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EFFECTIVENESS OF BASE TYPE ON THE PERFORMANCE OF PCC PAVEMENT ON ERI/LOR 2

INTERIM REPORT

For project entitled

CONTINUED MONITORING OF INSTRUMENTED PAVEMENT IN OHIO – State Job No. 14652(0)

Prepared for

OHIO DEPARTMENT OF TRANSPORTATION
and
FEDERAL HIGHWAY ADMINISTRATION

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16. Abstract

This interim report discusses the current status of the ERI / LOR 2 research project that is investigating the effects of various base materials and design features on the performance of Portland concrete cement pavement. In 1990, rehabilitation of the initial project begun in 1974 was undertaken through the construction of additional test pavements in the westbound lanes of SR 2 between Station 1835+10 in Erie County and Station 90 +23 in Lorain County.

Six base types and two aggregate sources were used in the new test sections. One of the aggregate base sources, #57 from Martin-Marietta in Woodville, Ohio, was considered resistant to D-cracking. The other, #57 from Sandusky Crushed Stone in Parkertown, Ohio, was considered susceptible to D-cracking. The six bases tested included ODOT 304, 310, 3071A, 307NJ, and asphalt- and cement-treated free draining bases.

Nondestructive testing was performed in June and August 1999. Falling Weight Deflectrometer (FWD) tests were conducted to determine load transfer on the test sections. Cracks in slabs were also evaluated through inspection and taking concrete cores. These core samples indicated that most of the cracks were initiated at the pavement surface and propagated downward. No D-cracking has been observed in the test sections. An extensive series of laboratory tests has also been completed to determine resilient modulus and the strength of each base type.

To date, the sections with bases 307NJ and CTFDB are performing poorly and have developed a substantial number of cracks. The ATFD base is performing the best of the test bases. Additional monitoring is needed to assess the overall performance of each base type and to address potential D-cracking.

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OVERVIEW

1.1 Project Background

In 1974, an experimental section of pavement was constructed on SR 2 in Erie and Lorain Counties near Vermilion, Ohio, to determine the effect of various materials and design features on the occurrence of D-cracking in Portland cement concrete (PCC) pavements. D-cracking is a phenomenon that was observed on many pavements in Ohio and elsewhere in the midwestern states in the 1960's where PCC slab boundaries along longitudinal and transverse joints deteriorated by becoming discolored and crumbling into pieces. Repairs were expensive, and involved the removal and replacement of the failed areas with either PCC or asphalt concrete. In severe cases, entire slabs had to be removed.

While the presence of moisture was believed to contribute heavily to D-cracking, many PCC pavements located in wet conditions performed well for several years without showing any signs of distress. Construction documents and preliminary laboratory tests suggested that coarse aggregate played a significant role in the development of D-cracking as it was exposed to moisture and freeze-thaw cycling in the pavement environment. Certain coarse aggregate sources were repeatedly linked with D-cracked pavements, while other sources did not have a single occurrence. The most effective way to evaluate various coarse aggregates and design parameters thought to be associated with D-cracking was to construct a test pavement and evaluate them side by side in a typical field situation. This resulted in a test pavement being constructed as Project 519 (72) on ERI/LOR 2 in 1974.

This test pavement was evaluated for a period of 16 years by Construction Technology Laboratories, Inc., (formerly Portland Concrete Association) in Skokie, Illinois. Mr. David Stark served as principal investigator through much of the evaluation. The major findings of this research were that: (1) certain coarse aggregates fracture more readily than others when exposed to moisture and freeze-thaw cycling and (2) when the size of susceptible aggregates is reduced from #57 to #8, D-cracking is significantly reduced. However, the frequency of transverse slab cracking later appeared to increase with this smaller aggregate.

By 1990, the usefulness of the test pavement had become minimal and many distressed sections needed to be replaced. As part of this rehabilitation (Project 6000-92), another set of test sections was constructed to further investigate the effects of base type on D-cracking, slab length on transverse slab cracking, and natural versus manufactured sand on skid resistance. Another component of the project was to provide selected repairs on certain PCC slabs for inclusion in SHRP experiments C-203 and C-206. Aggregate sources for Project 6000-92 were the same as those for Project 519 (72). This report documents the current status of how base type has affected the performance of this PCC pavement to date. Reports of how fine aggregate type affected skid resistance and how slab length affected the occurrence of transverse cracking will be published later. Results of the SHRP experiments were documented by ERES, a consulting firm from Champaign, Illinois contracted by SHRP to perform this work.

1.2 Objectives

Specific objectives for the test pavement constructed under Project 6000(92) included the following:

1. Evaluate the influence of various base materials in the formation of D-cracking on PCC pavements. Since the reduction of aggregate size for D-cracking susceptible aggregates tends to increase transverse slab cracking, it may be more cost effective to address the D-cracking

problem by facilitating the removal of water from under the pavement through the use of drainable bases.

2. Determine the difference in skid resistance when natural and manufactured sands are used in Portland cement concrete pavement.
3. Investigate the radius of relative stiffness as a design parameter to establish slab length on PCC pavements.

This report will focus on the first objective where different types of base materials were used under a PCC pavement to determine how they impacted performance. Skid tests were performed on sections where natural and manufactured sands were used in the PCC mix. The third objective is being explored by monitoring how transverse cracks are developing in PCC slabs with lengths of 21, 40 and 60 feet. Results of the skid resistance and cracking experiments will be reported at a later date.

