Project No. 10-69

Guidelines for Dowel Alignment in Concrete Pavements

APPENDIX B
FIELD TESTING RESULTS

Prepared for
NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM (NCHRP)
Transportation Research Board
of
The National Academies

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Minneapolis, MN
February 2009

APPENDIX B FIELD TESTING RESULTS

The field testing evaluations in the research report are detailed in this appendix. It includes an overview of the data collected, performance analysis within sections that experienced significant misalignments, and case studies giving insight into the field testing procedure.

B.1 Data Collection Overview

Table B.1 gives the details of each section, including parameters like the pavement design, traffic, age, climate, materials, and so on. Table B.2 lists the misalignments measured in each section given. The testing operations performed in each section are given in table B.3.

Table B.1. Specific details for test sections.

Section ID	State	LTPP ID	City	Route	Direction	Const. Year	ADT	Joint Spacing, m	Slab Thickness, mm	Dowel Size, mm	Basket/DBI	Scan Date	Lanes	Number of Joints	Number of Dowel Bars
1-AZ1	Arizona	04-0214	Phoenix	Interstate 10	EB	1993	52,000	4.57	211	32	Basket	9/5/2007	Lane 2	33	363
1-AZ2	Arizona	04-0222	Phoenix	Interstate 10	EB	1993	52,000	4.57	218	32	Basket	9/5/2007	Lane 2	33	362
1-AZ3	Arizona	04-0218	Phoenix	Interstate 10	EB	1993	52,000	4.57	211	32	Basket	9/5/2007	Lane 2	33	363
1-AZ4	Arizona	04-0220	Phoenix	Interstate 10	EB	1993	52,000	4.57	287	38	Basket	9/5/2007	Lane 2	32	382
1-AZ5	Arizona	04-0224	Phoenix	Interstate 10	EB	1993	52,000	4.57	272	38	Basket	9/6/2007	Lane 2	33	387
1-AZ6	Arizona	04-0216	Phoenix	Interstate 10	EB	1993	52,000	4.57	284	38	Basket	9/6/2007	Lane 2	32	379
1-AZ7	Arizona	04-0215	Phoenix	Interstate 10	EB	1993	52,000	4.57	287	38	Basket	9/6/2007	Lane 2	32	344
1-AZ8	Arizona	04-0223	Phoenix	Interstate 10	EB	1993	52,000	4.57	287	38	Basket	9/6/2007	Lane 2	32	349
1-AZ9	Arizona	n/a	Phoenix	Interstate 10	EB	1993	52,000	4.57	287	38	Basket	9/6/2007	Lane 2	13	143
1-CA1	California	n/a	Victorville	Interstate 15	SB	2005	56,000	4.57	280	38	Basket	8/28/2007	Lane 3	9	79
1-CA2	California	n/a	Victorville	Interstate 15	SB	2005	56,000	4.57	280	38	Basket	8/29/2007	Lane 3	38	304
1-CA3	California	n/a	Bakersfield	Route 58	EB	2001	78,000	4.57	240	38	Retrofit	8/30/2007	Lane 3	34	233
1-GA1	Georgia	13-3019	Gainesville	Route 23	SB	1987	35,000	6.09	229	29	Basket	12/18/2007	Lane 2	24	215
1-IL1	Illinois	n/a	Chicago	Interstate 355	NB	2007	115,000	4.57	300	38	DBI	7/23/2007	Lane 3	35	385
1-IL2	Illinois	n/a	Chicago	Interstate 355	NB	1988	95,000	4.57	250	38	Basket	7/24/2007	Lane 3	35	362
1-IN1	Indiana	n/a	Lafayette	Route 231	SB	1999	23,500	5.49	280	32	Basket	7/23/2007	Lane 2	47	542
1-IN2	Indiana	n/a	Lafayette	Route 231	SB	1998	23,500	5.49	280	32	Basket	7/23/2007	Lane 2	50	545
1-KS1	Kansas	n/a	Williamsburg	Interstate 35	NB	1996	14,500	4.57	290	38	DBI	9/27/2007	Lane 2	35	362
1-KS2	Kansas	n/a	Williamsburg	Interstate 35	NB	1998	14,500	4.57	280	38	DBI	9/27/2007	Lane 2	34	408
1-MN1A	Minnesota	n/a	Hawley	Route 10	WB	2007	11,500	4.57	180	32	Basket	7/19/2007	Lanes 1 & 2	9	197
1-MN1B	Minnesota	n/a	Hawley	Route 10	WB	2007	11,500	4.57	180	32	Basket	7/19/2007	Lanes 1 & 2	49	1083
1-MN2	Minnesota	n/a	Staples	Route 10	WB	2005	11,000	4.57	180	32	Basket	7/20/2007	Lane 1	35	334
1-MN3	Minnesota	n/a	Hutchinson	Route 22	WB	2006	7,000	4.57	215	32	Basket	7/20/2007	Lane 2	35	410
1-MN4	Minnesota	n/a	MnROAD	Low Vol. Loop		1993	n/a	4.57 Skewed	160	25	Basket	7/21/2007	Lanes 1 & 2	32	709
1-MO1	Missouri	n/a	Jefferson City	Route 63	SB	1993	20,000	4.57	300	38	Basket	11/28/2006	Lane 2	25	281
1-MO2	Missouri	n/a	Jefferson City	Route 54	EB	1994	26,000	4.57	300	38	Basket	11/28/2006	Lane 2	35	431
1-NC1	North Caroli	37-0207	Lexington	Route 52	SB	1992	22,000	4.57	275	38	DBI	12/19/2007	Lane 2	22	238
1-NC2	North Caroli	37-0260	Lexington	Route 52	SB	1992	22,000	4.57	275	38	DBI	12/19/2007	Lane 2	32	313
1-NC3	North Caroli	37-0211	Lexington	Route 52	SB	1992	22,000	4.57	275	38	DBI	12/19/2007	Lane 2	32	329
1-NC4	North Caroli	37-0212	Lexington	Route 52	SB	1992	22,000	4.57	275	38	DBI	12/19/2007	Lane 2	35	342
1-OH1	Ohio	39-0203	Columbus	Route 23	NB	1994	38,000	4.57	275	38	Basket	11/16/2007	Lane 2	33	396
1-OH2	Ohio	39-0207	Columbus	Route 23	NB	1994	38,000	4.57	275	38	Basket	11/16/2007	Lane 2	31	366
1-OH3	Ohio	39-0208	Columbus	Route 23	NB	1994	38,000	4.57	275	38	Basket	11/16/2007	Lane 2	31	325
1-OH4	Ohio	39-0262	Columbus	Route 23	NB	1994	38,000	4.57	275	38	Basket	11/16/2007	Lane 2	34	371
1-WI1	Wisconsin	n/a	Ashland	Route 2	EB	2005	16,500	4.57	230	32	Basket	5/16/2007	Lane 2	34	374
1-WI2	Wisconsin	n/a	Wausau	Route 29	WB	1990	9,500	Random*	275	38	Basket	7/25/2007	Lane 2	30	356
1-WI3	Wisconsin	n/a	Wausau	Route 29	WB	1989	9,500	Random**	275	38	Basket	7/25/2007	Lane 2	34	383

Table B.2. MIT Scan-2 results summary for test sections.

Section ID	Vertical Depth Deviation, mm negative is up				Horizontal Skew, mm				Vertical Skew, mm				Longitudinal Translation, mm Negative is left of joint			
	Actual Values		Absolute Values		Actual Values		Absolute Values		Actual Values		Absolute Values		Actual Values		Absolute Values	
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
1-AZ1	-9.2	9.7	11.9	6.1	-1.0	5.3	3.8	3.8	2.3	5.5	5.1	5.3	9.9	23.5	21.2	14.2
1-AZ2	-11.3	9.6	12.2	8.4	-6.7	6.2	7.4	5.3	0.6	4.9	4.0	2.9	-0.6	19.3	15.7	11.1
1-AZ3	-13.0	9.1	13.6	8.2	1.0	7.6	6.3	4.3	-0.6	4.8	4.0	2.7	-4.0	21.4	17.5	12.9
1-AZ4	-22.9	10.3	23.0	10.1	2.1	4.5	4.0	3.1	6.6	6.3	8.3	3.7	26.5	23.6	32.2	14.9
1-AZ5	-27.8	8.6	27.8	8.5	1.6	6.5	5.2	4.1	1.2	7.4	6.7	3.2	3.2	30.6	27.2	14.3
1-AZ6	-17.7	9.2	18.5	7.3	-3.7	6.3	5.5	4.8	-4.8	10.3	10.1	5.3	-15.2	32.9	32.7	15.6
1-AZ7	-20.7	14.0	21.3	13.1	-4.9	10.3	8.1	8.0	1.0	9.5	8.0	5.3	1.1	31.5	26.6	17.0
1-AZ8	-21.2	10.9	21.3	10.7	-0.9	6.5	5.2	4.1	-4.9	7.6	8.0	4.1	-18.8	30.3	31.5	16.6
1-AZ9	-22.7	7.5	22.7	7.5	2.3	5.2	4.5	3.4	1.0	6.5	5.1	4.2	4.0	22.2	18.8	12.4
1-CA1	8.8	14.3	16.2	4.1	1.8	4.4	3.6	3.0	5.7	7.8	7.8	5.7	28.5	19.9	28.7	19.6
1-CA2	19.3	3.4	19.3	3.4	-3.8	4.1	4.5	3.3	2.3	5.6	4.4	4.2	8.3	18.2	16.3	11.5
1-CA3	-2.8	6.0	4.6	4.7	-11.3	36.3	14.2	35.2	0.7	5.4	3.6	4.1	-5.7	27.8	14.7	24.2
1-GA1	18.8	9.8	20.2	6.4	-2.1	8.4	6.2	6.0	3.5	7.3	6.5	4.8	1.6	15.8	10.9	11.6
1-IL1	15.4	6.2	15.4	6.2	1.4	4.0	3.3	2.6	-0.7	6.6	4.0	5.3	-9.2	20.3	16.6	14.9
1-IL2	18.9	11.1	19.4	10.2	-1.2	12.7	9.4	8.6	4.3	18.3	13.1	13.5	25.0	43.4	40.2	29.7
1-IN1	5.2	10.6	9.8	6.6	-1.4	6.5	5.3	4.0	1.2	9.8	6.4	7.5	-1.6	17.6	13.2	11.7
1-IN2	20.4	14.5	21.1	13.4	-0.4	5.2	4.1	3.2	0.0	5.1	4.1	3.1	-7.0	9.7	9.5	7.4
1-KS1	3.7	9.9	8.3	6.5	0.5	6.6	5.2	4.1	5.0	7.0	6.8	5.2	-34.4	22.5	35.4	20.8
1-KS2	13.8	6.4	14.0	5.9	0.3	8.2	6.4	5.2	-5.1	8.4	7.8	5.9	-10.4	25.9	19.2	20.3
1-MN1A	-6.8	14.7	14.3	7.5	4.4	8.9	7.6	6.4	-20.1	14.7	20.3	14.4	-55.6	13.4	55.7	12.7
1-MN1B	-21.4	15.5	23.0	12.9	6.4	8.0	8.0	6.3	-7.0	23.1	14.2	19.5	-29.6	40.5	47.2	16.9
1-MN2	-9.2	12.4	12.0	9.7	0.7	10.4	8.4	6.1	-6.1	10.8	10.1	7.2	-29.4	31.1	40.9	12.4
1-MN3	-7.4	11.2	11.8	6.3	-0.1	6.6	4.9	4.4	-0.9	6.8	5.5	4.1	-9.0	38.8	35.5	18.1
1-MN4	16.4	7.5	16.4	7.4	0.1	11.8	9.1	7.5	5.8	14.4	10.7	11.2	-11.5	38.7	25.1	31.6
1-MO1	5.2	5.1	6.2	3.8	-3.5	5.6	5.3	3.9	-2.0	3.8	3.2	2.8	-14.6	19.0	18.2	15.6
1-MO2	2.2	14.4	11.7	8.7	-0.1	6.0	4.6	3.9	-2.2	6.7	5.3	4.6	2.5	18.2	14.2	11.6
1-NC1	-2.5	6.6	6.0	3.8	2.9	7.1	6.0	4.7	1.3	6.3	5.1	4.0	-2.1	16.0	12.1	10.7
1-NC2	4.8	7.2	6.9	5.2	1.5	6.1	4.7	4.2	4.6	7.9	6.5	6.5	-3.6	19.5	15.0	12.9
1-NC3	9.6	6.0	10.2	4.9	0.5	5.6	4.2	3.6	2.9	5.5	4.9	3.8	-6.1	20.1	15.5	14.1
1-NC4	-1.9	5.1	4.4	3.2	-1.1	6.1	5.1	3.6	2.6	6.0	5.1	4.1	-4.2	16.6	13.9	9.9
1-OH1	-22.7	7.5	22.7	7.5	-7.3	4.9	7.6	4.4	8.4	8.3	9.4	7.1	0.1	17.3	14.0	10.2
1-OH2	-10.4	6.1	10.7	5.6	-2.6	6.8	6.0	4.2	-4.3	10.0	8.5	6.9	-6.8	19.0	16.7	11.2
1-OH3	-10.0	5.9	10.0	5.8	-3.2	5.0	4.5	3.8	1.7	6.3	4.9	4.3	3.5	20.5	15.5	13.9
1-OH4	-6.4	9.2	9.6	5.8	-1.6	5.1	3.9	3.5	2.5	8.2	6.6	5.4	-2.9	16.8	14.3	9.2
1-WI1	3.0	15.3	11.3	10.8	-3.2	11.4	7.9	8.8	2.7	11.3	8.7	7.7	5.4	48.5	39.4	28.7
1-WI2	1.1	8.2	4.6	6.8	-0.2	8.1	3.9	7.1	5.3	7.8	7.2	6.1	-6.4	21.7	14.6	17.3
1-WI3	9.9	7.2	10.3	6.6	3.5	8.4	6.9	6.0	8.9	15.0	12.6	12.0	13.4	44.4	32.4	33.1

