Highway Concrete Pavement Technology Development and Testing: Volume IV—Field Evaluation of Strategic Highway Research Program (SHRP) C-206 Test Sites (Early Opening of Full-Depth Pavement Repairs)

ROAD TEST 151008

LTPP

Foreword

The objective of this study was to monitor and evaluate the performance of experimental full-depth repairs made with high-early-strength (HES) materials placed under Strategic Highway Research Program (SHRP) project C-206, Optimization of Highway Concrete Technology. The C-206 full-depth repair experiment was conducted to demonstrate and validate the technologies that allow early opening of full-depth portland cement concrete (PCC) pavement repairs to traffic and to document the information needed to apply this technology.

The experimental factors for the full-depth repair experiment included material type, strength at opening, and repair length. A total of 11 different HES concrete mixes with opening times ranging from 2 to 24 hours were evaluated at 2 field sites (U.S. I-20, Augusta, GA, and State Route 2, Vermilion, OH).

One goal of the SHRP C-206 full-depth repair experiment was to establish guidelines for the minimum strength required at opening time to ensure adequate performance of full-depth PCC pavement repairs. Based on analytical results, guidelines for early opening of full-depth PCC pavement repairs were developed under SHRP C-206; however, long-term monitoring was needed to verify the guidelines developed under SHRP C-206—that task was carried out under this study.

This report presents the results of annual surveys and analysis of the collected data. The report for each site begins with a brief description of the field sections, followed by a discussion of performance of test sections. Finally, conclusions and recommendations for possible changes to fast-track full-depth repair practice are provided based on findings of this study.

> Gary L. Henderson
> Director
> Office of Infrastructure
> Research and Development

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16. Abstract

The objective of this study was to monitor and evaluate the performance of experimental full-depth repairs made with high-early-strength (HES) materials placed under Strategic Highway Research Program (SHRP) project C-206, *Optimization of Highway Concrete Technology*. The C-206 full-depth repair experiment was conducted to demonstrate and validate the technologies that allow early opening of full-depth portland cement concrete (PCC) pavement repairs to traffic and to document the information needed to apply this technology. The experimental factors for the full-depth repair experiment included material type, strength at opening, and repair length. A total of 11 different HES concrete mixes with opening times ranging from 2 to 24 hours were evaluated at 2 field sites (U.S. I-20, Augusta, GA and State Route 2, Vermilion, OH).

The scope of this study included 5-year monitoring of SHRP C-206 full-depth experiment sections, analyzing the data, and revising the guidelines for early opening of full-depth PCC pavement repairs as needed. The monitoring program consisted of annual visual distress surveys to monitor the development of cracking, faulting, and spalling. The annual surveys were conducted from the fall of 1994 through the fall of 1998. The results of this evaluation showed that full-depth repairs made with HES PCC can provide good long-term performance; however, adverse temperature conditions during installation can cause premature failures. Extremely high PCC temperatures during curing should also be avoided. The fatigue damage due to early opening is negligible, especially for repairs of 3.7 m or shorter. Within the range of strength evaluated under SHRP C-206, the strength at opening could not be correlated to performance. Based on the results of this evaluation, no changes are recommended to the opening criteria suggested in the SHRP C-206 manual of practice.

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
LENGTH				
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
AREA				
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
VOLUME				
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
NOTE: volumes greater than 1000 L shall be shown in m^3				
MASS				
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
TEMPERATURE (exact degrees)				
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
ILLUMINATION				
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
FORCE and PRESSURE or STRESS				
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
LENGTH				
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
AREA				
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
VOLUME				
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
MASS				
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
TEMPERATURE (exact degrees)				
°C	Celsius	1.8C+32	Fahrenheit	°F
ILLUMINATION				
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
FORCE and PRESSURE or STRESS				
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.
(Revised March 2003)

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CHAPTER 1. INTRODUCTION

The objective of this study was to monitor and evaluate the performance of experimental full-depth repairs made with high-early-strength (HES) materials placed under Strategic Highway Research Program (SHRP) project C-206, Optimization of Highway Concrete Technology (Whiting et al. 1994). The C-206 full-depth repair experiment was conducted to demonstrate and validate the technologies that allow early opening of full-depth portland cement concrete (PCC) pavement repairs to traffic and to document the information needed to apply this technology.

The experimental factors for the full-depth repair experiment included material type, strength at opening, and repair length. A total of 11 different HES concrete mixes with opening times ranging from 2 to 24 hours (h) were evaluated at 2 field sites (U.S. Interstate 20 (I-20), Augusta, GA and State Route 2, Vermilion, OH). The repair materials included various HES PCC mixes made with Type I and Type III portland cement and mixes made with proprietary blended cements. The repair lengths ranged from 1.8 to 4.6 meters (m). A test section in this experiment consists of uniform-size repairs made with a single material. The repairs were made over a range of time and opened to traffic simultaneously when the last repair reached the target strength, which provided a range-of-strength at opening.

One of the goals of the SHRP C-206 full-depth repair experiment was to establish guidelines for the minimum strength required at opening time to ensure adequate performance of full-depth PCC pavement repairs. Based on analytical results, guidelines for early opening of full-depth PCC pavement repairs were developed under SHRP C-206 and incorporated in the manual of practice that was developed under that project (Yu et al., 1994). However, long-term monitoring was needed to verify the guidelines developed under SHRP C-206—that task was carried out under this study.

The scope of this study included 5-year monitoring of SHRP C-206 full-depth experiment sections, analyzing the data, and revising guidelines for early opening of full-depth PCC pavement repairs as needed. The monitoring program consisted of annual visual distress surveys to monitor the development of the following:

- Cracking.
- Faulting.
- Spalling.

The annual surveys were conducted from the fall of 1994 through the fall of 1998. At the Georgia site, deflection testing was also conducted in 1996 using a Falling Weight Deflectometer (FWD) as a nondestructive means of evaluating long-term repair material properties and to evaluate load-transfer efficiency (LTE) across repair joints. The deflection testing was not conducted at the Ohio site because most of the repairs at the Ohio site contained a longitudinal crack, and all of the repairs at this site are 1.8 m long, which is too short to obtain good backcalculation results, especially with the presence of the longitudinal crack.

This report presents the results of annual surveys and analysis of the collected data. The report for each site begins with a brief description of the field sections (full detail of the experiment is

provided in Whiting et al., 1994), followed by a discussion of performance of test sections. Finally, conclusions and recommendations for possible changes to fast-track full-depth repair practice are provided based on findings of this study. A summary of the results of annual condition survey is provided in appendix A. Appendix B provides summary tables of the data collected for all sections.

CHAPTER 2. EVALUATION OF GEORGIA SITE

DESCRIPTION OF FIELD SECTIONS

The Georgia site consists of three test sections located on eastbound U.S. Interstate 20 (I-20), near Augusta, GA, between mileposts 189 and 192. The existing pavement at this site is

230-millimeter (mm) jointed plain concrete pavement (JPCP) with 9-meter (m) joint spacing. The two-way annual average daily traffic (ADT) at this location was 25,750, with 19.5 percent trucks. The average truck factor during the time of field testing was 1.37.

The materials tested at this site include Georgia Department of Transportation's 4-hour (h) mix (GADOT), Fast Track I (FT I), and Very-High-Early-Strength (VES). The mix designs for these materials are given in table 1. GADOT has extensive experience with fast-track full-depth repairs, and the SHRP C-206 repairs were included as a part of an on-going repair project. FT I is a 12- to 24-h opening PCC mix developed by the Iowa DOT (Grove, Jones, and Bharil, 1993). VES is a 4-h opening PCC mix that utilizes a nonchloride accelerator (calcium nitrite) developed under SHRP C-205.

Table 1. Mix design for the materials used at the Georgia site (Whiting et al., 1994).

Mix Component (per cubic yard (yd^3))	GADOT	FT I	VES
Cement type	Type I	Type III	Type III
Cement, pound (lb)	752	740	870
Fine aggregate, lb	1,025	1,320	825
Coarse aggregate, lb	1,805	1,420	1,720
Water, lb	285	262	335
Water reducer, ounce (oz)	—	44.0	—
Accelerator (DSA), gallon (gal)	—	—	6.0
Accelerator ($CaCl_2$), gal	1.6	—	—
High-range water reducer, oz	—	—	43.5
Air entraining agent, oz	9.8	12.0	43.5
w/c ratio	0.38	0.35	0.39
Nominal opening time	4 hr	12 to 24 hr	4 hr

1 yd^3 = 0.7645 m^3; 1 lb = 0.4535 kg; 1 gal = 3.78 liter (L);
1 oz = 29.57 millileter (mL)

w/c = water to cement ratio

The Georgia sections were placed between about 10 p.m. and 2 a.m. and opened to traffic at 6 a.m. At this site, a typical day's work started at 6:30 p.m. with the closing of the work area to traffic. Concrete removal started as soon as enough of the work area was blocked off, and concrete placement typically started at 10 p.m. (Whiting et al., 1994).

Table 2 provides a summary of Georgia sections, including the strength at opening for each repair and calculated fatigue damage due to early opening. Fatigue damage due to early opening was defined as the damage incurred within the first 14 days of service in this project, based on typical curing time and the strength at the opening time for conventional projects. Fatigue damage was calculated on an hourly basis for the first 3 days, then on a daily basis for the remaining 11 days.

Table 2. Summary of Georgia sections.

Repair Number	Repair Size, ft	Age at Opening Hour, Days	Strength at Opening, psi		Early Opening Damage*
			f_c'	Modulus of Rupture	
Section 1, GADOT					
1-1	8	7.8	2,250	365	0.001
1-3	8	7.2	2,050	350	0.001
1-4	8	7.1	2,050	350	0.001
1-5	8	6.8	1,950	340	0.001
1-6	8	6.8	1,950	340	0.001
1-7	15	6.6	1,900	330	0.038
1-8	15	7.8	2,250	365	0.036
1-9	8	7.7	2,250	360	0.001
1-10	8	7.5	2,150	360	0.001
1-11	15	6.3	1,800	320	0.040
1-12	8	6.0	1,700	310	0.002
1-13	8	5.9	1,650	305	0.003
1-14	15	5.7	1,550	295	0.047
1-15	8	5.7	1,550	295	0.003
1-16	16	5.2	1,350	270	0.057
1-17	15	4.8	1,200	245	0.059
1-18	15	4.8	1,200	245	0.059
1-19	15	4.3	1,000	200	0.067
1-20	15	4.0	900	170	0.103
Section 2, FT I					
2-3A	7	8.8	1,300	250	0.006
2-4	10	8.5	1,300	245	0.011
2-5	6	8.3	1,250	245	0.003
2-6	12	8.3	1,250	245	0.048
2-7	10	8.3	1,250	245	0.011
2-8	10	8.1	1,250	240	0.011

*Miner's fatigue damage.
    1 m = 3.28 ft;
    1 megapascal (MPa) = 145.04 pounds per square inch (psi)

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Table 2. Summary of Georgia sections. *(continued)*

| Repair Number | Repair Size, ft | Age at Opening Hour, Days | Strength at Opening, psi | | Early Opening Damage* |
			f_c'	Modulus of Rupture	
2-9	10	7.8	1,200	230	0.012
2-10	10	7.8	1,200	230	0.012
2-11	10	7.6	1,150	230	0.012
2-12	6	7.5	1,150	225	0.004
2-13	11	7.5	1,150	225	0.027
2-14	6	7.3	1,100	220	0.004
2-15	6	7.2	1,100	215	0.005
2-16	6	7.1	1,100	215	0.005
2-17	6	6.8	1,000	205	0.006
2-18	7	6.8	1,000	205	0.012
Section 3, VES					
3-2	12	6.7	2,600	365	0.003
3-3	12	6.3	2,500	360	0.003
3-4	12	6.0	2,450	350	0.003
3-5	12	5.8	2,350	335	0.003
3-6	8	5.6	2,350	335	0.001
3-7	12	5.5	2,200	320	0.003
3-8	8	5.2	2,100	305	0.001
3-9	8	4.9	2,050	300	0.001
3-10	12	4.8	2,000	295	0.004
3-11	12	4.6	1,950	290	0.004
3-12	8	4.3	1,800	270	0.002
3-13	8	4.3	1,800	270	0.002
3-14	12	4.2	1,700	260	0.014
3-15	9	4.1	1,650	255	0.005
3-16	12	3.8	1,550	230	0.015
3-17	8	3.7	1,500	225	0.008
3-18	8	3.7	1,500	225	0.008
3-19	8	2.8	1,050	165	0.073
3-20	8	2.7	1,000	155	0.122

*Miner's fatigue damage.

    1 m = 3.28 ft;

    1 megapascal (MPa) = 145.04 pounds per square inch (psi)

PERFORMANCE OF GEORGIA SECTIONS

In general, the Georgia sections provided excellent performance. After 6 years of service, the only patches that developed any distresses were the 4.6-m repairs in the GADOT section and one 2.4-m repair in the same section. Faulting was minimal (less than 1 mm) and remained unchanged (within measurement error) throughout the monitoring period, although the LTE was somewhat less than that found in new pavements with an effective load transfer design. A summary of joint performance data is given in table 3; detailed data are given in appendix B. The Georgia sections also did not exhibit any material-related distresses.

ANALYSIS OF CRACKING IN GADOT SECTION

The cracking of the longer (4.6-m) repairs in the GADOT section is consistent with expectations. The Georgia sections were placed at night and opened to traffic at 6 a.m. At the time of concrete hardening, there was no difference in the temperature between the top and bottom of the PCC slab. Thus, the repair slabs were built flat with no built-in temperature gradients. Although an excessive built-in negative temperature gradient is undesirable because it contributes to top-down cracking, a moderate amount of built-in negative curling is beneficial because it moderates the effects of high daytime temperature gradients (Yu et al., 1998). Without any built-in curling, the 4.6-m repair length is excessive for a 230-mm repair slab. Differential shrinkage does provide equivalent built-in temperature of about –2.2 °C (28.04 °F), but that is not enough to counter sufficiently the effects of high daytime temperature gradients.

Table 3. Summary of joint performance of Georgia sections.

Section	Faulting, inch*					Average LTE, percent	
	1994	**1995**	**1996**	**1997**	**1998**	**1992**	**1996**
GA DOT	0.04	0.01	0.01	0.01	0.01	73	75
FT I	0.04	0.03	0.03	0.03	0.03	77	72
VES	0.04	0.01	0.01	0.00	0.03	77	80

*Average absolute faulting.

1 inch = 25.4 mm

The cracking problem was analyzed using the fatigue calculation procedure and model developed by Yu and colleagues (1998). The traffic data needed for the fatigue analysis are shown in figure 1. The traffic on I-20 through the project site is relatively high. The annual traffic is about 1.1 million equivalent single axles (ESALs) in the design lane.