1.3 Project Layout

A matrix consisting of six base types and two coarse aggregate sources for a 10-inch thick PCC pavement was established to address the first project objective. The pavement contained reinforcing mesh to control the growth of any transverse cracks that might occur. One of the coarse aggregates was to be resistant to D-cracking and the other was to be susceptible to D-cracking. By comparing the rate at which D-cracking progresses on pavements utilizing both aggregates and the six base types, an assessment can be made as to the cost effectiveness of base materials on long term performance. For coarse aggregate in the PCC, #57 from Martin-Marietta in Woodville, Ohio, was selected as the source of D-cracking resistant aggregate and #57 from Sandusky Crushed Stone in Parkertown, Ohio, was selected as the source of D-cracking susceptible aggregate. A joint spacing of 13 feet was used with the Parkertown coarse aggregate and a joint spacing of 25 feet was used with the Woodville coarse aggregate.

Base materials included ODOT 304 and 310 (both dense graded aggregate), ODOT 307IA and 307NJ (both unstabilized drainable aggregate), and asphalt and cement-treated free draining bases. These test sections were located in the westbound lanes of SR 2 between Station 1835+10 in Erie County and Station 90+23 in Lorain County. Limits of the individual sections are shown in Table 1.1.

Table 1.1 – Summary of Test Section Parameters

Westbound ERI/LOR 2

Station Limits		Base/Subbase		Joint	PCC Coarse
Begin	End	Thickness (in.)	Type	Spacing (ft.)	Aggregate
1835+10	0+01	4 / 6	310/304	13	Parkertown (D)
0+01	5+00	4 / 6	310/304	25	Woodville (ND)
5+00	9+80	4 / 6	307IA/304	25	Woodville (ND)
9+80	14+60	4 / 6	307IA/304	13	Parkertown (D)
56+06	60+33	4 / 6	304/304	13	Parkertown (D)
60+33	64+60	4 / 6	304/304	25	Woodville (ND)
64+60	68+87	4 / 6	307NJ/304	25	Woodville (ND)
68+87	73+14	4 / 6	307NJ/304	13	Parkertown (D)
73+14	77+41	4 / 6	ATFDB*/304	13	Parkertown (D)
77+41	81+68	4 / 6	ATFDB*/304	25	Woodville (ND)
81+68	85+96	4 / 6	CTFDB**/304	25	Woodville (ND)
85+96	90+23	4 / 6	CTFDB**/304	13	Parkertown (D)

(D) D-cracking susceptible (ND) D-cracking resistant
*Asphalt-treated free draining base
**Cement-treated free draining base

Chapter 2

FIELD DATA

2.1 PCC Mix Design

Tables 2.1 and 2.2 provide aggregate gradations and mix designs used in the 451 mesh reinforced PCC pavement as obtained from test reports issued at the time of construction and ODOT specifications applicable at the time. The mesh was W8.5 x W4 – 6 x 12 smooth steel wire and the concrete joints were square.

Table 2.1 – Gradation of Aggregates in PCC Pavement

	% Passing							
	#57 Ls Coarse Aggr.			Fine Aggregate				
Sieve				Natural Sand*		Man. Ls. Sand**		
No.	D	ND	Spec.	41P	42P	2D	7D	Spec.
1 ½"	100	100	100					
1"	100	100	95-100					
¾"	77	76						
½"	34	27	25-60					
3/8"	14	8		100	100	100	100	100
4	1	1	0-10	100	100	100	100	95-100
8	1	1	0-5	95	96	79	89	70-100
16	1	1		69	73	38	47	38-80
30				34	39	17	22	18-60
40				20	25	12	14	
50				11	15	8	9	5-30
70				6	8	5	5	
100				4	5	4	4	1-10
200				2.0	2.4	3.0	2.6	0-5
Specific Gravity	2.62	2.69		2.57	2.57		2.64	
Absorption (%)	1.77	1.55		1.56	1.56		1.45	
Fineness Modulus						3.54	3.29	

* Two samples of natural sand supplied by Norwalk Sand and Gravel in Norwalk, Ohio

** Two samples of manufactured limestone sand supplied by Sandusky Crushed Stone in Parkertown, Ohio

Table 2.2 – Mix Designs for PCC Pavement

	451 PCC Pavement (corrected lbs./cu. yd.)	
	D*	ND**
#57 Coarse aggregate	1635	1637
Natural sand fine aggregate	1242	1242
Type I cement (M. B. Guran)	510	510
Class "F" flyash (Avon Lake)	90	90
PCC Admixtures		
Air (Axim Caterol AE 260)	15 0z.	15 oz.
Range of water/cement ratio	.43-.50	.41-.49

* PCC with D-cracking susceptible coarse aggregate
** PCC with D-cracking resistant coarse aggregate

2.2 Base Materials

Table 2.3 is a summary of the gradation of aggregates used in the various bases on this project. ODOT permits the use of #57 or #67 aggregate in asphalt and cement-treated free draining bases. #57 was used on this project.

Table 2.3 – Gradation of Base Courses

Sieve	% Passing											
No.	304*	Spec.	307IA*	Spec.	307NJ*	Spec.	310*	Spec.	ATFDB*	CTFDB**	#57	#67
2"	100	100					100	100				
1½"	100					100	100		100	100	100	
1"	92	70-100	100	100	100	95-100	100	100	100	100	95-100	100
¾"	86	50-90	91		93		100		87	82		90-100
½"	73		56	50-80	65	60-80	100		37	30	25-60	
3/8"	65		36		49		100	80-100	8	5		20-55
4	44	30-60	31		42	40-55	100	60-100	1	1	0-10	0-10
8	22		25	10-35	14	5-25	83	45-85	1	1	0-5	0-5
16	22		14		4	0-8	83		1	1		
30	10	7-30	7		2		83					
40	10		5				16	15-50				
50	10		3	0-15	1	0-5	16					
70			2									
100	10		2				16					
200	6.6	0-13	1.3	0-6			2.3	0-10				

* Supplied by Wagner Quarries in Sandusky, Ohio
** Supplied by Sandusky Crushed Stone in Parkertown, Ohio

The 304 and 310 base materials were placed directly as they were delivered from Wagner Quarries. The 307 Type IA base was manufactured by blending 70% #57 limestone with 30% limestone sand. Moisture was between 5.5 and 6.3% and no water was added at the plant. The 307 Type NJ base was manufactured by blending 55% #57 limestone with 45% #9 limestone. Moisture in this material was between 4.0 and 5.0% and, again, no water was added at the plant. The stabilized bases were 100% #57 aggregate, with either asphalt cement or Portland cement added to bind the stone together.