Table B.3. Testing operations performed on each test section.

Section ID	MIT Scan-2 Dowel Alignment	Field Distress Survey	Faulting Measurements	Falling Weight Deflectometer
1-AZ1	X	X	X	b
1-AZ2	X	X	X	b
1-AZ3	X	X	X	b
1-AZ4	X	X	X	b
1-AZ5	X	X	X	b
1-AZ6	X	X	X	b
1-AZ7	X	X	X	b
1-AZ8	X	X	X	b
1-AZ9	X	X	X	
1-CA1	X	X	X	X
1-CA2	X	X	X	X
1-CA3	X	X	X	X
1-GA1	X	X	X	b
1-IL1	X	a	a	
1-IL2	X	X	X	
1-IN1	X	X	X	
1-IN2	X	X	X	
1-KS1	X	X	X	
1-KS2	X	X	X	
1-MN1A	X	a	a	
1-MN1B	X	a	a	
1-MN2	X	X	X	
1-MN3	X	a	a	
1-MN4	X	X	X	
1-MO1	X	X	X	
1-MO2	X	X	X	
1-NC1	X	X	X	b
1-NC2	X	X	X	b
1-NC3	X	X	X	b
1-NC4	X	X	X	b
1-OH1	X	X	X	b
1-OH2	X	X	X	b
1-OH3	X	X	X	b
1-OH4	X	X	X	b
1-WI1	X	X	X	
1-WI2	X	X	X	
1-WI3	X	X	X	

a New Pavement
b LTPP FWD Data

B.2 Project-Level Analysis

As discussed in the research report, project-level analysis was conducted to minimize the effect of confounding factors in the field comparisons, such as variation in design, traffic, age, climate, and materials. Since the dowel alignment levels are not uniform within each project, the effect of dowel misalignment on distresses within the sections was analyzed. Two types of analysis were conducted. Joints or slabs with high levels of distresses were grouped, and the dowel misalignments for those joints were compared with the misalignment of the dowels in joints with no significant distresses. Another approach involved ranking the joints with respect to misalignment level and comparing the distresses of those joints or adjacent slabs.

B.2.1 Section 1-AZ3

Thirty percent of the slabs on 1-AZ3 exhibited transverse cracking, and none of the joints had any major spalling. The project-level analysis included a statistical analysis comparing joints adjacent to slabs that exhibited transverse cracks with joints adjacent to slabs that did not exhibit any transverse cracking. Sixteen of the 33 joints were adjacent to slabs with transverse cracking (Group A), and 17 of the 33 joints had both adjacent slabs without any transverse cracking (Group B). Student's t-tests were conducted to establish if there were any statistical differences between these two sets of joints with regards to average absolute values of vertical and longitudinal translation, vertical skew, and horizontal tilt at the individual joints. The results are summarized in table B.4.

Table B.4. Student's t-test results for 1-AZ3 comparing vertical translation, longitudinal translation, vertical skew, and horizontal tilt of joints adjacent to transverse cracks with joints adjacent to intact slabs.

Measure	Group	Mean, mm	Standard Deviation, mm	t-stat	t-critical (95% 2 tail)	P-Value
Vertical translation	A (n = 16)	13.67	4.02	0.1252	2.0395	0.901
	B (n = 17)	13.51	3.17			
Longitudinal translation	A (n = 16)	17.82	10.32	0.1666	2.0395	0.869
	B (n = 17)	17.23	9.84			
Vertical skew	A (n = 16)	4.03	1.17	0.1061	2.0395	0.916
	B (n = 17)	3.97	1.80			
Horizontal tilt	A (n = 16)	4.98	1.97	3.0921	2.0395	0.004
	B (n = 17)	7.55	2.72			

* Group A: Adjacent to slabs with transverse cracking.
Group B: No transverse cracking on adjacent slabs.

Table B.5 shows that there is no statistical difference in average vertical translation, average longitudinal translation, and average vertical skew between joints that are adjacent to slabs exhibiting transverse cracking and joints adjacent to intact slabs. With

regards to horizontal tilt, for this section there is a statistical difference between the two groups. However, the joints adjacent to the intact slabs had higher levels of average horizontal tilt than the joints adjacent to cracked slabs. This is in all likelihood a statistical anomaly and not a causal factor—in other words, a higher level of horizontal misalignment does mean improved cracking performance. The actual levels of misalignments of both groups are below 8 mm, which is well within any available tolerance specifications. Laboratory data from this study and past studies show that this level of rotation is negligible and should not cause joint lockup.

An alternate analysis method is shown in table B.5. The average values of vertical translation, longitudinal translation, vertical tilt, and horizontal skew in the individual joints are sorted from low to high values, shown in the second column of each group. The corresponding joint numbers are shown in the first column. The third column for each group shows whether the joint is adjacent to a slab exhibiting transverse cracking. If joints with high levels of vertical translation, longitudinal translation, vertical tilt, or horizontal skew caused transverse cracking (e.g., through the locking of these joints), then more joints at the lower end of the table would correspond to transverse cracks and fewer joints at the upper end of the table would correspond to transverse cracks. However, it can be observed that the transverse cracks do not correspond with the higher levels of misalignment in section 1-AZ3.

It should be noted that this pavement section, as well as a majority of the other sections, did not have very high levels of misalignment. The highest levels of misalignments were observed in the basket section 1-IL2. However, even for this section, the Student's t-test shows that there is no statistical difference between the slab cracking for the joints with aligned and misaligned dowels. Therefore, the results of the project-level analysis suggest that, within the non-extreme levels of translations (vertical and horizontal) and misalignments (vertical tilt and horizontal skew) measured in this study, there apparently is no difference in the amount of transverse cracking or joint spalling between joints with low and high average translations and misalignments.

Table B.5. Transverse cracking at 1-AZ3 as related to sorted (low to high) values of individual joints average vertical translation, longitudinal translation, vertical tilt, and horizontal skew.

Vertical Translation			Longitudinal Translation			Vertical Tilt			Horizontal Skew		
Joint #	VT	Trans. Crk.?	Joint #	LT	Trans. Crk.?	Joint #	VT	Trans. Crk.?	Joint #	HS	Trans. Crk.?
18	7.6	TC	15	2.2	TC	11	2.0		18	2.7	TC
7	7.9		11	4.3		30	2.0		27	3.0	TC
15	8.4	TC	23	5.4	TC	23	2.1	TC	25	3.2	TC
12	9.2		24	6.3	TC	9	2.4		15	3.3	TC
14	9.3	TC	12	7.3		17	2.7		19	3.3	TC
3	9.4		1	7.6		26	2.7	TC	8	3.8	
27	9.6	TC	31	7.7		2	2.7		20	4.0	TC
10	10.1		17	8.5		3	2.8		24	4.3	TC
1	10.3		27	9.0	TC	24	2.9	TC	21	4.3	TC
6	10.3	TC	14	9.1	TC	33	3.0		4	4.6	
23	10.4	TC	28	12.3		14	3.1	TC	3	4.6	
16	11.8	TC	10	12.4		6	3.2	TC	13	4.6	TC
9	12.0		3	12.8		15	3.2	TC	17	4.7	
28	13.5		18	13.3	TC	12	3.2		23	5.1	TC
29	13.7		33	13.3		31	3.3		12	5.2	
33	13.9		30	13.4		16	3.3	TC	1	5.3	
31	14.1		26	15.1	TC	1	3.3		5	5.4	TC
19	14.2	TC	16	15.2	TC	10	3.4		14	5.8	TC
21	14.7	TC	9	17.7		27	3.7	TC	6	5.9	TC
22	15.7	TC	19	20.5	TC	28	4.0		32	6.0	
17	15.9		6	21.4	TC	5	4.2	TC	11	7.0	
32	16.0		21	23.6	TC	21	4.4	TC	16	7.2	TC
8	16.0		5	23.9	TC	18	4.7	TC	22	7.5	TC
24	16.2	TC	2	24.7		22	4.9	TC	28	7.6	
4	16.2		13	25.0	TC	19	5.0	TC	7	7.7	
11	16.4		25	25.2	TC	20	5.1	TC	10	7.7	
30	16.6		8	25.3		8	5.6		9	9.2	
25	17.1	TC	22	27.7	TC	25	6.0	TC	29	9.8	
5	17.2	TC	29	30.0		13	6.0	TC	26	10.0	TC
13	17.7	TC	32	30.4		4	6.0		33	10.3	
2	18.5		4	31.0		29	6.8		2	10.7	
20	18.9	TC	7	34.1		32	7.1		30	11.6	
26	19.8	TC	20	42.0	TC	7	7.1		31	12.5	

B.2.2 Section 1-AZ9

Thirty-one percent of the slabs on 1-AZ9 exhibited transverse cracking, and none of the joints had any major spalling. Five of the 13 joints were adjacent to slabs with transverse cracking (Group A), and 8 of the 13 joints had both adjacent slabs without any transverse cracking (Group B). The results of Student's t-tests between these two sets of joints with regards to average absolute values of vertical translation, longitudinal translation, vertical skew, and horizontal tilt, at the individual joints, are summarized in table B.6.

Table B.6. Student's t-test results for 1-AZ9 comparing vertical translation, longitudinal translation, vertical skew, and horizontal tilt of joints adjacent to transverse cracks with joints adjacent to intact slabs.

Measure	Group	Mean, mm	Standard Deviation, mm	t-stat	t-critical (95% 2 tail)	P-Value
Vertical translation	A (n = 5)	21.17	3.28	1.2349	2.2009	0.243
	B (n = 8)	23.62	3.59			
Longitudinal translation	A (n = 5)	16.17	12.36	0.7676	2.2009	0.459
	B (n = 8)	20.37	7.57			
Vertical tilt	A (n = 5)	3.70	2.99	1.2114	2.2009	0.251
	B (n = 8)	6.00	3.52			
Horizontal skew	A (n = 5)	4.39	1.16	0.1391	2.2009	0.891
	B (n = 8)	4.55	2.45			

* Group A: Adjacent to slabs with transverse cracking.
Group B: No transverse cracking on adjacent slabs.

