Fifteen Year Report
for
Iowa Highway Research Board
Research Project HR-165

FIBROUS P.C. CONCRETE OVERLAY RESEARCH in GREENE COUNTY, IOWA

August 1989

Highway Division
Iowa Department of Transportation

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for
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A Fifteen Year Performance Summary of Fibrous PC Concrete Overlay Research in Greene County, Iowa

By

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DISCLAIMER

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SUMMARY

The Greene County, Iowa, overlay project, completed in October 1973, was evaluated in October 1978, after five years in October 1983, after ten years and most recently in October 1988 after fifteen years of service.

The 33 fibrous concrete sections, four CRCP sections, two mesh reinforced and two plain concrete sections with doweled reinforcement were rated relative to each other on a scale of 0 to 100. The rating was conducted by original members of the Project Planning Committee, Iowa DOT, Iowa County, Federal Highway Administration and industry representatives. In all, there were 23, 25 and 17 representatives who rated the project in 1978, 1983 and 1988 respectively. The 23, 25 or 17 values were then averaged to provide a final rating number for each section or variable.

All experimental overlay sections had performed quite well in the period from five through 15 years, experiencing only limited additional deterioration. The 4" thick nonfibrous mesh reinforced continuous reinforced concrete pavement overlay sections provided the best performance in this research project. Another nonfibrous 5" thick bar reinforced overlay section performed second best. The best performance of a fibrous reinforced concrete section was obtained with 160 pounds of fiber per cubic yard.

The use of 750 pounds of cement per cubic yard in the fibrous concrete overlays provided no benefit over the use of 600 pounds of cement per cubic yard.

The performance of the fibrous overlays was directly related to fiber content of the concrete mix. The 160 pounds per cubic yard provided the best performance with the poorest performance exhibited by the 60 pounds of fiber per cubic yard. There is no significant difference in the performance of the 2 1/2" long and 1" long fibers.

The 3" thick fibrous concrete overlays yielded substantially better performance than the 2" fibrous overlays.

Substantial bonding was not achieved on any of the fibrous concrete overlay sections and, therefore, no conclusion can be reached in regard to the type of bonding.

In general, the thicker, nonfibrous pavement overlay sections performed better than the fibrous reinforced concrete overlays. The additional cost of the fibrous concrete overlays cannot be justified based upon the comparative performance of the fibrous and thicker nonfibrous overlay sections.

A FIFTEEN YEAR PERFORMANCE SUMMARY OF FIBROUS PC CONCRETE OVERLAY RESEARCH IN GREENE COUNTY, IOWA

BACKGROUND

The Greene County, Iowa, overlay project, completed in October 1973 is the most comprehensive study ever undertaken of fibrous concrete as an overlay for deteriorated highway pavement. The three-mile overlay project, constructed by Hallett Construction Company, includes 33 test sections of fibrous concrete, four test sections of continuously reinforced concrete pavement (CRCP), two test sections of mesh reinforced concrete, and two sections of dowel reinforced concrete.

The mix and design variables for the fibrous concrete overlays include:

1. concrete mix design (3)
2. fiber size (2)
3. fiber quantity (3)
4. special cement (Chem Comp (R))
5. overlay thickness (2)
6. joint spacing
7. type of bonding (3)

Replicate sections of several of the test sections were constructed. Tables 1A and 1B summarize the Greene County, Iowa, overlay project.

The overlay site is a three-mile section of Greene County, Iowa, Road E53 east of Jefferson, Iowa. The original Lincoln

Highway, US 30, partially reinforced concrete pavement (8.5 inches thick and 18 feet wide) was constructed in 1921 and 1922 without joints. At the time of the overlay (1973), the old pavement was severely cracked and spalled. The traffic count on the pavement 10 years after construction of the fibrous overlay was approximately 1100 vehicles per day with 4 to 4 1/2% trucks.

Prior to construction of the overlay, concrete strips two-feet wide were constructed on each side of the old pavement to increase the width from 18 feet to 22 feet. The widening strips, 4 inches thick, were constructed of good quality, lean nonreinforced PCC on grade.

Two basic concretes were used in the majority of the fibrous concrete sections. The mixes were chosen to represent extremes in cement content, namely, 600 and 750 lbs. of cement per cubic yard. Some fibrous concrete research had indicated that a greater cement content (750 lb.) was needed to derive total benefit of the fiber reinforcement. Other fibrous concretes used in the project contained a cement/fly ash mixture (five sections) or a shrinkage compensating cement (one section).

The steel fibers used were 0.010 inch by 0.022 inch by 1.0 inch long rectangular slit sheet supplied by the U.S. Steel Corporation and 0.025 inch OD by 2.5 inch long drawn fiber

supplied by the Atlantic Wire Company, Branford, Connecticut. Fiber addition rates were 60, 100 and 160 lbs. per cubic yard. Twenty-three of the fibrous concrete sections contain the 0.010 x 0.022 x 1.0 inch fiber while ten contain the 0.025 x 2.5 inch fiber.