The following table shows mix designs for the stabilized bases.

Table 2.4 – Mix Designs for Stabilized Base

	CTFDB (lbs./cu. yd.)	ATFDB (% by wt.)
#57 Coarse aggregate	2580	97.7
Type I cement (M. B. Guran)	220	
AC-20 Asphalt cement		2.3
Water reducer (Axim Type A)	4.40 oz.	

2.3 Traffic Loading

Table 2.5 is a summary of total monthly traffic loading from 1994 through 1998 on the two westbound lanes of SR 2 at the location of this experimental pavement in terms of ESALs.

Table 2.5 – Monthly ESAL Counts

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept	Oct.	Nov.	Dec.	Total
1994	25632	36692	44115	44585	45754	48110	37024	46048	41542	40746	39950	36247	488439
1995	27682	38159	45879	46368	55416	53976	42882	49581	50525	51904	43497	38945	546809
1996	34310	38434	47663	67838	49917	61942	40823	65662	58987	66715	53861	49037	637185
1997	45648	39971	74416	75326	75281	74343	73929	71470	71381	77161	72418	128597	881938
1998	174546	290414	150838	116048	81336	67547	76324	77523	79510	71505	58082	58704	1302377
												Total	3856748

A significant increase in traffic loading occurred in March 1997, which may have been about the time tolls were raised and construction was in progress on the Ohio Turnpike. A second increase was noted from December 1997 to February 1998, after which time the loading gradually returned to levels observed prior to 1997.

Chapter 3

LABORATORY TESTING

3.1 General

Laboratory tests were performed on three of the unstabilized base materials used in this field evaluation: ODOT 307NJ, 307IA and 304. Virgin aggregate was purchased for these tests from the same sources used during construction and blended to match sample gradations measured at that time. Samples were compacted equally using the modified Proctor method. Triaxial and resilient modulus tests were performed to confirm, and possibly explain, differences in measured and observed performance in the field. No tests were performed on the ATFDB or CTFDB materials. The University of Toledo conducted permeability tests on the unstabilized materials and documented the results in a report entitled "Permeability and Stability of Base and Subbase Materials." Because the in-situ base had been in service for several years, it was likely contaminated with fines from the underlying materials. Because this was a test of the effect of base type on D-cracking, no laboratory tests were performed on the concrete mix or the aggregate in the concrete.

3.2 Triaxial Testing

Moisture was determined as samples were being prepared for testing. All specimens were nominally six inches in diameter and twelve inches long. Table 3.1 summarizes the results of triaxial tests performed on these materials.

Table 3.1 – Summary of Triaxial Test Results

Sample No.	Moisture (%)	Dry Dens. (pcf)	Confining Stress (psi)	Deviator Stress @ Failure (psi)	Axial Strain @ Failure (%)	Angle of Internal Friction (degrees)
NJ-1	1.94	105.5	5.0	34.0	4.8	50.6
NJ-2	2.12	106.6	6.0	36.5	5.2	48.8
Avg.	2.03	106.1	5.5	35.3	5.0	49.7
IA-2	2.95	114.1	5.0	31.5	7.0	49.4
IA-3	3.90	111.9	6.0	39.0	6.8	49.9
Avg.	3.43	113.0	5.5	35.3	6.9	49.7
304-1	5.35	116.9	5.0	25.0	6.5	45.6
304-2	5.16	117.1	7.0	33.5	5.0	44.6
Avg.	5.26	117.0	6.0	29.3	5.8	45.1

Several trends can be observed from these data, including the following:

1. Moisture was lowest in the 307 NJ base, probably because of the lack of fine-grained material.
2. Density was significantly lower in the 307 NJ base, because of the lack of aggregate passing the #8 sieve to fill voids between the larger aggregate.
3. Axial strain at failure was highest for the 307 IA base and lowest for the 307 NJ base, with the 304 base falling in between. This suggests lower shear strength in the 307 NJ base.

3.3 Resilient Modulus Testing

Resilient modulus testing at the Ohio Research Institute for Transportation and the Environment (ORITE) was performed in accordance with SHRP LTPP protocol using a large triaxial chamber, an electro-servo controlled actuator, and computerized command generation and data acquisition. Test specimens were nominally six inches in diameter, twelve inches long, and weighed approximately 22 - 26 lbs. Resilient moduli were determined at three deviatoric stresses applied at confining stresses of 3, 5, 10, 15 and 20 psi. Table 3.2 summarizes moisture, dry density, permanent strain, and modulus constants measured on each sample of base material. K and n are constants obtained from a linear best-fit line drawn for all confining and deviatoric stresses on that sample on a log-log plot. The values of r ^{2} indicate how well the line represents these data. M_R shown for the five deviatoric stresses were calculated from the equation of that line.

