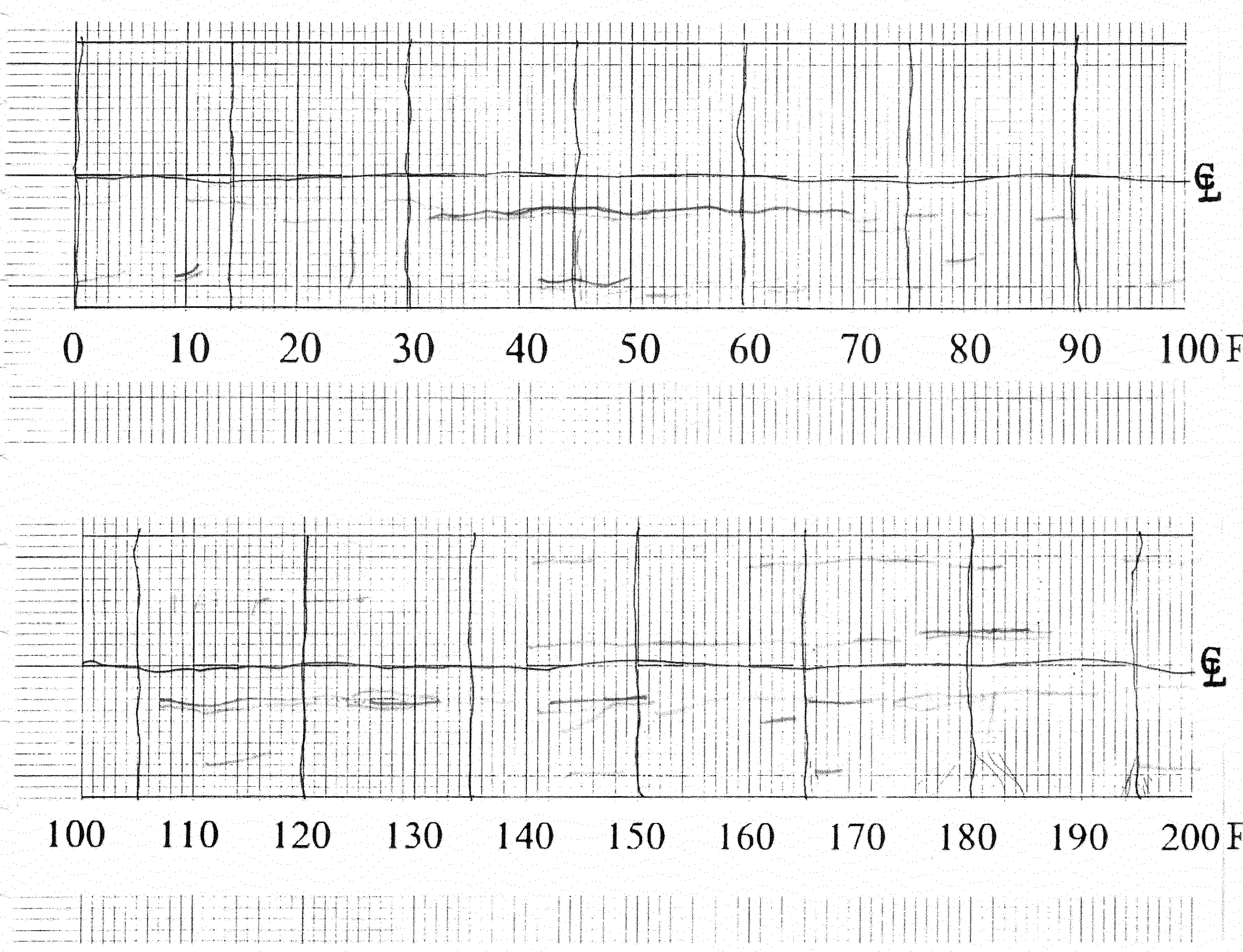
Figure 2. Crack Map Locations



CRACK MAPPING LEGEND

YEAR	LT LANE	RT LANE
November 89	No Cracks	No Cracks
June 90	No Cracks	No Cracks
June 91	Cracks	Cracks
July 92	Cracks	Cracks
September 93	Cracks	Cracks
September 94	Cracks	Cracks