All of the conventional PCC and CRCP sections were constructed using the Iowa DOT Class A concrete mix proportion containing 569 lbs. of Type I cement, 1499 lbs. of fine aggregate, 1522 lbs. of coarse aggregate (1 1/2 inch maximum size), and 270 lbs. of water per cubic yard of concrete. Two test sections were constructed with PCC reinforced with No. 4 bars, 12 feet long placed transversely on 3-foot centers at a depth of 2½ inches. Two test sections were constructed with PCC reinforced with a 6 x 6 inch steel mesh (wire diameter = 1/8 inch) placed at half the overlay depth. Twenty-two of the fibrous concrete test sections were three inches thick and eleven were two inches thick. The conventional PCC test sections were four and five inches thick and the CRCP sections were three and four inches thick.

Most of the fibrous concrete sections had transverse joints saw cut (1/4 inch wide) to 1/3 the overlay depth on 40-foot spacings. Centerline longitudinal joints (1/4 inch wide) were cut in most of the test sections at depths of 1/3 the thickness of the overlay. Transverse joints for the rebar and mesh reinforced concrete sections were saw cut (1/4 inch wide and

1/3 depth) on 20 or 30 foot spacings. Longitudinal joints were cut (1/4 inch wide and 1/3 depth) in all of these sections.

Three conditions of bonding were utilized for the fibrous concrete test sections:

1. Five sections intended to be fully bonded (cement paste bonding agent on wetted surface).

2. Twenty-five sections partially bonded (old pavement swept and cracks cleaned prior to overlay).

3. Three sections unbonded (double thickness of polyethylene sheet between overlay and old pavement).

Two fibrous concrete sections (3 inch design thickness) were placed on grade. The rebar and mesh reinforced concrete sections were all partially bonded. The CRCP sections were both bonded and unbonded (paraffin base cure).

A detailed report was prepared by the Iowa Concrete Paving Association giving job data on concrete mixture proportioning, concrete properties, test results, section locations, core locations and costs.(1) Also a report was written by D. R. Lankard and C. H. Henager.(2)

PERFORMANCE EVALUATIONS

The performance of the various overlay sections was documented by crack surveys during the first five years. These surveys, which detail the location, type (transverse and longitudinal) and length of the cracks were made six times in the first five years. The first crack survey was conducted in April 1974, followed by five crack surveys in October of the years 1974 through 1978. A report documenting these crack surveys is available from the Iowa Department of Transportation.(3) Much of the cracking and deterioration is due to the longitudinal joints between the original slab and the two feet of widening on each side. In retrospect, an evaluation of fibrous concrete overlay variables would have been better on a pavement without widening.

A 23-member rating panel evaluated all research sections in October 1978, at an age of five years. The five-year evaluation was an effort to rate the performance of the overlay sections on the basis of more comprehensive performance criteria. The personnel participating in the original planning committee, the five-year rating panel, the ten-year rating panel and the 15-year rating panel are listed in Table 2. There were 13 members on the original planning committee. There were 23 participants in the five-year evaluation rating panel, 24 participants in the 10-year evaluation rating panel and 17 participants in the 15-year rating panel.

The current assessment of the condition of the Greene County, Iowa overlay project at 15 years was made on October 14, 1988 by members of the original planning committee, Iowa DOT, Iowa County, Federal Highway Administration and industry representatives. Each of the 41 sections in the project was thoroughly examined with particular attention given to:

1. The type and amount of cracking.

2. The type and amount of other forms of pavement distress (spalling).

3. The presence of repaired areas and the prognosis for needed repairs or removal of the entire test section.

4. Overall condition relative to the other sections on the project.

After the careful evaluation, each participant was requested to utilize a "Greene County Evaluation Form" that had been provided to them (Appendix A). Each evaluator was to assign a rating to each section with a maximum value of 100 assigned to a section showing zero distress and wear. The rating number was based upon the criteria previously noted with four general categories:

1. 100-75 good with minor maintenance.

2. 75-50 above average - average maintenance.

3. 50-25 below average - repairs are needed.

4. 25-0 poor condition - major repairs needed.

The 23 values of 1978, 24 values of 1983 and the 17 values of 1988 were averaged to provide a final rating number of each section. The ratings are given in Table 1 and also in Table 3, where the sections have been listed in an order corresponding to the panel rating. The highest rating is listed first, descending to the lowest rating last. It is believed that the rating systems used in the five, ten and fifteen year evaluation gives a meaningful ranking of the experimental sections based on their condition and on speculation concerning their short term future performance.

A careful analysis of project records would indicate that construction problems or the absence thereof exhibited a definite effect on performance ratings. If few or no problems are noted in the project log and paving progressed rapidly, the ratings are higher than for sections where problems resulted in delays. A correlation of this factor is not realistic as numeric values were not assigned to the problems.

DISCUSSION

The data presented in Table 1 was analyzed with a view to identify the effect of a number of variables on the performance of the overlays through 15 years. Using the rating number as an index of relative performance, the effect of major material and design parameters on the performance of the overlay sections can be assessed.