Table 3.2 – Summary of Resilient Modulus Tests

Sample	Moisture	Dry Dens.	Perm.	M_R (psi) = K $(\sigma_d)^n$			M_R (psi) @ Deviatoric Stress of:				
No.	(%)	(pcf)	Strain (%)	K	n	r^2	2 psi	5 psi	10 psi	15 psi	20 psi
NJ-3	2.21	107.16	.71	2690	.487	.790	3770	5890	8256	10058	11571
NJ-4	2.64	107.58	.39	2074	.502	.840	2937	4653	6589	8076	9331
NJ-5	1.54	109.83	.42	2563	.498	.850	3619	5712	8068	9873	11395
NJ-6	NA	NA	.61	3340	.349	.621	4254	5858	7461	8595	9502
Avg.	2.13	108.19	.53				3645	5528	7594	9151	10450
IA-5	3.90	116.83	.97	2645	.448	.780	3608	5440	7420	8898	10122
IA-6	2.85	118.84	.44	3172	.305	774	3919	5182	6402	7245	7910
IA-7	4.68	117.01	.74	2334	.511	.797	3326	5313	7571	9314	10789
IA-8	3.17	119.84	.71	2000	.566	.868	2961	4974	7364	9264	10901
Avg	3.65	118.13	.72				3454	5227	7189	8680	9931
304-5	3.65	111.96	.76	3348	.440	.806	4542	6798	9222	11024	12512
304-6	NA	NA	.57	2175	.557	.839	3199	5330	7841	9828	11536
Avg.	3.65	111.96	.67				3871	6064	8532	10426	12024

Apparent trends from these data are as follows:

1. As in the triaxial tests, the 307 NJ base had the lowest moisture content and lowest dry density.
2. Average permanent strains measured for these three unstabilized materials were similar in magnitude, especially when considering the range of strain observed within each base type.

3. Considering the variation of M_R within each base type, the averages shown are about the same, with both the 307 IA and 307 NJ being slightly less than the 304.

3.4 Summary

From tests conducted in the laboratory, the stiffness characteristics of the 304, 307IA and 307NJ unstabilized base materials appear to be quite similar. However, the 307 NJ base was particularly difficult to compact in the laboratory, apparently due to the presence of large angular particles, and contractors have remarked about how difficult it is to compact in the field. For these reasons, laboratory test results for 307NJ base may be less representative of field placed 307NJ base than laboratory tests for other unstabilized materials.

As repeated traffic loads are applied in the field, the lack of fine-grained material in the 307 NJ base could permit some reorientation of aggregate particles and, hence, densification of the base layer. Densification will result in voids being created under the PCC slab and a loss of support, especially at joints as slabs curl and warp during curing and environmental cycling. This loss of support will result in higher stresses being induced in the slab, thereby increasing the probability of transverse cracking.

Chapter 4

PERFORMANCE

4.1 Crack Evaluation

While the principal objective of Project 6000-92 was to determine the impact of base type on D-cracking, none of the test sections have exhibited any symptoms of D-cracking to date. However, a number of unexpected transverse cracks were observed in certain sections. As shown in Table 4.1, sections with a 25-foot joint spacing and a CTFD, 307NJ, 307IA, 310 or 304 base, and the section with a 13-foot joint spacing and the 307NJ base have exhibited extensive transverse cracking and some longitudinal cracking after approximately seven years of service. None of these cracks appeared soon after construction and, therefore, are not attributed to conditions existing at the time of placement. The slabs with a 13-foot joint spacing on any base except 307NJ, and the 25-foot joint spacing on ATFD base have performed reasonably well to date. The test sections in this table are listed in order of increasing number of cracks per slab and are grouped into three levels of performance. These cracks were large enough to be easily seen when walking along the pavement. Individual crack locations are shown in Appendix A.

Table 4.1 – Transverse Cracking Survey on ERI/LOR 2 in June 1999

Base Type	Joint Spacing (ft.)	No. of Slabs in Section Observed	Total No. of Cracks	Avg. No. of Cracks per Slab
ATFDB	13	33	0	0.00
304	13	33	1	0.03
310	13	23	2	0.09
ATFDB	25	16	3	0.19
CTFDB	13	16	3	0.19
307IA	13	36	7	0.19
307NJ	13	20	19	0.95
304	25	17	17	1.00
310	25	20	22	1.11
307IA	25	19	23	1.21
307NJ	25	17	34	2.00
CTFDB	25	17	41	2.41

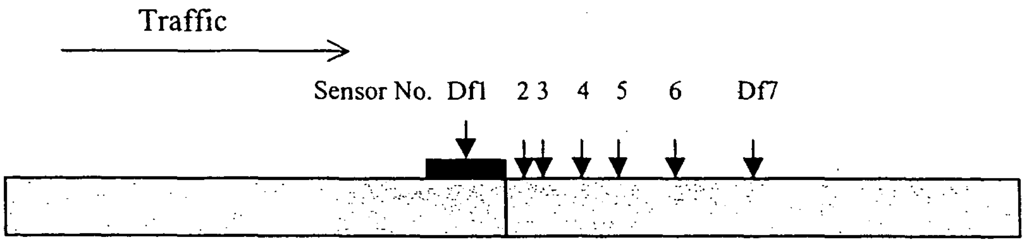
4.2 Nondestructive Testing

Nondestructive testing (NDT) was performed in June and August of 1999 with the Falling Weight Deflectometer (FWD) to determine the stiffness characteristics of PCC slabs constructed on different base materials. Included in this evaluation was an examination of how well the transverse contraction joints in these sections transferred load to adjacent slabs. The results of these evaluations are presented in the following sections. All tests were performed in the right wheelpath of the driving lane.

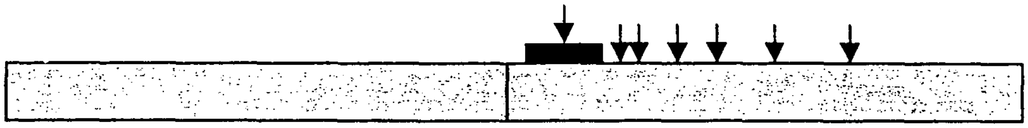
June 29, 1999

In this set of FWD measurements, a few slabs were selected for testing in each section containing a particular combination of joint spacing and base type. The load plate was placed on both sides of the joints and at one or more locations along the interior of the slab. In these configurations, the geophones measuring vertical surface deflection were located as shown in

Figure 4.1. Readings were initiated at 8:40 am, at which time the surface temperature of the pavement was 69° F.