This project did not include a material-testing program; therefore, certain assumptions had to be made regarding long-term strength development of the GADOT mix. Under SHRP C-206, extensive laboratory testing of repair materials was conducted to develop correlation relationships for maturity and pulse-velocity methods of determining in-place material properties (Whiting et al., 1994). Those tests showed that for the GADOT mix, the 90-day compressive strength is about 9 percent greater than the 28-day strength. Also under SHRP C-206, cores were retrieved from the test sections during a 2-month evaluation and tested for strength. Figure 2 summarizes the available information on Georgia site materials.
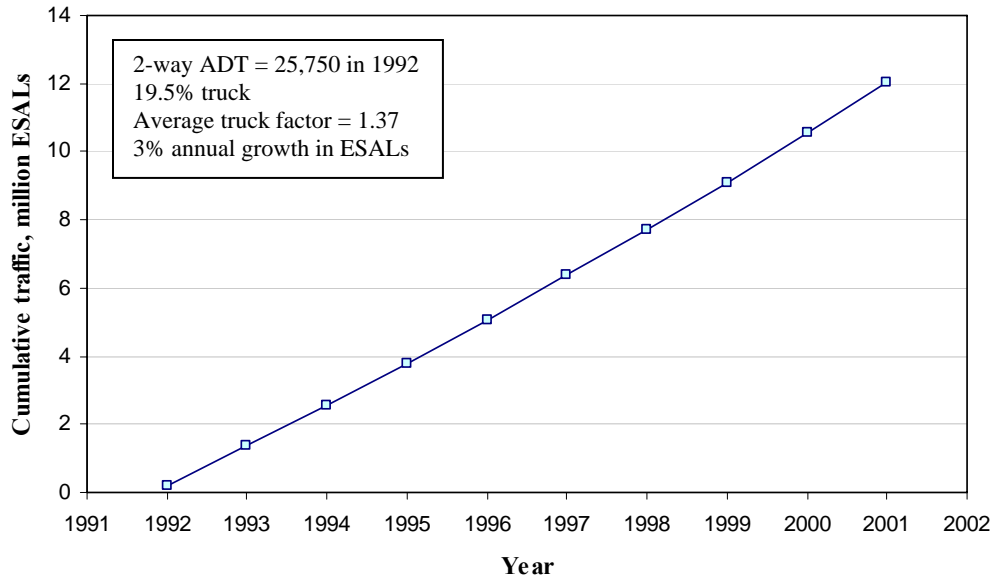
Figure 1. Estimated traffic on Georgia site.

Figure 2 shows lower strength for cores retrieved at 2 months, but this is likely caused by damage during coring or shipping of the cores and testing variability. Extensive material testing was conducted under task C of this project for VES and HES mixes, and the results of those tests showed that the long-term (5-yr) strength of those mixes is up to 18 percent greater than the 28-day strength. A comparison of early-age (up to 90 days) strength-gain characteristics of these mixes suggests that the long-term strength-gain characteristics of the GADOT mix should be similar to those of VES and HES. Based on this assumption, figure 3 was developed to show the long-term strength development of the GADOT mix.
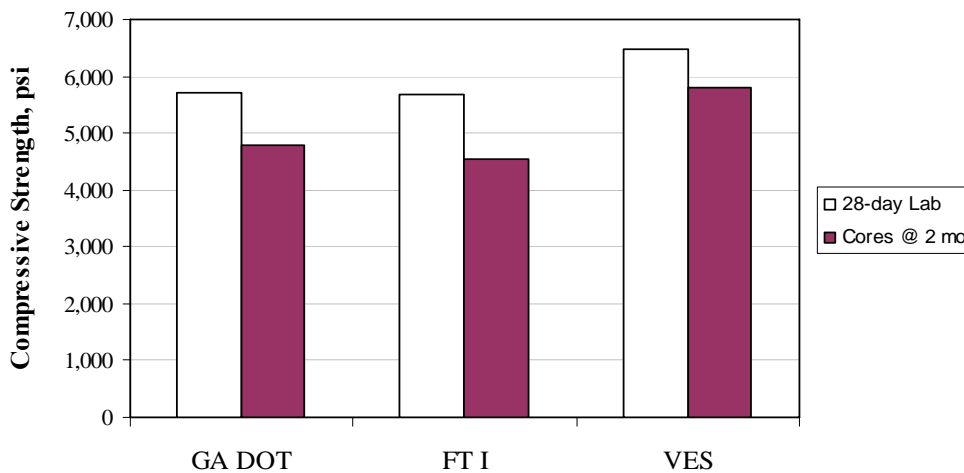
1 megapascal (MPa) = 145.04 psi

Figure 2. Available material strength data for the Georgia sections.
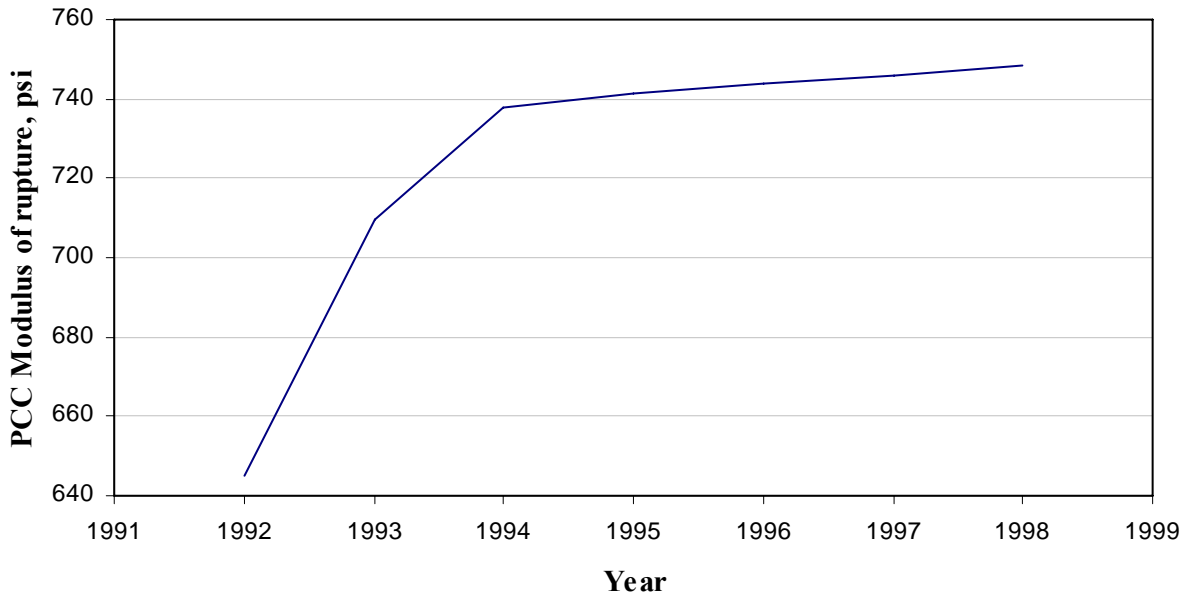
1 MPa = 145.04 psi

Figure 3. Estimated strength development of GADOT mix.

The results of fatigue analysis are shown in figure 4, along with the observed slab cracking. The model was run with built-in curling of –2.2 °C (28.04 °F), which accounts for differential shrinkage. The effects of damage due to early opening are illustrated in figure 5. As shown in table B1 in appendix B, the amount of fatigue damage attributable to early opening was minimal (Miner's damage of 0 to 0.07, except for 0.10 for the last patch). The damage due to early opening has the effect of shifting the time (or traffic) versus cracking curve upward, as illustrated in figure 5. However, for the Georgia sections, early opening to traffic had a negligible effect on the fatigue life of the repairs, even for the 4.6-m repairs. In fact, the last three 4.6-m repairs placed in the GADOT section (i.e., the repairs that were opened to traffic at the lowest strength) did not crack. For shorter repairs, the effects of early opening (and fatigue damage in general) are inconsequential.
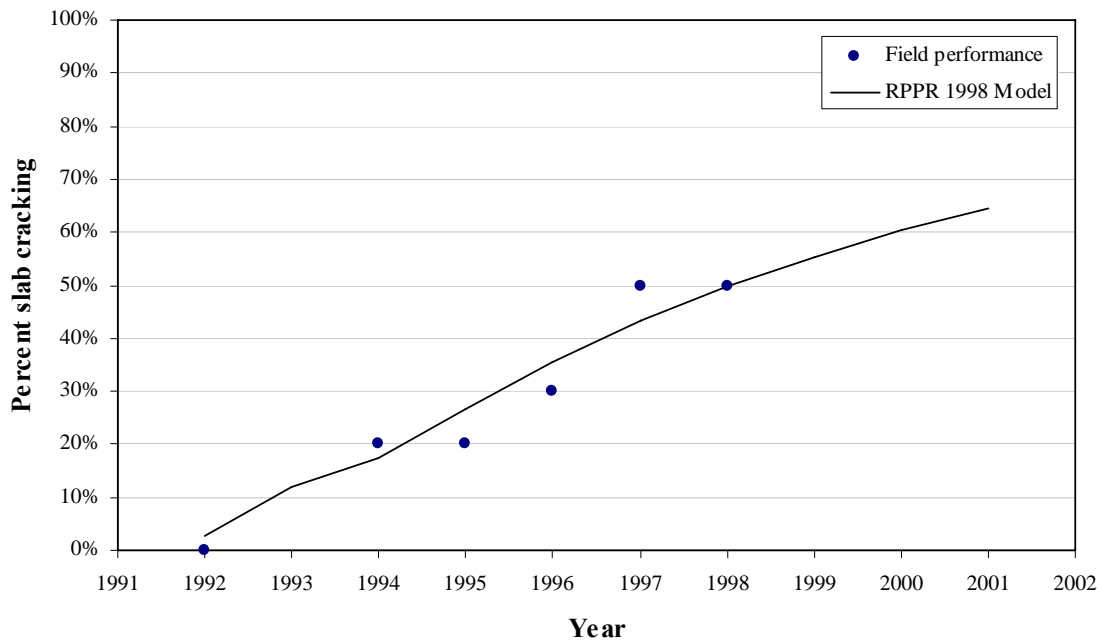
Figure 4. Comparison of field performance of 4.6-m repairs in the GADOT section and predicted cracking using the rigid pavement performance/rehabilitation (RPPR) 1998 model (Yu et al., 1998).
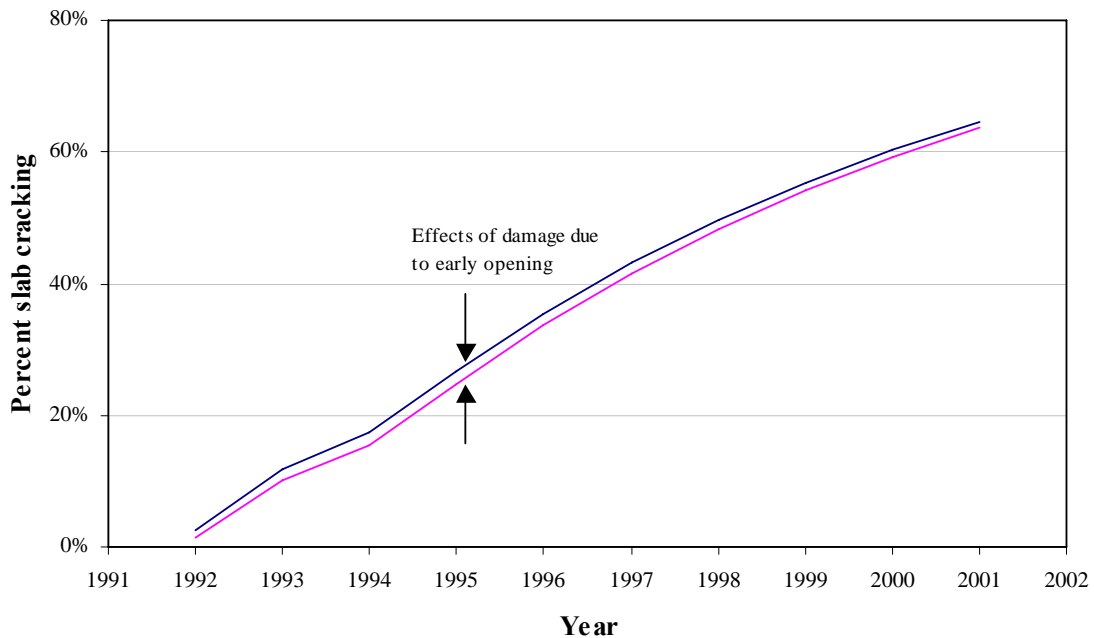
Figure 5. Illustration of the effects of damage due to early opening.

Figure 6 shows the effects of repair length and built-in curling on the fatigue performance of full-depth repairs. For bottom-up transverse cracking, the GADOT section represents the most adverse condition, because the repairs hardened with zero built-in temperature gradient.

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However, even under this condition, the 3.7-m repairs have an expected fatigue life of 10 or more years; shorter repairs should have practically unlimited fatigue life. Figure 6 also shows that if moderate built-in curling were introduced, the fatigue life of the 4.6-m repairs would increase dramatically. In this example, a total effective built-in temperature gradient of –5 °C (23 °F) was used, including the effects of temperature and differential shrinkage. This is a typical magnitude of built-in curling for PCC pavements in wet-nonfreeze climates. In general, for daytime construction, excessive built-in curling is more of a problem than is an inadequate amount of built-in curling.
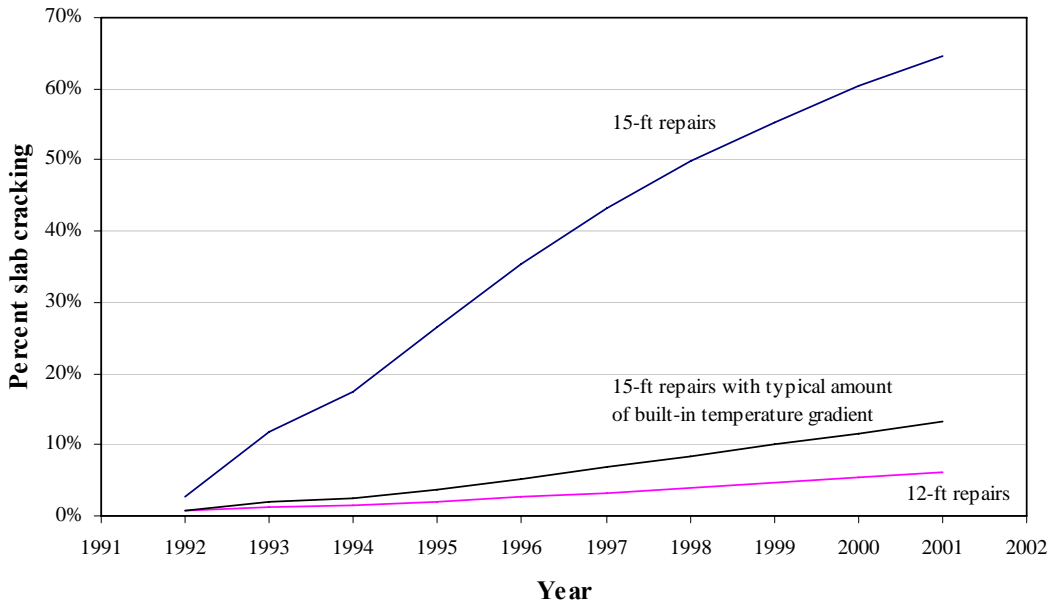
Figure 6. The effects of repair length and built-in curling on performance of full-depth repairs.

CHAPTER 3. EVALUATION OF OHIO SITE

DESCRIPTION OF FIELD SECTIONS

The Ohio site consists of eight test sections located on eastbound and westbound State Route 2, near Vermilion, OH, between the Baumhart Road and Vermilion Road exits. This section of State Route 2 is an Ohio Department of Transportation (ODOT) research road constructed in 1974 with 104 test sections to evaluate the effects of various pavement design and material factors on PCC pavement performance. Extensive research was conducted at this site into various material factors affecting D-cracking. The existing pavement through the project sections is 230-mm jointed reinforced concrete pavement (JRCP) with 12.2-m joint spacing. The ADT taken in 1990 was 14,400 with 22 percent trucks. The average truck factor during the time of field testing was 1.94.

Eight different materials were evaluated at this site:

- HES—a Type III PCC mix containing nonchloride accelerator (calcium nitrite) developed under SHRP C-205 to provide a 12- to 24-h opening time.

- FT I—a Type III PCC mix developed by Iowa DOT for 12- to 24-h opening.

- Pyrament (PC 1 and PC 2)—mixes made with proprietary blended cement (alkali-activated alumino-silicates). Two different mixes were tested: PC 1 for 2- to 4-h opening and PC 2 for 4- to 6-h opening.

- Rapid set (RSC 1 and RSC 2)—mixes made with another proprietary blended cement (sulfo-aluminate). Two different mixes were tested: RSC 1 for 2- to 4-h opening and RSC 2 for 4- to 6-h opening.

- VES—a Type III PCC mix containing nonchloride accelerator (calcium nitrite) developed under SHRP C-205 to provide a 2- to 4-h opening time.