General Comparison

A schematic display of the various variables of each section is given in Figure 1. The bonding condition and the admixture type were not considered major variables and are disregarded for evaluations within the report. The section identification numbers are contained in the individual spaces in the schematic display. A schematic display of the 15-year rating numbers is provided in Figure 2. the bonding condition and admixture type were disregarded for this schematic summary. Sections 23 (a bridge), 22 and 40A (on grade) and 25 (Chem Comp cement) were excluded from the rating summary. Using this summary rating chart, one can easily compare different variables of the fibrous concrete overlay. These can also be compared with the nonfibrous sections listed beneath the schematic display with the panel rating listed at the bottom of each block. Utilizing this schematic summary, it may be noted that the section receiving the highest 15-year rating was section 3, which was four inches thick utilizing a mesh continuous reinforced concrete pavement. The second highest average

rating was achieved by the five-inch thick rebar reinforced Type A concrete. The third highest rating was obtained by a four-inch mesh reinforced jointed section. The highest rating given to a fibrous reinforced concrete section with 750 pounds of cement and 160 pounds of 1" long fiber was 69.

The average cost of the various overlay sections (Table 4) was determined using 1973 prices. In general, the use of fibrous reinforcement results in a unit price greater than that of thicker conventionally reinforced overlays.

Personnel who had been on the evaluation panel for the five-year, the 10-year and the 15-year evaluations expressed the fact that they were pleasantly surprised with the relative condition of all overlay sections at the 10-year and the 15-year performance evaluations. It was the general consensus that based upon the five-year performance evaluation, substantially greater deterioration between five and 10 years had been expected. Most of the deterioration took place in the first five years after construction. The grand average of the rating numbers of October 1978, (Table 1) was 67 and the grand average of all ratings of October 1983 had decreased to 60. Based upon the five-year rating evaluation, many of the evaluators expressed the opinion that at 10 years consideration would need to be given for substantial rehabilitation. The general consensus of the 10-year evaluation panel was that the pavement had performed quite well and a substantial patching

in 1984 maintained the research sections for evaluation at 15 years.

Cement Content

Most of the fibrous concrete overlays were placed with concrete made with either 600 or 750 pounds per cubic yard of cement. There were, however, five overlay sections placed with 500 pounds of cement and 234 pounds of fly ash as the binder material. One section was placed using 750 pounds of Chem Comp cement per cubic yard. Comparisons of overlay sections in which the cement content is the only intended variable are shown in Table 5. The grand average favored the 600 pounds per cubic yard of cement. This is a relatively small difference and is not significant when considering other variables. The only explanation for this result would be the drying shrinkage caused by the additional cement with the relatively thin overlay sections being either 2" or 3". Obviously, the 750 pounds per cubic yard cement content does not provide better performance and, therefore, cannot be justified in view of the additional cost. The performance ratings of the sections with 500 lbs of cement and 234 lbs of fly ash were somewhat less than the sections with 600 or 750 lbs of cement. The only direct comparisons are sections 14 and 40 with a rating of 43 vs comparative sections for the 750 and 600 pounds of 51 and 59 respectively. This mix can also be compared with the 750 pounds per cubic yard mix with sections 15 vs 11 and 21 ratings of 37 and 53 respectively. Sections 11 and 25 pro-

vided a comparison of Chem Comp expansive cement and a standard 750 pound cement concrete mix. There was no significant benefit derived from the use of the Chem Comp expansive cement.

Fiber Content

Fiber contents of 60 pounds, 100 pounds, or 160 pounds per cubic yard were studied under this research. These fiber contents were used with both the 1" and the 2 1/2" fibers. A comparison of the overlay sections where the only intended major variable was the fiber content is given in Table 6. There are two sets of sections where all three fiber contents were used. When averaging these two, the grand average shows that the 160 pounds per yard is superior to both the 100 pound and the 60 pound with ratings of 68, 55 and 47 for the 160, 100 and 60 pound contents respectively. The comparative sections would show that the 100 pound fiber content yields a rating number approximately 10 points higher than that of the 60, and the 160 pound fiber content yields a rating number approximately 10 points better than the 100 pound fiber content. It would appear that the fiber content is one of the more important major variables as two of the 160 pound per cubic yard fibrous sections compared favorably with the 4" and 5" nonfibrous sections. Unfortunately, however, the 160 pounds of fiber per cubic yard increases the cost of the overlay sections substantially.

Fiber Type

Two different fiber types were used in this research as noted earlier. There are six sets of comparative sections (Table 7) where fiber type is the only major variable. At 10 years, the 2 1/2" fibers seemed to be providing better performance than 1" fibers. There is no significant difference between the 2 1/2" and 1" fibers at 15 years.