Joint Approach (JA)



Joint Leave (JL)

Midslab (M)

Sensor spacing from center of load plate: 0, 8, 12, 18, 24, 36 and 60 inches

Figure 4.1 FWD Load Plate and Sensor Positioning – June 1999

Df1 deflections measured with the FWD load plate located in the middle portion of the slab reflect the composite vertical stiffness of the entire layered pavement structure, including the pavement, base and subgrade. When slabs are cracked, there is likely to be some reduction in stiffness. Every effort should be made to have the FWD load plate and all geophones on an uncracked section of pavement; otherwise, there will probably be a discontinuity in the FWD deflection profile. Deflections measured with the FWD load plate located near a joint are indicative of the vertical stiffness of the slab ends at the time of the measurements. The presence of temperature and/or moisture gradients in PCC slabs cause the slab ends to curl and warp, thereby affecting the degree to which they are supported by the underlying layers. Therefore, the stiffness of slab ends can be low in the morning when they are curled upward and acting as a cantilever, and high in the afternoon as the pavement surface warms and brings the slab back into contact with the base layer. Once in contact with the base, slab end stiffness at joints is affected by moisture conditions in the base and subgrade around the joints.

Load transfer mechanisms, such as aggregate interlock and/or dowel bars, increase the stiffness of PCC slab ends by transferring vertical shear and bending forces to adjacent slabs. When the pavement is warm (> ~70° F), PCC slabs typically are sufficiently expanded horizontally to be in contact with neighboring slabs. At lower temperatures, load transfer will become less as slabs contract and aggregate is lost. The irregular aggregate surfaces at the slab ends then interlock and transfer load across the joint. Dowel bars also improve the magnitude of load transfer at joints under all temperature and moisture conditions.

If free water is present under the slab, fine material may be removed from the subgrade and/or base by the process of pumping as heavy traffic loads force the slab ends downward to expel this water containing suspended fines up through a joint or crack. When pumping occurs, material is generally removed more from under the leave side of joints and cracks, and FWD deflections there are higher than on the approach side.

Load transfer across PCC joints and cracks can be quantified with the FWD by placing the load plate and sensors in the joint approach position, and comparing deflection measured at the center of the load plate with deflection measured on the unloaded slab. The second sensor is sometimes moved to a position 12 inches behind the center of the load plate to measure load transfer in the joint leave position. Therefore, for consistency, the third sensor will be used to calculate load transfer at all times in the joint approach position ($LT_A = Df3/Df1$) and the second sensor will be used at all times to measure load transfer in the joint leave position (LT_L = Df2/Df1). In these equations, Sensors 2 and 3 are the same distance from the load plate. While load transfer, as defined at joints and cracks, is not a relevant term in the middle of an uncracked slab, the ratio of Df3/Df1 at midslab is indicative of slab bending stiffness and can be used to further refine the assessment of load transfer.

For example, if the average Df3/Df1 ratio is 0.70 at midslab and 0.65 at the joints on Pavement 1 and 0.85 at midslab and 0.70 at the joints on Pavement 2, which pavement has better load transfer at the joints? Pavement 1 does not distribute load as well as Pavement 2, as indicated by the lower Df3/Df1 ratio at midslab. The joints on Pavement 1 have an average stiffness across the joints equal to 0.65/0.70 = 0.93 or 93% of the midslab bending stiffness. The joints on Pavement 2 have an average stiffness of 0.70/0.85 = 0.82 or 82% of the midslab bending stiffness. Therefore, while the joints on Pavement 2 have a higher magnitude of load transfer, they have lost more of their potential ability to transfer load, assuming that the Df3/Df1 ratio at midslab and at the joints was approximately equal when the pavement was new. Table 4.2 is a summary of FWD deflection measurements collected during the June 1999 evaluation. Values shown in the table were obtained at loads approximating 9000 lb. and normalized to a 1000 lb. load. Individual measurements are shown in Appendix B.

Table 4.2 – Summary of June 1999 FWD Measurements

Base Type	Avg. Norm. Dfl Deflection in FWD Position (mils) JA	JL	M	Load Transfer (Df3/Dfl) in FWD Position (%) JA	M
		13-foot Joint Spacing			
304	0.51	0.70	0.25	41.6	77.1
310	0.66	0.60	0.35	49.2	87.3
307NJ	1.42	2.32	0.73	5.5	84.8
307IA	0.51	0.53	0.30	103.2	85.7
ATFDB	0.55	0.32	0.20	43.2	82.5
CTFDB	2.09	1.17	0.49	6.6	92.8
		25-foot Joint Spacing			
304	0.57	1.09	0.36	48.8	82.0
310	0.73	0.52	0.33	28.1	88.5
307NJ	1.32	1.28	0.69	7.1	89.4
307IA	0.51	0.56	0.36	62.2	82.2
ATFDB	0.24	0.28	0.11	61.6	76.6
CTFDB	0.37	0.43	0.27	91.9	86.0

Several interesting observations can be made from Table 4.2, as follows:

1. With the exception of slabs on CTFD base, the midslab vertical deflection (Dfl) of 13 and 25-foot long slabs with the same type of base material was similar, with the ATFD base having the lowest deflection and the 307NJ base having the highest deflection in both cases. Base type had a greater effect on FWD deflection than slab length in these tests.
2. Dfl deflection in the joint leave (JL) position is typically equal to or greater than the Dfl deflection in the joint approach (JA) position on in-service PCC pavements. Past experience in Ohio with the Dynaflect suggests that, when deflection on the leave side becomes two to three times greater than the approach side, faulting is likely to occur as the slab on the leave side of the joint settles. On the ERI/LOR 2 test sections, joint leave deflections were generally larger than the joint approach deflections, except on the stabilized ATFD and CTFD bases with a 13-foot joint spacing, and the

310 base with a 25-foot joint spacing. In these sections, deflections on the approach side were much higher than on the leave side. It is doubtful the slab end on the approach side of these joints will settle much below the slab end on the leave side of the joints, because of impact forces being imposed by traffic on the elevated leave slab that would tend to also force it down. There is no obvious reason why the approach readings were higher in these sections.