Table B.6 shows that there is no statistical difference in average vertical translation, average longitudinal translation, average vertical skew, and average horizontal tilt between joints that are adjacent to slabs exhibiting transverse cracking and joints adjacent to intact slabs.

The average values of individual joints vertical translation, longitudinal translation, vertical tilt, and horizontal skew sorted from low to high values are shown in table B.7. The table shows that the transverse cracks are evenly distributed from the top to the bottom of the table in each of the four categories, suggesting no significant effect of average vertical translation, longitudinal translation, vertical tilt, or horizontal skew on transverse cracking on 1-AZ9.

Table B.7. Transverse cracking at 1-AZ9 related to sorted (low to high) values of individual joints average vertical translation, longitudinal translation, vertical tilt, and horizontal skew

Vertical Translation			Longitudinal Translation			Vertical Tilt			Horizontal Skew		
Joint #	VT	Trans. Crk.?	Joint #	LT	Trans. Crk.?	Joint #	VT	Trans. Crk.?	Joint #	HS	Trans. Crk.?
7	16.5		9	5.1	TC	9	1.1	TC	10	1.7	
13	17.2	TC	13	8.5	TC	13	1.5	TC	2	1.8	
8	19.1	TC	11	9.2	TC	4	1.8		3	3.0	
11	21.2	TC	4	10.1		11	2.2	TC	13	3.1	TC
2	21.9		5	14.7		10	3.0		1	3.4	
9	22.7	TC	10	15.2		7	3.1		12	3.4	TC
5	23.0		7	16.6		5	4.1		9	4.3	TC
4	23.3		3	19.8		12	6.1	TC	5	4.8	
3	23.8		12	24.0	TC	3	6.5		8	5.4	TC
1	25.1		2	27.3		8	7.6	TC	11	5.7	TC
12	25.7	TC	1	29.6		1	8.6		7	6.6	
10	26.5		6	29.8		6	10.2		6	7.4	
6	28.7		8	34.0	TC	2	10.7		4	7.7	

B.2.3 Section 1-IL2

Fourteen percent of the slabs on 1-IL2 exhibited transverse cracking, and one joint had major spalling. Nine of the 35 joints were adjacent to slabs with transverse cracking (Group A), and 26 of the 35 joints had both adjacent slabs without any transverse cracking (Group B). The results of Student's t-tests between these two sets of joints with regards to average absolute values of vertical translation, longitudinal translation, vertical skew, and horizontal tilt, at the individual joints, are summarized in table B.8. The table shows that there is no statistical difference in average vertical translation, average longitudinal translation, average vertical skew, and average horizontal tilt between joints that are adjacent to slabs exhibiting transverse cracking and joints adjacent to intact slabs. The average values of individual joints vertical translation, longitudinal translation, vertical tilt, and horizontal skew sorted from low to high values are shown in table B.9. The table shows that the transverse cracks are evenly distributed from the top to the bottom of the table in each of the four categories, suggesting no significant effect of average vertical translation, longitudinal translation, vertical tilt, or horizontal skew on transverse cracking on 1-IL2.

Table B.8. Student's t-test results for 1-IL2 comparing vertical translation, longitudinal translation, vertical skew, and horizontal tilt of joints adjacent to transverse cracks with joints adjacent to intact slabs.

Measure	Group	Mean, mm	Standard Deviation, mm	t-stat	t-critical (95% 2 tail)	P-Value
Vertical translation	A (n = 9)	20.14	5.65	0.5330	2.0345	0.598
	B (n = 26)	18.96	5.78			
Longitudinal translation	A (n = 9)	40.26	26.01	0.0849	2.0345	0.933
	B (n = 26)	41.11	25.91			
Vertical tilt	A (n = 9)	15.52	6.71	1.0237	2.0345	0.313
	B (n = 26)	12.48	7.97			
Horizontal skew	A (n = 9)	7.70	3.49	1.2727	2.0345	0.212
	B (n = 26)	9.98	4.94			

* Group A: Adjacent to slabs with transverse cracking.
Group B: No transverse cracking on adjacent slabs.

Table B.9. Transverse cracking at 1-IL2 as related to sorted (low to high) values of individual joints average vertical translation, longitudinal translation, vertical tilt, and horizontal skew.

Vertical Translation			Longitudinal Translation			Vertical Tilt			Horizontal Skew		
Joint #	VT	Trans. Crk.?	Joint #	LT	Trans. Crk.?	Joint #	VT	Trans. Crk.?	Joint #	HS	Trans. Crk.?
7	2.9		20	9.4		33	3.5		10	3.0	
1	6.5		23	10.8	TC	35	5.3		22	3.3	TC
4	9.3	TC	35	11.6		18	5.4		23	4.5	TC
28	11.9		33	12.2		16	5.6		20	4.7	
29	13.7		5	15.7		8	5.9		31	4.8	
5	14.0		18	18.1		20	5.9		32	5.0	
10	15.3		8	19.3		23	6.9	TC	35	5.7	
24	16.0	TC	2	21.7		28	7.5		33	5.9	
11	16.9		16	22.5		6	7.7		4	6.0	TC
31	17.3		22	22.6	TC	2	8.2		6	6.4	
33	18.6		13	23.0	TC	21	8.8	TC	3	6.7	TC
32	19.1		3	27.6	TC	5	9.3		30	6.9	
18	19.1		6	27.7		15	9.4		14	7.1	
21	19.4	TC	14	27.8		14	10.1		27	7.3	
20	19.5		9	30.2		27	10.3		19	7.5	
8	19.8		21	32.2	TC	19	10.8		21	7.5	TC
19	19.9		7	32.9		4	11.6	TC	13	7.7	TC
12	19.9	TC	11	33.6		32	12.5		18	8.4	
25	20.0	TC	24	39.3	TC	31	12.7		16	8.6	
34	20.2		28	39.4		3	13.1	TC	24	8.8	TC
13	20.6	TC	4	40.6	TC	17	13.3		12	9.1	TC
26	20.6		27	41.6		11	13.9		7	10.0	
3	20.8	TC	10	42.1		1	14.6		9	10.2	
6	21.2		32	42.4		30	14.7		5	10.3	
35	21.9		31	42.5		9	15.9		29	10.6	
17	22.0		17	46.8		24	16.0	TC	26	11.2	
27	22.7		15	58.3		13	16.7	TC	17	11.3	
15	23.0		30	59.9		22	17.0	TC	34	13.1	
16	23.2		19	62.5		10	18.3		11	13.5	
2	23.3		34	64.8		34	18.6		8	13.9	
14	24.4		12	80.1	TC	7	18.8		28	14.3	
23	26.1	TC	1	81.7		25	20.0	TC	2	14.6	
9	26.4		25	86.3	TC	26	23.4		25	15.6	TC
22	29.2	TC	26	90.1		12	29.5	TC	1	22.3	
30	29.8		29	114.1		29	42.8		15	22.8	

B.2.4 Section 1-WI2

Forty percent of the joints on 1-WI2 exhibited high- or medium-severity spalling. Twelve of the 30 joints had high- or medium-severity spalling (Group A), and 18 of the 30 joints had no spalling or very minor (low severity) spalling shallower than 0.5 in. The results of Student's t-tests between these two sets of joints with regards to average absolute values of vertical translation, longitudinal translation, vertical skew, and horizontal tilt, at the individual joints, are summarized in table B.10. The table shows

that there is no statistical difference in average vertical translation, average longitudinal translation, average vertical skew, and average horizontal tilt between joints with high/medium severity spalling and joints with no/minimal spalling. The average values of individual joints vertical translation, longitudinal translation, vertical tilt, and horizontal skew sorted from low to high values are shown in table B.11. The table shows that the high- and medium-severity spalls are evenly distributed from the top to the bottom of the table in each of the four categories, suggesting no significant effect of average vertical translation, longitudinal translation, vertical tilt, or horizontal skew on spalling on 1-WI2.

Table B.10. Student's t-test results for 1-IL2 comparing vertical translation, longitudinal translation, vertical skew, and horizontal tilt of joints with high and medium severity spalling versus joints with minimal or no spalling.

Measure	Group	Mean, mm	Standard Deviation, mm	t-stat	t-critical (95% 2 tail)	P-Value
Vertical translation	A (n = 12)	5.04	3.90	0.6022	2.0484	0.552
	B (n = 18)	4.39	2.04			
Longitudinal translation	A (n = 12)	18.55	15.65	1.0483	2.0484	0.303
	B (n = 18)	12.34	16.03			
Vertical skew	A (n = 12)	6.76	3.68	0.6573	2.0484	0.516
	B (n = 18)	7.46	2.17			
Horizontal tilt	A (n = 12)	2.77	0.72	1.4811	2.0484	0.150
	B (n = 18)	4.62	4.25			

* Group A: Joints with high or medium severity spalling.
Group B: Joints without any spalling or only minor (low severity) spalling.

Table B.11. High and medium severity spalling at 1-WI2 as related to sorted (low to high) values of individual joints average vertical translation, longitudinal translation, vertical tilt, and horizontal skew.

Vertical Translation			Longitudinal Translation			Vertical Tilt			Horizontal Skew		
Joint #	VT	HS/MS Spall?	Joint #	LT	HS/MS Spall?	Joint #	VT	HS/MS Spall?	Joint #	HS	HS/MS Spall?
6	1.7	HS	29	1.4		4	2.3	HS	3	1.9	MS
19	1.8		20	2.0	HS	23	3.8	HS	20	1.9	HS
25	2.1		13	3.0		3	4.0	MS	6	1.9	HS
14	2.5	HS	28	3.2		11	4.0		12	2.0	
4	2.6	HS	25	3.5		7	4.2	MS	14	2.0	HS
15	2.7	HS	18	3.9		14	4.3	HS	16	2.1	
17	2.8	HS	10	4.3	HS	19	4.4		21	2.1	
13	2.9		11	4.6		21	4.5		28	2.2	
24	3.0		9	5.3		15	4.8	HS	25	2.4	
8	3.0		16	5.6		1	5.7	MS	7	2.5	MS
27	3.1		8	5.7		5	5.8		19	2.6	
20	3.1	HS	3	5.9	MS	24	5.9		4	2.6	HS
28	3.3		15	6.0	HS	27	6.4		18	2.7	
11	3.5		21	7.1		28	6.6		29	2.8	
5	3.6		2	8.3	HS	8	6.9		17	3.0	HS
7	3.8	MS	26	8.5		18	7.2		15	3.0	HS
29	4.1		30	9.6		30	7.3		24	3.1	
23	4.3	HS	5	11.8		10	7.7	HS	27	3.3	
26	4.3		6	12.6	HS	13	7.8		26	3.4	
3	4.3	MS	24	15.2		9	8.1		2	3.4	HS
16	4.4		22	17.3		12	8.8		10	3.5	HS
18	4.7		4	17.4	HS	26	8.9		23	3.6	HS
12	5.0		7	18.0	MS	20	9.4	HS	13	3.7	
9	5.9		23	20.1	HS	22	9.5		1	3.9	MS
21	6.8		19	22.3		2	9.5	HS	5	3.9	
10	7.0	HS	27	23.3		16	9.8		8	4.0	
22	7.3		14	40.6	HS	6	10.8	HS	11	5.6	
30	10.0		1	43.6	MS	29	10.8		30	6.8	
2	11.7	HS	17	43.8	HS	25	11.6		9	11.5	
1	13.9	MS	12	70.8		17	14.7	HS	22	19.0	

The results of the project-level analysis suggest that, within the normal levels of translations (vertical and horizontal) and misalignments (vertical tilt and horizontal skew), there apparently is no difference in the amount of transverse cracking or joint spalling between joints with low and high average translations and misalignments. However, it should be noted that none of these sections had very high levels of translations and misalignments. The highest levels of translations and misalignments were observed in the basket section 1-IL2. At 1-IL2, a larger percent of the joints with average vertical tilts greater than 5/8 in. (16 mm) had adjacent slabs that exhibited transverse cracking.