Overlay Thickness

The thickness of the overlay was intended to be either 2" or 3" except for transition sections. This 2" or 3" thickness was to be a nominal thickness and due to the irregular rough surface of the underlying original concrete, there was substantial variation in the thickness. Some thicknesses of only 1" were sited. There were five sets of sections where the only intended major variable was overlay thickness (Table 8). The 3" overlays provide substantially better performance ratings than do those of their comparative 2" sections. The grand average is 56 for the 3" vs 47 for the 2" or a 9 point superiority for the 3" overlays.

Type of Bonding

There are a few sections where the type of intended bonding is the only variable. These are presented in Table 9. At the time of construction, no equipment for determining the degree of bond was readily available and no testing of this aspect was conducted. During the five years following construction a

Delamtect testing device was developed to identify delaminations in bridge decks. This device was capable of indicating delaminated relatively thin layers. In October 1978, the entire length of the project was tested in the outside wheel track of both lanes. The project was almost completely delaminated except for the 4" and 5" sections. The "bonded" sections exhibited no greater degree of bonding than the "partial" or "unbonded" sections. Experience has shown that overlays are either "bonded" or "unbonded" as a "partial bond" yields an unbonded overlay. Research has shown that a cement grout squeegeed onto a properly prepared dry concrete surface prior to placing the new concrete mix results in a well bonded overlay. For this reason, the type of bonding was not considered as a major variable in this evaluation.

There are, however, four sets of comparative sections where the type of bonding is the only intended variable. Because of the limited number and the variation among the rating numbers on those comparative sections, no conclusions can be reached.

Pavement on Grade

The two sections which were placed on grade contained 160 pounds of fiber per cubic yard and were 3" thick. These two sections had performed quite well through five years (ratings of 69 and 76) but have shown substantial deterioration in the period from five through 15 years with substantial patching and now exhibit ratings of 50 and 51.

CONCLUSIONS

Based upon the results of the current survey utilizing the rating numbers of the panel as the relative performance of the experimental overlay sections after 15 years of service, it can be concluded that:

1. The 4" thick nonfibrous mesh continuous reinforced concrete pavement provided the best performance in this research project. A nonfibrous 5" thick number 4 deformed bar reinforced concrete section performed almost as well.

2. The best performance of fibrous reinforced concrete was by those sections containing 160 pounds of fiber per cubic yard.

3. In general, the fibrous concrete overlays have provided a 15-year performance superior to that expected at the 5-year evaluation.

4. The performance ratings of the fibrous concrete overlays containing the 600 pounds of cement per cubic yard were just slightly better than those of the overlays with 750 pounds of cement per cubic yard. It is obvious that in this project increasing the cement content from 600 to 750 pounds per cubic yard with its increase in cost, did not significantly improve overlay performance.

5. The performance of the overlays was directly related to the fiber content of the concrete mix with the 160 pounds of fibers per cubic yard mixes providing the best performance, followed by those containing 100 pounds of fibers per cubic yard, with the poorest performance exhibited by the mixes containing only 60 pound of fibers per cubic yard.

6. The length of fiber had no significant effect on the performance of fibrous concrete.

7. The 3" thick fibrous concrete overlays yielded substantially better performance than the 2" fibrous overlays.

8. Substantial bonding was not achieved on any of the fibrous concrete overlay sections and, therefore, no conclusions can be reached in regard to type of bonding.

9. The additional cost of the fibrous reinforcement cannot be justified based upon the 15-year comparative performance of the fibrous and 4" and 5" thick nonfibrous sections.

ACKNOWLEDGEMENTS

We wish to express our appreciation to the Planning Committee (Table 2) and especially C. A. Elliott and the Greene County Board of Supervisors who made this project a reality.

Marlin Knutson was a major contributor in the conception, construction, evaluation and reporting on this research.

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Lone Star Industries
Marquette Cement Co.
Martin-Marietta Cement
Missouri Portland Cement Co.
Northwestern St. Portland Cement Co.
Penn Dixie Cement Corporation
Universal Atlas Cement -
Div. U.S. Steel

Battelle Corp.
Wire Reinforcement Inst.
Construction Materials
Contractors' Steel Corp.
Des Moines Steel Co.
Master Builders
Sioux City Foundry
Chicago Fly Ash
GOMACO
Rex
CMI

REFERENCES

1. Knutson, M. J., "Greene County, Iowa Concrete Overlay Research Report", Iowa Concrete Paving Association, West Des Moines, Iowa, pp. 1-79 (January 1974).

2. Lankard, D. R., Henager, C. H., "The Condition of the Wirand(R) Concrete Overlay Project in Greene County, Iowa as of September 1977 (November 15, 1977).

3. Crack Surveys, Iowa Department of Transportation, Ames, Iowa, April 1974; October 1974; October 1975; October 1976; and October 1977.