3. As joints deteriorate, stiffness and load transfer at the slab ends both tend to decrease on intact, in-service PCC pavements. High deflections and extremely low load transfer were observed at the ends of both the 13 and 25-foot long slabs on the 307NJ base, and the 13-foot long slabs on the CTFD base. These three sections also had the lowest average composite stiffness (highest deflection) at midslab.

   Other than the high deflections mentioned above, it is difficult to explain why slab ends in these three sections exhibited lower stiffness than slab ends in some of the other sections. The presence and the condition of transverse cracks in the slabs would undoubtedly affect how the ends respond to dynamic loading. However, the 307NJ sections with 13 and 25-foot long slabs average one and two cracks per slab respectively, the CTFDB section with 13-foot long slabs has minimal cracking, and several other sections with significant cracking ($\geq$ 0.95 cracks/slab) showed reasonably good slab end deflection and load transfer. With Dfl being significantly higher on the leave side than on the approach side of joints in the 307NJ section with 13-foot long slabs, some joint faulting may become evident in this section in the near future.

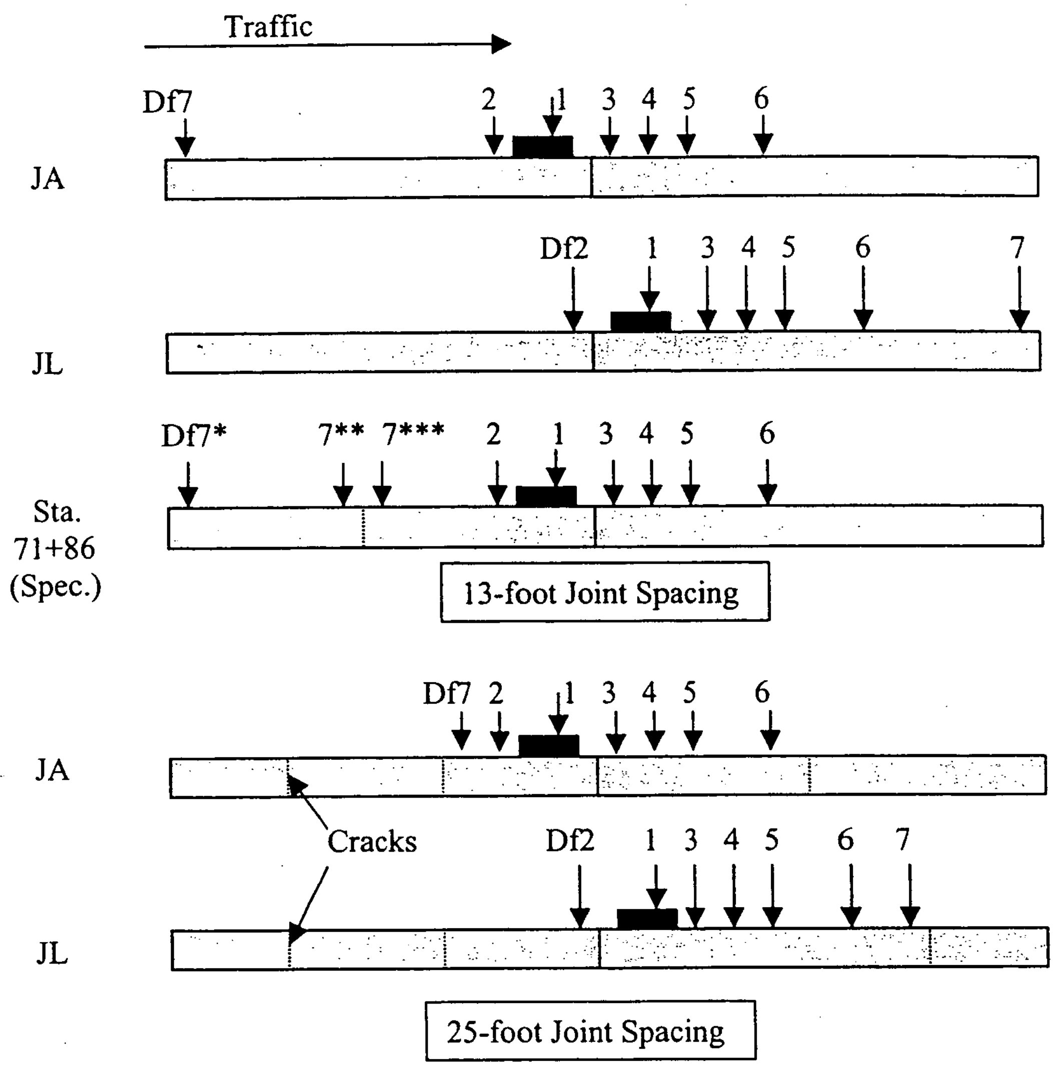
4. While the average load transfer of 103.2% measured on the section with 13-foot long slabs and 307IA base appears to be too high, load transfer at the three consecutive joints used to obtain this average were 100.2%, 97.4% and 112.1%. This consistency of unusually large values of load transfer at PCC joints may have been caused by some rocking phenomenon in the slabs. Unfortunately, no additional data are available to support this premise.