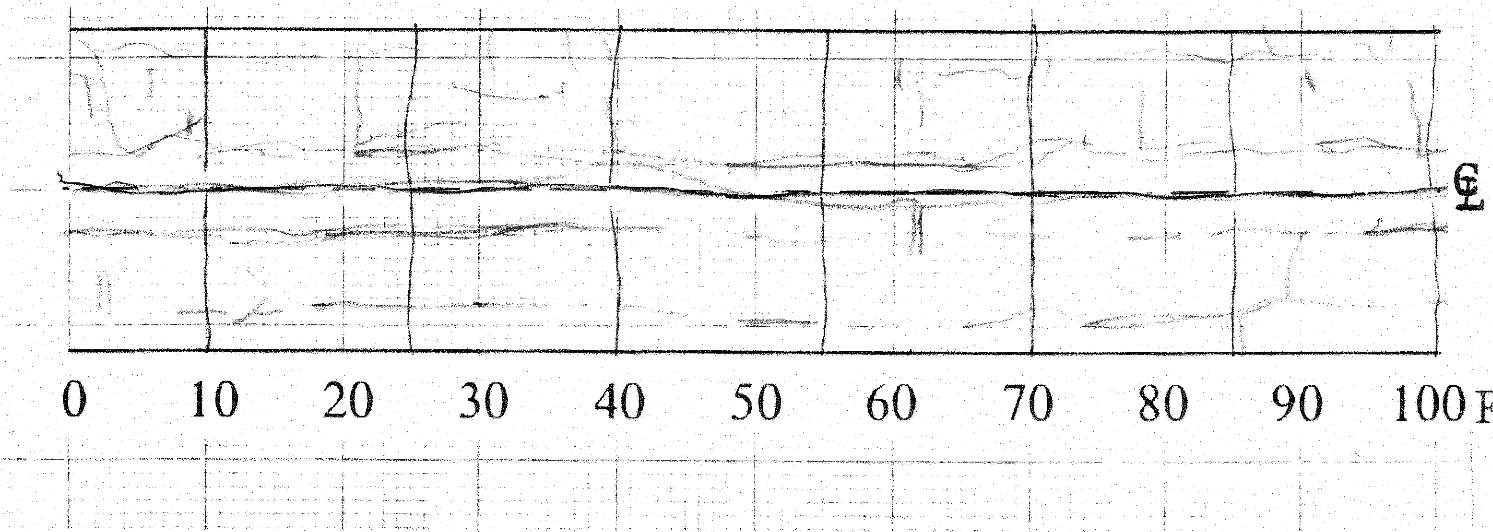
Figure 3. Crack Map of Section I, US 169- 0.3 km (0.2 mi) north of SH 28 extending north for 60 m (200 ft).

