FAST TRACK PORTLAND CEMENT CONCRETE PAVEMENT

Final Report
Iowa Department of Transportation
Project HR-538

April 1997

Project Development Division

Iowa Department of Transportation

FAST TRACK
PORTLAND CEMENT CONCRETE
PAVEMENT

Final Report
for
Iowa Department of Transportation
Project HR-538

By

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8. ABSTRACT

In 1987, 1.5 km (0.935 mi.) of Spruce Hill Drive in Bettendorf, Iowa was reconstructed. It is an arterial street with commercial usage on both termini with single family residential dwellings along most of the project. A portland cement concrete (PCC) pavement design was selected, but a 14 day curing period would have been an undue hardship on the residents and commercial businesses. An Iowa DOT Class F fast track concrete was used so the roadway could be used in 7 to 10 days.

The Class F concrete with fly ash was relatively sticky and exhibited early stiffening problems and substantial difficulty in obtaining the target entrained air content of 6.5%. These problems were never completely resolved on the project.

Annual visual field reviews were conducted through 1996. In November 1991, severe premature distress was identified on the westbound two lanes of the full width replacement. The most deteriorated section in a sag vertical, 152 m (500 ft.) of the westbound roadway, was replaced in 1996. Premature distress has been identified on a dozen other conventional PCC Iowa pavements constructed between 1983 and 1989, so the deterioration may not be related to the fact that it was fast track pavement.

9. KEY WORDS

Portland cement concrete
Pavement
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Early opening

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16

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DISCLAIMER

INTRODUCTION

Normal portland cement concrete (PCC) pavement requires approximately seven days to obtain strength sufficient to carry heavy traffic loads. This time element can vary dependent on the cement ratio employed. Current specifications prohibit usage during the curing period for both the contractor and general public.

In developed urban areas, the delay of usage of the new pavement causes severe hardship on the abutting and adjacent residential and commercial properties and the general public. In most instances there is insufficient right-of-way and funding to provide for temporary access roads. Limiting the work area or staging construction generally extends the disruption and inconvenience, particularly increasing the hardship to commercial establishments.

OBJECTIVE

The primary goal of this project was to minimize the hardship to the adjacent and abutting properties and the general public. Use of the rapid strength gain characteristics of Class F concrete would allow the contractor, and ultimately vehicular traffic, to use the new pavement in a substantially shorter period of time. The intent was to reduce this period from 3 or 4 weeks down to 7 to 10 days.

Evaluation of the initial construction and associated project costs and monitoring of the pavement's durability is expected to provide a known alternative for future use.

PROJECT LOCATION

This project is located just east of Interstate 74 on Spruce Hills Drive in Bettendorf (Scott County), Iowa, generally having a western terminus of Utica Ridge Road extending east about 1.5 km (0.935 mi.) to 18th Street (Figure 1). The pavement was constructed as Scott County City of Bettendorf project M-2234(2)--81-82.

PROJECT DESCRIPTION

Spruce Hills Drive serves as an arterial street and is characterized by having commercial usage at either terminus with single family residential dwellings for the majority of its length between. The roadway was constructed originally over a several year span in the mid and late 1960s as residential growth expanded northward. The typical pavement was 20 cm (8 in.) thick, 12.5 m (41 ft. 2 in.) back-to-back of curb and carried four travel lanes of about 3 m (10 ft.) width. The vertical and horizontal geometrics were characteristic of a low-speed, low-volume collector.

The project entailed reconstruction and replacement to improve geometrics and riding quality and increase roadway width to 15 m (49 ft.) back-to-back. The western 457 m (1500 ft.) was removed and replaced in its entirety. This section was primarily a sag curve with nine percent grades in a horizontal alignment. Safe traveling speed was upgraded from 35 to 56 kmh (22 to 35 mph). The remainder of the work involved the removal of the curb and gutter, widening each side 2 m (6.5 ft.) with integral curb, full-depth patching and milled, partial-depth finish patching.