- ODOT FS (FS)—a Type III PCC mix containing calcium chloride developed by ODOT to provide a 4- to 6-h opening time.

The mix designs for the materials tested at the Ohio site are given in table 4. All repairs placed at this site are 1.8 m long.

All work at the Ohio site was carried out during daytime hours. Work started about 7 a.m. each day with the closing of the work area to traffic and concrete removal operation. Concrete placement typically started about 10 a.m., and the sections were opened to traffic generally by 5:30 p.m. One material (section) was placed per day.

Table 5 provides a summary of Ohio sections. As for the Georgia sections, fatigue damage due to early opening was defined as the damage incurred during the first 14 days of service. The same procedure was used to calculate the damage.

Table 4. Mix design for the materials used at the Ohio site (Whiting et al., 1994).

Mix Component (per yd³)	2- to 4-hour opening			4- to 6-hour opening			12- to 24-hour opening	
	PC 1	RSC 1	VES	PC 2	RSC 2	FS	FT I	HES
Cement type	Pyrament	Rapidset	Type III	Pyrament	Rapidset	Type III	Type III	Type III
Cement, lb	900	750	915	850	650	900	750	870
Fine aggregate, lb	1,430	1,390	1,180	1,450	1,400	1,000	1,360	775
Coarse aggregate, lb	1,370	1,290	1,090	1,400	1,300	1,420	1,200	1,645
Water, lb	240	302	409	246	325	360	369	357
Water reducer, oz	–	–	–	–	–	–	45	–
Accelerator (DCI®), gal	–	–	6	–	–	–	–	4.0
Accelerator (CaCl₂), gal	–	–	–	–	–	18	–	–
Set retarder, oz	–	–	–	–	–	–	–	–
Citric acid, lb	–	11.25	–	–	7.8	–	–	–
High-range water reducer, oz	–	–	45.75	–	–	–	–	209
Air entraining agent, oz	–	22.5	73	–	26	90	52.5	69.6
w/c ratio	0.27	0.40	0.45	0.29	0.50	0.40	0.49	0.41

1 yd³ = 0.7645m³

1 lb = 0.4535 kg

1 gal = 3.78 L

1 oz = 29.57 mL

Table 5. Summary of Ohio sections

Repair Number	Repair Size, ft.	Age at opening h	Strength at Openings, psi		Early Opening Damage*
			F_c'	Modulus of Rupture	
HES—10- to 26-h opening					
A-2	6	16.8	4,650	520	0.000
A-3	6	15.8	4,600	520	0.000
A-4	6	14.7	4,450	510	0.000
A-5	6	14.1	4,350	500	0.000
A-6	6	10.3	3,800	455	0.000
A-7	6	10.2	3,750	455	0.000
A-8	6	10.1	3,750	455	0.000
A-9	6	9.6	3,700	450	0.000
A-10	6	9.5	3,700	450	0.000
FT I – 10 to 26-h opening					
B-2	6	19.0	4,350	585	0.000
B-3	6	18.2	4,300	580	0.000
B-4	6	18.0	4,300	575	0.000
B-5	6	15.4	4,100	560	0.000
B-6	6	15.3	4,100	560	0.000
B-7	6	15.3	4,100	555	0.000
B-8	6	12.4	3,900	530	0.000
B-9	6	12.3	3,850	530	0.000
B-10	6	12.3	3,850	530	0.000
PC 1 – 1- to 6-h opening					
C-2	6	5.8	1,900	325	0.000
C-3	6	5.2	1,850	320	0.000
C-4	6	4.8	1,800	315	0.000
C-5	6	4.2	1,750	305	0.001
C-6	6	3.9	1,650	300	0.001
C-7	6	3.3	1,500	280	0.002
C-8	6	3.0	1,500	275	0.002
C-9	6	2.5	1,300	255	0.005
C-10	6	2.0	1,150	230	0.010
RSC 1 – 1- to 6-h opening					
D-2	6	5.5	4,100	480	0.000
D-3	6	3.7	3,950	460	0.000
D-4	6	3.6	3,900	455	0.000
D-5	6	3.1	3,750	440	0.000
D-6	6	3.0	3,700	435	0.000
D-7	6	2.3	3,200	380	0.001
D-8	6	2.3	3,200	380	0.001
D-9	6	1.9	2,150	245	0.004
D-10	6	1.8	2,150	245	0.004

*Miner's fatigue
1 m = 3.28 ft
1 MPa = 145.04 psi

Repair Number	Repair Size, ft.	Age at opening h	Strength at Openings, psi		Early Opening Damage*
			F_c'	Modulus of Rupture	
VES—3- to 8-h opening					
E-2	6	6.5	3,100	375	0.000
E-3	6	6.0	3,050	370	0.000
E-4	6	5.0	2,550	340	0.000
E-5	6	4.3	2,050	310	0.001
E-6	6	4.3	2,050	310	0.001
E-7	6	3.8	1,300	260	0.002
E-8	6	3.8	1,300	260	0.002
E-9	6	3.3	1,000	240	0.004
E-10	6	3.3	1,000	240	0.004
PC 2—3- to 8-h opening					
F-2	6	6.6	1,500	290	0.001
F-3	6	5.9	1,400	275	0.002
F-4	6	5.7	1,400	270	0.003
F-5	6	4.9	1,350	260	0.004
F-6	6	4.8	1,350	255	0.005
F-7	6	4.3	1,300	250	0.010
F-8	6	4.1	1,250	250	0.011
F-9	6	3.7	1,200	235	0.011
F-10	6	3.5	1,150	220	0.011
RSC 2—3- to 8-h opening					
G-2	6	5.5	3,950	535	0.000
G-3	6	4.3	3,350	500	0.000
G-4	6	3.9	3,150	465	0.000
G-5	6	3.8	3,150	465	0.000
G-6	6	3.3	2,600	420	0.000
G-7	6	3.2	2,600	420	0.000
G-8	6	2.8	2,150	375	0.000
G-9	6	2.6	1,950	350	0.000
G-10	6	2.4	1,850	310	0.001
FS—3- to 8-h opening					
H-2	6	6.8	5,250	540	0.000
H-3	6	7.8	5,500	565	0.000
H-4	6	6.5	5,150	535	0.000
H-5	6	6.3	5,100	530	0.000
H-6	6	4.1	4,550	470	0.000
H-7	6	3.9	4,450	465	0.000
H-8	6	2.3	1,100	135	0.150
H-9	6	2.2	1,100	135	0.150
H-10	6	2.0	1,100	135	0.150

*Miner's fatigue
1 m = 3.28 ft
1 MPa = 145.04 psi

PERFORMANCE OF OHIO SECTIONS

The performance of Ohio sections was plagued by the longitudinal cracking that developed in the majority of repairs shortly after construction. The cracks appeared within weeks of construction. Three sections also developed transverse cracks and corner breaks, but those distresses are secondary cracking that is unlikely to have occurred had the longitudinal cracking not occurred. Transverse fatigue cracking is not an issue for short (1.8-m) repairs.

The distress data for Ohio sections are summarized in table B2 (appendix B). Faulting performance of Ohio sections is summarized in table 6; the detailed joint performance data are given in table B3. As with the Georgia sections, all Ohio sections gave excellent joint performance except for RSC 1, which developed excessive faulting.

Table 6. Summary of joint performance of Ohio sections.

Section	Faulting, in[1]					Average LTE
	1994	1995	1996	1997	1998	
HES	0.03	0.02	0.02	0.02	0.02	74%
FT I	0.04	0.02	0.03	0.03	0.05	64%
PC 1	0.01	0.01	0.01	0.01	0.01	74%
RSC 1	0.14	0.18	0.17	n/a[2]	n/a[2]	77%
VES	0.02	0.01	0.01	0.01	0.02	79%
PC 2	0.02	0.03	0.02	0.02	0.01	82%
RSC 2	0.02	0.02	0.02	0.02	0.02	80%
FS	0.04	0.02	0.02	0.02	0.03	75%

[1]Absolute average.   1 in = 25.4 mm

[2]Overlaid after 1996 survey.

The unusually poor joint performance RSC 1 section is inexplicable. The possible causes of excessive faulting in doweled full-depth repairs include the following:

- Excessive curling due to high temperature gradient at the time of concrete hardening.

- Excessive dowel bearing stress due to low compressive strength at the time of opening.

- Improper installation—inadequate coverage of grouting material around the dowels or poor consolidation of concrete around the dowels.

This section did not have an unusually high temperature gradient at the time of concrete hardening, and the compressive strength at opening was relatively high. Improper installation is a possibility, but not likely because this is the only section with this problem. The RSC 1 section was overlaid after the 1996 survey.

As mentioned in appendix A, the VES and FS sections started to show map cracking in 1997 (figure 7). The suspected cause of the map cracking is delayed ettringite formation (DEF). DEF is possible if the concrete temperature during hydration exceeds about 70 ºC. The peak temperature in the VES section was just above this threshold temperature, and that in the FS section was significantly higher (80.6 ºC). Core testing confirmed DEF in these sections.

Continued development of D-cracking in the surrounding concrete was also a problem at this site. As a part the pavement rehabilitation program, edgedrains were installed after the completion of all repair work in 1992. However, the edgedrains were not effective in mitigating D-cracking in the original pavement at this site, although the RPPR study showed a significant benefit of edgedrains provided at the time of initial construction (Smith et al., 1995). As mentioned earlier, the project site in Ohio contains 104 test sections, many of which were evaluated in the RPPR study. The result of a field survey conducted under the RPPR study showed that the sections originally provided with edgedrains exhibited significantly less spalling due to D-cracking at this site. However, the retrofitted edgedrains installed in 1992 did not appear effective in mitigating D-cracking. By 1998, some repairs started showing signs of D-cracking on the original pavement side of the repair joints. This may be an indication that accumulated internal damage over the years does play a significant role in the development of D-cracking, as commonly believed.
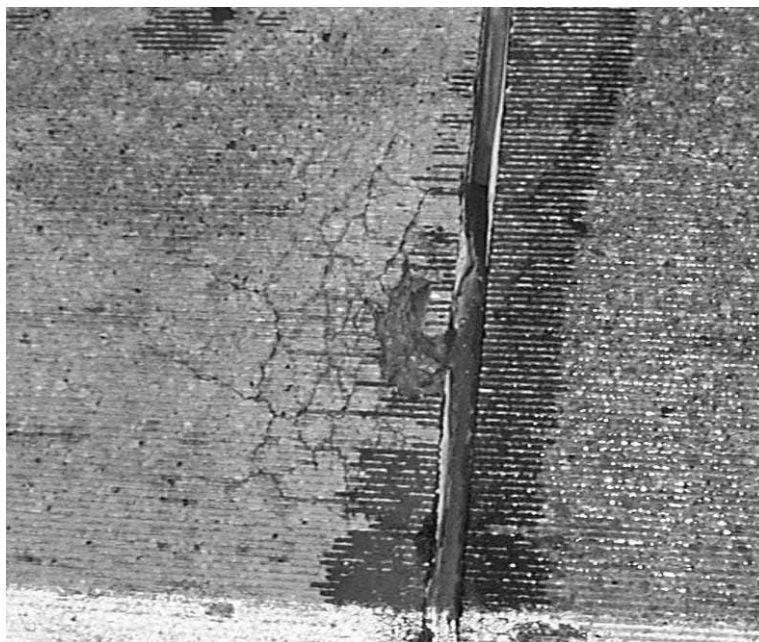
Figure 7. Map cracking observed in FS section in 1997.

ANALYSIS OF THE CRACKING PROBLEM

By far the most significant distress in the Ohio test sections is the early development of longitudinal cracking in nearly all repairs. Typical longitudinal cracking at this site is illustrated in figure 8. These cracks typically occurred in about the outer one-third of the slab. The rate of development of longitudinal cracking in Ohio sections is shown in figure 9. By the 2-month follow-up survey conducted under SHRP C-206, 100 percent of the FS section and 90 percent of the RSC 1 section had developed longitudinal cracking. By the time of first survey under this project in 1994, five of the eight sections had developed additional longitudinal cracking. Under SHRP C-206, the following were identified as possible causes of the cracking problem:

- The restriction of horizontal movement in the transverse direction caused by dowels.
- Excessive curling stress.
- Excessive compressive force exerted on the repairs by surrounding concrete.
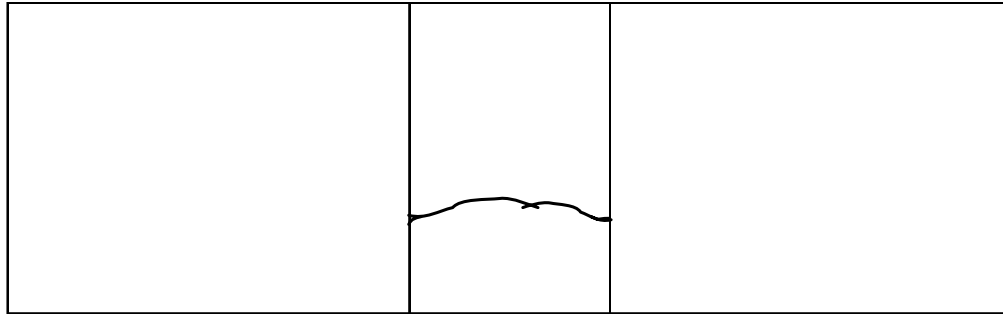
Figure 8. Illustration of typical longitudinal cracking in Ohio sections.
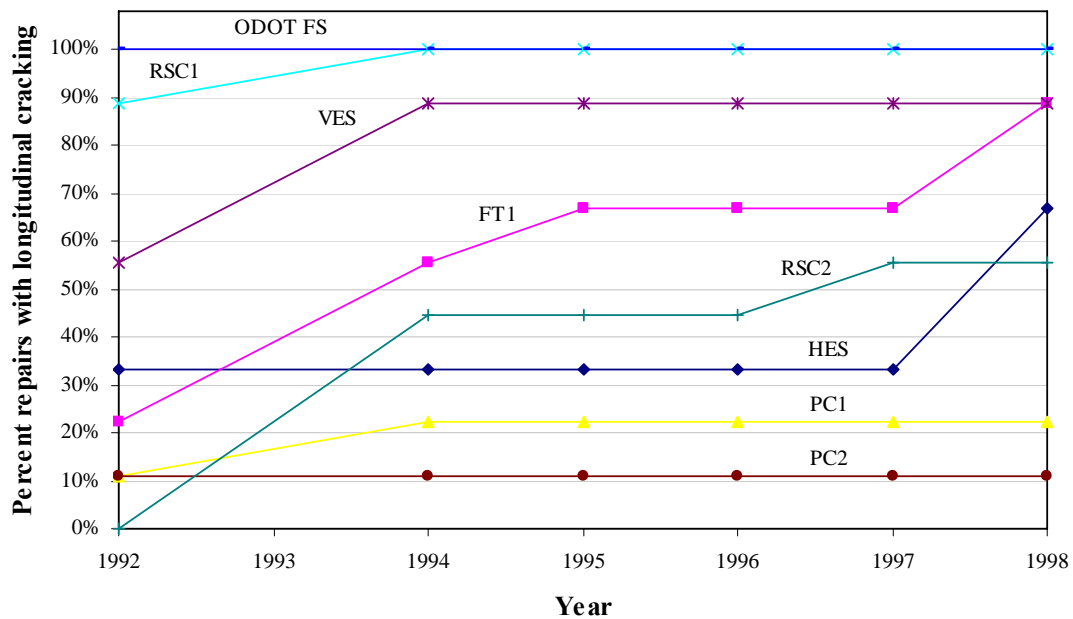
Figure 9. Development of longitudinal cracking in Ohio sections.