NOTE: Cores taken in the sections with ATFD base at the time of the FWD testing showed extensive stripping of the asphalt cement in the base, to the point where there was essentially no bonding of the aggregate.

August 11, 1999

A second set of FWD measurements was conducted in August 1999 to verify some results obtained at joints during the first set of measurements in June, and to provide additional information on load transfer and rocking of the 13-foot long slabs. In this evaluation, Sensor 2 was moved from 8 inches in front of the center of the load plate to 12 inches behind the center of the load plate. With the load plate in the joint approach position, load transfer was defined in the forward direction as Df3/Df1 and, with the load plate in the joint leave position, load transfer was defined in the reverse direction as Df2/Df1. While it seems that load transfer should be about the same in both directions, it is occasionally different for some unknown reason. Readings were initiated at 9:30 am and the pavement temperature was 68° F at that time.

As mentioned earlier, another parameter investigated during the August 1999 FWD measurements was slab rocking. To see if a cracked slab was rocking, the load plate was positioned in either the joint approach or joint leave position, and a remote geophone with a long cable was connected to the connector for Sensor 7. This geophone was placed by hand just inside the nearest joint or crack on the slab where the load plate was located. In this configuration, the load plate with Sensor 1 was on one end of the slab and Sensor 7 was on the other end of the uncracked slab or cracked partial slab. If the slab was rocking, it was expected that there would be a measurable negative deflection at the slab end opposite the load. Unfortunately, the FWD only records the peak downward deflection for each drop and, therefore, geophones located in the area of the slab moving upward would measure zero as the peak downward deflection. In hindsight, a deflection history should have been run with the FWD during these runs to actually determine this negative deflection. Another possible test for a rocking slab would be to position the remote sensor at various distances along the length of the slab, plot the positive (downward) maximum deflections measured over that portion of the slab moving downward, and extrapolate these values across the upward moving portion of the slab. Because of the stiffness of the PCC slab, these deflections should plot as a straight line. The point of zero deflection would be the fulcrum over which the slab was rocking. Figure 4.2 shows the positioning of the load plate and geophones in the August 1999 readings.



Sensor spacing from center of load plate: -12, 0, 12, 18, 24 and 36 inches,
with Df7 being placed just inside the nearest crack or joint on the loaded slab

Figure 4.2 FWD Load Plate and Sensor Positioning – August 1999

Table 4.3 summarizes the results of the August 1999 measurements. As can be seen in this table, these tests were limited to sections with 13-foot long slabs and the one section of 25-foot long slabs on the 307NJ base. Normalized Df7 measurements on the CTFD and 307NJ bases suggest the entire partial slabs on which the FWD load plate was located moved downward under the load. Individual measurements are shown in Appendix C.

Table 4.3 – Summary of August 1999 FWD Measurements

Base Type	Avg. Norm. Dfl Defl. in FWD Position (mils)		Avg. Norm. Df7 Defl. in FWD Position (mils)		Load Transfer (Df3/Df1) in FWD Position (%)	
	JA	JL	JA	JL	JA	JL
13-foot Joint Spacing						
304	0.47	1.06	0.00	0.00	34.7	17.7
310	0.53	0.49	0.02	0.02	69.1	75.3
307NJ	1.39	2.00	0.09	0.14	7.0	5.6
307IA	0.66	0.79	0.02	0.03	61.1	56.2
ATFDB	0.55	0.51	0.01	0.01	44.0	54.8
CTFDB	1.75	1.32	0.28	0.26	15.2	18.3
25-foot Joint Spacing						
307NJ	1.38	1.04	0.03	0.09	9.8	16.9

Observations from the August 1999 FWD measurements include the following:

1. As was seen during the June 1999 FWD measurements, Sensor 1 (Dfl) in the joint leave (JL) position was generally about the same or greater than Dfl in the joint approach (JA) position, with the following exceptions: the 13-foot long slabs on the asphalt and cement stabilized bases and 25-foot long slabs on 310 base. In August, joint deflections on the 13-foot long slabs with a CTFD base remained higher on the approach side, but deflections on the ATFD base had equalized. Dfl was slightly higher in the JA position than the JL position on 25-foot long slabs with a 307NJ base. The 310 base with 25-foot long slabs was not tested in August.
2. High slab-end deflections continued to be associated with low load transfer across joints. Though not a precise correlation, it is interesting to note in the August measurements that the higher average Dfl measured in either the JA or JL position on each section also had a lower load transfer in that position.
3. In June and August, all slab ends with an average normalized deflection of over 1.00 mils had an average load transfer of less than 20% in that measurement position. The

same three sections with extremely low load transfer in June showed the same trend in August. Load transfer in the 307IA/13' section decreased to 61.1% in August from the unrealistically high levels registered in June.

4.3 Performance Summary

Data presented earlier in this chapter on cracking frequency and FWD deflections have been combined together in Table 4.4. The June and August 1999 FWD readings are both included as shown with a slash separating them. Since somewhat different types of data were obtained each time and since not all of the sections with 25-foot long slabs were tested in August, all data were not duplicated. When data are not available, a dash was inserted in the table.

Unless considerable background information is available with FWD data, it is difficult to determine from this table alone how the sections are performing. To better visualize overall performance, qualitative ratings were established for each measured parameter, as shown in Table 4.5. It is important to note that these ratings are not standards, nor were they obtained from other sources. They are ranges of measured performance based solely on the experience of the authors and values obtained for the various parameters on this project.