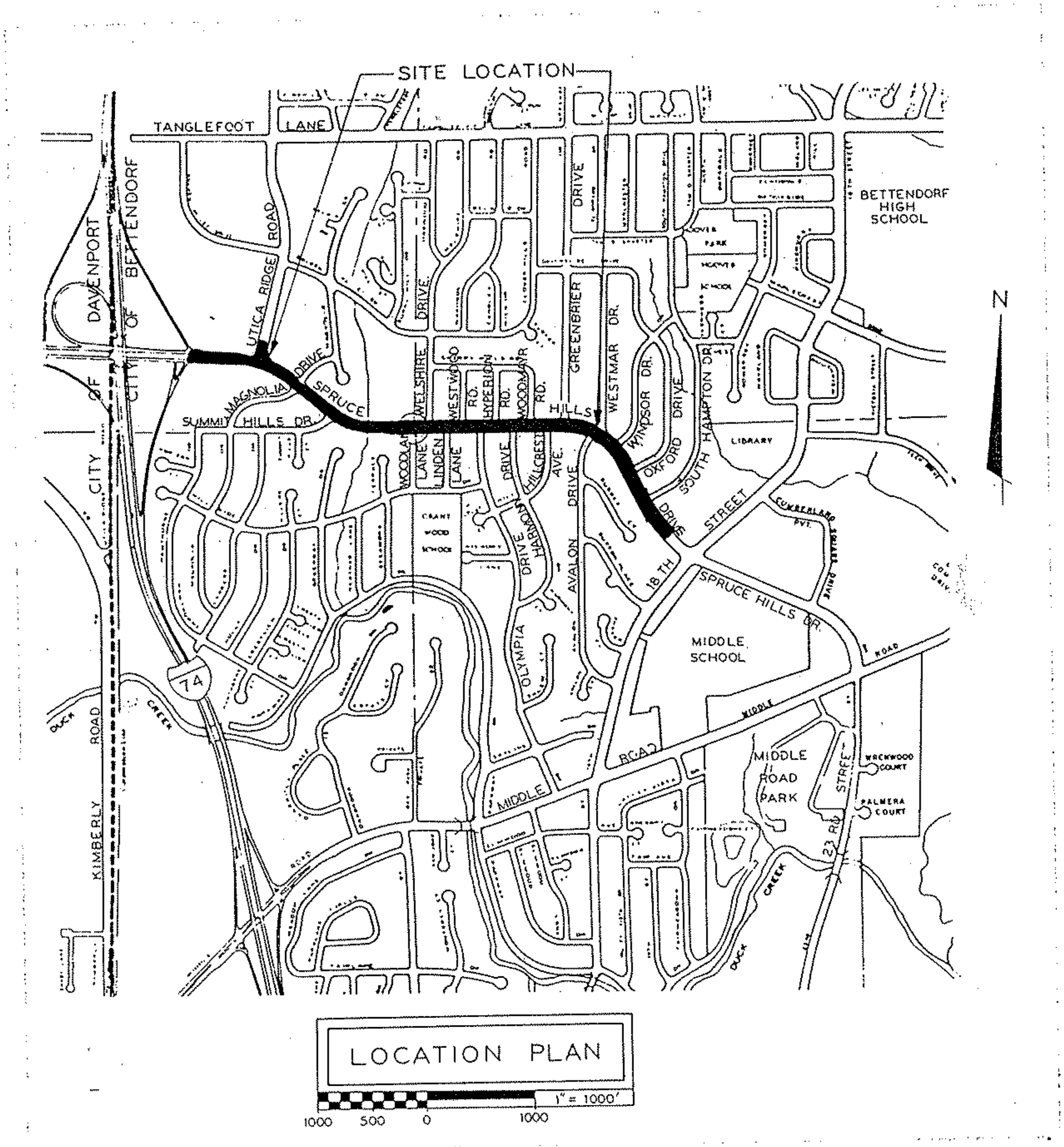

Figure 1 - Project Location

The overall plan was to have general traffic use and direct property access restored within three working days of strength achievement. Removal and replacement was to be done within a two-day period. Widening and patching were done under traffic, allowing one lane in each direction. Neighborhood characteristics limited the widening work area to four blocks at any one time.

MATERIALS

The intended material use for all work, but sidewalk replacement, was Class F concrete. The option of using fly ash was permitted. A Type 3 cement, meeting AASHTO M-85 with a compressive mortar strength (ASTM C-109) of 9 mPa (1300 psi) or greater in 12 hours, was required. The portland cement was primarily supplied by the Continental Cement Company from Hannibal, Missouri. The fly ash was Type C from Louisa - Plant 5. The entrained air admixture employed was Dricrete. A Plastocrete 161 Sika water reducing admixture was used.