Of the three potential causes considered, the last (excessive compressive force) is unlikely, because the repair concrete was set during the hottest part of the day. By the time the repairs were opened to traffic (typically 5:30 p.m.), the surrounding concrete was well into the daily cooling cycle. Excessive built-in curling, in combination with a highly nonlinear negative temperature gradient, can cause top-down cracking (overnight, in extreme cases); however, a high rate of cracking also occurred in sections that had relatively low temperature gradients at the time of concrete hardening. On the other hand, the RSC 2 section, which had a very high temperature gradient at the time of concrete hardening, had a relatively low level of cracking (none at the time of the 2-month evaluation). Temperature conditions at the time of concrete hardening and peak temperatures reached during hydration are summarized in table 7.

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**Table 7. Estimated temperature conditions at the time
of concrete hardening, and the peak temperature
reached during curing for the Ohio sections, ºF.**

Section	Top	Middle	Bottom	Average	Top - Bottom	Peak	Average Including Peak
HES	90.0	100.0	90.0	93.3	**0.0**	145.0	**106.3**
FT I	90.0	98.0	85.0	91.0	**5.0**	130.0	**100.8**
PC 1	104.0	107.0	92.0	101.0	**12.0**	108.0	**102.8**
RSC 1	110.0	118.0	98.0	108.7	**12.0**	127.0	**113.3**
VES	100.0	103.0	97.0	100.0	**3.0**	157.0	**114.3**
PC 2	105.0	104.0	92.0	100.3	**13.0**	108.0	**102.3**
RSC 2	109.0	108.0	89.0	102.0	**20.0**	129.0	**108.8**
FS	132.0	125.0	100.0	119.0	**32.0**	177.0	**133.5**

ºC = (ºF-32)/1.8

Of the temperature parameters shown in table 7, the one most closely correlated with longitudinal cracking is the average temperature including the peak temperature reached during hydration. This is a simple average of top, middle, and bottom temperature at the time of concrete hardening and the peak temperature. Another factor that appears to have been significant is the overnight temperature during early ages of concrete. The concrete temperatures at the time of concrete hardening and the peak temperature reached during hydration for the Georgia sections are not significantly different from those of the Ohio sections, but none of the sections in Georgia developed longitudinal cracking, including 1.8-m (6-ft) repairs. The temperature data for the Georgia sections are shown in table 8.

**Table 8. Estimated temperature conditions at the time of
concrete hardening, and the peak temperature
reached during curing for the Georgia sections, ºF.**

Section	Top	Middle	Bottom	Average	Top - Bottom	Peak	Average Including Peak
VES	98.0	110.0	98.0	102.0	**0.0**	138.0	**111.0**
FT I	100.0	110.0	104.0	104.7	**-4.0**	123.0	**109.3**
GADOT	96.0	98.0	98.0	97.3	**-2.0**	140.0	**108.0**

ºC = (ºF-32)/1.8

The main difference in temperature conditions at the two sites is the overnight low temperature during early ages of the concrete. At the Ohio site, the overnight temperatures dropped below 10 ºC during construction of the test sections. The overnight temperature at the Georgia site was above 21 ºC at all times. The difference between the average slab temperature at early ages, including the peak temperature, and the overnight low temperature appears to have been the most critical factor affecting the potential for longitudinal cracking. The difference between the average curing temperature and overnight low temperature is summarized in table 9. The

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correlation between this parameter and longitudinal cracking in Ohio sections is shown in figures 10, 11, and 12 for the correlation at 2 months, 2 years, and 6 years of age. Figure 10 shows excellent correlation between this parameter and longitudinal cracking. If the cracking is caused by dowel restraint (of the horizontal movement in the transverse direction), this should be an effect that mostly influences the early-life behavior. Various factors would alleviate this effect at later ages, including creep and higher material strength. This is consistent with the trends shown in figures 10, 11, and 12. The best correlation is exhibited in figure 10 at 2 months of age, and the correlation becomes progressively worse for later ages.

Table 9. Comparison of the difference between average concrete temperature during curing including the peak temperature and overnight low temperature, ºF.

Section	Average Temp. During Curing, °F	Overnight Low	Difference
Ohio sections			
HES	106.3	50	56.3
FT I	100.8	50	50.8
PC 1	102.8	50	52.8
RSC 1	113.3	50	63.3
VES	114.3	50	64.3
PC 2	102.3	50	52.3
RSC 2	108.8	50	58.8
FS	133.5	50	83.5
Georgia sections			
VES	111.0	70	41.0
FT I	109.3	70	39.3
GA DOT	108.0	70	38.0

ºC = (ºF-32)/1.8
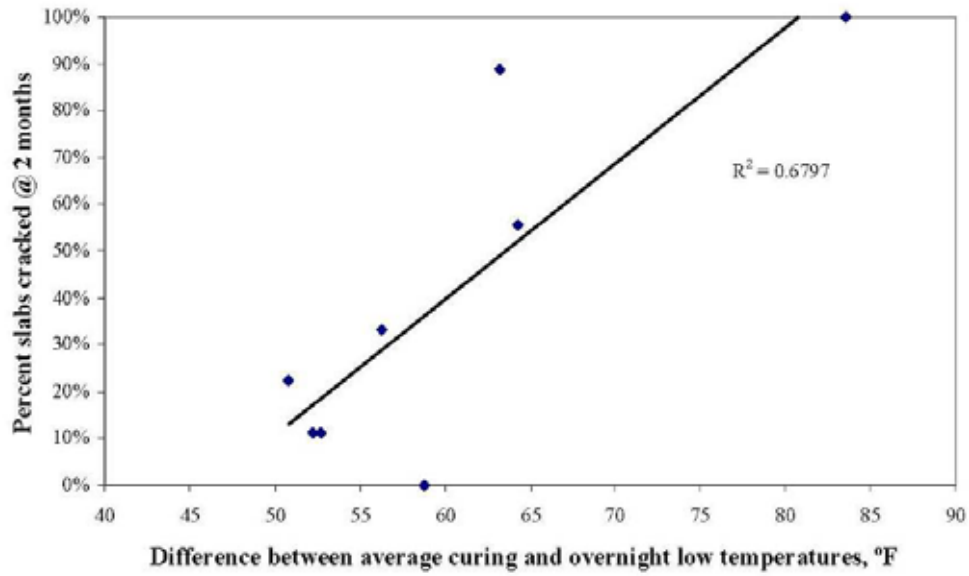
°C = (°F-32)/1.8

Figure 10. Correlation between the difference of average curing and overnight low temperatures and longitudinal cracking in Ohio sections at 2 months.
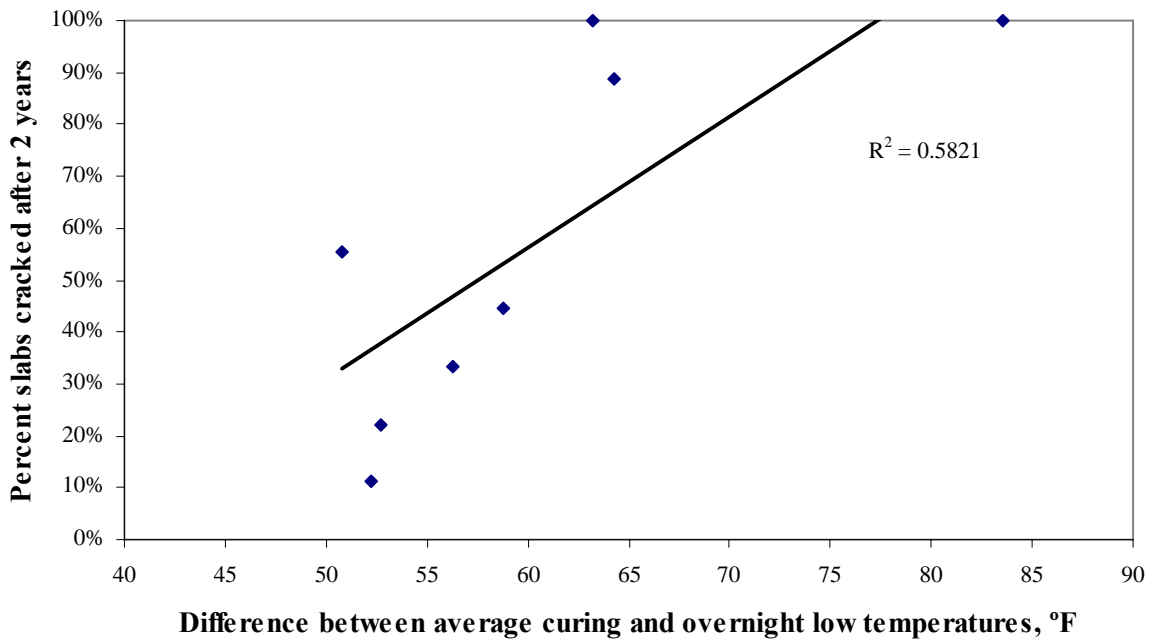
°C = (°F-32)/1.8

Figure 11. Correlation between the difference of average curing and overnight low temperatures and longitudinal cracking in Ohio sections at 2 years.
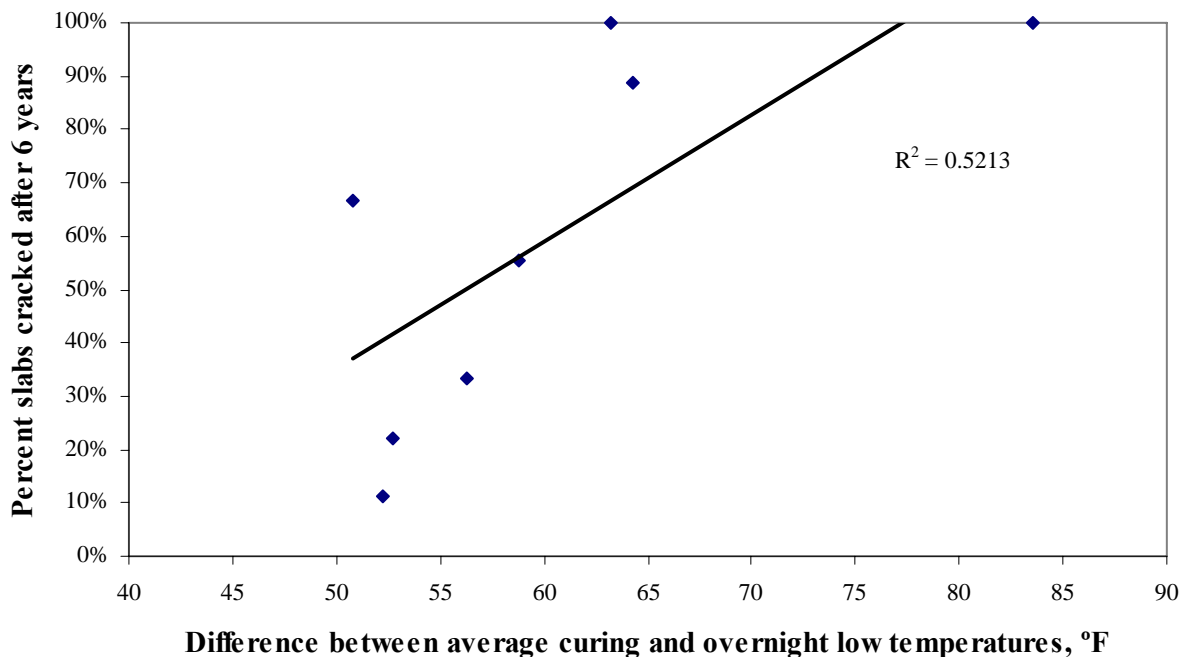
°C = (°F-32)/1.8

**Figure 12. Correlation between the difference of average curing and overnight
low temperatures and longitudinal cracking in Ohio sections at 6 years.**

The results shown in table 9 and figures 10 through 12 strongly suggest that the climatic conditions during construction played a major role in early development of longitudinal cracking in the Ohio sections. Figure 10 shows that if the difference between average curing temperature and overnight low temperature is less than about 10 °C (50 °F), the risk of developing longitudinal cracking due to dowel restraint is relatively low. That difference was less than 5 °C (41 °F) for all the Georgia sections, and none of the Georgia sections developed longitudinal cracking.

The risk of early age cracking can be evaluated using FHWA's software HIPERPAV (McCullough and Rasmussan 1999; Forster 1998). The software takes key environmental, structural design, mix design, and construction inputs and generates a graph showing the development of PCC strength and stress over the first 72 hours after placement. If the stress exceeds the strength at any time, a high potential for uncontrolled cracking is indicated. For such cases, adjustments can be made to mixes, curing practice, or time of PCC placement to reduce the potential for cracking. Where a significant difference between the average curing temperature and overnight low temperature is possible (i.e., greater than 10 °C (50 °F)), the use of HIPERPAV is recommended.

CHAPTER 4. CONCLUSIONS AND RECOMMENDATIONS

The full-depth repairs made with HES materials placed under SHRP C-206 gave variable long-term performance. All sections in Georgia provided excellent performance; however, the performance of the Ohio sections was plagued by the longitudinal cracking that developed in a majority of the repairs within few weeks after the repairs were opened to traffic. An analysis conducted under this study showed that the most likely cause of the longitudinal cracking in the Ohio sections is the excessive difference between the PCC temperature during curing and the nighttime low temperatures. Two of the Ohio sections (VES and FS) also started to develop map cracking by 1997. These two sections developed extremely high temperatures during curing (excess of 70 ºC); DEF is the suspect cause of the map cracking.

The following conclusions can be made based on the performance of the full-depth repairs at the two SHRP C-206 test sites:

- Full-depth repairs made with HES PCC can provide good long-term performance; however, adverse temperature conditions during installation can cause premature failures.

- A large difference in the average PCC temperature during curing and overnight low temperatures should be avoided. If this difference in temperature is large, longitudinal cracking is possible, because the thermal contraction in the transverse direction is restrained by dowels.

- The temperature data from the Ohio site suggest that the risk of longitudinal cracking is high if the difference in average curing temperature and nighttime low temperatures exceeds about 10 °C (50 °F). The use of HIPERPAV is recommended in adverse conditions to avoid premature failures.

- Extremely high PCC temperatures during curing should be avoided. If the PCC temperature during curing exceed 70 ºC, DEF is possible. Two of the Ohio sections (VES and FS) showed map cracking characteristic of DEF, and core testing confirmed DEF in those sections.

- All sections except the RSC 1 section in Ohio showed excellent faulting performance. Average faulting was less than 1 mm and remained unchanged throughout the monitoring period.

- The fatigue damage due to early opening is negligible, especially for repairs 3.7 m (12 ft) or shorter. The repairs in each experimental section had a range of strength at the time of opening to traffic; however, within the range of strength evaluated, the strength at opening could not be correlated to performance. The minimum compressive strength at opening was 6.9 megapascals (MPa) for all sections.

The results of this evaluation showed that in terms of fatigue damage or faulting performance, the repairs could be opened to traffic at much lower strengths than those typically recommended. However, opening at strengths much less than those recommended in various manuals of practice (ACPA 1995; Yu et al., 1994; Snyder et al., 1989) is not advisable because of the risk of random failures caused by a single heavy load at an early age. Therefore, the following opening criteria suggested in the SHRP C-206 manual of practice are still recommended:

- PCC modulus of rupture of 2.0 MPa by third-point testing.

- Compressive strength of 13.8 MPa.

No change is recommended to the minimum repair size, but further research is recommended into the effects of repair size on potential for longitudinal cracking. The Ohio site where the longitudinal cracking was a problem only had 1.8-m repairs. Therefore, the effects of repair size could not be determined. Although the temperature conditions during construction appear to be the dominant factor affecting the risk of longitudinal cracking, it is possible for repair dimension to be a factor.

SUMMARY OF ANNUAL SURVEY RESULTS

1994 Survey

At both sites, the full-depth PCC repairs are performing very well. None of the repairs exhibited any material problems at either site.

Georgia Site

At the Georgia site, only two of the long (4.6-m or longer) repairs developed cracks. No other repair distresses were observed. The surrounding pavement at the Georgia site did not show any significant further deterioration, but it exhibited very high deflection under load. The deflection of the pavement under truck wheel loads was readily visible.