B.3 Joint Opening Analysis

Two of the sections where dowel alignment data were collected using the MIT Scan-2 were sections where joint opening had been monitored over the years as part of the LTPP program: 1-AZ7 (LTPP section 04-0215) and 1-GA1 (LTPP section 13-3019). The joint opening data for these two sections were retrieved from the LTPP database. Joint opening data was collected as part of the LTPP program at six joints (joints 27 through 32) on section 1-AZ7 and five joints (joints 1 through 5) on section 1-GA1 over a period of approximately 10 years using the LTPP protocol for measuring joint opening. Figures B.1 and B.2 show the joint opening at 1-AZ7 and 1-GA1 over the years the data were collected. Each point represents the average gage readings of three locations (pavement edge, middle of lane, inside lane edge) at a joint relative to the smallest average gage reading at that joint.

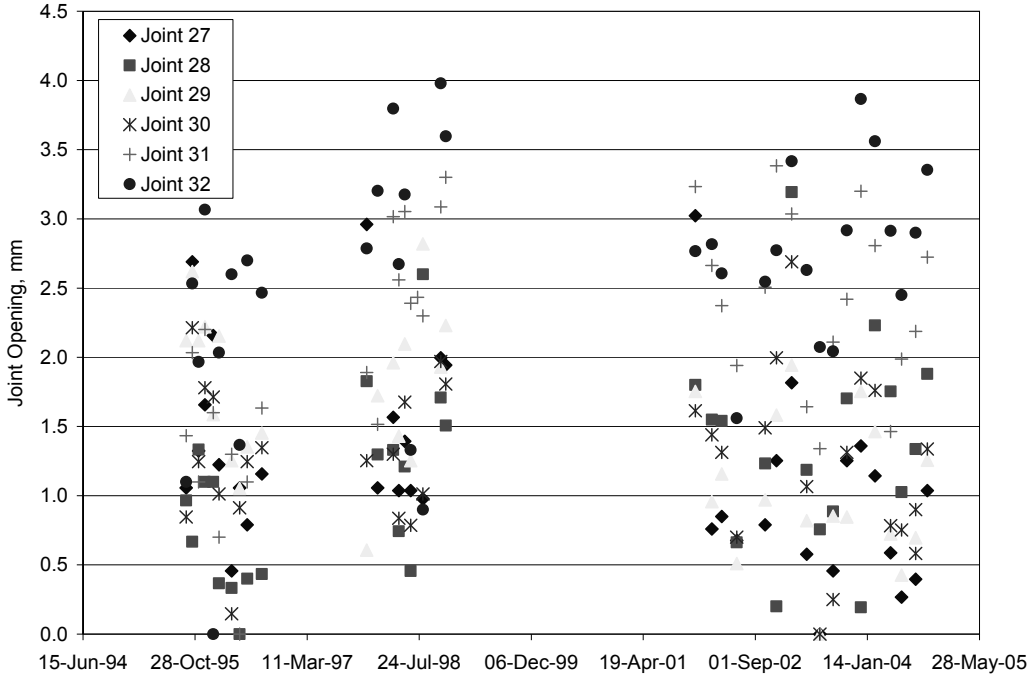


Figure B.1. Joint opening at 1-AZ7 (LTPP 04-0215) measured over a 10-year period.

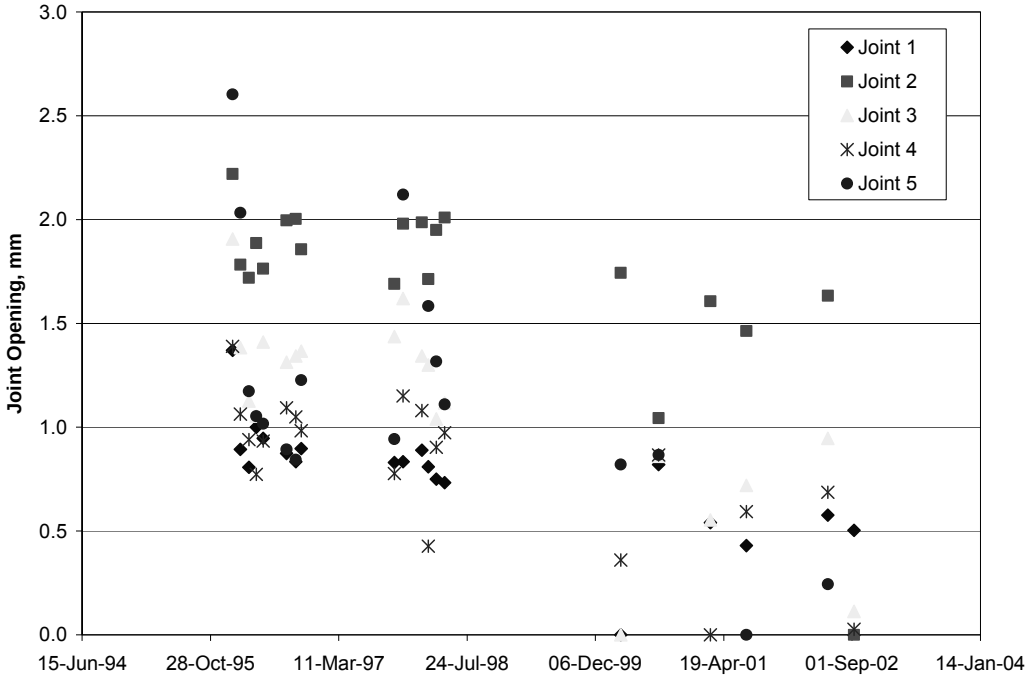


Figure B.2. Joint opening at 1-GA1 (LTPP 13-3019) measured over a 10-year period.

All 11 joints opened and closed (moved) depending on ambient conditions of temperature, moisture, and slab-base friction over the 10-year period. Tables B.12 and B.13 show the maximum joint opening, average vertical translation, average longitudinal translation, average vertical tilt, and average horizontal skew for joints at 1-AZ1 and 1-GA1, respectively. No effects of translations or misalignments can be seen. It should be noted that none of these joints had very high levels of translations or misalignments, and nine joints is a very small sample size; any conclusions should be used cautiously.

Table B.12. Maximum joint opening, vertical translation, longitudinal translation, vertical tilt, and horizontal skew for joints 27 through 32 at 1-AZ1.

JOINT NO	OPENING (MM)	Vertical Translation	Longitudinal Translation	Vertical Tilt	Horizontal Skew
27	3.0	22	18	5	7
28	3.2	26	20	6	2
29	2.8	11	26	5	3
30	2.7	26	48	10	5
31	3.4	15	30	9	6
32	4.0	17	20	8	6

Table B.13. Maximum joint opening, vertical translation, longitudinal translation, vertical tilt, and horizontal skew for joints 1 through 5 at 1-GA1.

JOINT NO	OPENING (MM)	Vertical Translation	Longitudinal Translation	Vertical Tilt	Horizontal Skew
1	1.4	9	34	9	4
2	2.2	26	4	5	6
3	1.9	26	9	2	7
4	1.4	25	10	4	6
5	2.6	28	16	14	6

B.4 Case Studies

The case studies detail the general testing procedure followed at all of the test sections in this study. Four example case studies are included below:

- 1-IN1—Good to excellent dowel alignment and position with minimal distresses
- 1-WI2—Good to excellent dowel alignment but significant high severity joint spalling (unrelated to dowel alignment or position)
- 1-OH1—Poor to fair dowel alignment but no distresses
- 1-IL2—Poor to fair dowel alignment and position and distresses that could not be correlated to dowel alignment or position

B.4.1 Section 1-IN1

This project was constructed in 1999 just south of Lafayette, IN, and consists of an 11-in. JPCP on cement treated base, 18-ft joint spacing, 1.25-in. dowel bars placed in basket, and tied concrete shoulders. The surveyed section starts about 1,000 ft south of South River Rd. All data were collected in the outside lane (lane 2). This section is subject to moderately high traffic: the 2002 ADT on this section was 19,490, and the estimated 2007 ADT on this section is 23,500.

This section has good dowel alignment. Figure B.3 shows that only 0.9% of bars have horizontal skew greater than 18 mm, and only 4.4% of bars have vertical tilt greater than 18 mm. The distributions of mean and range of end to end horizontal skews and vertical tilts for each of the bar positions are shown in Figures B.4 and B.5. A summary table of the results and descriptions of terms in the table are shown in Figure B.6. A photographic overview of 1-IN1 is shown in Figures B.7 through B.9.

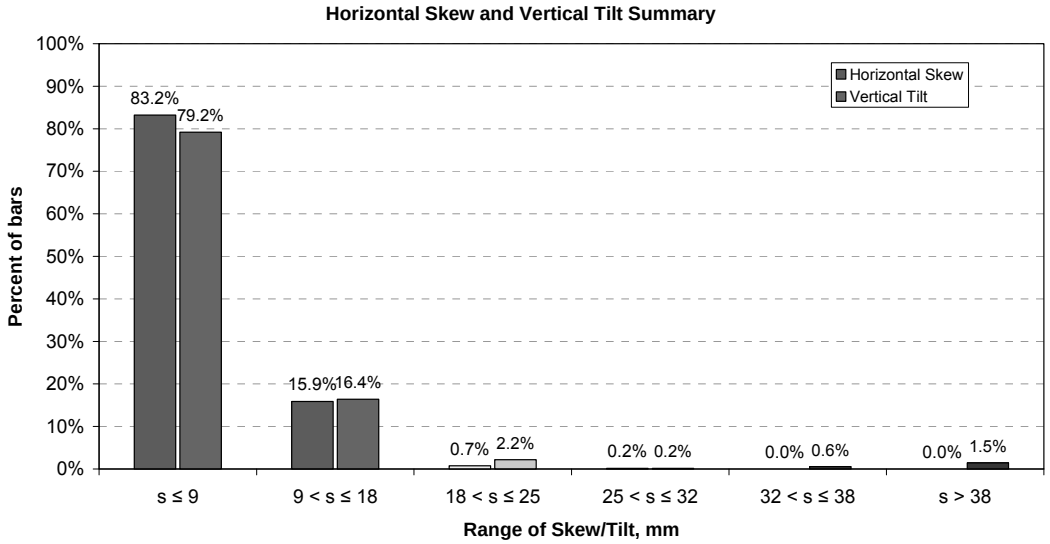


Figure B.3. Distribution of horizontal skews and vertical tilts results for 1-IN1.