Epoxy coated reinforcing steel and dowels were used to tie the widening and full-depth finish patches to the adjacent pavement. Partial-depth finished patches required the use of a bonding grout of equal parts of portland cement and concrete sand. A Type I cement was used for the patching.

Curing was by use of a white pigmented curing compound supplemented by a thermal blanket. The blanket consisted of a layer of plastic film and a layer of closed cell polystyrene foam, rigid insulation board or insulation blanket with a minimum R-Value of 0.5. The curb was allowed to be covered with two layers of plastic film separated by two layers of burlap.

CONSTRUCTION

The initial phase of construction consisted of the removal and placement of partial-depth finish patches. The contractor was required to saw all edges and remove pavement to a 7.6 cm (3 in.) depth by milling or grinding. Use of pneumatic tools was limited to small, localized areas of a patch with a hammer weight not exceeding 13.6 kg (30 lbs.). The patch area was then thoroughly cleaned by sandblasting and airblasted to remove all sand and loose particles. A one-to-one PCC/sand grout, mixed to a stiff slurry, was placed and spread by stiff broom to provide a complete, thin, even coating. Cement-to-water contact time of the grout could not exceed 90 minutes. The contractor utilized the supplier's ready mix operation to supply the slurry. This provided a more consistent mix and insured adequate availability.

Removal of 0.76 m (2.5 ft.) of existing curb and pavement and full-depth patches followed behind the partial-depth patch work. Full-depth saw cuts were required. To minimize subgrade disturbance, full-depth patches were required to be lifted out. Case by case exceptions were made for Type II (over 9.75 m (32 ft.) length) patches adjacent to the widening. In these cases a pavement breaker was used after the saw cutting. All saw cuts were required to be blown clean prior to lift-out or breaking and removal to eliminate spalling of the adjacent pavement due to binding or incompressible materials.

Full-depth finish patches were tied on all sides by epoxy coated dowels or reinforcing steel. Dowels were used on the transverse joints and reinforcing on the longitudinal joints. An epoxy grout was injected into the drilled holes. The bar was inserted and the grout allowed to set before concrete placement.

The contractor conducted the widening pavement removal and Class 13 excavation in one operation. The subgrade was scarified, blended, and compacted to obtain a uniform, natural subgrade with a minimum 90 percent modified proctor density. Replacement pavement was 2 m (6.5 ft.) wide with an integral curb. The contractor utilized a fabricated steel strike-off with attached curb mule for widening placement. Internal vibration was done using hand-held vibrators.

Full-width replacement was done half width, 7.5 m (24.5 ft.) with integral curb. Standard paving and natural subgrade preparation procedures were used. Pavement was placed using full-depth fixed forms and an Emmpco Fixed-Form PavSaver with curb mule.

All concrete work, except sidewalks, generally was sawed between four and five hours after texturing. After sawing, the thermal blanket was placed. Contract intent was to have sawing and covering completed within five hours of surface texture. Because of the labor time involved in placing the thermal blanket, the contractor was extremely reluctant to cover within the specified time if the pavement was too green to saw. The contractor did not provide adequate attention and labor to placement of the cover to follow up immediately behind sawing. Initial covering efforts did not provide complete encapsulation. No visually apparent problems were noted because of the time delay in covering.

Concrete placement began on May 12, 1987 and ended on August 18, 1987. The contractor opted to use the 10 percent fly ash substitution. The initial mix proportions had 290 kg (640 lbs.) of cement and 32 kg (70 lbs.) of fly ash. Target w/c was 0.425 with a maximum permissible of 0.480. Previous experiences with Class F paving were in 32°C (90°F) mid-summer weather.

The first week was primarily partial-depth patches and smaller full-depth patches. No water reducer was used. The supplier noted a difficulty in obtaining adequate air content when supplying 2.3 to 3.1 cubic meter (3 to 4 cubic yard) loads. The amount of air entrainment on short loads was greater than for full loads. The finishers commented that the mix was sticky. It should be noted that, in general, the finishers had not worked with a mix of this cement content before and were extremely concerned with the anticipated short initial set time. Finishing efforts were rushed. By the end of the first week the finishers were comfortable with the workability of the mix.

Widening began on May 20, 1987. Water reducer was added. The air content problems persisted on short loads. The finishers indicated the mix was less sticky, but still more so than a normal mix.