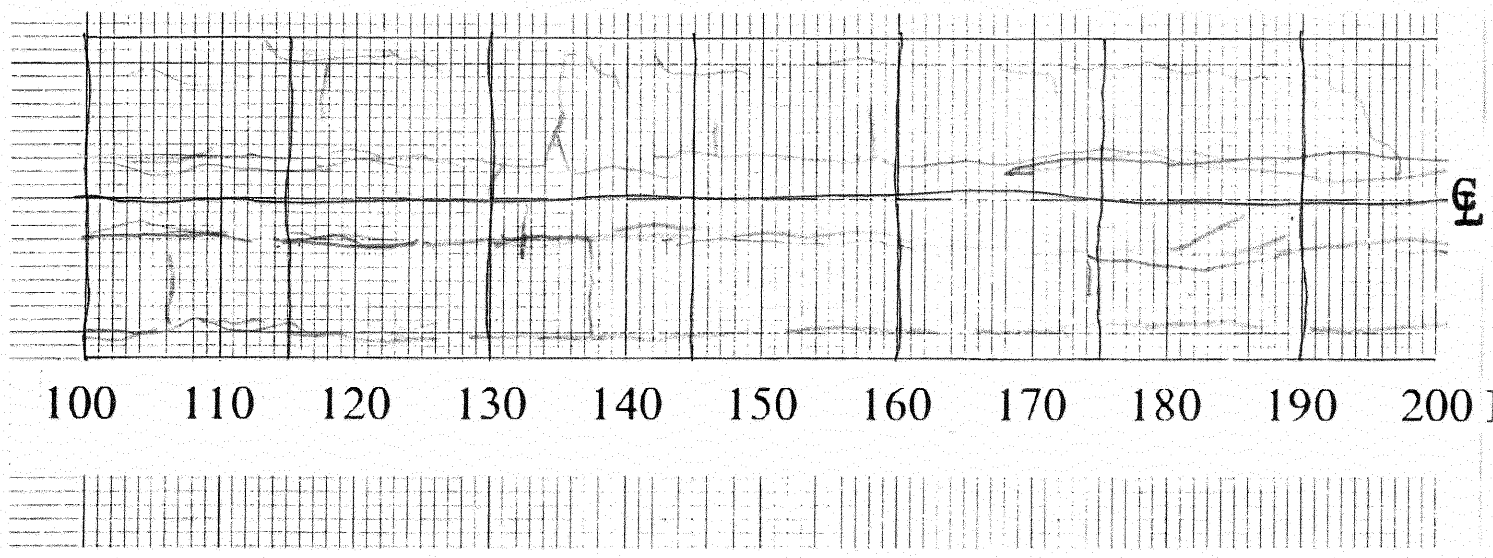


CRACK MAPPING LEGEND

YEAR	LT LANE	RT LANE
November 89	No Cracks	No Cracks
June 90	No Cracks	No Cracks
June 91	No Cracks	No Cracks
July 92	Cracks	Cracks
September 93	Cracks	Cracks
September 94	Cracks	Cracks

Figure 4. Crack Map of Section II, US 169- 7.2 km (4.5 mi) north of SH 28 extending north for 60 m (200 ft).





CRACK MAPPING LEGEND

YEAR	LT LANE	RT LANE
November 89	No Cracks	No Cracks
June 90	No Cracks	No Cracks
June 91	No Cracks	No Cracks
July 92	Cracks ▬	Cracks ▬
September 93	Cracks ▬	Cracks ▬
September 94	Cracks ▬	Cracks ▬

Figure 5. Crack Map of Section III, US 169- 9.0 km (5.6 mi) north of SH 28 extending north for 60 m (200 ft).

The profilograph survey was run on the outside wheel path in both lanes. The numerical values are in inches of roughness per mile. The measurement invervals are every 0.3 km (0.2 mi). An average is recorded for each lane. On this project, the north bound lane averaged 145 millimeters of roughness per kilometer (9.2 in/mi). While the south bound lane averaged 154 millimeters roughness per kilometer (9.8 in/mi). See Appendix A for Profilograph Report.

Nondestructive Benkelman beam deflection testing (AASHTO 256) determined the structural strength of the pavement. The north bound lane was tested in 32 locations. Five tested locations gave low readings that indicated an overlay was needed. The south bound lane was tested 32 times. Eleven locations gave low readings that indicated an overlay was needed. These eleven locations were on the south bound lane on the northern most end of the project. See Appendix B for the Benkelman Beam Deflection Overlay Program.

Experience with rutting indicates that any reading that is 5 mm (0.2 in) or less is generally not a roadway problem. This roadway averaged 5 mm (0.2 in) of rutting. Less than 25% of the pavement has readings of as much as 8 mm (0.3 in). Twelve percent of the roadway showed no rutting.

COST

The breaking and seating method of construction, project number MAF-193(45) was rehabilitated by J. H. Shears and Sons Construction. A direct comparison of a full depth PCCP removal and replacement was asset. See Table 1 for Cost.

Table 1. COST

DESCRIPTION	UNIT	ITEM QUANTITY	UNIT PRICE	BID AMOUNT
BREAKING AND SEATING				
Break and Seat	m2 (y2)	73,569 87,991	$1.18 0.99	$87,111
Fabric	m2 (y2)	137,455 164,400	0.43 0.36	59,184
Tack Coat	liter (gal)	98,762 26,100	0.16 0.59	15,299
Asphalt Binder	liter (gal)	217,735 57,541	0.15 0.56	32,222
Type A, AC	Mg (ton)	24,848 27,390	17.87 16.21	443,991
Type B, AC	Mg (ton)	38,786 42,753	20.31 18.43	787,937
Total				1,425,844
FULL DEPTH REMOVAL AND REPLACEMENT				
PCCP Removal	m2 (y2)	73,569 87,991	$5.38 4.50	$395,959
Lime Treated Subgrd	m2 (y2)	73,569 87,991	1.79 1.50	131,866
Lime	Mg (ton)	1,425 1,571	71.66 65.00	102,115
Asphalt Binder	liter (gal)	217,735 57,541	0.15 0.56	32,222
Tack Coat	liter (gal)	98,762 26,762	0.16 0.59	15,399
Type A, AC	Mg (ton)	42,133 46,443	19.02 16.21	801,471
Type B, AC	Mg (ton)	38,786 42,753	20.31 18.43	787,937
Total				2,266,969

DISCUSSION AND CONCLUSION

Facts are, that some portions of the rehabilitated roadway showed advanced deterioration in just five years. This casts a cloud over the results and confounds any clear cut conclusion concerning the performance of rubblizing. The presence of fatigue cracking in the wheel path on the north end of the project indicates a possible weak base condition. This is corroborated by the weaker supporting ability as shown by Benkelman beam deflection tests.