Ohio Site

The observed changes in the Ohio sections (since the follow-up survey conducted during SHRP C-206) consist of:

- Further progression of longitudinal cracking that developed shortly after opening of the test sections to traffic.

- Development of transverse cracking in one slab.

- Development of corner breaks in two slabs (both VES).

Two of the repairs in the Pyrament 1 section (PC 1) had been removed and replaced. The most likely reason for this replacement is the deterioration of the surrounding pavement and not the repairs themselves. Many of the C-206 repairs are surrounded by very short slabs (1.8 to 2.4 m), resulting from the placement of the repairs. If the deterioration of the original joint in the surrounding slabs is excessive (due to D-cracking, which is a widespread problem at this site), the only way the repairs can be made is by removing all of the short slabs in the immediate area and replacing them with full slabs. The other important noticeable change at the Ohio site was the deterioration of the surrounding pavement. D-cracking in the surrounding pavement had progressed significantly since the placement of the repairs. Virtually all original joints in the surrounding pavement exhibited extensive D-cracking.

1995 Survey

In 1995, the Ohio sections were surveyed on November 15, and the Georgia sections were surveyed on November 30. At both sites, the PCC repairs are performing well. None of the repairs exhibited any material problems at either site.

Georgia Site

Considering the length of some of the Georgia repairs, the Georgia sections are performing very well. The GADOT section contained the longest repairs (repair lengths up to 4.9 m). During the

1994 survey, a transverse crack was observed on two of the 4.6-m repairs in this section (one medium- and one high-severity). Both repairs had been partially replaced before the 1995 survey to repair the cracked portion. The remaining portions of these two repairs are now 2.7 m and 3.7 m. Full-depth repairs have also been made adjacent to two of the 1.8-m repairs in the FT 1 section. No other distresses were observed at this site. Faulting in all sections was minimal (less than 1.0 mm (0.04 in)).

The shoulders at the Georgia site were replaced with a new asphalt shoulder in November 1995. The contractor was just finishing the construction of the new shoulder in section 3 when it was surveyed. Because of the construction work in the area, the FWD testing originally planned for this section could not be completed. That testing will be completed next year.

Ohio Site

The observed changes in the Ohio sections consist of:

- One repair in the FT1 section (B5) developed a longitudinal crack. The longitudinal cracking is prevalent in all Ohio sections. The likely cause of these cracks is the excessive temperature gradients that were present in the slabs when the concrete hardened.

- One repair in the VES section (E3) developed a transverse crack. This repair also has a longitudinal crack at about 1.8 m from the lane-shoulder joint.

- With the exception of RSC 1, which has an average faulting of -4.6 mm on the approach side and 4.8 mm on the leave side, faulting in all sections is minimal (less than 1.3 mm).

Another noticeable change at the Ohio site is the general condition of the surrounding pavement. A significant number of transverse joints in the surrounding pavement were badly deteriorated due to D-cracking. All of these joints had been repaired since the last survey, either by full-depth repair, patching, or sealing. Many of the cracks in the surrounding pavement were also repaired by full-depth repair.

1996 Survey

In 1996, the Ohio site was surveyed on September 19, and the Georgia sections were surveyed on November 13.

Georgia Site

This year, FWD testing was conducted in addition to the visual distress survey to detect changes in LTE and PCC modulus (E_{PCC}). The results of the visual distress survey and faulting measurements are shown in table B1. Since last year, only one 4.5-m repair in section 1 (GADOT mix) developed a crack. This amounts to 30 percent of 4.5-m repairs, but this is substantially better than the predicted performance. None of the shorter repairs developed cracks. The level of faulting in all sections remains about the same.

The FWD testing results are summarized in table A1. The backcalculated moduli from this year's test results show that PCC properties have not changed significantly over the 4 years the repairs have been in place. The backcalculated subgrade k-values from this year's test results

appear high. The variability of the backcalculated k-value and E_{PCC} is illustrated in figures A1, A2, and A3 for the three sections. The variability of subgrade k shown on these figures appears reasonable, but the variability of E_{PCC} is more likely due to slab thickness variations rather than the actual variability of E_{PCC}.

The deflection measurements from the testing conducted at the transverse edges were used to determine deflection LTE. The deflection LTEs also appear to have remained about the same. Table A1 shows improved LTE in some cases. This anomaly is most likely due to the difference in the mix of joints tested, but the temperature and moisture conditions during testing can also affect the deflection testing results. More slabs were tested this year than during SHRP, but not all of the slabs tested during SHRP were tested this year. Tables A2, A3, and A4 provide more details of the LTE testing results.

Table A1. Summary of Falling Weight Deflectometer test results.

Section	Subgrade k psi/inch		E_{PCC} million psi		LTE w/Load Plate On, %				Average LTE	
					Approach Side		Leave Side			
	SHRP	1996	SHRP	1996	SHRP	1996	SHRP	1996	SHRP	1996
GA 1, GADOT	199	275	6.12	6.03	62%	74%	83%	77%	73%	75%
GA 2, FT1	218	328	5.64	5.38	72%	70%	81%	75%	77%	72%
GA 3, VES	299	309	5.27	5.13	71%	76%	84%	84%	77%	80%

1 MPa = 145.04 psi
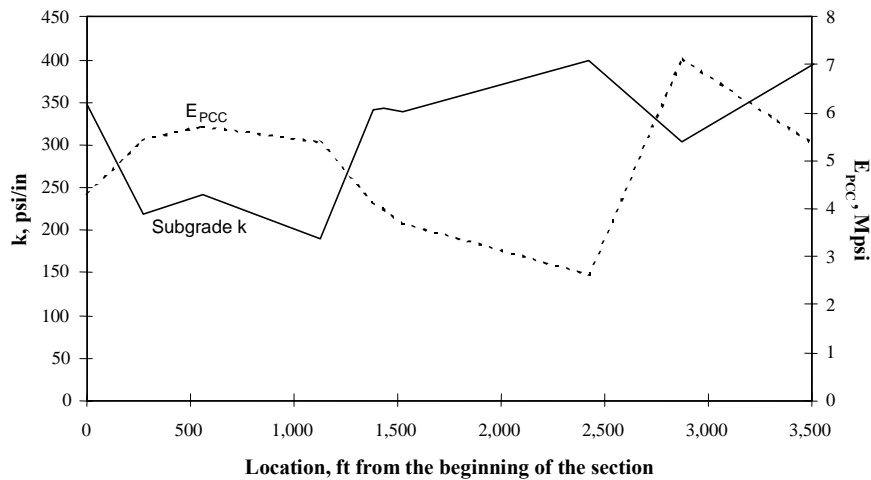
1 MPa = 6.89.45.04 (psi)
1 m = .3053.28 ft

Figure A1. Backcalculation results for the GADOT section.
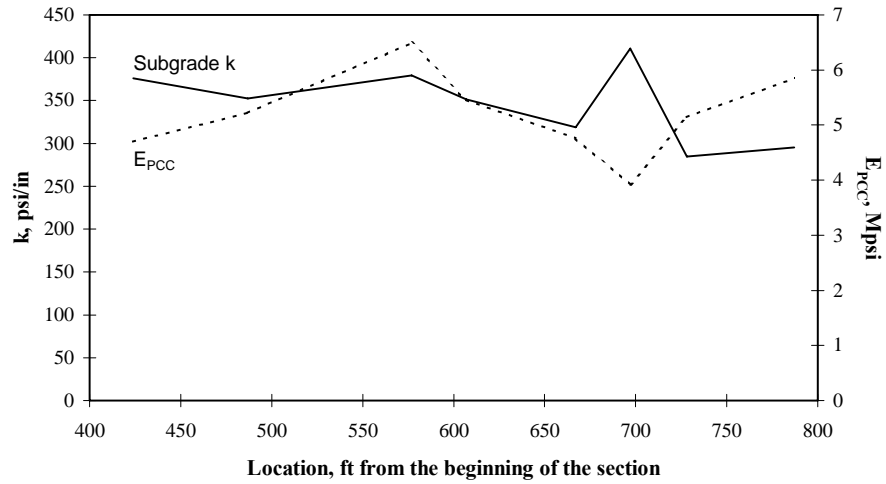
1 MPa = 145.04 psi
1 m = 3.28 ft

Figure A2. Backcalculation results for the FT 1 section.
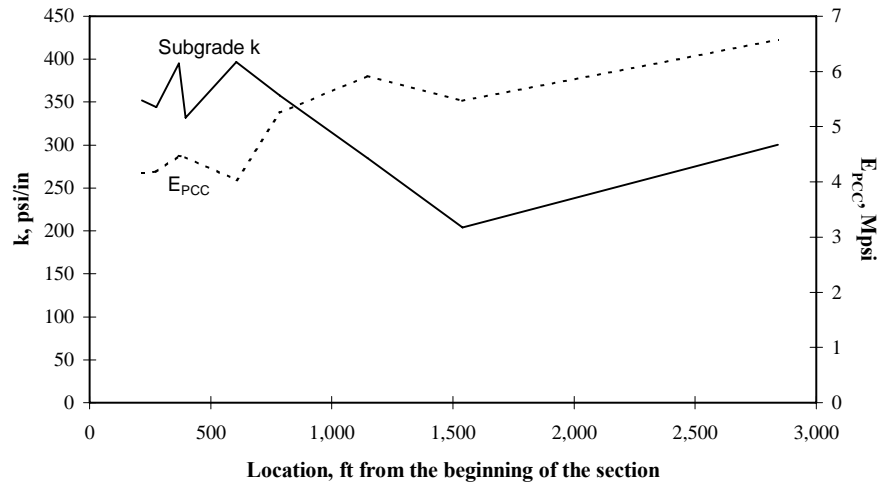
1 MPa = 6.89145 psi
1 m = .3053.28 ft

Figure A3. Backcalculation results for the VES section.

Table A2. Deflection load transfer test results of section GA 1, GADOT.

Section ID	Slab Size, ft	Joint	Relative Station	LTE w/ Load Plate On		Average LTE
				Approach Side	Leave Side	
1-1	8	Approach	0+00	83%	88%	86%
1-1	8	Leave	0+05	69%	66%	68%
1-2	8	Approach	1+06	34%	61%	48%
1-2	8	Leave	1+22	84%	81%	82%
1-3	8	Approach	2+69	70%	79%	75%
1-3	8	Leave	2+76	85%	85%	85%
1-4	8	Approach	5+57	71%	86%	78%
1-4	8	Leave	5+65	83%	89%	86%
1-5	8	Approach	11+28	78%	72%	75%
1-5	8	Leave	11+39	82%	80%	81%
1-6	8	Approach	11+61	53%	53%	53%
1-6	8	Leave	11+69	86%	83%	85%
1-8	15	Approach	15+22	56%	59%	57%
1-8	15	Leave	15+37	85%	92%	88%
1-16	16	Approach	19+73	54%	60%	57%
1-16	16	Leave	19+89	85%	77%	81%
1-17	15	Approach	20+34	72%	72%	72%
1-17	15	Leave	20+48	89%	90%	90%
1-18	15	Approach	24+24	70%	75%	73%
1-18	15	Leave	24+39	87%	90%	88%
Average LTE				**74%**	**77%**	**75%**

1 m = 3.28 ft

Table A3. Deflection load transfer test results of section FT 1.

Section ID	Slab Size, ft	Joint	Relative Station	LTE w/ Load Plate On		Average LTE
				Approach Side	Leave Side	
2-3A	7	Approach	0+00	63%	70%	67%
2-3A	7	Leave	0+08	86%	84%	85%
2-4	10	Approach	4+19	73%	74%	74%
2-4	10	Leave	4+28	88%	89%	89%
2-5	6	Approach	4+57	65%	71%	68%
2-5	6	Leave	4+62	71%	72%	72%
2-7	10	Approach	5+71	60%	61%	61%
2-7	10	Leave	5+82	78%	76%	77%
2-9	10	Approach	6+60	59%	69%	64%
2-9	10	Leave	6+70	88%	89%	88%
2-10	10	Approach	6+91	74%	71%	73%
2-10	10	Leave	7+01	78%	81%	80%
2-11	10	Approach	7+23	69%	85%	77%
2-11	10	Leave	7+33	81%	85%	83%
2-12	6	Approach	7+83	19%	24%	22%
2-12	6	Leave	7+90	86%	93%	89%
2-13	11	Approach	10+50	74%	79%	77%
2-13	11	Leave	10+62	10%	37%	23%
2-15	6	Approach	11+86	79%	86%	83%
2-15	6	Leave	11+91	93%	93%	93%
Average LTE				**70%**	**75%**	**72%**

1 m = 3.28 ft

Table A4. Deflection load transfer test results of section GA 3, VES.

Section ID	Slab Size, ft	Joint	Relative Station	LTE w/ Load Plate On Approach Side	LTE w/ Load Plate On Leave Side	Average LTE
3-2	12	Approach	2+10	65%	79%	72%
3-2	12	Leave	2+23	85%	88%	86%
3-5	12	Approach	3+92	72%	80%	76%
3-5	12	Leave	4+03	94%	84%	89%
3-7	12	Approach	6+03	67%	82%	74%
3-7	12	Leave	6+16	83%	85%	84%
3-9	8	Approach	7+25	76%	97%	86%
3-9	8	Leave	7+33	85%	88%	86%
3-12	8	Approach	8+87	87%	75%	81%
3-12	8	Leave	8+95	80%	79%	80%
3-13	8	Approach	9+09	70%	89%	80%
3-13	8	Leave	9+17	85%	97%	91%
3-15	9	Approach	12+70	59%	77%	68%
3-15	9	Leave	12+78	82%	81%	82%
3-16	12	Approach	15+40	52%	74%	63%
3-16	12	Leave	15+54	89%	101%	95%
3-18	8	Approach	22+43	51%	57%	54%
3-18	8	Leave	22+52	88%	90%	89%
3-19	8	Approach	28+46	63%	81%	72%
3-19	8	Leave	28+59	86%	86%	86%
Average LTE				**76%**	**84%**	**80%**

1 m = 3.28 ft

These tables show that the approach joints are consistently faulted more than the leave joints, and the repair size does not appear to be a factor on this effect.

The FWD testing was conducted at different load levels to determine the presence of voids under the repair joints. The void detection is possible because the presence of voids causes nonlinear response of pavement deflections. If edge deflections were plotted against applied load, the best-fit line through the data points should go through zero if the pavement response is linear. However, if voids are present, then a certain amount of deflection will take place with minimal applied load until the slab comes in full contact with the subgrade. Hence, the presence of voids causes increased deflection at all load levels, causing an upward shifting of the plot of load versus deflection.

A positive intercept on the load versus deflection plot, therefore, indicates a possible presence of voids under the joint, and the value of the intercept is related to the magnitude of the voids. However, the best-fit line on the load-deflection plot may not always go through zero even when no voids are present because other factors can cause nonlinear response of pavement deflections (e.g., load response of the subgrade and the base layers). Depending on the temperature conditions, upward curling of the slabs may also show up as voids, because the curling can cause the slab corners to lift off the foundation. In general, a positive y-intercept greater than about 0.05 mm may be a possible indication of the presence of voids.