The mix design was adjusted on May 28, 1987. Target w/c was reduced to 0.365 with a maximum permissible of 0.410. On-site water addition was greatly reduced. Finishing appeared to be enhanced. Air content difficulties stabilized.

Full-width placement began on July 10, 1987, while partial and full patch and widening work continued. Partial-depth patch work was generally completed July 15, 1987, with full-depth patch and widening generally completed July 20, 1987.

On the full-width placement, an excessive amount of water was added on-grade prior to discharge. The finishers were having a difficult time closing the surface. The w/c was running near the maximum permissible. Air content was inconsistent. The mix design was readjusted on July 24, 1987. Target w/c was brought back up to the original 0.425. Maximum permissible w/c was set at 0.465.

The supplier had extreme difficulty providing consistent air content which generally ran 1 percent below the 6.5% target. At least one-third of the delivered material on July 24, 1987 required on-grade addition of air entrainment admixture. The finishers continued having a difficult time closing the surface.

Lack of air content consistency and the finishers difficulty in closing up the surface was primarily on the half-width 7.5 m (24.5 ft.) placement. An adjustment in starting time was made to complete placement before mid-afternoon because it was noted that the problems appeared to worsen as the temperature increased. The change in the w/c target ratio did not appear to significantly decrease the problems.

On the fourth half-width pavement placement, the surface closure problems and continued lack of air content consistency resulted in the supplier removing the fly ash substitution. Air content did not stabilize, but was more consistently near or above target rather than below target. No problem was noted in surface closure after the fly ash removal.

The remainder of the work was placed with the fly ash substitution. The amount of air entrainment admixture was increased. Air content was more consistently supplied and near or above target.

TESTING

In general, flexural testing was used to determine concrete strength. Tests were conducted at 24 hours, 7 days, 14 days, and 28 days. Major full-width placements were also tested at 12 hours. A tabulation of average values follows:

Flexural Strength, mPa (psi)

	Overall		Partial Depth Patches		Full Depth Patches		6.5 ft. Widening		Full Width	
12 hr.	3.8	(553)	----		----		----		3.8	(544)
24 hr	4.8	(694)	4.7	(677)	5.1	(736)	4.9	(705)	4.9	(717)
7 day	6.1	(880)	5.9	(861)	5.9	(856)	6.0	(866)	6.3	(908)
14 day	6.3	(917)	5.9	(874)	6.2	(906)	6.5	(942)	6.5	(944)
28 day	6.3	(912)	6.5	(941)	6.5	(937)	6.8	(979)	6.3	(914)

Temperature, °C (°F)

	Overall		Partial Depth Patches		Full Depth Patches		6.5 ft. Widening		Full Width	
High	32	(90)	31	(87)	29	(85)	32	(89)	29	(84)
Low	19	(66)	15	(59)	17	(63)	19	(66)	17	(63)
Overnight	14	(57)	16	(60)	13	(56)	21	(69)	15	(59)

Two series of compressive strength testing were conducted. Test periods were 12 hours, 24 hours, 7 days, 14 days, and 28 days. The results are tabulated in Appendix A.

ANNUAL VISUAL EVALUATIONS

The annual visual evaluations were usually made between September and December. In 1988 two short cracks were recorded. A few corner cracks at the intersection of the longitudinal and transverse joints and a couple of spalls were noted in 1990.

The condition of the fast track pavement had changed substantially by November 1991 when severe premature distress was identified (Figure 2). The worst deterioration was in the two full-width westbound lanes in the sag vertical curve. There was closely spaced cracking about 15 cm (6 in.) wide on both sides of the transverse joints (Figure 3) in this sag vertical. There was cracking along some of the westbound longitudinal joint. By October 1992 there was substantial spalling at many of the westbound lane transverse joints. Cold bituminous patching material had been used to fill the bigger deeper spalls (Figure 4). Many of these were at the intersection of the transverse and longitudinal joints. Some of these bituminous patches were 0.6 m (2 ft.) long and wide by November 1994. The condition has continued to deteriorate, requiring more and more maintenance. The most deteriorated section in the sag vertical curve, 152 m (500 ft.) of the westbound roadway (2 lanes), was replaced in 1996.