The optimum AC overlay thickness for ″rubblized″ PCCP is yet to be established (1). The ODOT Pavement Design Engineer currently assigns a layer coefficient for rubblized pavement at 0.22 (6). This is approximately equivalent to a dense graded aggregate base. Reducing the size of the PCC slabs seems to reduce reflection cracking. The smaller the cracked pieces, the more the potential for reflective cracking is reduced, however the structural strength provided by the PCC pavement is also reduced (1). Loss of strength was a factor in the performance of this pavement. After five years, some rutting and longitudinal cracking was detected. The longitudinal cracking appeared to be fatigue cracking. Fatigue cracking is interpreted as cracks in a pavement layer caused by the combination of repetitive strains and apparent reduction of tensile strength caused by failure of the layer material, and usually the the result of passing wheel loads. The block cracking is considered to be a product of AC degradation (7).

After five years, raveling was the number one distress found on the roadway with cracking second. The aggregate used in the AC mix could be the cause of the raveling and cracking problem. According to Al Lambert of the Oklahoma

Asphalt Paving Association (8), limestone aggregate with an absorption factor greater than 2.5 percent makes it difficult to achieve proper compaction and air void content in a dense graded mix. The ODOT Materials lab ran the absorption test, AASHTO T-85, on the coarse aggregate samples from the overlay. The result was a 3.3 percent absorption. The high absorption factor allows asphalt to enter the aggregate pores affecting bonding, binder and void content. So, the raveling and cracking observed may have had no connection with the performance of the rubblizing process.

The profilograph report provides readings from both lanes. The pavement had higher (good) readings on the south end of project. But the average roughness was 154 mm/km (9.8 in/mi). Both lanes have a smooth ride.

Patching was the only maintenance activity performed on the roadway. It totaled 0.5 percent of the surface. The Benkelman beam deflections showed no structural loss in five years of service. See Appendix for Benkelman beam deflection data. Since rut depths were generally less than 3 mm (0.2 in), they were not considered to be a problem.

It was found that PCCP rubblizing prior to an AC overlay maybe a reasonable treatment in minimizing joint reflection cracking. The resonant pavement breaker was able to provide the specified small size pavement particles. Its performance was reasonably dependable and production rates were acceptable. The rubblized pavement can be a viable alternative to full depth removal and replacement.

The cost of rubblizing could produce a substantial savings. The performance of the rubblizing and overlay system should be considered when severe D cracking in a PCCP is encountered.

REFERENCE

1. Marshall R. Thompson. "Breaking/Cracking and Seating Concrete Pavements". National Cooperative Highway Research Program Synthesis of Highway Practice 144, Transportation Reseach Board, National Reseach Council, Washington, D.C., March 1989.

2. "Portland Cement Concrete Rehabilitation Rubblizing". TB-3, Asphalt Institute, College Park, MD.

3. Wilson Brewer Jr. "Breaking and Seating of US 169, Nowata County". Oklahoma Department of Transportation, Oklahoma City, Oklahoma, March 1991.

4. Kathleen T. Hall, Micheal I Darter and James P. Hall. "Performance of Asphalt Concrete Resurfacing of Interstate Highway System". Transportation Reseach Record No. 1307, Washington D.C.

5. D. Stark. "Field and Laboratory Studies of the Effects of Subbase Type on the Development of D-Cracking". Highway Reseach Record 342 HRB, National Reseach Council, Washington D.C., 1970.

6. Tim Borg. Pavement Design Engineer, Oklahoma Department of Transportation, Oklahoma City, Oklahoma. Personal communication, August 1995.

7. Thomas W. Kennedy, Freddy L. Roberts, and J. Brent Rauhut. "Distresses and Related Material Properties for Premium Pavements". Transportation Research Record 715, TRB, Washington, D.C. 1979, page 16.

8. Al Lambert. Oklahoma Asphalt Paving Association. Personal communication, January 1994.

9. "Proscan The Computerized Profilogram Scanning Reduction System for Noncomperized Profilographs", User's Guide, Devore Systems, Inc., Manhattan, Ks, 1994.

