PERFORMANCE OF NONGROUTED THIN BONDED PCC OVERLAYS

Construction Report

Iowa Highway Research Board
Project HR-291

August 1986

CONSTRUCTION REPORT
IOWA HIGHWAY RESEARCH BOARD
PROJECT HR-291

PERFORMANCE OF NONGROUTED THIN BONDED P.C.C. OVERLAYS

AUGUST, 1986

BY

MARK K. KALER
CONSTRUCTION ENGINEER
IOWA CONCRETE PAVING ASSOCIATION
(515) 278-0606

AND

JOHN LANE
P.C. CONCRETE ENGINEER
IOWA DEPARTMENT OF TRANSPORTATION
(515) 239-1226

AND

MILTON L. JOHNSON, P.E.
COUNTY ENGINEER
WAPELLO COUNTY
(515) 684-5425

TABLE OF CONTENTS

INTRODUCTION

The Iowa road system has approximately 13,000 miles of Portland Cement Concrete Pavements, many of which are reaching the stage where major rehabilitation is required. Age, greater than anticipated traffic, heavier loads and deterioration related to coarse aggregate in the original pavement are some of the reasons that these pavements have reached this level of distress.

One method utilized to rehabilitate distressed or underdesigned PCC pavements is the thin bonded Portland Cement Concrete overlay. Since the introduction of thin bonded overlays on highway pavements in 1973, the concrete paving industry has made progress in reducing the construction costs of this rehabilitation technique. With the advent of the shotblast machine, surface preparation costs have decreased from over $4.00 per square yard to most recently $1.42 per square yard. Other construction costs, including placement, grouting and sawing, have also declined. With each project, knowledge and efficiency have improved.

In an effort to further reduce the construction costs, elimination of the grouting operation in the thin bonded overlay techniques has been proposed. The grout has been used in the past to facilitate bond between the new slab and the existing slab, however, the grout with the necessary high water cement ratio may actually impede both the bond strength growth and ultimate bond strength. Preliminary work with nongrouted successfully bonded overlays has included field trials on several pavement overlay projects and on new bridges which use precast stay-in-place floor panels with cast-in-place concrete wearing surface. Additionally, a nongrouted section was an experimental feature on secondary road project RS-7701(9) on the Monroe-Wapello County line constructed in the summer of 1985.

OBJECTIVE

The objective of this research is to evaluate the performance of the non-grouted sections of the Monroe-Wapello County thin bonded PCC overlay.

EVALUATION

The evaluation will consist of bond shear strengths, pavement deflection data and a visual inspection of both the pavement structure and the individual cores. Other projects which will be monitored include Vine Street in West Des Moines, constructed in 1981, and the Burlington Airport constructed in 1985. In addition, two projects in 1986 will have sections constructed without the use of grout. These projects are the FAUS project, M-5258(1), in Oskaloosa and project FR-71-7(32), on U.S. 71 in Buena Vista County.

PRELIMINARY INVESTIGATION

County Road T-61 is located on the Monroe-Wapello County line in southeast Iowa. After it was originally paved in 1972, it carried mostly local traffic (380-410 ADT with 15% trucks). In 1984, Cargill Inc., constructed a corn sweetner refinement plant near the north end of the project approximately one-half mile south of the junction with Ia. #137. The anticipated traffic growth due to this new development is expected to be equivalent to one hundred 5-axle (80,000 pounds) semi tractor trailers per day. This is an addition of 175 E-18's (single equivalent axle loads) per lane per day.

The original road was built in 1972 to the specifications of that time. It was constructed by Central Construction Company of Indianola, Iowa, 22 feet wide on natural subgrade with an initial PSI rating of 4.2. The road segment is 2.96 miles long and had 40 foot joint spacings with aggregate interlock for load transfer. The existing pavement showed no signs of unusual distress or wear. The maintenance history indicated that very little repair work had been required.

CONSTRUCTION CRITERIA AND PROCEDURES

The 4 inch thin bonded overlay was constructed during the month of June, 1985. The existing pavement surface was prepared by the shotblasting method. Prior to the paving operation, areas seriously distressed were full-depth patched. Where the grout was applied, it was pressure sprayed as per Iowa DOT specification guidelines. Concrete mixed in a central mix batch plant was hauled in dump trucks, which backed up on the slab to discharge in front of the paver. A Rex Town and County slipform paver finished up to 6400 L.F. per day of the 4 inch thin bonded overlay 22 feet wide. The new slab was transversely textured and 1.5 times the normal application rate of white pigmented curing compound was applied immediately. Transverse joints were sawed full depth over the existing transverse joint, and an additional 20 ft. intermediate joint was sawed while the longitudinal joint was sawed T/2, or 2", over the existing centerline joint. After sand and air cleaning, the joints were sealed with a hot pour Sof-Seal as per Iowa DOT specification.