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TABLE 1A

SUMMARY, GREENE COUNTY, IOWA OVERLAY PROJECT

Section Number	Station Numbers Begin	Station Numbers End	Cement (lbs.)	Fiber Content (lbs.) 1"	Fiber Content (lbs.) 2-1/2"	14 Day Flexural Strength (PSI)	Overlay Thickness (In.)	Bond
1	0 + 00	4 + 50	569	(Dowels)		563	5	Partial
2	4 + 50	9 + 00	569	(Mesh)		559	4	Partial
3	9 + 00	11 + 00	569	(CRCP Anchor)		575	4	Bonded
4	11 + 00	17 + 00	569	(CRCP)		565	4	Unbonded
4A	17 + 00	17 + 97	569	(CRCP)		---	Var.	Unbonded
5	17 + 97	24 + 00	569	(CRCP)		671	3	Unbonded
6	24 + 00	26 + 17	569	(CRCP Anchor)		614	3	Bonded
7	26 + 17	31 + 90	600	60	--	575	3	Partial
8	31 + 90	34 + 05	750	--	60	730	3	Partial
9	34 + 05	37 + 75	600	100	--	603	3	Partial
10	37 + 75	42 + 00	750	100	--	680	3	Partial
11	42 + 00	45 + 95	750	--	100	739	3	Unbonded
12	45 + 95	50 + 00	750	100	--	811	3	Bonded
13	50 + 00	54 + 40	600	60	--	718	3	Partial
14	54 + 40	57 + 95	500	100	--	664	3	Partial
15	57 + 95	62 + 00	500	--	100	615	3	Partial
16	62 + 00	66 + 25	600	--	60	662	3	Partial
17	66 + 25	69 + 90	750	60	--	769	3	Partial
18	69 + 90	73 + 65	600	160	--	705	3	Partial
19	73 + 65	77 + 60	600	160	--	811	3	Partial
20	77 + 60	81 + 70	750	160	--	809	3	Partial
21	81 + 70	86 + 05	750	--	100	775	3	Bonded
22	86 + 05	88 + 63.1	500	160	--	677	3	On Grade
23	88 + 63.1	90 + 22.8	750	160	--	775	2 1/4	Bonded
24	90 + 22.8	95 + 70	600	100	--	644	3	Partial
25	95 + 70	99 + 70	750	--	100	719	3	Unbonded
26	99 + 90	104 + 20	750	--	160	674	2	Partial
27	104 + 20	107 + 70	600	100	--	680	2	Partial
28	107 + 70	112 + 00	750	100	--	755	2	Partial
29	112 + 00	116 + 05	750	100	--	741	2	Bonded
30	116 + 05	119 + 75	750	160	--	834	2	Partial
31	119 + 75	123 + 35	600	100	--	612	2	Partial
32	123 + 35	127 + 65	750	100	--	726	2	Partial
33	127 + 65	132 + 10	600	160	--	664	2	Partial
34	132 - 10	136 + 30	750	160	--	808	2	Partial
35	136 - 30	140 + 00	750	--	100	731	2	Unbonded
36	140 + 00	144 + 00	750	--	100	791	2	Bonded
37	144 + 00	147 + 92.9	600	--	60	668	3	Partial
38	147 + 92.9	151 + 83.8	569	(Mesh)		605	4	Partial
39	151 + 83.8	155 + 84	569	(Dowels)		602	5	Partial
40	155 + 84	158 + 00	500	100	--	621	3	Partial
40A	158 + 00	160 + 18.1	500	160	--	865	3	On Grade

TABLE 1B
SUMMARY, GREENE COUNTY, IOWA OVERLAY PROJECT

Sec. #	Spacing (ft.)	Center Line Joint	Panel Rating Oct. 78	Oct. 83	Oct. 88	Remarks
1	20	Yes	90	86	79	Steel Dowels ½" x 12' - 3-ft c/c
2	30	Yes	81	80	76	Steel Mesh 6" x 6"
3	0	Yes	84	82	84	No crack initiators-welded wire mesh
4	8	Yes	78	72	74	Crack initiators 8-ft c/c
4A	8	Yes	--	--	--	Crack initiators 8-ft c/c
5	8	Yes	52	46	46	Crack initiators 8-ft c/c--66
6	0	Yes	54	53	53	No crack initiators-welded wire mesh
7	40 FD	Yes	64	56	52	FD-joints sawed full depth
8	40	Yes	69	60	51	
9	40	Yes	69	65	51	
10	40	Yes	59	55	48	
11	40	Yes	68	66	52	
12	40	Yes	64	62	54	
13	40	No	56	50	48	
14	40	Yes	40	40	34	Fly ash addition 234 lbs.
15	40	Yes	42	43	37	Fly ash addition 234 lbs.
16	40	Yes	60	60	54	
17	40	Yes	55	50	44	
18	40	Yes	86	80	67	
19	40	Yes	82	77	68	
20	40	Yes	83	73	69	
21	40	Yes	68	59	53	
22	40	Yes	69	55	50	Fly ash addition 234 lbs.
23	0	No	83	86	76	Bridge deck overlay 2½ in. depth
24	40	Yes	79	76	67	Curb section
25	See Remarks	No	69	60	56	Chem Comp R cement
26	40	Yes	79	64	50	
27	40	Yes	65	58	50	
28	40 FD	Yes	55	45	47	FD-Joints sawed full depth
29	40 FD	Yes	56	50	49	FD-Joints sawed full depth
30	40	Yes	70	60	53	
31	40	No	56	52	51	
32	40	No	50	48	45	
33	40	Yes	72	62	45	
34	40	Yes	69	56	45	
35	40	Yes	44	37	40	
36	40	Yes	63	52	45	
37	40	No	71	52	45	
38	30	Yes	84	70	77	Steel mesh 6" x 6"
39	20	Yes	82	76	79	Steel dowels ½" x 12' - 3 ft c/c
40	Various	No	59	45	51	Fly ash addition 234 lbs.
40A	40	Yes	76	51	51	Fly ash addition 234 lbs.
	Gr. Avg.		67	60	55	