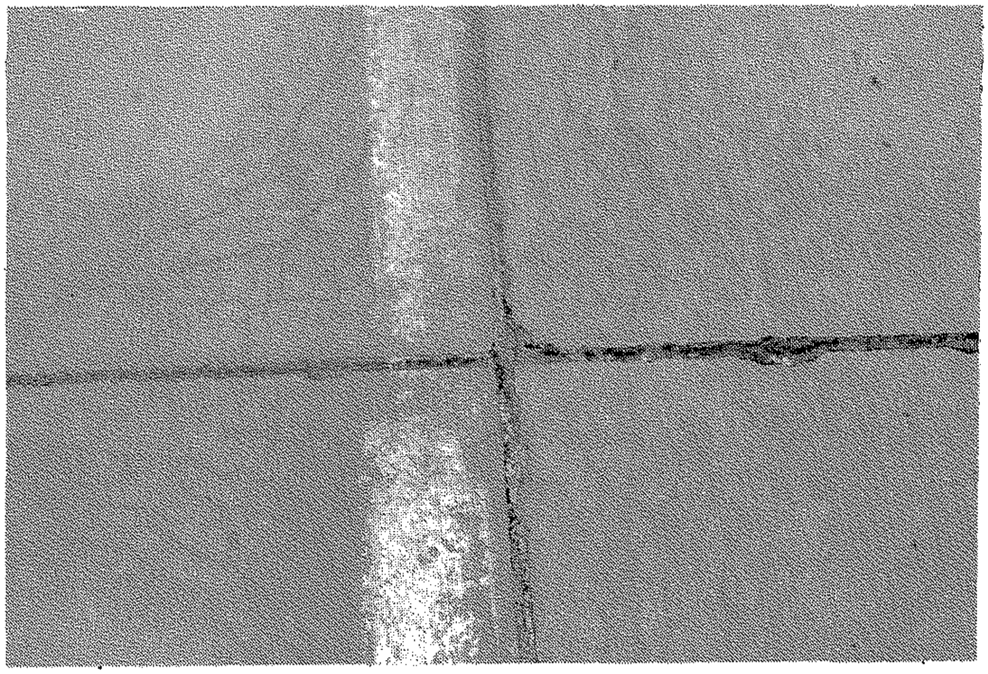

Figure 2 - Severe Premature Distress in November 1991

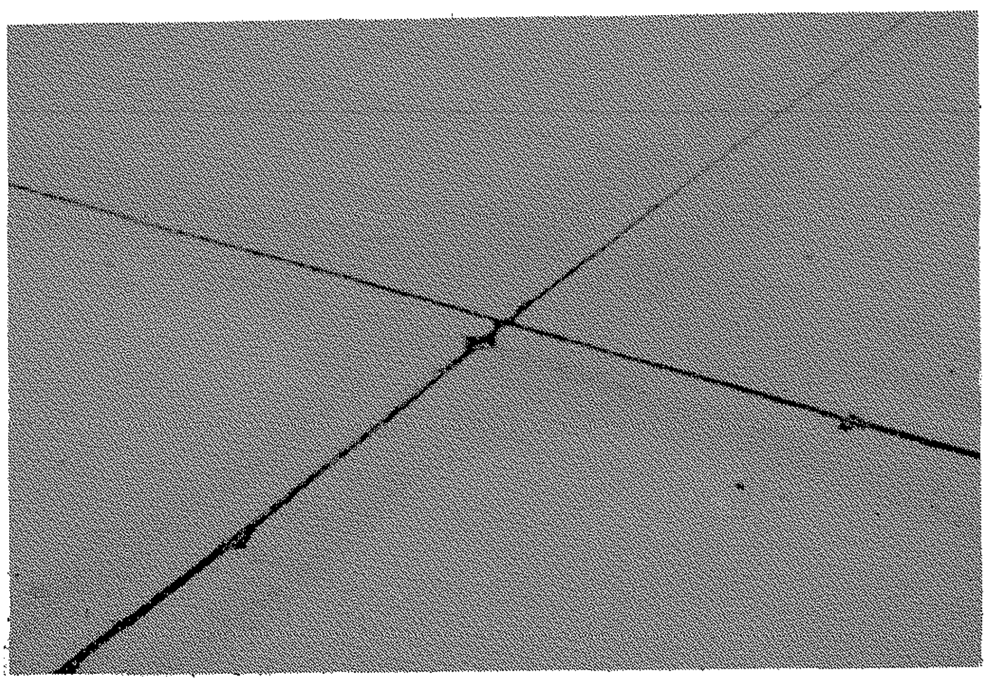

Figure 3 - Cracking Along Both Sides of a Transverse Joint

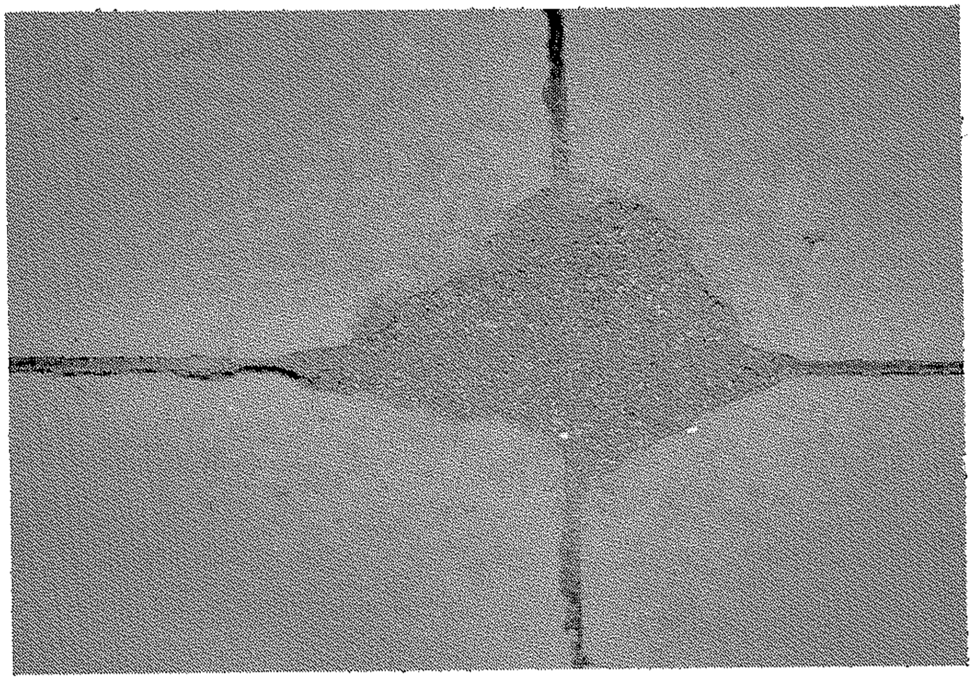

Figure 4 - Bituminous Patching of Spalling at the Joint Intersections

DISCUSSION

The deterioration described in the previous section may or may not have any relationship to whether it was fast track pavement. There are about a dozen conventional PCC pavement projects in Iowa that were constructed with Type I cement that have exhibited premature distress of a similar nature. The premature distress has been studied since 1990. There is not yet a consensus as to the initiating cause or the major deterioration mechanism involved in the premature distress.

CONCLUSIONS

This research to study fast track PCC pavement would support the following conclusions:

1. There were early stiffening and air content problems when placing the fast track PCC pavement.

2. The fast track pavement on this project did not provide the desired longevity.

3. The premature distress may not be related to the fact that it was fast track PCC pavement.