PERFORMANCE

As outlined previously, this research project is intended to evaluate the performance of bonded overlays constructed without the use of grout. Cores were taken from each project previously identified soon after construction, and tested for shear strength. In an effort to evaluate the performance of these sections over time, cores will be taken and tested at regular intervals. These cores will be obtained from locations thought to be most critical in terms of bond, such as at the header, wheel paths and near the centerline joint. Also cores will be taken at less critical areas in order to distinguish variations between different sections. In addition, several cores will be stored in the DOT Materials laboratory out of the natural environment, and will be tested periodically in an effort to determine the effects of weather and temperature on bond performance.

During the paving sequence of the Monroe-Wapello project, two 250-foot sections were constructed without the grout application. These test sections are located between Stations 419+75 - 422+25 and Stations 443+25 - 445+25. Within twenty four hours of paving, three cores were taken in the first test section and tested for bond shear strength. The cores were tested in accordance with IDOT I.M. 406B. Figure A. The results ranged between 278 psi and 596 psi with an average of 408 psi. For design purposes a bond strength of 200 psi is specified. However, the higher the bond strengths achieved, the higher the fatigue and durability inherent to the rehabilitated pavement. Since the first test section yielded positive results, a second test section was built the next day coming directly off of the header. This section was selected as a greater challenge in terms of achieving bond. Cores were taken at the midpanel, wheel path, and near the longitudional joint in both test sections as well as in the adjacent control sections. These cores were tested at 14 days. The grouted sections had an average bond strength of 388 psi while the non-grouted sections had an average bond strength of 640 psi. The grouted sections ranged from 199 psi to 577 psi while the non-grouted sections ranged from 378 psi to 947 psi. See Table 1-1 and Table 1-2 for complete results. It appears that there was a significant bond strength advantage when constructing the bonded overlay without the use of grout.

In June, 1986 the second stage of this research evaluation began. The same test sections were cored and tested for shear strength. For the nongrouted sections the results of the six cores ranged between 398 psi and 955 psi with an average sheer strength of 638 psi. The grouted control section test results ranged from 282 psi to 1,527 psi with an average shear strength of 685. (Table 1-3) There was a significant increase in bond strength over the past year for the grouted sections while the nongrouted remained rather constant. The reason for the appearance of a substantial bond strength gain in the grouted sections is not fully understood. Additional cores were taken and tested and results are shown in Table 1-4, however, the locations of the cores were not according to the coring scheme previously established. Road rater data taken shows no indication of any abnormal results. (Table 1-5) The data shows that significant bond strengths were obtained without the use of grout, and that this procedure could be justified in future bonded overlays.

CONCLUSION

Even though there appears to be some advantage provided by the non-grouted method, it is too early to conclusively make any statements with regards to the overall performance of nongrouted thin bonded overlays.

FIGURE A

Test Method No. Iowa 406-B
September 1984

IOWA DEPARTMENT OF TRANSPORTATION
HIGHWAY DIVISION

Office of Materials

METHOD OF TEST FOR DETERMINING THE SHEARING STRENGTH OF BONDED CONCRETE

Scope

This method covers the procedure used in determining the shearing strength at the bonded interface between new and old concrete. The test is normally conducted on cores drilled from completed structures or pavements.

Procedure

A. Apparatus

1. Testing jig to accommodate a 4" diameter specimen. The jig is designed to provide a direct shearing force at the bonded interface.

2. Hydraulic testing machine capable of applying a smooth and uniform tensile load. The accuracy of the reading shall be with ± 1.0% of the indicated load.

B. Test Specimens

1. Four-inch-diameter cores are the normal test specimen. Unless otherwise specified the cores are tested in an "as received" condition.

C. Test Procedure

1. Placing the specimen

   (a) Place the specimen in the testing jig in such a manner that the bonded interface is placed in the space between the main halves of the jig.

   (b) In the event that the interface is irregular and cannot entirely be placed within the specified space, the interface will be placed as close as practical and a special notation made.

   (c) Carefully align the testing jig in the testing machine with the central axis of the jig in the center of the testing machine.

2. Rate of Loading

   (a) Apply the tensile load continuously and without shock. Apply the load at a constant rate within the range of 400 to 500 psi per minute.

   (b) Continue the loading until the specimen fails, and record the maximum load carried by the specimen during the test.

D. Calculations

1. Calculate the shear bond strength of the specimen by dividing the maximum load carried by the specimen during the test by the cross-sectional area and express the result to the nearest psi.