TABLE 2
Planning and Rating Personnel

NAME	COMPANY	Planning Committee	2 Year Rating Panel	10 Year Rating Panel	15 Year Rating Panel
1. Don Anderson	Iowa Dot	X	X	X	X
2. Clair Ball	Portland Cement Association	X		X	
3. Bill Bester	Portland Cement Association	X			
4. Mack Capper	Central Paving Company	X			X
5. Charles Davis	Hallett Construction Company	X	X		
6. C. A. Elliott	Greene County	X			
7. Gene Hardy	Dallas County	X			
8. M. J. Knutson	American Concrete Paving Assoc.	X	X	X	X
9. John Lane	Iowa DOT	X	X	X	
10. Dave Lankard	Battelle Corp.	X			
11. Glenn Perkins	Quad City Construction	X			
12. Al Schwarz	U.S. Steel	X			
13. W. A. Yrjanson	American Concrete Paving Assoc.	X	X	X	
14. Jerry Bergren	Iowa DOT		X	X	X
15. Ron Betterton	Greene County		X	X	
16. Ralph Britson	Iowa DOT		X	X	
17. Mike Darter	University of Illinois		X		
18. Dave Hamilton	Penn-Dixie Industries Inc.		X	X	X
19. Frank Howell	FHWA - Iowa		X	X	X
20. John F. McDermott	U.S. Steel		X		
21. Len McGill	Universal Atlas Cement		X		
22. Vernon J. Marks	Iowa DOT		X	X	X
23. Mikael Olsen	University of Illinois		X		
24. E. J. Renier	Portland Cement Association		X	X	X
25. Lowell Richardson	Iowa DOT		X		
26. Matt Ross	Iowa Concrete Paving Assoc.		X	X	
27. John R. Schultz	FHWA - Washington		X		
28. Dick Smith	Iowa DOT		X	X	X
29. John H. Stevens	U.S. Steel		X		
30. Jerry Stoner	Jensen Construction Co.		X	X	X
31. C. K. (Bill) Wilson	U.S. Steel		X		
32. Frank Botelho	FHWA - Washington			X	
33. George Calvert	Iowa DOT			X	
34. Chuck Huisman	Iowa DOT			X	
35. Mel Galinet	Michell Fibercon, Inc.			X	
36. Ron Palmieri	University of Illinois			X	
37. R. C. Richardson	Davis Walker Corporation			X	
38. Peter Tatnall	Bekaert Steel Wire Corp.			X	
39. Shiraz D. Tayabji	Portland Cement Assoc.			X	
40. William V. Wagner,Jr.	Wire Reinforcement Institute			X	
41. Al Walker	Battelle Development Corp.			X	
42. Robert Given	Iowa Concrete Paving Assoc.				X
43. Larry Jesse	Iowa DOT				X
44. John Lower	Fibermesh Company				X
45. Don VanGilder	Greene County				X
46. Gerald Voigt	American Concrete Paving Assoc.				X
47. Mark Callahan	Iowa DOT				X
48. Jim Grove	Iowa DOT				X

TABLE 3
OVERLAY SECTIONS ARRANGED IN
ORDER OF THE 15 YEAR PERFORMANCE RATING

Sec. #	Panel Rating	Cement Content (Lb/yd³)	Reinforcement or Fiber Type	Amount of Fiber (Lb/yd³)	Overlay Thickness Inches	Types of Bond
3	84	569	CRCP	---	4	B
1	79	569	Dowels	---	5	P
39	79	569	Dowels	---	5	P
38	77	569	Mesh	---	4	P
23	76	750	1"	160	2 1/4	B.B.
2	76	569	Mesh	---	4	P
4	74	569	CRCP	---	4	U
20	69	750	1"	160	3	P
19	68	600	1"	160	3	P
18	67	600	1"	160	3	P
24	67	600	1"	100	3	P
25	56	750	2 1/2"	100	3	U
12	54	750	1"	100	3	B
16	54	600	2 1/2"	60	3	P
30	53	750	1"	160	2	P
21	53	750	2 1/2"	100	3	B
6	53	569	CRCP	---	3	B
11	52	750	2 1/2"	100	3	U
7	52	600	1"	60	3	P
9	51	600	1"	100	3	P
8	51	750	2 1/2"	60	3	P
31	51	600	1"	100	2	P
40A	51	500*	1"	160	3	O.G.
40	51	500*	1"	100	3	P
26	50	750	2 1/2"	160	2	P
27	50	600	1"	100	2	P
22	50	500*	1"	160	3	O.G.
29	49	750	1"	100	2	B
10	48	750	1"	100	3	P
13	48	600	1"	60	3	P
28	47	750	1"	100	2	P
5	46	569	CRCP	---	3	U
33	45	600	1"	160	2	P
34	45	750	1"	160	2	P
36	45	750	2 1/2"	100	2	B
37	45	600	2 1/2"	60	3	P
32	45	750	1"	100	2	P
17	44	750	1"	60	3	P
35	40	750	2 1/2"	100	2	U
15	37	500*	2 1/2"	100	3	P
14	34	500*	1"	100	3	P