4. More research is needed to determine the cause of the premature distress.

Appendix A
Compressive Strength Testing

Form 820968
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Project M-2234(2)--81-82 Contract No. City of Bettendorf County Scott Lab. No.

Producer W.G. Block Company Plant Downtown Davenport Contractor Hawkeye Paving Corp.

Unit of Material "Fast-Track" Concrete - Type III Cement

Sampled by M. Huebner Date Received Date Reported June 18, 1987

Lab. Number	Time	Date Made	Date To Test	Prop. No.	% Air Content	Slump	W/C	Description	Tested Date	Tested Age	Total Load	Lb/Sq. In.	Average of Set
D87-4	1:45P	5-12	5-13		4.0 *5.8	3-1/4"	.365	Patching	5-13	24 hr	51,750	3254	3497
5	"	"	"		"	"	↑	"	"	24 hr	55,690	3502	
6	"	"	"		"	"		"	"	24 hr	59,400	3735	
	5-13-87 poured but none made												
D87-7	2:30P	5-14	5-21		6.2	2-3/4"		Patching	5-21	7 day	75,910	4773	5007
8	"	"	"		"	"		"	"	7 day	85,100	5351	
9	"	"	"		"	"		"	"	7 day	77,860	4896	
D87-10	9:30A	5-15	5-15		6.9	2-3/4"		Patching	5-15	12 hr	55,525	3491	3428
11	"	"	"		"	"		"	"	12 hr	56,300	3540	
12	"	"	"		"	"		"	"	12 hr	51,750	3254	
D87-13	1:45P	5-18	6-01		5.8	2-3/4"	↓	Patching	6-01	14 day	80,000	5030	5046
14	"	"	"		"	"	.365	"	"	14 day	80,140	5039	