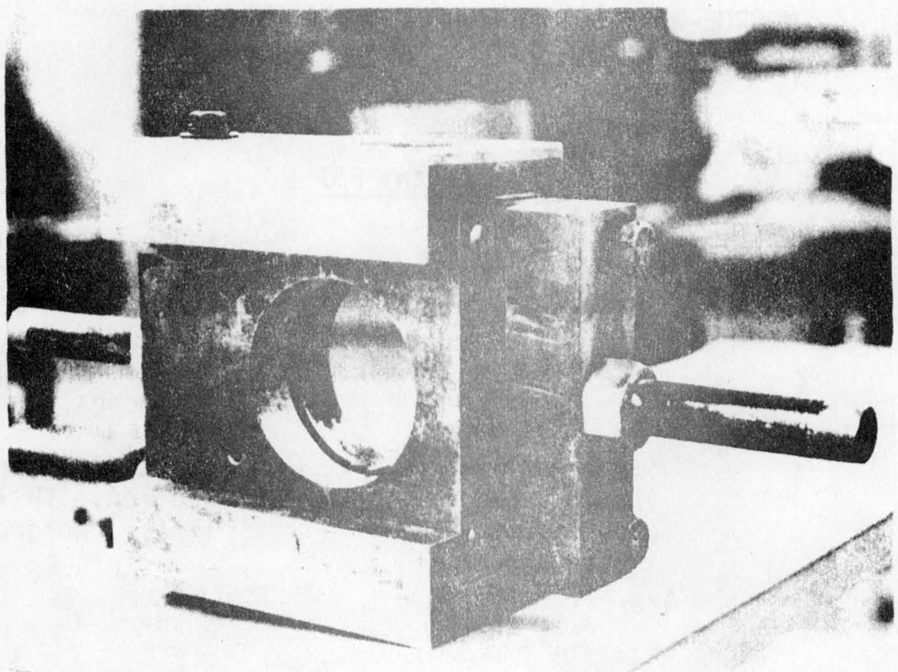

Figure 1. Testing jig

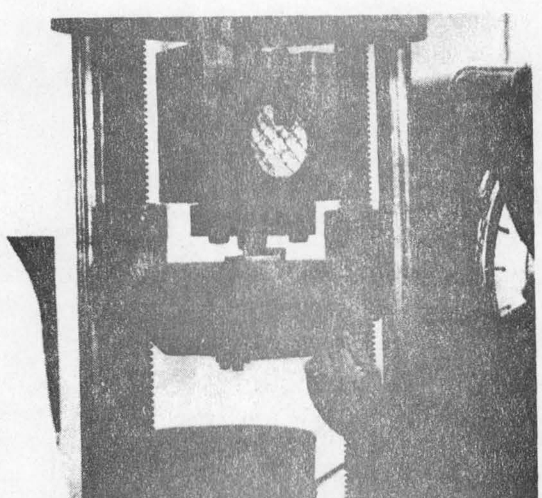

Figure 2. Hydraulic Testing Machine, Testing jig and specimen

TABLE 1-1

MONROE-WAPELLO SECONDARY BONDED OVERLAY
SHEAR STRENGTH RESULTS
June 28, 1985

Lab No.	Core No.	Shear Strength, PSI	Location
ACE5-1083	1	350	South end of nongrouted section 25 ft. from grouted area. 18 Inches from centerline.
ACE5-1084	2	596	Middle of nongrouted section. 18 Inches from west edge.
ACE5-1085	3	278	25 Ft. from north edge of test section. 18 Inches from centerlinel. Nongrouted.
		Avg. = 408	

TABLE 1-2

MONROE-WAPELLO SECONDARY BONDED OVERLAY
SHEAR STRENGTH RESULTS

July 30, 1985

ACE5-	CORE NO.	TOTAL LOAD, LBS	SHEAR STR., PSI.	STATION	LOCATION	REMARKS
1267	1	5500	438	418+80	5'Rt. CL	Grouted
1268	2	2500	199	419+50	2'Rt. CL	Grouted
1269	3	10900	867	420+30	9'Rt. CL	Nongrouted
1270	4	5600	446	420+00	4'Lt. CL	Nongrouted
1271	5	7400	589	421+90	6'Rt. CL	Nongrouted
1272	6	2650	211	422+80	7'Lt. CL	Grouted
1273	7	4400	350	423+80	4'Rt. CL	Grouted
1274	8	4400	350	441+40	6'Rt. CL	Grouted
1275	9	7000	557	442+50	3'Lt. CL	Grouted
1276	10	8350	664	443+40	8'Rt. CL	Nongrouted
1277	11	11900	947	444+50	9'Rt. CL	Nongrouted
1278	12	4750	378	445+00	2'Rt. CL	Nongrouted
1279	13	7250	577	446+00	3'Lt. CL	Grouted
1280	14	5250	418	446+90	5'Rt. CL	Grouted