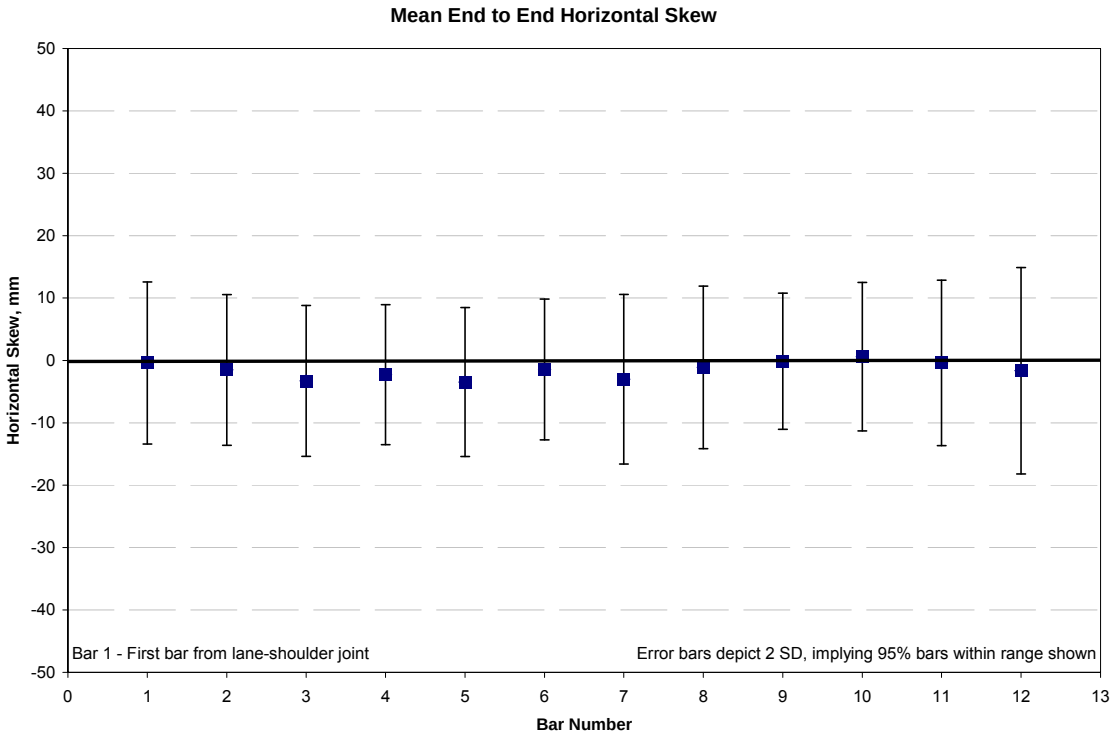


Figure B.4. Mean and range of horizontal skews for each bar position for the 40 scanned joints for 1-IN1 (first and last bar were not used in analysis due to tie-bar effects).

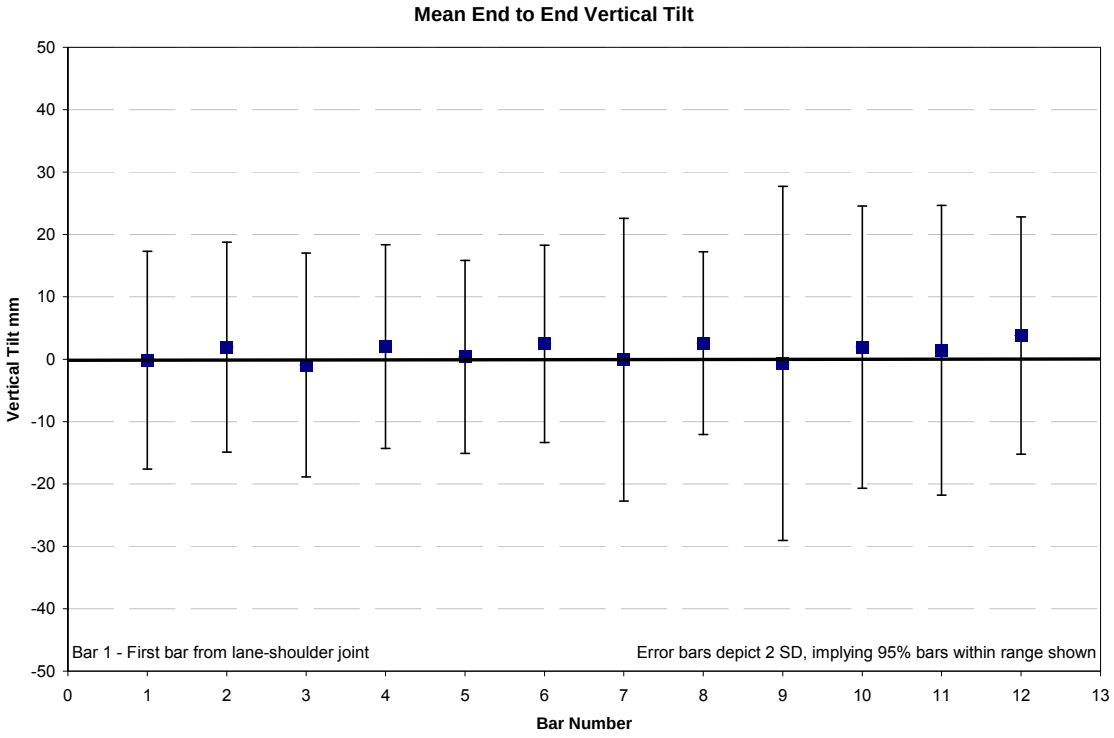


Figure B.5. Mean and range of vertical tilts for each bar position for the 40 scanned joints for 1-IN1 (first and last bar were not used in analysis due to tie-bar effects).

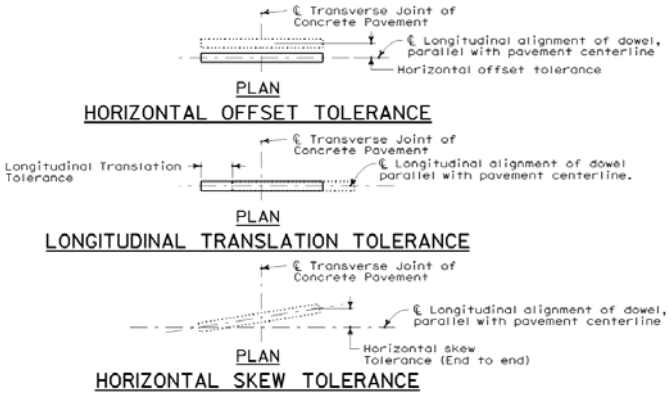
Summary of Results **Project:** Route 231 **Location:** Lafayette **PCC Thickness (mm):** 280

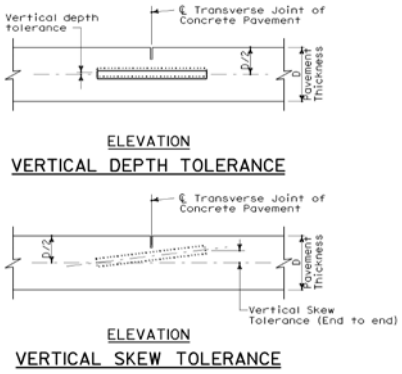
Starting Station: **Dowel Diameter (mm):** 32

	Actual Values		Absolute Values		Absolute Values, Percent Bars					
	Mean	Standard Deviation	Mean	Standard Deviation	d ≤ 9	9 < d ≤ 18	18 < d ≤ 25	25 < d ≤ 32	25 < d ≤ 38	d > 38
Vertical Depth Deviation, mm negative is up	5.25	10.60	9.82	6.59	50.92%	38.75%	7.01%	2.95%	0.18%	0.18%
Horizontal Skew, mm	-1.53	6.34	5.33	3.97	83.21%	15.87%	0.74%	0.18%	0.00%	0.00%
Vertical Tilt, mm	1.21	9.81	6.39	7.54	79.15%	16.42%	2.21%	0.18%	0.55%	1.48%
Maximum Skew, mm			8.44	7.16	66.24%	28.97%	2.40%	0.37%	0.55%	1.48%
Total Skew, mm			9.29	7.44	60.33%	33.58%	3.32%	0.55%	0.55%	1.66%

	Actual Values		Absolute Values		Absolute Values, Percent Bars					
	Mean	Standard Deviation	Mean	Standard Deviation	d ≤ 25	25 < d ≤ 50	50 < d ≤ 75	75 < d ≤ 100	100 < d ≤150	d > 150
Longitudinal Translation, mm Negative is left of joint	-1.62	17.57	13.16	11.74	82.84%	16.61%	0.55%	0.00%	0.00%	0.00%
Horizontal Offset, mm										
Minimum Cover, mm			125.86	11.02						

Percent bars with both horizontal skew and vertical tilt > 9 mm	3.87%
Percent bars with both horizontal skew and vertical tilt > 18 mm	0.55%
Percent bars with both horizontal skew and vertical tilt > 25 mm	0.00%





Definitions:

Actual Values: Using both positive and negative measured values, irrespective of direction. e.g. two dowel bars with deviations of 4 mm and -6 mm, respectively, would have an average deviation of -1 mm. This is useful in evaluating directionality of deviations.

Absolute Values: Using only magnitudes of measured values. e.g. two dowel bars with deviations of 4 mm and -6 mm, respectively, would have an average deviation of 5 mm. This is useful in evaluating deviations assuming that they are random and there is no directionality bias.

Maximum Skew: Maximum of horizontal skew and vertical skew for a given joint.

Total Skew: Square root of sum of squares of horizontal skew and vertical skew for a given joint.

Figure B.6. Summary of MIT Scan-2 results for 1-IN1.

Figure B.7. Photographic overview of 1-IN1 showing no significant distresses.

Figure B.8. Minor spalling on joint 14 on 1-IN1.

Figure B.9. Mid-panel transverse crack on slab 14 on 1-IN1.

Note that the only mid-panel crack observed on this section was on slab 14, which also coincides with the joint with the highest amount of vertical tilt. Joint 14 has average vertical tilt of 41 mm, which significantly exceeds the project average absolute vertical tilt of 6 mm. The average horizontal skew of joint 14 was 6 mm. Based on the station/date stamp near joint 14, it is surmised that this joint was a construction joint. Overall, the section was in excellent condition, with only two joints showing minor spalling, the single transverse crack on slab 14, and average faulting of 0.005 in. (0.1 mm). Most slabs had faulting less than 0.05 in. (1.3 mm), and many slabs measured minor amounts of negative faulting, likely due to differences in curling between the adjacent slabs.

B.4.2 Section 1-WI2

This project was constructed in 1990 on US 29, just west of Wausau, WI, and consists of an 11-in. JPCP with skewed joints at spacing of 19-18-20-17 ft and 1.5-in. dowel bars placed in basket. All data were collected in the outside lane (lane 2). The traffic on this section is low, with an estimated 2007 ADT of 9,500.

A majority of the joints scanned exhibited good to excellent dowel position/alignment. Only 1.7% of the joints have vertical depth deviation greater than 25 mm. Figure B10 shows that 2.0% of bars have horizontal skew greater than 18 mm, and 4.8% of bars have vertical tilt greater than 18 mm. The distributions of mean and range of end to end horizontal skews and vertical tilts for each of the bar positions are shown in Figures B.11 and B.12. A summary table of the results is shown in Figure B13. A photographic overview of 1-WI2 is shown in Figures B.14 through B.16.

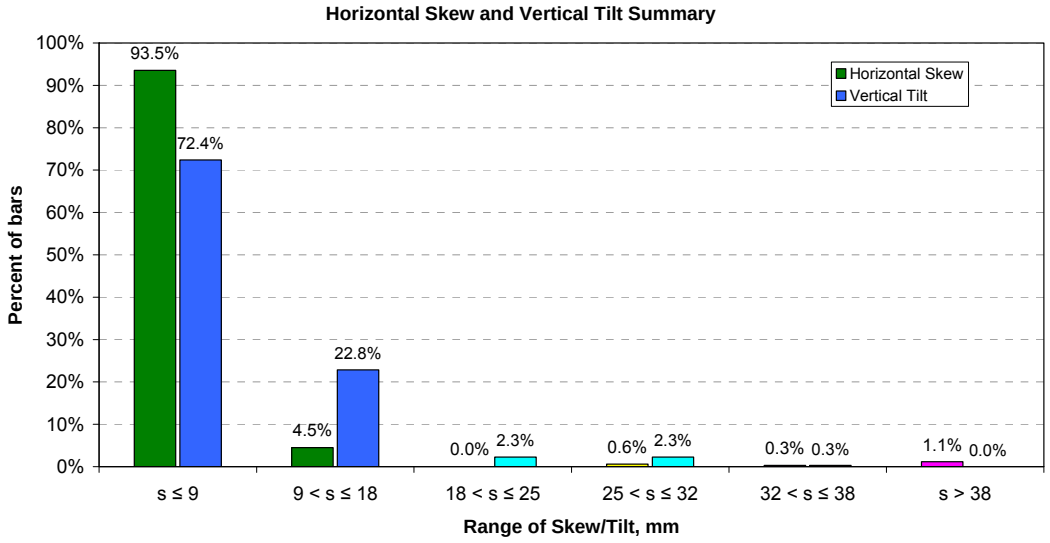


Figure B.10. Distribution of horizontal skew and vertical tilt results for 1-WI2.