The intercept values from the load-deflection plots are shown in figures A4, A5, and A6. The figures show possible voids under the repairs 1-3, 2-13, 2-15, 3-13, and 3-15, but most joints tested show good support under the joints. These results show that the slabs were not curled up at the time of testing.
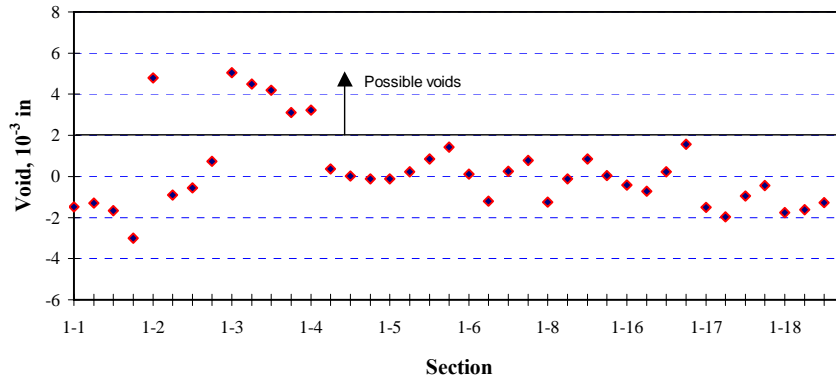
1 inch = 25.4 mm

Figure A4. Void detection test results for section GA 1.
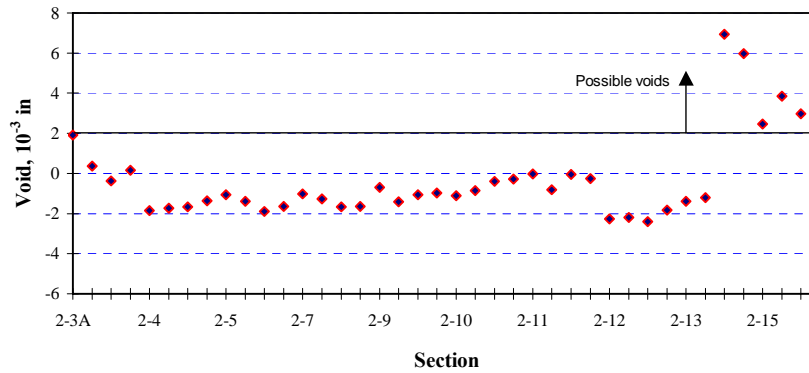
1 inch = 25.4 mm

Figure A5. Void detection test results for section FT 1.
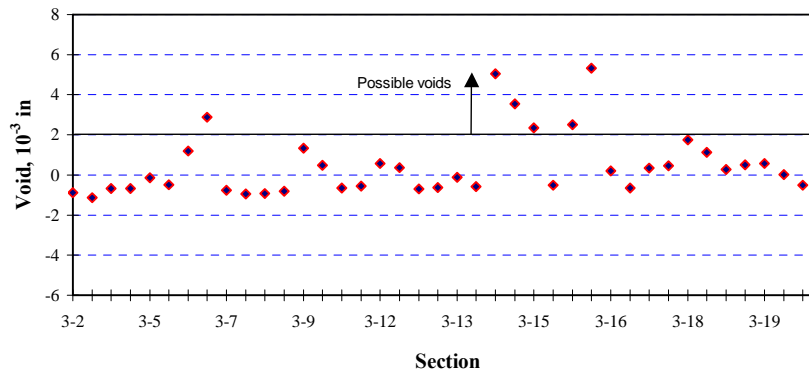
1 inch = 25.4 mm

Figure A6. Void detection test results for section VES.

<u>Ohio Site</u>

In general, the condition of the test patches had not changed significantly from the previous year. The surface cracking in some areas appeared to have progressed somewhat, but none of these cracks are severe enough to be called block cracking yet. The distress data from the Ohio site are summarized in table B2, and the faulting measurements are summarized in table B3. The faulting remained virtually unchanged, but the following changes in slab cracking were noted:

- FT 1—two longitudinal cracks (patches B7 and B8) went from low to medium severity.

- RSC 1—two longitudinal cracks (patches D5 and D9) went from low to medium severity. This section was overlaid shortly after the 1996 survey.

- VES—Patch E3 was partially replaced with asphalt concrete (AC). This patch contained a longitudinal crack and a transverse crack that divided the outer half of the patch into two pieces. The quartered portion of the patch was replaced with AC.

The condition of the surrounding pavement had not changed significantly since the last survey. Very few original joints remain at this site. Virtually all joints had been replaced with full-depth repairs because of severe D-cracking problems. Most cracks in the original pavement have also been repaired, so very few slabs are long enough to develop transverse cracks. Since the last survey, the ODOT apparently went through a cycle of AC patching at this site. Any areas showing spalling had been filled with AC patching material.

The original concrete near the patch joints started to show signs of D-cracking in some areas. Fine cracks in the D-cracking pattern were found at several repair joints at the corners of the original concrete. So far, these cracks are very tight. Similar cracks were also found on a few of the repairs, but most of the repairs are free of this type of cracking.

1997 Survey

In 1997, the Georgia sections were surveyed on October 30, and the Ohio sections were surveyed on November 6-7.

<u>Georgia Site</u>

At the Georgia sections, the only significant change from last year is the additional cracking in section 1 (GADOT mix). Two of the 4.5-m repairs had developed a crack. One of the 2.4-m repairs also was lost from this section, apparently because of the failure adjacent to the repair slab; the whole area had been removed and replaced with a new repair slab. No significant change in faulting was noted, and no material-related problems were observed.

<u>Ohio Site</u>

At the Ohio site, the only significant change is the noticeable increase in map cracking in the VES and ODOT FS mix sections (sections E, H, and I). As discussed under task B, delayed ettringite formation is the suspect cause of the noticeable increase in map cracking in these sections. In 1997, it was planned that additional cores would be taken in 1998 to verify the cause

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of the map cracking. As previously reported, the RSC 1 section was overlaid after the 1996 survey.

1998 Survey

In 1998, the Ohio sections were surveyed on October 22-23, and the Georgia sections were surveyed on November 4.

Georgia Site

The Georgia sections did not show any change in either structural or material condition since the last survey. Faulting levels remain very low and virtually unchanged throughout the entire monitoring period.

Ohio Site

The structural condition of the Ohio sections remained largely unchanged since the last survey, but some of the sections showed modest increase in map cracking that first became significantly noticeable in 1997. The only changes in structural condition were in section B (FT I) and section E (VES). Each section developed two additional transverse cracks. Faulting levels were again very low and virtually unchanged throughout the entire monitoring period. Sections E, H, and I (VES and FS mix sections) showed a modest increase in map cracking. Delayed ettringite formation was the suspected cause of the map cracking in these sections. Additional cores were taken from those sections to verify the cause of the map cracking. Both Pyrament sections (sections C and F) also exhibited some map cracking.

APPENDIX B

SUMMARY TABLES OF ANNUAL SURVEY DATA

Appendix B presents the distress summary tables for the Georgia and Ohio sites. Surveys from 1994 through 1998 are summarized in these tables. The following distress types are covered:

- Faulting.
- Transverse cracking.
- Longitudinal cracking.
- Corner breaks.

Table B1. Distress summary of SHRP C-206 (task D) sections in Georgia.

Repair No.	Repair Len, ft	f'c¹ psi	MR¹ psi	Transverse Cracking						Faulting, in — Approach Joint					Faulting, in — Leave Joint				
				SHRP	1994	1995	1996	1997	1998	1994	1995	1996	1997	1998	1994	1995	1996	1997	1998
Section 1, GA DOT																			
1-1	8	2,250	365	-	-	-	-	-	-	-0.07	-0.02	0.01	0.01	-0.04	0.15	-0.02	-0.04	-0.04	-0.08
1-3	8	2,050	350	-	-	-	-	-	-	0.00	0.02	0.00	-0.04	-0.07	0.00	-0.01	0.01	0.00	-0.02
1-4	8	2,050	350	-	-	-	-	-	-	0.02	-0.01	0.01	0.06	0.00	0.12	-0.01	0.00	-0.01	0.00
1-5	8	1,950	340	-	-	-	-	-	-	0.00	0.00	0.01	-0.02	0.01	0.05	0.00	0.00	-0.03	-0.04
1-6	8	1,950	340	-	-	-	-	-	-	-0.01	0.01	-0.02	0.00	-0.03	0.06	-0.01	0.00	0.00	-0.02
1-7	15	1,900	330	-	H	Replaced				-0.03	n/a	n/a	n/a	n/a	0.01	n/a	n/a	n/a	n/a
1-8	15	2,250	365	-	-	-	-	-	-	-0.02	-0.01	0.01	-0.02	-0.03	0.12	-0.01	0.00	0.03	0.00
1-9	8	2,250	360	-	-	-	-	-	-	-0.02	0.00	0.03	0.08	0.04	0.02	-0.01	-0.01	-0.02	-0.02
1-9A	18	-	-	-	-	-	-	-	-	0.01	0.02	0.02	0.06	0.03	0.05	-0.01	0.00	-0.05	-0.04
1-10	8	2,150	360	-	-	-	-	-	-	0.01	0.01	-0.01	0.00	0.00	0.09	-0.01	0.01	0.00	0.01
1-11	15	1,800	320	-	M	Replaced				-0.10	n/a	n/a	n/a	n/a	0.13	n/a	n/a	n/a	n/a
1-12	8	1,700	310	-	-	-	-	-	-	-0.10	0.03	0.02	0.04	0.06	0.05	0.00	0.02	0.01	0.02
1-13	8	1,650	305	-	-	-	-	-	-	-0.04	0.00	0.00	-0.01	0.01	0.08	0.01	0.02	0.03	0.06
1-14	15	1,550	295	-	-	-	-	H	Replaced	0.06	0.02	0.03	0.05	n/a	0.05	-0.01	-0.05	-0.06	n/a
1-15	8	1,550	295	-	-	-	-	Replaced	Replaced	-0.08	0.02	0.09	n/a	n/a	0.13	-0.01	-0.02	n/a	n/a
1-16	16	1,350	270	-	-	-	-	M	M	-0.01	0.04	0.03	-0.02	-0.08	0.02	-0.01	-0.02	-0.07	-0.07
1-17	15	1,200	245	-	-	-	H	Replaced	Replaced	-0.05	0.05	0.04	n/a	n/a	0.02	-0.01	0.00	n/a	n/a
1-18	15	1,200	245	-	-	-	-	-	-	-0.04	0.01	0.05	0.07	0.07	0.02	-0.02	0.00	-0.02	-0.04
1-19	15	1,000	200	-	-	-	-	-	-	0.00	0.03	0.02	0.02	0.02	-0.05	-0.01	0.06	0.06	-0.03
1-20	15	900	170	-	-	-	-	-	-	-0.01	0.00	-0.01	-0.01	-0.07	-0.01	-0.01	0.02	-0.02	-0.04
Percent Slab Cracking										**Approach Joint Average**					**Leave Joint Average**				
8-ft repairs				0%	0%	0%	0%	10%	10%	**1994**	**1995**	**1996**	**1997**	**1998**	**1994**	**1995**	**1996**	**1997**	**1998**
15-ft repairs				0%	20%	200%	30%	50%	50%	-0.02	0.01	0.02	0.02	-0.01	0.06	-0.01	0.00	-0.01	-0.02

¹Material properties at the time of opening to traffic; ²Repairs made adjacent to the existing repair.

1 m = 3.28 ft
1 MPa = 145.04 psi

Table B1. Distress summary of SHRP C-206 (task D) sections in Georgia. *(continued)*

Repair No.	Repair Len, ft	f'c[1] psi	MR[1] psi	Transverse Cracking						Faulting, in									
										Approach Joint					Leave Joint				
				SHRP	1994	1995	1996	1997	1998	1994	1995	1996	1997	1998	1994	1995	1996	1997	1998
Section 2, FT I																			
2-3A	7	1,300	250	-	-	-	-	-	-	0.00	0.05	0.05	0.05	0.05	0.02	-0.01	-0.03	0.00	-0.03
2-4	10	1,300	245	-	-	-	-	-	-	0.02	0.04	0.04	0.07	0.05	0.00	0.00	-0.01	0.01	-0.02
2-5	6	1,250	245	-	-	-	-	-	-	0.04	0.06	0.02	0.02	0.05	-0.05	-0.01	-0.03	-0.01	-0.04
2-6	12	1,250	245	-	-	-	-	-	-	0.05	0.05	0.04	0.01	0.01	0.00	-0.02	0.02	-0.01	-0.01
2-7	10	1,250	245	-	-	-	-	-	-	0.00	0.01	0.02	0.00	0.03	0.09	-0.01	-0.05	0.04	0.01
2-8	10	1,250	240	-	-	-	-	-	-	0.04	0.07	0.02	0.04	0.02	0.02	0.05	0.00	0.01	0.03
2-9	10	1,200	230	-	-	-	-	-	-	-0.01	0.02	0.03	0.06	0.03	0.09	0.02	0.03	0.02	0.02
2-10	10	1,200	230	-	-	-	-	-	-	0.03	0.00	0.05	0.02	0.01	0.02	0.04	0.00	0.02	0.00
2-11	10	1,150	230	-	-	-	-	-	-	0.06	0.09	0.04	0.03	0.01	0.07	0.00	0.01	-0.02	-0.03
2-12	6	1,150	225	-	-	-	-	-	-	0.06	0.04	0.18	0.20	0.29	0.08	0.08	0.07	0.09	0.08
2-13	11	1,150	225	-	-	-	-	-	-	0.05	0.10	0.06	0.04	0.08	0.28	0.09	0.10	0.19	0.14
2-14	6	1,100	220	-	-	-	-	-	-	0.00	-0.01	0.00	0.01	-0.02	0.12	0.05	0.06	0.07	0.07
2-15	6	1,100	215	-	-	-	-	-	-	0.02	0.11	0.05	0.05	0.07	0.09	0.02	0.02	0.03	0.01
2-16	6	1,100	215	-	-	-	-	-	-	-0.01	0.01	0.00	-0.01	-0.04	0.07	0.01	0.01	0.00	0.05
2-17	6	1,000	205	-	-	-	-	-	-	0.01	0.04	0.04	0.03	0.02	0.07		Replaced[2]		
2-18	7	1,000	205	-	-	-	-	-	-	-0.02	0.03	0.01	0.02	0.05	0.00	-0.01	-0.01	-0.03	-0.08
Percent Slab Cracking										**Approach Joint Average**					**Leave Joint Average**				
6- and 7-ft repairs				0%	0%	0%	0%	0%	0%	**1994**	**1995**	**1996**	**1997**	**1998**	**1994**	**1995**	**1996**	**1997**	**1998**
10- and 12-ft repairs				0%	0%	0%	0%	0%	0%	0.02	0.04	0.04	0.04	0.04	0.06	0.02	0.01	0.03	0.01

[1]Material properties at the time of opening to traffic; [2]Repairs made adjacent to the existing repair.