*500 lb of cement + 234 lb of fly ash
B.B. - Bonded on Bridge Deck
P - Partial Bond
B - Bonded
U - Unbonded
O.G. - On Grade

TABLE 4
AVERAGE COST OF OVERLAYS

Thickness	Cement lbs./cu.yd.	Fiber lbs./cu.yd.	Cost Sq. Yd.
2"	600	100	$3.40
2"	600	160	$4.10
2"	750	100	$3.52
2"	750	160	$4.22
3"	500 + 234 fly ash	100	$4.94
3"	500 + 234 fly ash	160	$5.61
3"	750	160	$6.64
3"	750	100	$4.56
3"	750	60	$3.86
3"	600	160	$5.42
3"	600	100	$4.30
3"	600	60	$3.61

SPECIAL SECTIONS

Description	Cost per square yard
5" plain concrete	$3.57
4" type A concrete with mesh	$3.58
4" CRCP with elastic joints	$4.41
3" CRCP with elastic joints	$3.48

TABLE 5
PERFORMANCE RATINGS AND FLEXURAL STRENGTHS OF
FIBROUS CONCRETE OVERLAY SECTIONS WHERE CEMENT CONTENT
WAS THE ONLY MAJOR VARIABLE

COMPARATIVE OVERLAY SECTIONS			FLEXURAL STRENGTH, PSI			AVERAGE 15 YEAR PERFORMANCE RATING		
500 lb/yd³ +234 lb F.A.	750 lb/yd³	600 lb/yd³	500 lb/yd³ +234 lb F.A.	750 lb/yd³	600 lb/yd³	500 lb/yd³ +234 lb F.A.	750 lb/yd³	600 lb/yd³
14, 40	10, 12	9, 24	643	745	624	43	51	59
	30, 34	33		821	664		49	45
	8	37, 16		730	665		51	50
	17	7, 13		769	647		44	50
	28, 29, 32	27, 31		741	646		47	51
	20	18, 19		809	758		69	68
	Grand Average			753	667	43	52	54
15	11, 21		615	757		37	53	
	Grand Average		629	751		40	52	

TABLE 6
PERFORMANCE RATINGS OF
FIBROUS CONCRETE OVERLAY SECTIONS
WHERE FIBER CONTENT WAS THE ONLY MAJOR VARIABLE

COMPARATIVE OVERLAY SECTIONS			AVERAGE 15 YEAR PERFORMANCE RATING		
60 lb/yd³	100 lb/yd³	160 lb/yd³	60 lb/yd³	100 lb/yd³	160 lb/yd³
7, 13	9, 24	18, 19	50	59	68
17	10, 12	20	44	51	69
		Grand Average	47	55	68
	27, 31	33		51	45
	28, 29, 32	30, 34		47	49
	35, 36	26		43	50
		Grand Average		50	56
8	11, 21		51	53	
		Grand Average	48	54	

TABLE 7
PERFORMANCE RATING OF
FIBROUS CONCRETE OVERLAY SECTIONS
WHERE FIBER TYPE WAS THE ONLY MAJOR VARIABLE

COMPARATIVE OVERLAY SECTIONS		AVERAGE 15 YEAR PERFORMANCE RATING	
0.010 x 0.022 X1" Fiber	0.025 x 2.5" Fiber	0.010 x 0.022 x 1" Fiber	0.025 x 2.5" Fiber
7, 13	16, 37	50	50
17	8	44	51
10, 12	11, 21	51	53
14, 40	15	43	37
30, 34	26	49	50
28, 29, 32	35, 36	47	43
	Grand Average	47	47

TABLE 8
PERFORMANCE RATING OF
FIBROUS CONCRETE OVERLAY SECTIONS
WHERE OVERLAY THICKNESS WAS THE ONLY MAJOR VARIABLE

COMPARATIVE OVERLAY SECTIONS		AVERAGE 15 YEAR PERFORMANCE RATING	
3 inches	2 inches	3 inches	2 inches
18, 19	33	68	45
11, 21	35, 36	53	43
9, 24	27, 31	59	51
10, 12	28, 29, 32	51	47
20	30, 34	49	49
	Grand Average	56	47