(cont'd)

Signed Harold McCullough

Page 2 of 2 FIRST SERIES - 3 cylinders each: 12 hr.s, 24 hr.s, 7 days, 14 days, 28 days

Form 820968
10-76

IOWA DEPARTMENT OF TRANSPORTATION
Office of Materials
Concrete Compression

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Producer W.G. Block Company Plant Downtown Davenport Contractor Hawkeye Paving Corp.

Unit of Material "Fast-Track" Concrete - Type III Cement

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Lab. Number	Time	Date Made	Date To Test	Prop. No.	% Air Content	Slump	W/C	Description	Tested Date	Tested Age	Total Load	Lb/Sq. In.	Average of Set
D87-15	1:45P	5-18	6-01		5.8	2-3/4"	.365	Patching	6-01	14 day	80,600	5068	5046
D87-16	2:15P	5-20	6-17		6.6	4"	↑	Widening	6-17	28 day	114,320	7188	6936
17	"	"	"		"	"	↓	"	"	28 day	102,490	6444	
18	"	"	"		"	"	.365	"	"	28 day	114,150	7177	

NEXT SERIES WILL BE TAKEN ON FULL-WIDTH PAVING USING FAST-TRACK CONCRETE

cc: Ames
~~R. Holland~~
R.C. Henely
File
W.G. Block

Signed Harold McCullough

 2nd and last series - 3 cylinders each: 12 hour, 24 hour, 7 day, 14 day, 28 day

cc: Ames
~~R.~~ Holland
M. Burr
W.G. Block
File

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Form 820958
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IOWA DEPARTMENT OF TRANSPORTATION
Office of Materials

Concrete Compression

Project M-2234(2)--81-82 Contract No. City of Bettendorf County Scott Lab. No.

Producer W.G. Block Company Plant Mt. Joy Contractor Hawkeye Paving

Unit of Material Type III Cement - "fast-track" concrete

Sampled by M. Huebner Date Received Date Reported

Lab. Number	Time ~~Sdrs. Number~~	Date Made	Date To Test	Prop. No.	% Air Content	Slump	W/C	Description	Tested Date	Tested Age	Total Load	Lb/Sq. In.	AVE.
D87-22	11:10A	7-10	7-11-87		6.4	2-1/2"	.365	Full-Width	7-11-87	24 hr	67,650	4254	4216
23		"	"		"	"		"	"	"	65,710	4132	
24		"	"		"	"		"	"	"	67,770	4261	
D87-25	8:15A	7-16	7-16-87		5.6	1-1/2"		Full-Width	7-16-87	12 hr	55,685	3501	3563
26		"	"		"	"		"	"	"	59,601	3748	
27		"	"		"	"		"	"	"	54,700	3439	
D87-28	9:20A	7-16	7-23-87		6.4	3"		Full-Width	7-23-87	7 day	87,140	5479	5505
29		"	"		"	"		"	"	"	84,298	5300	
30		"	"		"	"		"	"	"	91,220	5736	
D87-31	9:00A	7-24	8-07-87		5.8	3"		Full-Width	8-07-87	14 day	89,195	5608	5813
32		"	"		"	"		"	"	"	89,298	5615	
33		"	"		"	"	↓	"	"	"	98,870	6217	

Signed Harold McCullough

 2nd & last series - 3 cylinder each: 12 hour, 24 hour, 7 day, 14 day, 28 day

Form 820958
10-75

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D87-34	9:45A	7-24	8-21-87		5.0	3"	.365	Full-Width	8-21-87	28 day	100,400	6313	5801
35		"	"		"	"		"	"	"	88,180	5545	
36		"	"		"	"	↓	"	"	"	88,180	5545	

Signed Harold McCullough