1 m = 3.28 ft
1 MPa = 145.04 psi

Table B1. Distress summary of SHRP C-206 (task D) sections in Georgia. *(continued)*

Repair No.	Repair Len, ft	f'c[1] psi	MR[1] psi	Transverse Cracking						Faulting, in									
				SHRP	1994	1995	1996	1997	1998	Approach Joint					Leave Joint				
										1994	1995	1996	1997	1998	1994	1995	1996	1997	1998
Section 3, VES																			
3-2	12	2,600	365	-	-	-	-	-	-	-0.06	0.01	0.01	0.00	0.00	0.01	0.01	0.01	-0.02	-0.03
3-3	12	2,500	360	-	-	-	-	-	-	-0.07	0.08	-0.01	-0.02	-0.05	0.01	0.01	0.00	0.07	0.03
3-4	12	2,450	350	-	-	-	-	-	-	-0.09	-0.01	0.03	-0.06	-0.07	0.01	0.06	0.03	0.05	0.02
3-5	12	2,350	335	-	-	-	-	-	-	-0.07	-0.01	-0.01	-0.05	-0.08	0.05	0.04	0.00	0.01	-0.02
3-6	8	2,350	335	-	-	-	-	-	-	-0.12	-0.01	-0.09	-0.06	-0.08	0.02	0.02	0.02	0.01	-0.03
3-7	12	2,200	320	-	-	-	-	-	-	-0.18	0.00	0.03	0.01	-0.01	0.08	-0.01	0.01	0.03	0.01
3-8	8	2,100	305	-	-	-	-	-	-	-0.05	0.00	-0.03	-0.02	-0.08	-0.01	-0.01	-0.04	-0.02	-0.07
3-9	8	2,050	300	-	-	-	-	-	-	-0.04	0.01	-0.03	-0.05	-0.06	0.00	0.01	-0.02	-0.01	-0.04
3-10	12	2,000	295	-	-	-	-	-	-	-0.01	0.00	-0.02	-0.02	n/a[2]	0.03	0.01	0.01	0.00	-0.03
3-11	12	1,950	290	-	-	-	-	-	-	0.01	0.02	0.01	0.04	-0.03	0.03	0.05	0.00	0.02	-0.04
3-12	8	1,800	270	-	-	-	-	-	-	-0.05	Replaced[2]				0.01	-0.02	-0.08	-0.11	-0.06
3-13	8	1,800	270	-	-	-	-	-	-	-0.05	0.03	0.04	0.05	0.00	0.04	-0.01	-0.03	-0.04	-0.02
3-14	12	1,700	260	-	-	-	-	-	-	-0.08	-0.03	-0.04	-0.01	-0.05	0.06	0.00	0.00	-0.02	-0.05
3-15	9	1,650	255	-	-	-	-	-	-	-0.01	-0.04	-0.03	0.00	0.00	-0.02	0.02	0.01	-0.02	0.00
3-16	12	1,550	230	-	-	-	-	-	-	-0.05	0.03	0.02	0.03	0.02	0.07	0.01	0.02	0.02	0.02
3-17	8	1,500	225	-	-	-	-	-	-	-0.01	0.00	0.01	0.00	-0.05	0.02	-0.01	-0.01	0.01	-0.07
3-18	8	1,500	225	-	-	-	-	-	-	-0.08	0.08	0.01	0.06	-0.01	0.05	0.00	0.00	0.03	-0.02
3-19	8	1,050	165	-	-	-	-	-	-	-0.07	0.05	-0.03	0.01	-0.05	0.01	-0.02	-0.03	-0.01	0.01
3-20	8	1,000	155	-	-	-	-	-	-	-0.01	0.00	0.01	0.04	0.02	0.03	-0.01	0.00	0.00	-0.02
Percent Slab Cracking										**Approach Joint Average**					**Leave Joint Average**				
8-ft repairs				0%	0%	0%	0%	0%	0%	1994	1995	1996	1997	1998	1994	1995	1996	1997	1998
12-ft repairs				0%	0%	0%	0%	0%	0%	-0.06	0.01	-0.01	0.00	-0.03	0.03	0.01	-0.01	0.00	-0.02

[1]Material properties at the time of opening to traffic; [2]Repairs made adjacent to the existing repair.

1 m = 3.28 ft
1 MPa = 145.04 psi

Table B2. Distress summary of SHRP C-206 (task D) sections in Ohio.

No.	Station	f'c[1] psi	MR[1] psi	Longitudinal Cracking						Transverse Cracking						Corner Breaks					
				SHRP	1994	1995	1996	1997	1998	SHRP	1994	1995	1996	1997	1998	SHRP	1994	1995	1996	1997	1998
HES - 10 to 26 hr Opening																					
A-2	148+17	4,650	520	L	L	L	L	L	L	-	-	-	-	-	-	-	-	-	-	-	-
A-3	148+57	4,600	520	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
A-4	148+82	4,450	510	L	L	L	L	L	L	-	-	-	-	-	-	-	-	-	-	-	-
A-5	149+00	4,350	500	-	-	-	-	-	L	-	-	-	-	-	-	-	-	-	-	-	-
A-6	149+21	3,800	455	-	-	-	-	-	L	-	-	-	-	-	-	-	-	-	-	-	-
A-7	149+40	3,750	455	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
A-8	149+53	3,750	455	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
A-9	149+65	3,700	450	L	L	L	L	L	L	-	-	-	-	-	-	-	-	-	-	-	-
A-10	150+05	3,700	450	-	-	-	-	-	L	-	-	-	-	-	-	-	-	-	-	-	-
Percent Slabs Cracked				33%	33%	33%	33%	33%	67%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
FT I - 10 to 26 hr Opening																					
B-2	113+57	4,350	585	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B-3	113+92	4,300	580	-	L	L	L	L	L	-	-	-	-	-	-	-	-	-	-	-	-
B-4	114+56	4,300	575	-	-	-	-	-	L	-	-	-	-	-	-	-	-	-	-	-	-
B-5	114+96	4,100	560	-	-	L	L	L	L	-	-	-	-	-	-	-	-	-	-	-	-
B-6	115+11	4,100	560	-	-	-	-	-	L	-	-	-	-	-	-	-	-	-	-	-	-
B-7	115+37	4,100	555	-	L	L	M	M	M	-	-	-	-	-	-	-	-	-	-	-	-
B-8	115+52	3,900	530	L	L	L	M	M	M	-	-	-	-	-	-	-	-	-	-	-	-
B-9	115+77	3,850	530	L	L	L	L	L	L	-	-	-	-	-	L	-	1L	1L	1L	1L	1L
B-10	115+94	3,850	530	-	L	L	L	L	L	-	-	-	-	-	L	-	-	-	-	-	-
Percent Slabs Cracked				22%	56%	67%	67%	67%	89%	0%	0%	0%	0%	0%	22%	0%	11%	11%	11%	11%	11%
PC 1 - 1 to 6 hr Opening																					
C-2	58+56	1,900	325	L	L	L	L	L	L	-	-	-	-	-	-	-	-	-	-	-	-
C-3	58+96	1,850	320	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
C-4	59+12	1,800	315	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
C-5	59+36	1,750	305	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
C-6	59+54	1,650	300	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
C-7	61+88	1,500	280	-	1994²	1994²	1994²	1994²	1994²	-	-	-	-	-	-	-	-	-	-	-	-
C-8	62+18	1,500	275	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
C-9	62+29	1,300	255	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
C-10	63+00	1,150	230	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Percent Slabs Cracked				11%	22%	22%	22%	22%	22%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

[1]Material properties at the time of opening to traffic; ²Year removed.

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1 MPa = 145.04 psi
1 m = 3.28 ft

Table B2. Distress summary of SHRP C-206 (task D) sections in Ohio. (*continued*)

No.	Station	f'c[1] psi	MR[1] psi	LT Cracking						Trans Cracking						Corner Breaks					
				SHRP	1994	1995	1996	1997	1998	SHRP	1994	1995	1996	1997	1998	SHRP	1994	1995	1996	1997	1998
RSC 1 - 1 to 6 hr Opening																					
D-2	1828+72	4,100	480	L	L	M	M	n/a[4]	n/a[4]	-	-	-	-	n/a[4]	n/a[4]	-	-	-	-	n/a[4]	n/a[4]
D-3	1829+11	3,950	460	L	L	L	L	n/a[4]	n/a[4]	-	-	-	-	n/a[4]	n/a[4]	-	-	-	-	n/a[4]	n/a[4]
D-4	1829+83	3,900	455	L	1994[2]	1994[2]	1994[2]	n/a[4]	n/a[4]	-	-	-	-	n/a[4]	n/a[4]	-	-	-	-	n/a[4]	n/a[4]
D-5	1830+25	3,750	440	-	L	L	M	n/a[4]	n/a[4]	-	-	-	-	n/a[4]	n/a[4]	-	-	-	-	n/a[4]	n/a[4]
D-6	1830+38	3,700	435	L	L	L	L	n/a[4]	n/a[4]	-	-	-	-	n/a[4]	n/a[4]	-	-	-	-	n/a[4]	n/a[4]
D-7	1831+84	3,200	380	L	L	M	M	n/a[4]	n/a[4]	-	-	-	-	n/a[4]	n/a[4]	-	-	-	-	n/a[4]	n/a[4]
D-8	1832+20	3,200	380	L	L	L	L	n/a[4]	n/a[4]	-	-	-	-	n/a[4]	n/a[4]	-	-	-	-	n/a[4]	n/a[4]
D-9	1832+34	2,150	245	L	L	L	M	n/a[4]	n/a[4]	-	-	-	-	n/a[4]	n/a[4]	-	-	-	-	n/a[4]	n/a[4]
D-10	1832+61	2,150	245	L	L	L	L	n/a[4]	n/a[4]	-	-	-	-	n/a[4]	n/a[4]	-	-	-	-	n/a[4]	n/a[4]
Percent Slabs Cracked				89%	100%	100%	100%	-	-	0%	0%	0%	0%	-	-	0%	0%	0%	0%	-	-
VES - 3 to 8 hr Opening																					
E-2	106+58	3,100	375	L	L	L	L	L	L	-	-	-	-	-	-	-	-	-	-	-	-
E-3	106+28	3,050	370	HL	L	L	1996[3]	1996[3]	1996[3]	-	-	H	1996[3]	1996[3]	1996[3]	-	-	-	1996[3]	1996[3]	1996[3]
E-4	105+82	2,550	340	-	L	L	L	L	L	-	-	-	-	-	-	-	2L	2L	2L	2L	2L
E-5	105+44	2,050	310	HL	L	L	L	L	L	-	-	-	-	-	-	-	-	-	-	-	-
E-6	105+04	2,050	310	L	L	L	L	L	L	-	-	-	-	-	1998[3]	-	-	-	-	-	-
E-7	104+65	1,300	260	-	L	L	L	L	L	-	-	-	-	-	1998[3]	-	-	-	-	-	-
E-8	104+20	1,300	260	L	L	L	L	L	L	-	-	-	-	-	-	-	-	-	-	-	-
E-9	103+87	1,000	240	-	L	L	L	L	L	-	-	-	-	-	-	-	1L	1L	1L	1L	1L
E-10	103+30	1,000	240	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Percent Slabs Cracked				56%	89%	89%	89%	89%	89%	0%	0%	11%	11%	11%	33%	0%	22%	22%	22%	22%	22%
PC 2 - 3 to 8 hr Opening																					
F-2	112+02	1,500	290	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
F-3	111+77	1,400	275	L	L	L	L	L	L	-	-	-	-	-	-	-	-	-	-	-	-
F-4	111+65	1,400	270	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
F-5	111+45	1,350	260	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
F-6	111+24	1,350	255	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
F-7	111+07	1,300	250	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
F-8	110+29	1,250	250	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
F-9	109+91	1,200	235	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
F-10	109+40	1,150	220	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Percent Slabs Cracked				11%	11%	11%	11%	11%	11%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

[1]Material properties at the time of opening to traffic; [2]Year removed; [3]Partially patched over with AC; [4]Overlaid in 1996.

1 MPa = 145.04 psi
1 m = 3.28 ft

Table B2. Distress summary of SHRP C-206 (task D) sections in Ohio. *(continued)*

No.	Station	f'c[1] psi	MR[1] psi	LT Cracking						Trans Cracking						Corner Breaks					
				SHRP	1994	1995	1996	1997	1998	SHRP	1994	1995	1996	1997	1998	SHRP	1994	1995	1996	1997	1998
RSC 2 - 3 to 8 hr Opening																					
G-2	135+70	3,950	535	-	L	L	L	L	L	-	-	-	-	-	-	-	-	-	-	-	-
G-3	134+73	3,350	500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
G-4	133+69	3,150	465	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
G-5	133+42	3,150	465	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
G-6	132+67	2,600	420	-	-	-	-	L	L	-	-	-	-	-	-	-	-	-	-	-	-
G-7	131+44	2,600	420	-	L	L	L	L	L	-	-	-	-	-	-	-	-	-	-	-	-
G-8	131+11	2,150	375	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
G-9	129+94	1,950	350	-	L	L	L	L	L	-	-	-	-	-	-	-	-	-	-	-	-
G-10	129+43	1,850	310	-	L	L	L	L	L	-	-	-	-	-	-	-	-	-	-	-	-
Percent Slabs Cracked				0%	44%	44%	44%	56%	56%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
FS - 3 to 8 hr Opening																					
H-2	152+53	5,250	540	L	L	L	L	L	L	-	L	L	L	L	H	-	-	-	-	-	-
H-3	151+11	5,500	565	L	L	L	L	L	L	-	-	-	-	-	-	-	-	-	-	-	-
H-4	149+48	5,150	535	L	L	L	L	L	L	-	-	-	-	-	-	-	-	-	-	-	-
H-5	148+66	5,100	530	L	L	L	L	L	L	-	-	-	-	-	-	-	-	-	-	-	-
H-6	147+57	4,550	470	L	L	L	L	L	L	-	-	-	-	-	-	-	-	-	-	-	-
H-7	147+03	4,450	465	L	L	L	L	L	L	-	-	-	-	-	-	-	-	-	-	-	-
H-8	146+68	1,100	135	L	L	L	L	L	L	-	-	-	-	-	-	-	-	-	-	-	-
H-9	145+04	1,100	135	L	L	L	L	L	L	-	-	-	-	-	-	-	-	-	-	-	-
H-10	144+25	1,100	135	L	L	L	L	L	L	-	-	-	-	-	L	-	-	-	-	-	-
Percent Slabs Cracked				100%	100%	100%	100%	100%	100%	0%	11%	11%	11%	11%	22%	0%	0%	0%	0%	0%	0%

[1]Material properties at the time of opening to traffic.

1 MPa = 145.04 psi
1 m = 3.28 ft

Table B3. Faulting summary of SHRP C-206 (task D) sections in Ohio.