TABLE 9
PERFORMANCE RATINGS OF
FIBROUS CONCRETE OVERLAY SECTIONS
WHERE THE ONLY INTENDED VARIABLE WAS THE TYPE OF BONDING

COMPARATIVE OVERLAY SECTIONS			AVERAGE 15 YEAR PERFORMANCE RATING		
Bonded	Unbonded	Partially Bonded	Bonded	Unbonded	Partially Bonded
12		10	54		48
21	11		53	52	
36	35		45	40	
29		28, 32	49		46

FIGURE CAPTIONS

1. Schematic Summary of the Variables of Each Overlay Section
2. Schematic Summary of the Variables and Performance Ratings at 15 Years

Figure 1

SCHEMATIC SUMMARY OF THE VARIABLES OF EACH OVERLAY SECTION

FIBROUS SECTIONS

AS BUILT

Pavement Thick. (in.)	Cement Content (lbs.)	Bonding Condition	Fiber Size (in.)	1									2½								
			Fiber Content (lbs.)	60			100			160			60			100			160		
			Admixture Type	O	N	R	O	N	R	O	N	R	O	N	R	O	N	R	O	N	R
3	600	U																			
		B						Curb													
		P		7	13		9	24			18 19			16	37						
	750	U																11 25		← Chem. Comp.	
		B						12			23	←	Bridge				21				
		P			17		10				20			8							
	500+ 234 FA	U																			
		B										On Grade									
		P						14	40		22	40 A	←				15				
2	600	U																			
		B																			
		P						27 31			33										
	750	U																35			
		B						29										36			
		P						28 32			30 34									26	
	500+ 234 FA	U																			
		B																			
		P																			

Admixture
- O None
- N Water Reducer
- R Set Retarder

Bonding
- P Partial
- B Bonded
- U Unbonded

FA - Fly Ash

NON-FIBROUS SECTIONS

Sections 1 and 39	Sections 2 and 38	Section 3	Section 4	Section 5	Section 6
5 in.	4 in.	4 in.	4 in.	3 in.	3 in.
Type A	Type A	Type A	Type A	Type A	Type A
Plain	6x6 Mesh	CRC Mesh	CRC Mesh	CRC Mesh	CRC Mesh
Partial	Partial	Anchor	Unbonded	Unbonded	Anchor
Bond	Bond	Bonded			Bonded
No Admix.	No Admix.	No Admix.	No Admix.	No Admix.	No Admix.

Gra 028A-C
5601 2 10 86

Figure 2

SCHEMATIC SUMMARY OF THE VARIABLES AND PERFORMANCE RATINGS AT 15 YEARS

FIBROUS SECTIONS

Fiber Size *(in.)*			1			2½		
Fiber Content *(lbs.)*			60	100	160	60	100	160
Pavement Thick *(in.)*	Cement Content *(lbs.)*							
3	600		*50	*59	*68	*50		
3	750		*44	*51	*69	*51	53	
3	500+ 234 FA			*43			*37	
2	600			*51	*45			
2	750			*47	*49		*43	*50
2	500+ 234 FA							

* Average Performance Rating at 15 Years

Note: Sections 22, 23, 25 & 40A were not included in the average performance ratings.

FA - Fly Ash

NON-FIBBROUS SECTIONS

Sections 1 and 39	Sections 2 and 38	Section 3	Section 4	Section 5	Section 6
5 in.	4 in.	4 in.	4 in.	3 in.	3 in.
Type A	Type A	Type A	Type A	Type A	Type A
Plain	6x6 Mesh	CRC Mesh	CRC Mesh	CRC Mesh	CRC Mesh
Partial Bond	Partial Bond	Anchor Bonded	Unbonded	Unbonded	Anchor Bonded
No. Admix.	No Admix.	No Admix.	No Admix.	No Admix.	No Admix.
*79	*77	*84	*74	*46	*53

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APPENDIX A

GREENE COUNTY
EVALUATION FORM

The purpose of this sheet is to evaluate independently the 42 different test sections on E-53 Greene County Road from the east corporation limits of Jefferson west 3.0 miles. We ask that each evaluator be objective in their rating and pay particular attention to:

1. The type and amount of cracking.
2. The type and amount of other forms of pavement distress (spalling).
3. The presence of repaired areas and the prognosis for needed repairs or removal of the entire test section.
4. Overall condition relative to the other sections on the project.

The following rating system will be used:

0-25	Poor Condition Major repairs are needed. (Please comment if the section should be replaced.)	25-50	Below Average Repairs are needed.	50-75	Above Average Average maintenance is needed.	75-100	Good Only minor or no maintenance is is needed.

Number	Bond Type P Partial Bonded U Unbonded B Bonded	Section	Overlay Thickness	Rating	Comments
1	P	Type "A" Plain Concrete 1/2" x 12' Tie Bars	5"		
2	P	Type "A" Plain Concrete Mesh Rein. 6" x 6"	4"		
3	B	CRC 3" x 16" Steel	4"		
4	U	CRC 8' Crack In. 3" x 16" Steel	4" - 4 3" - 4A		