10. "Standard Specification for Highway Construction". Oklahoma Department of Transportation, 1988.
    All new or milled and overlaid pavements having profile indexes in excess of 190 millimeters per kilometer (12 in/mi) or 470 millimeters per kilometer (30 in/mi), respectively are unacceptable.
    See Oklahoma Department of Transportation Special Provisions Text 430-6QA(C) 91S, Pavement and Bridge Floor Smoothness.

APPENDIX A

Pavement Smoothness

The profilograph generates a tracing on paper. A computerized profilogram scanning reduction system for noncomputerized profilographs called, "Proscan" is a device used to read the profilograph tracings. The tracing is loaded in the proscan, it is scanned at a rate of about a quarter mile per minute. When all the profilograph traces have been scanned the user can request a report and may also request a plot(9).

All new or milled and overlaid pavements having profile indexes in excess of 18.9 centimeters per kilometer (12 in/mi) or 47.3 centimeters per kilometer (30 in/mi), respectively is unacceptable. See Oklahoma Department of Transportation Special Provisions Text 430-6QA(C) 91S, Pavement and Bridge Floor Smoothness(10).

PROSCAN - PROFILOGRAPH REPORT OF PAVEMENT SMOOTHNESS

Project No 2264 _ BREAK / SEAT ______ County_ NOWATA _____

Contractor ______________________________ Pavement Type_ ASPHALT

Station____0+00.0 to station__319+11.0 Traffic Direction______________

No. of Lanes_ 2 __ Direction of Paving______________________________

Date [Placed/Corrected]______________________ Date Tested____070594_____

Tested by (Evaluated by ProScan)______________________________

Paving Action______________________________ Special Prov.__________

Track 1 Seg	Leng (mi)	Meas'd Rough (in)	PRI (in/mi)	Track 2 Seg	Leng (mi)	Meas'd Rough (in)	PRI (in/mi)	Track 3 Seg	Leng (mi)	Meas'd Rough (in)	PRI (in/mi)	Avg PRI (in/mi)
1	.100	2.25	22.5	1	.100	0.85	8.5					15.5
2	.100	1.00	10.0	2	.100	1.35	13.5					11.8
3	.100	2.40	24.0	3	.100	1.45	14.5					19.2
4	.100	1.00	10.0	4	.100	1.15	11.5					10.8
5	.100	1.05	10.5	5	.100	0.60	6.0					8.3
6	.100	1.40	14.0	6	.100	1.85	18.5					16.2
7	.100	1.50	15.0	7	.100	1.85	18.5					16.8
8	.100	2.10	21.0	8	.100	1.80	18.0					19.5
9	.100	1.55	15.5	9	.100	0.85	8.5					12.0
10	.100	0.65	6.5	10	.100	0.95	9.5					8.0
11	.100	0.80	8.0	11	.100	1.25	12.5					10.2
12	.100	1.40	14.0	12	.100	0.55	5.5					9.8
13	.100	0.45	4.5	13	.100	0.45	4.5					4.5
14	.100	1.10	11.0	14	.100	0.60	6.0					8.5
15	.100	0.70	7.0	15	.100	1.00	10.0					8.5
16	.100	0.95	9.5	16	.100	0.85	8.5					9.0
17	.100	0.85	8.5	17	.100	0.30	3.0					5.8
18	.100	1.00	10.0	18	.100	0.35	3.5					6.8
19	.100	0.50	5.0	19	.100	0.65	6.5					5.8
20	.100	0.75	7.5	20	.100	0.90	9.0					8.3
21	.100	0.75	7.5	21	.100	0.75	7.5					7.5
22	.100	1.00	10.0	22	.100	0.85	8.5					9.3
23	.100	0.75	7.5	23	.100	1.15	11.5					9.5
24	.100	0.60	6.0	24	.100	0.70	7.0					6.5
25	.100	0.50	5.0	25	.100	0.55	5.5					5.3