No.	Station	f'c[1] psi	MR[1] psi	Approach 1994	1995	1996	1997	1998	Leave 1994	1995	1996	1997	1998
				Faulting, in									
HES - 10 to 26 hr Opening													
A-2	148+17	4,650	520	-0.01	-0.01	0.00	0.00	0.03	0.06	0.05	0.04	0.04	0.05
A-3	148+57	4,600	520	-0.01	0.01	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00
A-4	148+82	4,450	510	0.02	0.01	0.01	0.02	0.02	0.12	0.10	0.13	0.07	n/a
A-5	149+00	4,350	500	-0.02	-0.02	0.01	-0.01	-0.01	0.01	0.00	-0.01	-0.02	-0.02
A-6	149+21	3,800	455	0.00	-0.01	-0.01	-0.05	0.00	0.07	0.02	0.06	0.07	0.04
A-7	149+40	3,750	455	-0.02	-0.01	-0.01	-0.02	0.00	0.05	0.08	0.03	0.06	0.05
A-8	149+53	3,750	455	-0.05	-0.05	-0.06	-0.07	-0.06	-0.01	0.02	0.01	-0.01	0.00
A-9	149+65	3,700	450	0.04	0.02	0.02	0.04	0.01	0.02	0.03	0.06	0.05	0.06
A-10	150+05	3,700	450	-0.01	-0.01	0.00	-0.02	-0.04	0.06	0.03	0.05	0.07	0.07
			Average	**-0.01**	**-0.01**	**0.00**	**-0.01**	**-0.01**	**0.05**	**0.04**	**0.04**	**0.04**	**0.03**
FT I - 10 to 26 hr Opening													
B-2	113+57	4,350	585	0.03	0.02	0.01	-0.01	0.03	0.06	0.01	0.04	0.00	0.04
B-3	113+92	4,300	580	0.01	0.03	0.01	0.03	0.04	0.12	0.10	0.12	0.13	0.13
B-4	114+56	4,300	575	0.01	0.00	-0.02	-0.04	0.00	0.00	0.00	-0.01	-0.03	-0.02
B-5	114+96	4,100	560	0.00	0.00	0.01	0.01	0.03	0.13	0.10	0.10	0.10	0.10
B-6	115+11	4,100	560	0.01	0.01	0.02	0.05	0.06	0.07	0.04	0.03	0.05	0.06
B-7	115+37	4,100	555	0.00	0.01	0.03	0.06	0.07	0.12	0.05	0.03	0.00	0.09
B-8	115+52	3,900	530	0.04	0.04	0.06	0.10	0.20	0.01	-0.02	n/a	n/a	n/a
B-9	115+77	3,850	530	0.04	0.02	0.04	0.03	0.01	0.09	-0.02	0.00	0.04	0.04
B-10	115+94	3,850	530	0.01	0.03	0.02	0.04	0.04	0.01	0.02	0.03	0.02	0.00
			Average	**0.02**	**0.02**	**0.02**	**0.03**	**0.05**	**0.07**	**0.03**	**0.04**	**0.04**	**0.06**
PC 1 - 1 to 6 hr Opening													
C-2	58+56	1,900	325	0.02	0.00	0.00	-0.01	0.01	0.00	-0.01	-0.02	-0.01	0.01
C-3	58+96	1,850	320	0.01	0.00	-0.01	-0.01	-0.01	0.02	-0.01	0.00	0.02	-0.01
C-4	59+12	1,800	315	-0.01	0.00	0.01	-0.05	-0.05	0.01	-0.01	0.01	-0.01	0.00
C-5	59+36	1,750	305	0.01	0.00	-0.01	-0.01	-0.01	0.02	0.03	0.03	0.04	0.04
C-6	59+54	1,650	300	-0.01	-0.01	0.00	-0.01	0.00	0.02	0.01	0.03	0.00	0.02
C-7	61+88	1,500	280	1994[2]	1994[2]	1994[2]	1994[2]	1994[2]	1994[2]	1994[2]	1994[2]	1994[2]	1994[2]
C-8	62+18	1,500	275	0.00	-0.02	-0.02	-0.03	-0.03	0.00	0.01	0.01	-0.02	0.01
C-9	62+29	1,300	255	0.02	0.01	0.01	0.01	0.00	0.01	0.00	0.01	-0.02	-0.01
C-10	63+00	1,150	230	0.00	-0.01	-0.02	0.01	-0.01	0.05	0.04	0.01	-0.04	0.03
			Average	**0.01**	**0.00**	**-0.01**	**-0.01**	**-0.01**	**0.02**	**0.01**	**0.01**	**-0.01**	**0.01**
RSC 1 - 1 to 6 hr Opening													
D-2	1828+72	4,100	480	-0.28	-0.28	-0.27	n/a[3]	n/a[3]	0.13	0.19	0.16	n/a[3]	n/a[3]
D-3	1829+11	3,950	460	-0.24	-0.19	-0.17	n/a[3]	n/a[3]	0.13	0.19	0.16	n/a[3]	n/a[3]
D-4	1829+83	3,900	455	1994[2]	1994[2]	1994[2]	n/a[3]	n/a[3]	0.13	0.19	0.16	n/a[3]	n/a[3]
D-5	1830+25	3,750	440	-0.10	-0.07	-0.07	n/a[3]	n/a[3]	0.13	0.19	0.16	n/a[3]	n/a[3]
D-6	1830+38	3,700	435	-0.12	-0.20	-0.20	n/a[3]	n/a[3]	0.13	0.19	0.16	n/a[3]	n/a[3]
D-7	1831+84	3,200	380	-0.18	-0.18	-0.16	n/a[3]	n/a[3]	0.13	0.19	0.16	n/a[3]	n/a[3]
D-8	1832+20	3,200	380	-0.33	-0.24	-0.27	n/a[3]	n/a[3]	0.13	0.19	0.16	n/a[3]	n/a[3]
D-9	1832+34	2,150	245	-0.16	-0.14	-0.10	n/a[3]	n/a[3]	0.13	0.19	0.16	n/a[3]	n/a[3]
D-10	1832+61	2,150	245	0.19	-0.10	-0.12	n/a[3]	n/a[3]	0.13	0.19	0.16	n/a[3]	n/a[3]
			Average	**-0.15**	**-0.18**	**-0.17**	**n/a**	**n/a**	**0.13**	**0.19**	**0.16**	**n/a**	**n/a**

[1]Material properties at the time of opening to traffic; [2]Year removed; [3]Overlaid in 1996

1 MPa = 145.04 psi
1 inch = 25.4 mm

Table B3. Faulting summary of SHRP C-206 (task D) sections in Ohio. *(continued)*

No.	Station	f'c[1] psi	MR[1] psi	Approach 1994	1995	1996	1997	1998	Leave 1994	1995	1996	1997	1998
VES - 3 to 8 hr Opening													
E-2	106+58	3,100	375	0.03	0.00	0.02	0.01	0.01	0.04	0.05	0.03	0.04	0.05
E-3	106+28	3,050	370	-0.03	-0.02	1996[3]	1996[3]	1996[3]	-0.02	0.00	1996[3]	1996[3]	1996[3]
E-4	105+82	2,550	340	0.05	0.04	0.05	0.06	0.06	0.05	-0.01	0.03	0.00	0.02
E-5	105+44	2,050	310	0.02	0.03	0.02	0.00	0.02	0.02	0.00	0.00	0.00	0.02
E-6	105+04	2,050	310	-0.01	-0.02	-0.02	-0.05	-0.08	0.00	-0.01	-0.01	0.00	1998[3]
E-7	104+65	1,300	260	0.01	-0.02	0.00	0.00	1998[3]	0.03	0.04	0.02	0.01	1998[3]
E-8	104+20	1,300	260	0.01	0.00	0.01	0.00	0.01	0.05	0.04	0.04	0.05	0.08
E-9	103+87	1,000	240	-0.01	0.00	-0.01	0.03	1998[3]	0.05	0.04	0.04	0.05	0.04
E-10	103+30	1,000	240	0.00	-0.02	-0.04	-0.02	-0.02	0.07	0.02	0.03	0.03	0.03
			Average	**0.01**	**0.00**	**0.00**	**0.00**	**0.00**	**0.03**	**0.02**	**0.02**	**0.02**	**0.04**
PC 2 - 3 to 8 hr Opening													
F-2	112+02	1,500	290	-0.03	-0.04	0.00	-0.01	0.00	0.00	0.01	-0.01	-0.03	-0.02
F-3	111+77	1,400	275	-0.01	0.00	-0.01	-0.02	-0.02	-0.01	0.00	0.00	-0.01	0.00
F-4	111+65	1,400	270	-0.01	-0.01	-0.01	-0.01	0.02	0.07	0.08	0.07	0.07	0.07
F-5	111+45	1,350	260	0.00	-0.02	0.02	-0.01	-0.01	0.04	0.07	0.07	0.04	0.04
F-6	111+24	1,350	255	0.02	-0.01	0.00	0.01	0.03	0.02	0.01	0.02	0.01	0.03
F-7	111+07	1,300	250	0.01	-0.03	-0.02	-0.02	-0.01	0.04	0.00	0.03	0.04	0.02
F-8	110+29	1,250	250	-0.03	-0.06	-0.01	-0.03	-0.03	0.02	0.02	0.02	0.02	0.01
F-9	109+91	1,200	235	-0.01	-0.01	0.01	-0.01	-0.01	0.06	0.05	0.04	0.03	0.03
F-10	109+40	1,150	220	-0.01	0.00	-0.02	-0.01	0.00	0.03	0.03	0.02	0.02	0.02
			Average	**-0.01**	**-0.02**	**0.00**	**-0.01**	**0.00**	**0.03**	**0.03**	**0.03**	**0.02**	**0.02**
RSC 2 - 3 to 8 hr Opening													
G-2	135+70	3,950	535	0.03	0.05	0.07	0.06	0.09	0.00	-0.01	-0.02	0.02	-0.02
G-3	134+73	3,350	500	0.00	-0.02	0.01	0.00	0.01	0.01	0.07	0.09	0.07	0.08
G-4	133+69	3,150	465	0.05	0.06	0.05	0.07	0.05	0.06	-0.03	-0.02	-0.03	-0.05
G-5	133+42	3,150	465	0.04	0.02	0.00	0.00	0.01	0.06	-0.01	-0.02	-0.04	0.00
G-6	132+67	2,600	420	0.00	0.03	0.02	0.04	0.01	0.01	0.00	0.02	0.01	0.04
G-7	131+44	2,600	420	0.05	0.08	0.05	0.02	0.02	0.02	0.00	-0.02	0.00	-0.03
G-8	131+11	2,150	375	0.00	0.02	0.00	n/a	n/a	0.05	0.03	0.03	0.02	0.01
G-9	129+94	1,950	350	0.01	0.05	0.07	0.03	0.04	-0.03	-0.03	-0.04	-0.06	-0.04
G-10	129+43	1,850	310	0.01	0.02	0.01	0.05	n/a	0.04	0.03	0.03	0.06	0.06
			Average	**0.02**	**0.03**	**0.03**	**0.03**	**0.03**	**0.02**	**0.01**	**0.01**	**0.01**	**0.01**
FS - 3 to 8 hr Opening													
H-2	152+53	5,250	540	0.01	0.00	0.01	0.02	n/a	0.06	0.02	0.05	0.06	n/a
H-3	151+11	5,500	565	0.05	0.03	0.02	0.03	0.01	0.11	0.07	0.10	0.05	0.07
H-4	149+48	5,150	535	0.04	0.02	0.04	0.01	n/a	0.06	0.04	0.03	0.04	0.00
H-5	148+66	5,100	530	0.04	0.02	0.01	0.01	n/a	0.00	0.00	0.01	-0.01	0.00
H-6	147+57	4,550	470	0.02	0.00	0.00	0.00	0.03	0.05	0.00	0.01	0.02	0.04
H-7	147+03	4,450	465	0.02	0.00	0.00	-0.01	-0.01	0.00	-0.01	-0.01	0.00	-0.01
H-8	146+68	1,100	135	0.01	0.00	0.02	-0.02	0.10	0.04	0.03	0.08	0.07	0.07
H-9	145+04	1,100	135	0.00	0.02	-0.01	-0.02	0.01	0.04	0.00	-0.01	0.02	0.00
H-10	144+25	1,100	135	0.05	0.04	0.03	n/a	n/a	0.04	0.03	0.01	0.02	n/a
			Average	**0.03**	**0.01**	**0.01**	**0.00**	**0.03**	**0.04**	**0.02**	**0.03**	**0.03**	**0.02**

[1]Material properties at the time of opening to traffic; [2]Year removed; [3]Partially patched over with AC.

1 MPa = 145.04 psi
1 inch = 25.4 mm

Table B3. Faulting summary of SHRP C-206 (task D) sections in Ohio. *(continued)*

No.	Station	f'c[1] psi	MR[1] psi	Faulting, in Approach					Leave				
				1994	1995	1996	1997	1998	1994	1995	1996	1997	1998
VES - 3 to 8 hr Opening													
E-2	106+58	3,100	375	0.03	0.00	0.02	0.01	0.01	0.04	0.05	0.03	0.04	0.05
E-3	106+28	3,050	370	-0.03	-0.02	1996[3]	1996[3]	1996[3]	-0.02	0.00	1996[3]	1996[3]	1996[3]
E-4	105+82	2,550	340	0.05	0.04	0.05	0.06	0.06	0.05	-0.01	0.03	0.00	0.02
E-5	105+44	2,050	310	0.02	0.03	0.02	0.00	0.02	0.02	0.00	0.00	0.00	0.02
E-6	105+04	2,050	310	-0.01	-0.02	-0.02	-0.05	-0.08	0.00	-0.01	-0.01	0.00	1998[3]
E-7	104+65	1,300	260	0.01	-0.02	0.00	0.00	1998[3]	0.03	0.04	0.02	0.01	1998[3]
E-8	104+20	1,300	260	0.01	0.00	0.01	0.00	0.01	0.05	0.04	0.04	0.05	0.08
E-9	103+87	1,000	240	-0.01	0.00	-0.01	0.03	1998[3]	0.05	0.04	0.04	0.05	0.04
E-10	103+30	1,000	240	0.00	-0.02	-0.04	-0.02	-0.02	0.07	0.02	0.03	0.03	0.03
			Average	**0.01**	**0.00**	**0.00**	**0.00**	**0.00**	**0.03**	**0.02**	**0.02**	**0.02**	**0.04**
PC 2 - 3 to 8 hr Opening													
F-2	112+02	1,500	290	-0.03	-0.04	0.00	-0.01	0.00	0.00	0.01	-0.01	-0.03	-0.02
F-3	111+77	1,400	275	-0.01	0.00	-0.01	-0.02	-0.02	-0.01	0.00	0.00	-0.01	0.00
F-4	111+65	1,400	270	-0.01	-0.01	-0.01	-0.01	0.02	0.07	0.08	0.07	0.07	0.07
F-5	111+45	1,350	260	0.00	-0.02	0.02	-0.01	-0.01	0.04	0.07	0.07	0.04	0.04
F-6	111+24	1,350	255	0.02	-0.01	0.00	0.01	0.03	0.02	0.01	0.02	0.01	0.03
F-7	111+07	1,300	250	0.01	-0.03	-0.02	-0.02	-0.01	0.04	0.00	0.03	0.04	0.02
F-8	110+29	1,250	250	-0.03	-0.06	-0.01	-0.03	-0.03	0.02	0.02	0.02	0.02	0.01
F-9	109+91	1,200	235	-0.01	-0.01	0.01	-0.01	-0.01	0.06	0.05	0.04	0.03	0.03
F-10	109+40	1,150	220	-0.01	0.00	-0.02	-0.01	0.00	0.03	0.03	0.02	0.02	0.02
			Average	**-0.01**	**-0.02**	**0.00**	**-0.01**	**0.00**	**0.03**	**0.03**	**0.03**	**0.02**	**0.02**
RSC 2 - 3 to 8 hr Opening													
G-2	135+70	3,950	535	0.03	0.05	0.07	0.06	0.09	0.00	-0.01	-0.02	0.02	-0.02
G-3	134+73	3,350	500	0.00	-0.02	0.01	0.00	0.01	0.01	0.07	0.09	0.07	0.08
G-4	133+69	3,150	465	0.05	0.06	0.05	0.07	0.05	0.06	-0.03	-0.02	-0.03	-0.05
G-5	133+42	3,150	465	0.04	0.02	0.00	0.00	0.01	0.06	-0.01	-0.02	-0.04	0.00
G-6	132+67	2,600	420	0.00	0.03	0.02	0.04	0.01	0.01	0.00	0.02	0.01	0.04
G-7	131+44	2,600	420	0.05	0.08	0.05	0.02	0.02	0.02	0.00	-0.02	0.00	-0.03
G-8	131+11	2,150	375	0.00	0.02	0.00	n/a	n/a	0.05	0.03	0.03	0.02	0.01
G-9	129+94	1,950	350	0.01	0.05	0.07	0.03	0.04	-0.03	-0.03	-0.04	-0.06	-0.04
G-10	129+43	1,850	310	0.01	0.02	0.01	0.05	n/a	0.04	0.03	0.03	0.06	0.06
			Average	**0.02**	**0.03**	**0.03**	**0.03**	**0.03**	**0.02**	**0.01**	**0.01**	**0.01**	**0.01**
FS - 3 to 8 hr Opening													
H-2	152+53	5,250	540	0.01	0.00	0.01	0.02	n/a	0.06	0.02	0.05	0.06	n/a
H-3	151+11	5,500	565	0.05	0.03	0.02	0.03	0.01	0.11	0.07	0.10	0.05	0.07
H-4	149+48	5,150	535	0.04	0.02	0.04	0.01	n/a	0.06	0.04	0.03	0.04	0.00
H-5	148+66	5,100	530	0.04	0.02	0.01	0.01	n/a	0.00	0.00	0.01	-0.01	0.00
H-6	147+57	4,550	470	0.02	0.00	0.00	0.00	0.03	0.05	0.00	0.01	0.02	0.04
H-7	147+03	4,450	465	0.02	0.00	0.00	-0.01	-0.01	0.00	-0.01	-0.01	0.00	-0.01
H-8	146+68	1,100	135	0.01	0.00	0.02	-0.02	0.10	0.04	0.03	0.08	0.07	0.07
H-9	145+04	1,100	135	0.00	0.02	-0.01	-0.02	0.01	0.04	0.00	-0.01	0.02	0.00
H-10	144+25	1,100	135	0.05	0.04	0.03	n/a	n/a	0.04	0.03	0.01	0.02	n/a
			Average	**0.03**	**0.01**	**0.01**	**0.00**	**0.03**	**0.04**	**0.02**	**0.03**	**0.03**	**0.02**

[1]Material properties at the time of opening to traffic; [2]Year removed; [3]Partially patched over with AC.

1 MPa = 145.04 psi
1 inch = 25.4 mm

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