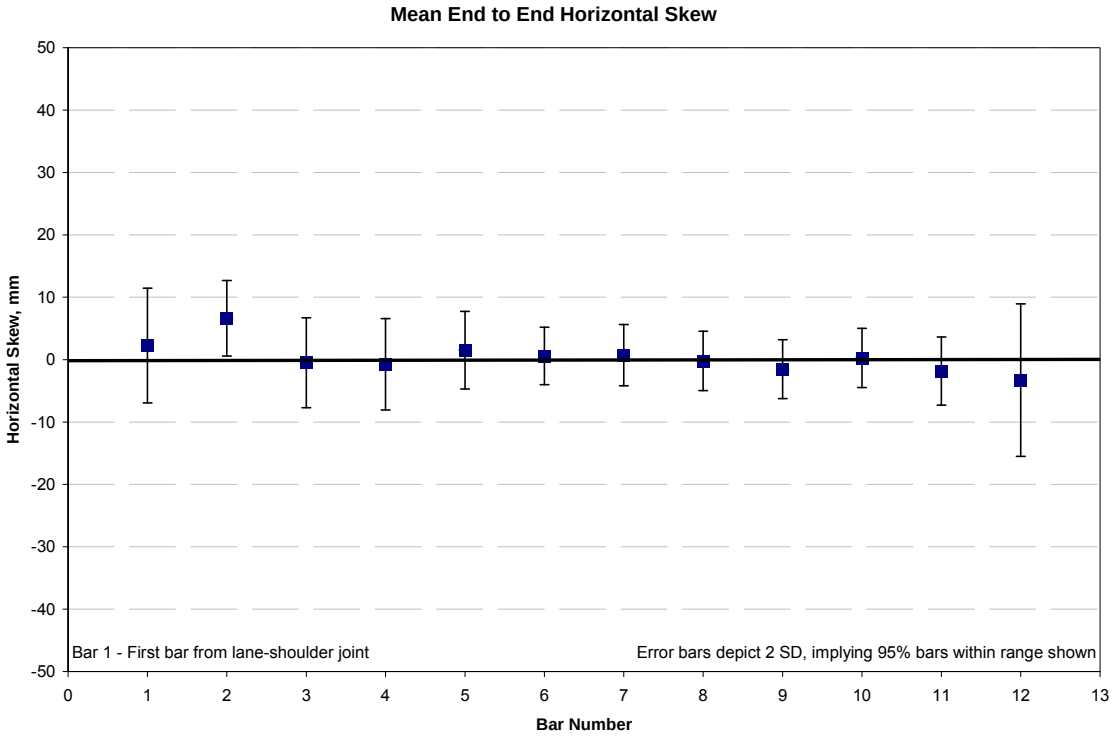


Figure B.11. Mean and range of horizontal skews for each bar position for the 30 scanned joints for 1-WI2.

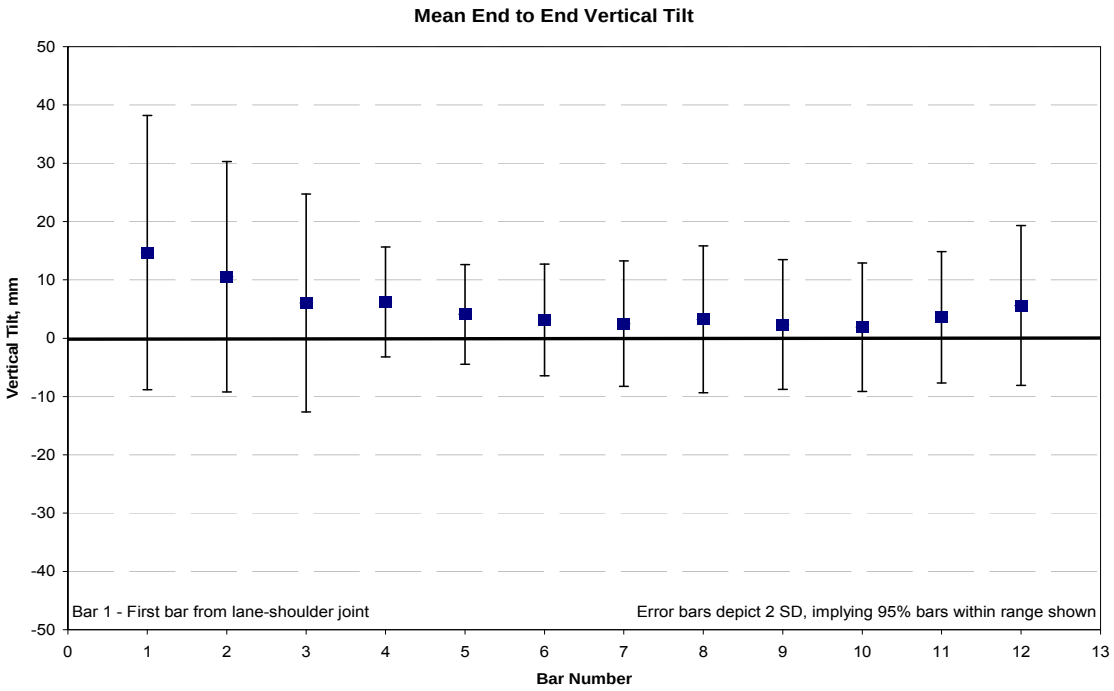


Figure B.12. Mean and range of vertical tilts for each bar position for the 30 scanned joints for 1-WI2.

Summary of Results **Project:** Route 23 **Location:** Wausau **PCC Thickness (mm):** 275
Starting Station: 412+50 **Dowel Diameter (mm):** 38

	Actual Values		Absolute Values		Absolute Values, Percent Bars					
	Mean	Standard Deviation	Mean	Standard Deviation	d ≤ 9	9 < d ≤ 18	18 < d ≤ 25	25 < d ≤ 32	25 < d ≤ 38	d > 38
Vertical Depth Deviation, mm negative is up	1.10	8.16	4.57	6.85	92.13%	5.90%	0.28%	0.56%	0.28%	0.84%
Horizontal Skew, mm	0.30	4.04	3.86	7.10	93.54%	4.49%	0.00%	0.56%	0.28%	1.12%
Vertical Tilt, mm	5.27	7.79	7.18	6.07	72.39%	22.82%	2.25%	2.25%	0.28%	0.00%
Maximum Skew, mm			8.40	8.27	69.38%	24.16%	1.97%	2.81%	0.56%	1.12%
Total Skew, mm			8.99	8.52	66.29%	26.12%	2.81%	2.81%	0.56%	1.40%

	Actual Values		Absolute Values		Absolute Values, Percent Bars					
	Mean	Standard Deviation	Mean	Standard Deviation	d ≤ 25	25 < d ≤ 50	50 < d ≤ 75	75 < d ≤ 100	100 < d ≤150	d > 150
Longitudinal Translation, mm Negative is left of joint	-6.40	21.70	14.60	17.27	82.25%	12.11%	5.07%	0.56%	0.00%	0.00%
Horizontal Offset, mm										
Minimum Cover, mm			118.45	7.52						

Percent bars with both horizontal skew and vertical tilt > 9 mm	3.37%
Percent bars with both horizontal skew and vertical tilt > 18 mm	0.28%
Percent bars with both horizontal skew and vertical tilt > 25 mm	0.00%

Figure B.13. Summary of MIT Scan-2 results for 1-WI2.

Figure B.14. Photographic overview of 1-WI2 showing significant high-severity joint spalling.

Figure B.15. Typical high-severity spalling on 1-WI2.

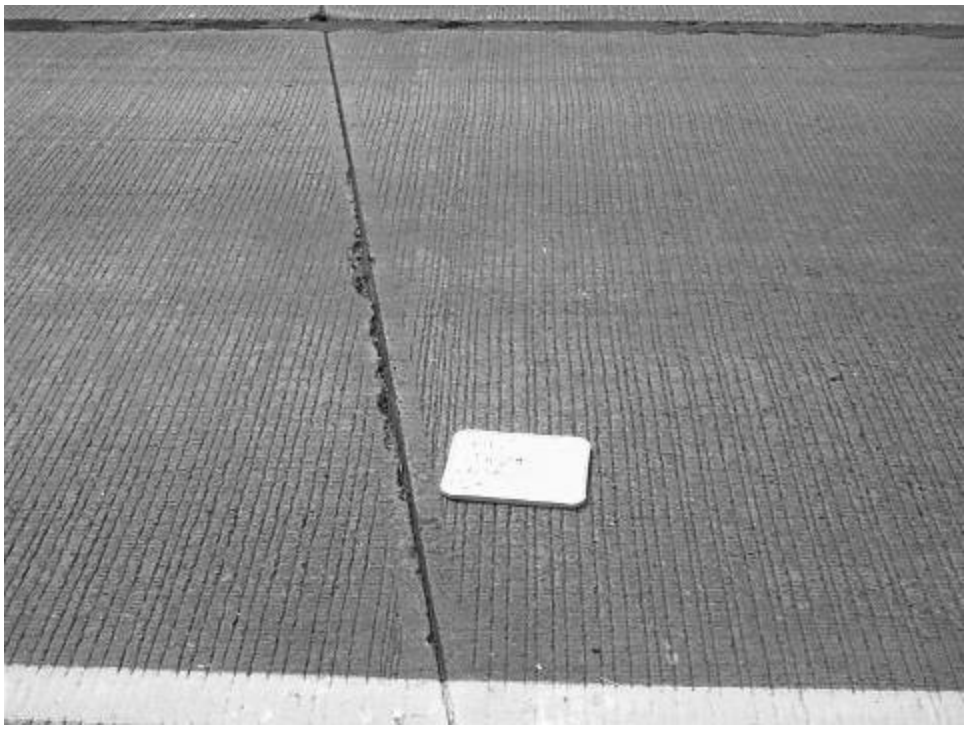


Figure B.16. Typical high-severity spalling on 1-WI2.

Forty percent of the joints on this project had high-severity spalling; however, none of the slabs on this project exhibited any transverse cracking. One suspected cause for the significant spalling on this project was dowel misalignment. However, MIT Scan-2 scanning and analysis showed good to excellent dowel alignment at the joints and no correlation between distressed joints and dowel position or alignment. Overall, the section was in poor condition with a large number of high-severity spalls that had been patched with HMA. The average faulting was 0.03 in. (1 mm). Most slabs had faulting less than 0.05 in. (1.3 mm).

B.4.3 Section 1-OH1

This project is an LTPP SPS-2 project (39-0203) that was constructed in 1994 on US 23, north of Columbus, OH, and consists of an 11-in. JPCP with 15-ft joint spacing and 1.5-in. dowel bars placed in baskets. All data were collected in the outside lane (lane 2). The traffic on this section is moderately heavy, with an estimated 2007 ADT of 38,000.

Several of the joints scanned exhibited poor to moderate vertical dowel position and tilt and excellent horizontal skew. Approximately 34.3% of the joints have vertical depth deviation greater than 25 mm. Figure B.17 shows that 0.8% of bars have horizontal skew greater than 18 mm, but 10.4% of bars have vertical tilt greater than 18 mm. The distribution of mean and range of end to end horizontal skews and vertical tilts for each of the bar positions is shown in Figures B.18 and B.19. A summary table of the results is shown in Figure B.20. A photographic overview of 1-OH1 is shown in Figures B.21 and B.22.