Scallop (Filter 15)
- min height .025 in
- min width .08 in
- resolution .05 in

Blanking band .20 in
Defect template .40 in

Certified by: ______________________

Title: ______________________

Organization: ______________________

	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)
26	.100	0.70	7.0	26	.100	0.75	7.5					7.3
27	.100	0.50	5.0	27	.100	2.05	20.5					12.7
28	.100	1.15	11.5	28	.100	0.60	6.0					8.7
29	.100	0.70	7.0	29	.100	1.05	10.5					8.8
30	.100	0.40	4.0	30	.100	0.60	6.0					5.0
31	.100	0.55	5.5	31	.100	0.65	6.5					6.0
32	.100	0.75	7.5	32	.100	0.65	6.5					7.0
33	.100	0.45	4.5	33	.100	0.85	8.5					6.5
34	.100	0.85	8.5	34	.100	1.65	16.5					12.5
35	.100	0.80	8.0	35	.100	0.25	2.5					5.2
36	.100	1.15	11.5	36	.100	0.75	7.5					9.5
37	.100	1.25	12.5	37	.100	1.50	15.0					13.7
38	.100	3.05	30.5	38	.100	0.65	6.5					18.5
39	.100	1.15	11.5	39	.100	0.65	6.5					9.0
40	.100	1.60	16.0	40	.100	1.05	10.5					13.3
41	.100	1.25	12.5	41	.100	1.25	12.5					12.5
42	.100	0.55	5.5	42	.100	0.85	8.5					7.0
43	.100	0.40	4.0	43	.100	1.10	11.0					7.5
44	.100	1.65	16.5	44	.100	0.25	2.5					9.5
45	.100	0.90	9.0	45	.100	0.50	5.0					7.0
46	.100	0.45	4.5	46	.100	0.70	7.0					5.8
47	.100	0.75	7.5	47	.100	0.75	7.5					7.5
48	.100	0.75	7.5	48	.100	1.35	13.5					10.5
49	.100	0.75	7.5	49	.100	0.20	2.0					4.8
50	.100	0.40	4.0	50	.100	0.90	9.0					6.5
51	.100	0.70	7.0	51	.100	0.30	3.0					5.0
52	.100	0.75	7.5	52	.100	1.25	12.5					10.0
53	.100	0.85	8.5	53	.100	1.10	11.0					9.8
54	.100	0.10	1.0	54	.100	0.70	7.0					4.0
55	.100	0.35	3.5	55	.100	1.10	11.0					7.3
56	.100	0.10	1.0	56	.100	1.60	16.0					8.5
57	.100	0.80	8.0	57	.100	0.80	8.0					8.0
58	.100	0.95	9.5	58	.100	0.50	5.0					7.3
59	.100	1.40	14.0	59	.100	1.30	13.0					13.5
60	.100	1.75	17.5									17.5
61	.044	1.50	34.1									34.1
				60	.038	1.05	27.6					27.6
Total/Avg												
	6.044	59.15	9.8		5.938	54.85	9.2					9.5

Defect Locations:
0+15.5 (b,1,1) 1+66.5 (b,2,1) 5+52.5 (b,1,2) 9+87.5 (b,2,2)

Scallop (Filter 15)
min height .025 in
min width .08 in
resolution .05 in
Blanking band .20 in
Defect template .40 in

Certified by: ______________________

Title: ______________________

Organization: ______________________

Track 1			Track 2			Track 3			
Seg Leng (mi)	Meas'd Rough (in)	PRI (in/mi)	Seg Leng (mi)	Meas'd Rough (in)	PRI (in/mi)	Seg Leng (mi)	Meas'd Rough (in)	PRI (in/mi)	Avg PRI (in/mi)

12+94.0 (b,1,3)	13+16.0 (b,1,3)	14+03.5 (b,1,3)	15+45.0 (b,1,3)
15+87.5 (b,1,4)	19+02.5 (b,2,4)	27+80.0 (b,1,6)	29+53.0 (b,2,6)
29+82.0 (b,2,6)	30+47.0 (b,1,6)	34+89.5 (b,1,7)	36+29.0 (b,2,7)
36+95.5 (b,2,8)	36+95.5 (b,2,7)	38+26.5 (b,1,8)	40+20.5 (b,2,8)
41+78.0 (b,1,8)	41+90.0 (b,2,8)	42+11.5 (b,1,8)	42+32.0 (b,2,9)
43+37.0 (b,1,9)	55+87.0 (b,2,11)	61+04.5 (b,1,12)	115+18.5 (b,1,22)
119+27.0 (b,2,23)	138+41.0 (b,2,27)	152+26.0 (b,2,29)	158+90.0 (b,2,31)
193+25.0 (b,2,37)	195+80.0 (b,1,38)	196+88.0 (b,1,38)	197+14.5 (b,1,38)
199+04.5 (b,1,38)	200+43.5 (b,1,38)	205+13.0 (b,1,39)	205+82.5 (b,1,39)
208+85.5 (b,1,40)	210+92.0 (b,1,40)	212+58.5 (b,1,41)	214+00.5 (b,2,41)
214+98.0 (b,2,41)	219+11.0 (b,1,42)	220+25.0 (b,2,42)	224+71.0 (b,2,43)
230+95.0 (b,1,44)	231+51.5 (b,1,44)	231+77.0 (b,1,44)	250+96.0 (b,2,48)
251+64.0 (b,2,48)	256+05.0 (b,1,49)	263+10.5 (b,2,50)	275+45.5 (b,2,53)
276+30.0 (b,1,53)	294+10.5 (b,2,56)	299+17.0 (b,1,57)	310+94.5 (b,1,59)
313+15.5 (b,2,60)	317+44.5 (b,1,61)		