TABLE 1-3

MONROE-WAPELLO SECONDARY BONDED OVERLAY
SHEAR STRENGTH RESULTS
June 3, 1986

14 - Day 1985

STATION	TYPE	LOCATION	SHEAR STR. PSI	AVE. SH. STR. PSI
418+33	Grouted	5' Rt.	438	
419+80	Grouted	2' Lt.	199	318
420+47	Nongrouted	9' Rt.	867	
421+00	Nongrouted	4' Lt.	446	
421+90	Nongrouted	6' Rt.	589	634
422+70	Grouted	7' Lt.	211	
423+74	Grouted	4' Rt.	350	
441+45	Grouted	6' Rt.	350	
442+37	Grouted	3' Lt.	557	367
443+40	Nongrouted	8' Rt.	664	
444+50	Nongrouted	9' Lt.	947	
445+03	Nongrouted	2' Rt.	378	663
446+00	Grouted	3' Lt.	577	
446+90	Grouted	5' Rt.	418	497

1985 Ave.
Grouted - 388 psi
Nongrouted - 648 psi

ONE YEAR RESULTS - 1986

STATION	TYPE	LOCATION	SHEAR STR. PSI	AVE. SH. STR. PSI
418+33	Grouted	5' Rt. +	306	
419+80	Grouted	4' Lt.	282	294
420+47	Nongrouted	8' Rt.	955	
421+00	Nongrouted	5' Lt.	418	
422+15	Nongrouted	5' Lt.	497	623
422+70	Grouted	8' Lt.	664	
423+74	Grouted	4' Rt. +	545	
441+45	Grouted	7' Rt.	1527	
442+37	Grouted	4' Lt.	732	867
443+40	Nongrouted	8' Rt. +	398	
444+70	Nongrouted	8' Lt.	608	
445+03	Nongrouted	3' Rt.	955	653
446+00	Grouted	3' Lt. +	748	
446+90	Grouted	6' Rt.	676	712

1986 Ave. - 685 psi
Grouted
Nongrouted - 638 psi

TABLE 1-4

ADDITIONAL TEST RESULTS

MONROE-WAPELLO SECONDARY BONDED OVERLAY
SHEAR STRENGTH RESULTS
May 5, 1986

Lab No.	Core No.	Station	Type	Total Load Lbs.	PSI	Remarks
1062	1	445+00	Non-grouted	No core	---	1/4 pt.-S.B.
1063	2	444+70	Non-grouted	7,650	608	OWP-S.B.
1064	5	449+15	Grouted	8,100	644	IWP-S.B.
1065	7	448+80	Grouted	7,350	585	1/4 pt.-S.B.
1066	9	448+00	Grouted	7,100	565	OWP-S.B.
1067	12	465+25	Grouted	6,350	505	1/4 pt.-S.B.
1068	13(H)	465+25	Grouted	No core	---	1/4 pt.-S.B.
1069	14	465+00	Grouted	12,800	1,018	OWP-S.B.
1070	15	422+15	Non-grouted	9,600	764	1/4 pt.-S.B.
1071	16(H)	422+15	Non-grouted	6,250	497	1/4 pt.-S.B.
1072	18	421+70	Non-grouted	No core	---	IWP-S.B.
1073	19	421+50	Non-grouted	5,200	414	OWP-S.B.

TABLE 1-5

MAY 20, 1986 ROAD RATER
HR-291 WAPELLO CO.

Sta.	Sen 1	Sen 2	SR	K
390	0.72	0.70	6.9	145
392	0.93	0.88	5.6	150
394	1.10	1.00	4.9	165
396	0.76	0.72	6.6	165
398	0.71	0.68	7.0	155
400	0.80	0.75	6.4	165
402	0.74	0.70	6.8	160
404	0.99	0.95	5.4	130
406	1.10	1.00	4.9	165
408	0.88	0.81	5.9	175
410	0.76	0.76	6.6	110
412	1.30	1.20	4.3	140
414	0.56	0.55	8.5	150
416	1.20	1.10	4.6	150
418	0.79	0.77	6.4	140
420	0.77	0.76	6.6	120
422	0.80	0.76	6.4	155
424	0.90	0.88	5.9	120
426	0.66	0.64	7.4	155
428	0.77	0.74	6.6	155
430	0.58	0.57	8.3	150
432	0.95	0.93	5.6	110
434	0.67	0.66	7.3	135
436	0.77	0.74	6.6	155
438	0.66	0.63	7.3	170
440	0.93	0.90	5.6	130
442	0.92	0.90	5.7	115
444	0.93	0.88	5.6	145
446	0.65	0.63	7.5	155
448	0.74	0.72	6.8	145

AVE.	0.835	0.797
STD. D	0.177	0.154
SR =	6.1	
K =	150	