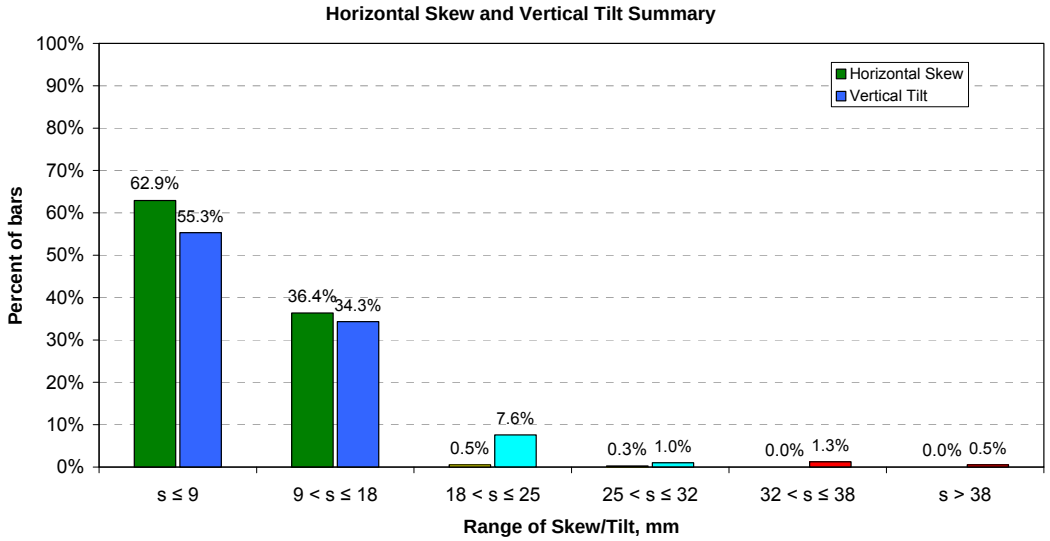


Figure B.17. Distribution of horizontal skew and vertical tilt results for 1-OH1.

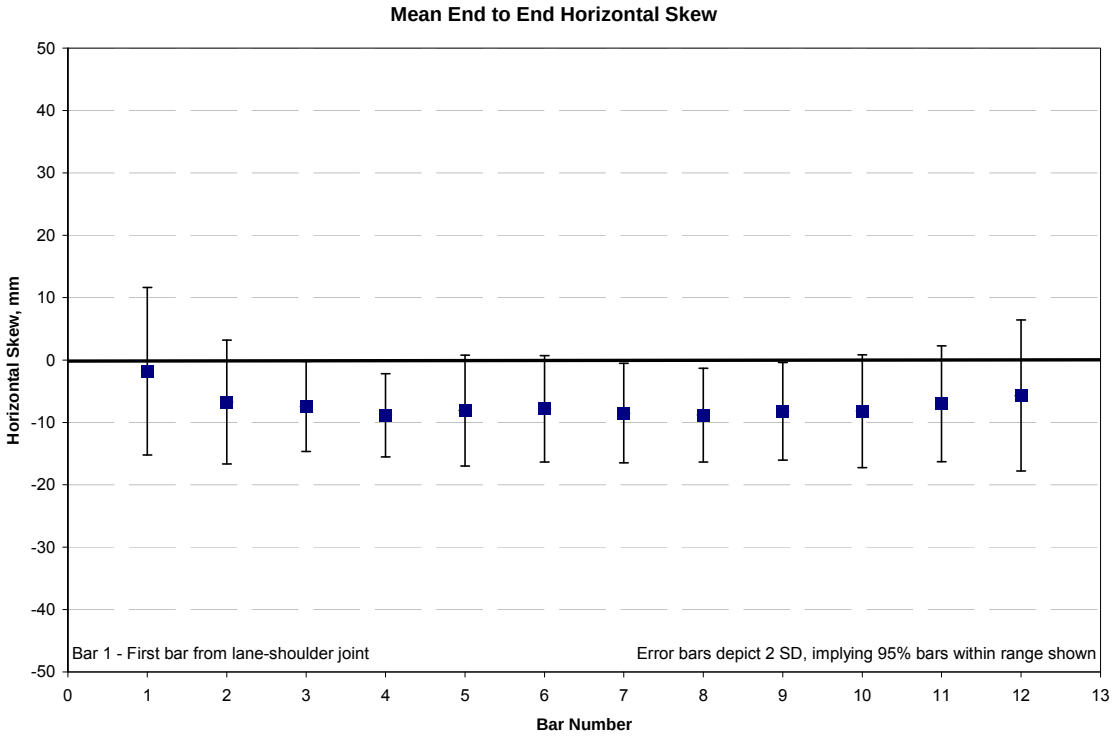


Figure B.18. Mean and range of horizontal skews for each bar position for the 33 scanned joints for 1-OH1.

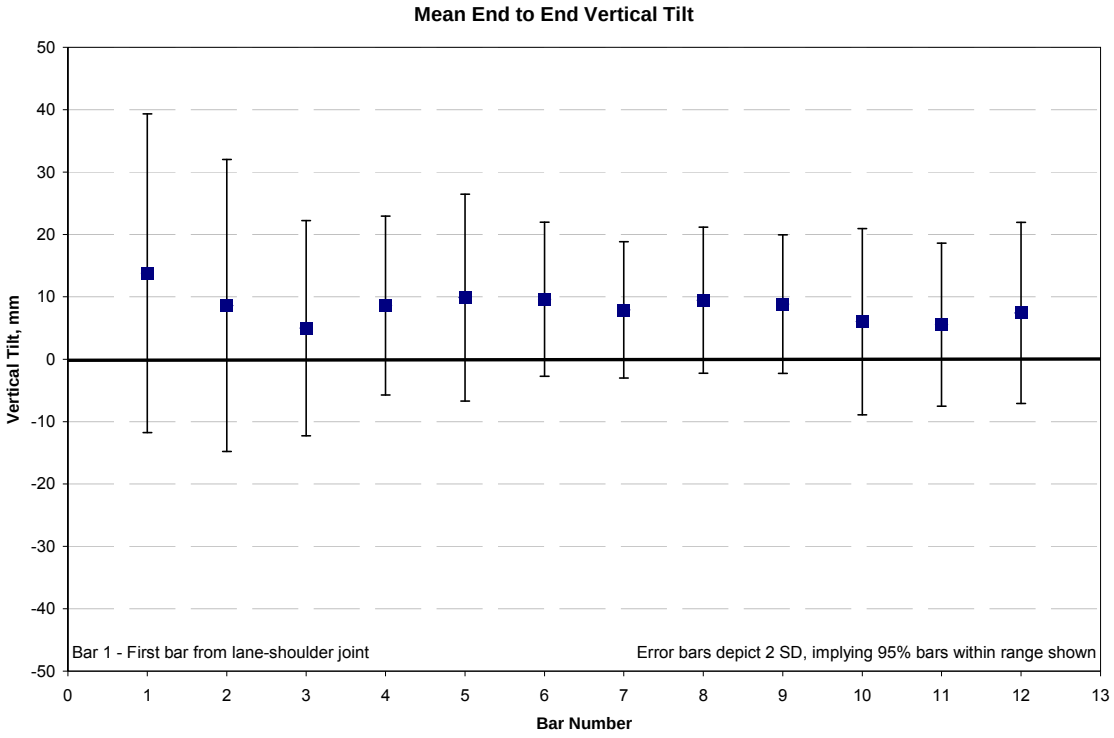


Figure B.19. Mean and range of vertical tilts for each bar position for the 33 scanned joints for 1-OH1.

Summary of Results **Project:** Route 23 **Location:** Columbus **PCC Thickness (mm):** 275
Starting Station: **Dowel Diameter (mm):** 38

	Actual Values		Absolute Values		Absolute Values, Percent Bars					
	Mean	Standard Deviation	Mean	Standard Deviation	d ≤ 9	9 < d ≤ 18	18 < d ≤ 25	25 < d ≤ 32	25 < d ≤ 38	d > 38
Vertical Depth Deviation, mm negative is up	-22.66	7.47	22.66	7.47	2.02%	27.27%	36.36%	21.46%	9.60%	3.28%
Horizontal Skew, mm	-7.27	4.92	7.57	4.44	62.88%	36.36%	0.51%	0.25%	0.00%	0.00%
Vertical Tilt, mm	8.39	8.26	9.41	7.08	55.30%	34.34%	7.58%	1.01%	1.26%	0.51%
Maximum Skew, mm			11.77	6.11	32.83%	56.57%	7.58%	1.26%	1.26%	0.51%
Total Skew, mm			13.20	6.43	22.98%	60.61%	12.37%	1.77%	1.52%	0.76%

	Actual Values		Absolute Values		Absolute Values, Percent Bars					
	Mean	Standard Deviation	Mean	Standard Deviation	d ≤ 25	25 < d ≤ 50	50 < d ≤ 75	75 < d ≤ 100	100 < d ≤150	d > 150
Longitudinal Translation, mm Negative is left of joint	0.12	17.32	13.99	10.19	88.13%	10.86%	1.01%	0.00%	0.00%	0.00%
Horizontal Offset, mm										
Minimum Cover, mm			90.89	8.39						

Percent bars with both horizontal skew and vertical tilt > 9 mm	14.65%
Percent bars with both horizontal skew and vertical tilt > 18 mm	0.51%
Percent bars with both horizontal skew and vertical tilt > 25 mm	0.00%

Figure B.20. Summary of MIT Scan-2 results for 1-OH1.

Figure B.21. Photographic overview of 1-OH1 showing no major distresses on the PCC pavement.

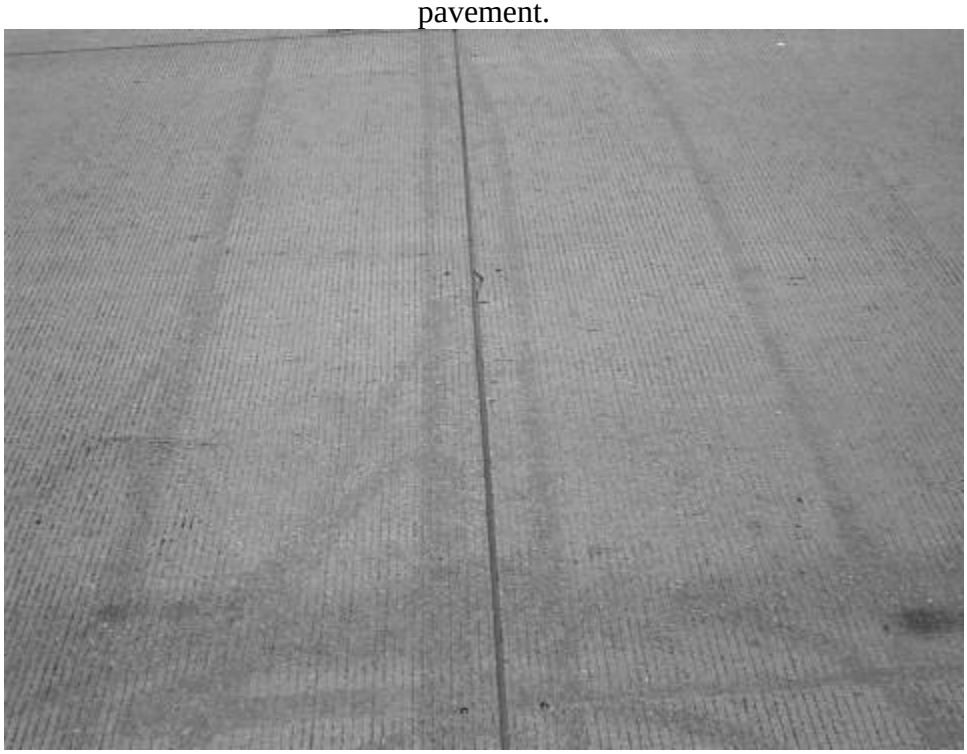


Figure B.22. One joint with very minor spalling on 1-OH1.