Scallop (Filter 15)
min height .025 in
min width .08 in
resolution .05 in
Blanking band .20 in
Defect template .40 in

Certified by: ____________________

Title: ____________________

Organization: ____________________

APPENDIX B

Benkelman Beam Deflection Overlay Program

This method consists of measuring total pavement deflections with a Benkelman beam device as described in AASHTO T-256. The measurement values are recorded and converted into pavement supporting ability. The overlay program then takes the measurement values and calculates the inches of AC overlay equivalent requirement for the pavements wheel load design.

AC OVERLAY PROGRAM

DATE 02-01-95

DIVISION 8 COUNTY NOWATA TEST DATE 06-22-94

PROJECT NUMBER 2264

DESCRIPTION
US 169 NORTHBOUND

RUT DEPTH (0.1 IN.)	MILEAGE EXTENTS	BEAM DEFLECTION (IN.)	SUPPORTING ABILITY (LBS.)	INCHES OF A.C. EQUIVALENT REQUIRED — WHEEL LOAD DESIGN 5000.	6000.	7000.	8000.	9000.
3	0.0	0.002	******	0.0	0.0	0.0	0.0	0.0
4	1000.00	0.014	******	0.0	0.0	0.0	0.0	0.0
0	2000.00	0.008	******	0.0	0.0	0.0	0.0	0.0
3	3000.00	0.004	******	0.0	0.0	0.0	0.0	0.0
2	4000.00	0.004	******	0.0	0.0	0.0	0.0	0.0
0	5000.00	0.006	******	0.0	0.0	0.0	0.0	0.0
0	6000.00	0.006	******	0.0	0.0	0.0	0.0	0.0
2	7000.00	0.006	******	0.0	0.0	0.0	0.0	0.0
0	8000.00	0.002	******	0.0	0.0	0.0	0.0	0.0
3	9000.00	0.006	******	0.0	0.0	0.0	0.0	0.0
0	10000.00	0.004	******	0.0	0.0	0.0	0.0	0.0
2	11000.00	0.001	******	0.0	0.0	0.0	0.0	0.0
2	12000.00	0.002	******	0.0	0.0	0.0	0.0	0.0
2	13000.00	0.001	******	0.0	0.0	0.0	0.0	0.0
2	14000.00	0.004	******	0.0	0.0	0.0	0.0	0.0
2	15000.00	0.004	******	0.0	0.0	0.0	0.0	0.0
0	16000.00	0.002	******	0.0	0.0	0.0	0.0	0.0
0	17000.00	0.008	******	0.0	0.0	0.0	0.0	0.0
2	18000.00	0.014	******	0.0	0.0	0.0	0.0	0.0
0	19000.00	0.008	******	0.0	0.0	0.0	0.0	0.0
3	20000.00	0.016	******	0.0	0.0	0.0	0.0	0.0
3	21000.00	0.018	18611.	0.0	0.0	0.0	0.0	0.0
0	22000.00	0.001	******	0.0	0.0	0.0	0.0	0.0
2	23000.00	0.016	******	0.0	0.0	0.0	0.0	0.0
0	24000.00	0.004	******	0.0	0.0	0.0	0.0	0.0
0	25000.00	0.016	******	0.0	0.0	0.0	0.0	0.0
2	26000.00	0.001	******	0.0	0.0	0.0	0.0	0.0
2	27000.00	0.006	******	0.0	0.0	0.0	0.0	0.0
2	28000.00	0.002	******	0.0	0.0	0.0	0.0	0.0