MIT Scan-2 scanning and analysis showed poor to moderate dowel alignment at some of the joints. Over 10% of the dowel bars had vertical tilt greater than 18 mm, and over 34% of the dowel bars had vertical position shift greater than 25 mm. A majority of this

misalignment and position deviation was in the first and second dowel bars closest to the lane-shoulder joint. Note that this section had AC shoulders and not tied PCC shoulders. Tie bars in tied PCC shoulders can affect the MIT Scan-2 readings, resulting in greater errors for the first two bars, but this was not the case here. The pavement showed excellent performance with no major distresses and only a few joints with very minor surface spalling after 13 years of moderately heavy traffic. The average faulting on this section was 0.03 in. (1 mm).

B.4.4 Section 1-IL2

This project is on the North-South Tollway (I-355) west of Chicago, IL, that was constructed in 1988 and consists of a 10-in. JPCP with 15-ft joint spacing and 1.5-in. dowel bars placed in baskets. All data were collected in the outside lane (lane 3). The traffic on this section is heavy, with an estimated 2007 ADT of 95,000.

Several of the joints scanned exhibited poor to moderate dowel position and alignments. Approximately 21.6% of the joints have vertical depth deviation greater than 25 mm. Figure B.23 shows that 14.4% of bars have horizontal skew greater than 18 mm, and 27.1% of bars have vertical tilt greater than 18 mm. The distributions of mean and range of end to end horizontal skews and vertical tilts for each of the bar positions are shown in Figures B.24 and B.25. A summary table of the results is shown in Figure B.26. A photographic overview of 1-IL2 and some of the distresses are shown in Figures B.27 and B.28.

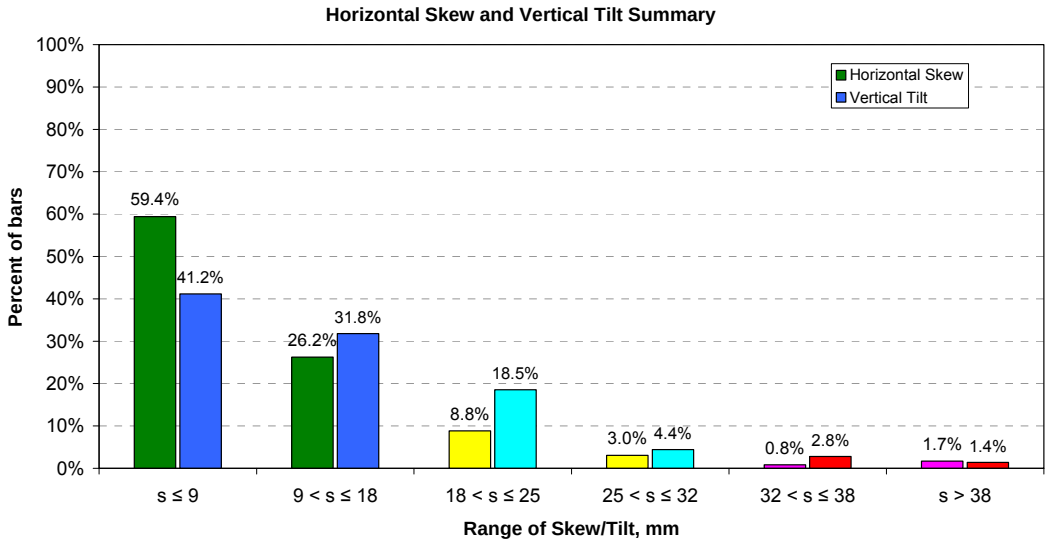


Figure B.23. Distribution of horizontal skew and vertical tilt results for 1-IL2.

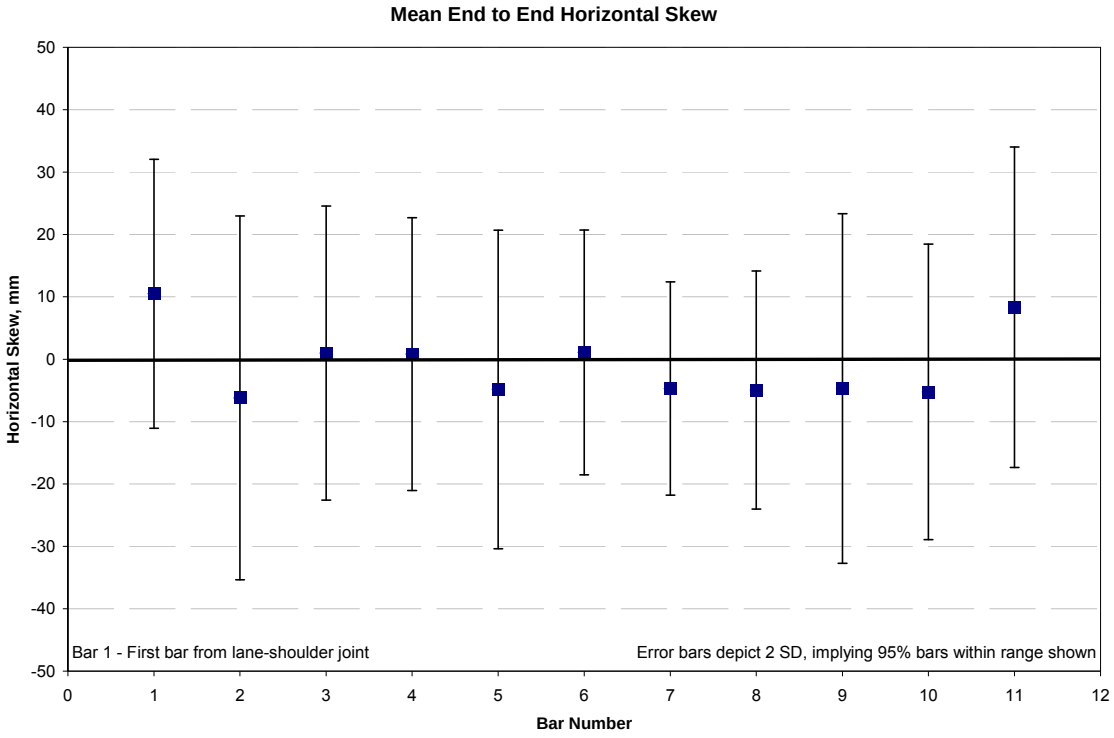


Figure B.24. Mean and range of horizontal skews for each bar position for the 35 scanned joints for 1-IL2.

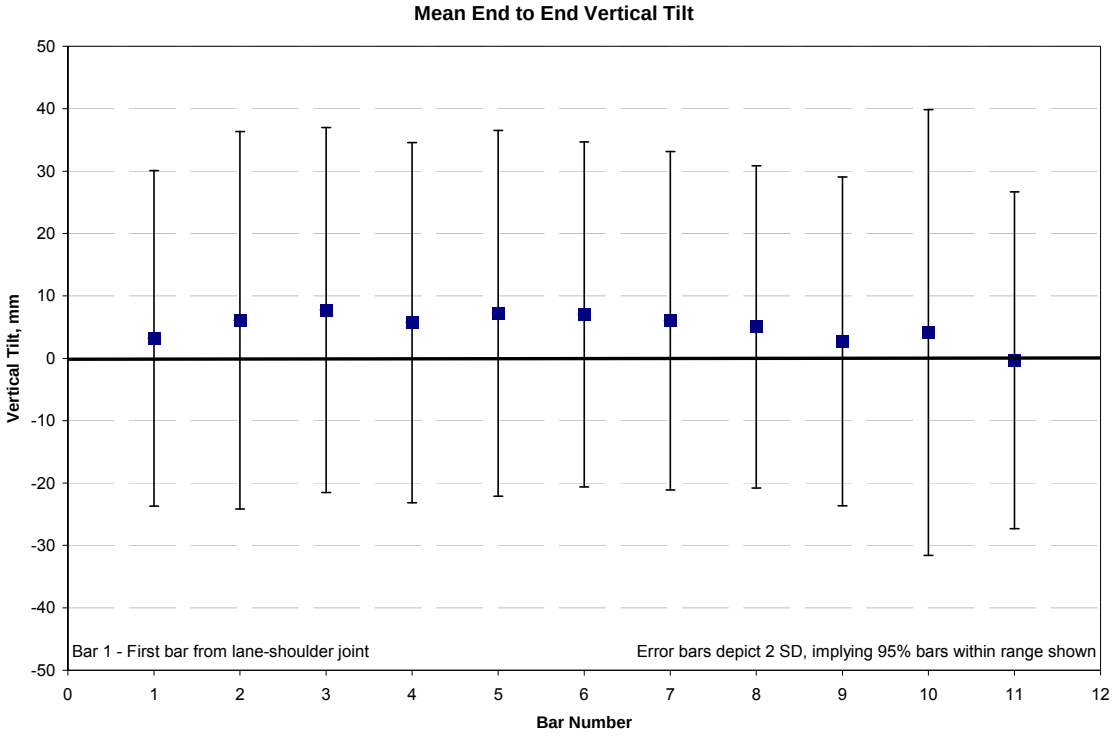


Figure B.25. Mean and range of vertical tilts for each bar position for the 35 scanned joints for 1-IL2.

Summary of Results **Project:** I-355 NS Tollway **Location:** MP 122.5 **PCC Thickness (mm):** 250
Starting Station: **Dowel Diameter (mm):** 38

	Actual Values		Absolute Values		Absolute Values, Percent Bars					
	Mean	Standard Deviation	Mean	Standard Deviation	d ≤ 9	9 < d ≤ 18	18 < d ≤ 25	25 < d ≤ 32	25 < d ≤ 38	d > 38
Vertical Depth Deviation, mm negative is up	18.92	11.09	19.43	10.17	11.88%	33.98%	32.60%	12.43%	3.59%	5.52%
Horizontal Skew, mm	-1.21	12.69	9.41	8.59	59.39%	26.24%	8.84%	3.04%	0.83%	1.66%
Vertical Tilt, mm	4.25	18.35	13.08	13.54	41.16%	31.77%	18.51%	4.42%	2.76%	1.38%
Maximum Skew, mm			16.22	13.63	25.69%	38.67%	21.55%	7.46%	3.59%	3.04%
Total Skew, mm			17.89	14.02	19.89%	40.33%	18.78%	11.05%	6.35%	3.59%

	Actual Values		Absolute Values		Absolute Values, Percent Bars					
	Mean	Standard Deviation	Mean	Standard Deviation	d ≤ 25	25 < d ≤ 50	50 < d ≤ 75	75 < d ≤ 100	100 < d ≤150	d > 150
Longitudinal Translation, mm Negative is left of joint	24.96	43.36	40.24	29.69	35.64%	34.25%	17.13%	9.12%	3.31%	0.55%
Horizontal Offset, mm										
Minimum Cover, mm			118.13	14.09						

Percent bars with both horizontal skew and vertical tilt > 9 mm	25.14%
Percent bars with both horizontal skew and vertical tilt > 18 mm	5.80%
Percent bars with both horizontal skew and vertical tilt > 25 mm	0.00%

Figure B.26. Summary of MIT Scan-2 results for 1-IL2.

Figure B.27. Photographic overview of 1-IL2 showing mid-panel cracking.

Figure B.28. Mid-panel transverse cracking on 1-IL2 on I-355.

MIT Scan-2 scanning and analysis showed poor to moderate dowel alignment at some of the joints. Over 27% of the dowel bars had vertical tilt greater than 18 mm, and over 21% of the dowel bars had vertical position shift greater than 25 mm. The pavement also had moderate levels of distresses, with 14% of the slabs exhibiting mid-panel transverse cracking. One slab had longitudinal cracking, and one joint exhibited high-severity spalling. However, the MIT Scan-2 analysis showed that the dowel misalignment and position deviations did not correlate to the observed distresses.