****** - WHEEL LOAD GREATER THAN 20000 LB.

PAGE 1 OF 2

RUT DEPTH (0.1 IN.)	MILEAGE EXTENTS	BEAM DEFLECTION (IN.)	SUPPORTING ABILITY (LBS.)	INCHES OF A.C. EQUIVALENT REQUIRED				
				WHEEL LOAD DESIGN				
				5000.	6000.	7000.	8000.	9000.
3	29000.00	0.004	******	0.0	0.0	0.0	0.0	0.0
3	30000.00	0.010	******	0.0	0.0	0.0	0.0	0.0
3	31000.00	0.004	******	0.0	0.0	0.0	0.0	0.0

****** - WHEEL LOAD GREATER THAN 20000 LB.

PAGE 2 OF 2

AC OVERLAY PROGRAM

DATE 02-01-95

DIVISION 8 COUNTY NOWATA TEST DATE 06-22-94

PROJECT NUMBER 2264 SITE 1

DESCRIPTION
US 169 SOUTHBOUND

RUT DEPTH (0.1 IN.)	MILEAGE EXTENTS	BEAM DEFLECTION (IN.)	SUPPORTING ABILITY (LBS.)	INCHES OF A.C. EQUIVALENT REQUIRED WHEEL LOAD DESIGN 5000.	6000.	7000.	8000.	9000.
1	32000.00	0.040	7225.	0.0	0.0	0.0	0.9	2.0
1	33000.00	0.038	7678.	0.0	0.0	0.0	0.4	1.5
1	34000.00	0.034	8759.	0.0	0.0	0.0	0.0	0.3
1	35000.00	0.020	16427.	0.0	0.0	0.0	0.0	0.0
1	36000.00	0.036	8186.	0.0	0.0	0.0	0.0	0.9
2	37000.00	0.048	5821.	0.0	0.2	1.3	2.4	3.5
1	38000.00	0.036	8186.	0.0	0.0	0.0	0.0	0.9
1	39000.00	0.040	7225.	0.0	0.0	0.0	0.9	2.0
1	40000.00	0.042	6819.	0.0	0.0	0.2	1.3	2.4
2	41000.00	0.032	9412.	0.0	0.0	0.0	0.0	0.0
2	42000.00	0.036	8186.	0.0	0.0	0.0	0.0	0.9
3	43000.00	0.018	18611.	0.0	0.0	0.0	0.0	0.0
2	44000.00	0.008	******	0.0	0.0	0.0	0.0	0.0
2	45000.00	0.004	******	0.0	0.0	0.0	0.0	0.0
0	46000.00	0.006	******	0.0	0.0	0.0	0.0	0.0
4	47000.00	0.018	18611.	0.0	0.0	0.0	0.0	0.0
2	48000.00	0.004	******	0.0	0.0	0.0	0.0	0.0
2	49000.00	0.008	******	0.0	0.0	0.0	0.0	0.0
2	50000.00	0.001	******	0.0	0.0	0.0	0.0	0.0
2	51000.00	0.018	18611.	0.0	0.0	0.0	0.0	0.0
3	52000.00	0.006	******	0.0	0.0	0.0	0.0	0.0
2	53000.00	0.001	******	0.0	0.0	0.0	0.0	0.0
2	54000.00	0.002	******	0.0	0.0	0.0	0.0	0.0
3	55000.00	0.004	******	0.0	0.0	0.0	0.0	0.0
3	56000.00	0.001	******	0.0	0.0	0.0	0.0	0.0
2	57000.00	0.004	******	0.0	0.0	0.0	0.0	0.0
0	58000.00	0.004	******	0.0	0.0	0.0	0.0	0.0
3	59000.00	0.004	******	0.0	0.0	0.0	0.0	0.0
0	60000.00	0.002	******	0.0	0.0	0.0	0.0	0.0

****** - WHEEL LOAD GREATER THAN 20000 LB.

PAGE 1 OF 2

RUT DEPTH (0.1 IN.)	MILEAGE EXTENTS	BEAM DEFLECTION (IN.)	SUPPORTING ABILITY (LBS.)	INCHES OF A.C. EQUIVALENT REQUIRED				
				WHEEL LOAD DESIGN				
				5000.	6000.	7000.	8000.	9000.
0	61000.00	0.008	******	0.0	0.0	0.0	0.0	0.0
0	62000.00	0.014	******	0.0	0.0	0.0	0.0	0.0
2	63000.00	0.004	******	0.0	0.0	0.0	0.0	0.0

****** - WHEEL LOAD GREATER THAN 20000 LB.

PAGE 2 OF 2