Table 4.4 – Quantitative Summary of Section Performance

			FWD Measurements - June/August 1999				
			Dfl Deflection (mils)			Load Transfer (%)	
Base Type	Slab Length (ft.)	Trans. Cracking (Avg. # Cracks/Slab)	Mdsb.	JA	JL	LT_A	LT_L
304	13	0.03	.25/ -	.51/.47	.70/1.06	41.6/34.7	- /17.7
	25	1.00	.36/ -	.57/ -	1.09/ -	48.8/ -	- / -
310	13	0.09	.35/ -	.66/.53	.60/.49	49.2/69.1	- /75.3
	25	1.11	.33/ -	.73/ -	.52/ -	28.1/ -	- / -
307NJ	13	0.95	.73/ -	1.42/1.39	2.32/2.00	5.5/7.0	- /5.6
	25	2.00	.69/ -	1.32/1.38	1.28/1.04	7.1/9.8	- /16.9
307IA	13	0.19	.30/ -	.51/.66	.53/.79	103.2/61.1	- /56.2
	25	1.21	.36/ -	.51/ -	.56/ -	62.2/ -	- / -
ATFDB	13	0.00	.20/	.55/.55	.32/.51	43.2/44.0	- /54.8
	25	0.19	.11/ -	.24/ -	.28/ -	61.6/ -	- / -
CTFDB	13	0.19	.49/ -	2.09/1.75	1.17/1.32	6.6/15.2	- /18.3
	25	2.41	.27/ -	.37/ -	.43/ -	91.9/ -	- / -

Table 4.5 – Descriptive Ranges of Performance

		FWD Measurements - June/August 1999		
		Dfl Deflection (mils)		Load Transfer (%)
Rating	Trans. Cracking (Avg. # Cracks/Slab)	Midslab	Joints (JA and JL)	JA and JL
Excellent (Ex)	0 – 0.05	0 – 0.20	0 – 0.40	91 - 100
Good (Gd)	0.06 – 0.25	0.21 – 0.40	0.41 – 0.70	71 - 90
Fair (Fr)	0.26 – 0.50	0.41 – 0.60	0.71 – 1.00	51 - 70
Poor (Pr)	0.51 – 1.50	0.61 – 0.80	1.01 – 1.50	30 - 50
Very Poor (VP)	> 1.50	> 0.80	> 1.50	< 30

Table 4.6 is a duplicate of Table 4.4, except that qualitative ratings were used instead of the actual data, and the excellent and good rankings have been highlighted for easier visualization.

Table 4.6 – Qualitative Summary of Section Performance

			FWD Measurements - June/August 1999				
			Dfl Deflection (mils)			Load Transfer (%)	
Base Type	Slab Length (ft.)	Trans. Cracking (Avg. # Cracks/Slab)	Mdsb.	JA	JL	LT_A	LT_L
304	13	Excellent	Gd/ -	Gd/Gd	Gd/Pr	Pr/Pr	- /VP
	25	Poor	Gd/ -	Gd/ -	Pr/ -	Pr/ -	- / -
310	13	Good	Gd/ -	Gd/Gd	Gd/Gd	Pr/Fr	- /Gd
	25	Poor	Gd/ -	Fr/ -	Gd/ -	VP/ -	- / -
307NJ	13	Poor	Pr/ -	Pr/Pr	VP/VP	VP/VP	- /VP
	25	Very Poor	Pr/ -	Pr/Pr	Pr/Pr	VP/VP	- /VP
307IA	13	Good	Gd/ -	Gd/Gd	Gd/Fr	Ex/Fr	- /Fr
	25	Poor	Gd/ -	Gd/ -	Gd/ -	Fr/ -	- / -
ATFDB*	13	Excellent	Ex/ -	Gd/Gd	Ex/Gd	Pr/Pr	- /Fr
	25	Good	Ex/ -	Ex/ -	Ex/ -	Fr/ -	- / -
CTFDB	13	Good	Fr/ -	VP/VP	Pr/Pr	VP/VP	- /VP
	25	Very Poor	Gd/ -	Ex/ -	Gd/ -	Ex/ -	- / -

- Cores revealed severe stripping of the asphalt cement from the base aggregate

Three major conclusions can be drawn from Table 4.6, as follows:

1. None of the parameters measured on the two sections with 307NJ base are classified as being good or excellent. This included transverse slab cracking, midslab and joint deflection, and load transfer at joints. Similarly, the section with 13-foot long slabs on CTFD base, though largely uncracked, also had high FWD deflections throughout. This would suggest that additional cracking may become evident soon. The 25-foot long slabs on CTFD base, while having good FWD response, are the most severely cracked on the project. Based on these data, both 307NJ and CTFDB sections can be considered to be performing poorly.

2. Both sections on the ATFD base received the highest ratings for the parameters measured, even though load transfer was still marginal. This would suggest that these sections are performing the best at this point in time. Severe stripping was observed in cores taken from the AC base.
3. Excellent to good FWD response (low deflection) at slab ends is not always indicative of good load transfer. Though somewhat related, some deviation is reasonable since numerous mechanisms are involved. Deflection at slab ends is sensitive to internal temperature gradients, which cause the slabs to curl, and load transfer is sensitive to average slab temperature, which affects aggregate interlock at the slab faces. Curling is most prominent in the spring and fall when the seasons are changing, and during days when there are either significant changes in temperature or rainfall events. Load transfer is generally high in the summer when the slabs are warm and expanded, and low in the winter when the slabs are cold. Slab deflections and load transfer tend to be inversely proportional, but there are times when both parameters can be good or bad. At the time of the FWD measurements on ERI/LOR 2, it appears the slab ends were not curled severely, as indicated by low deflections in the better performing sections, Also, the slabs were not warm enough to consistently provide aggregate interlock on all sections.

Chapter 5

CONCLUSIONS

5.1 Laboratory Testing of Base Materials

1. Samples of 307 NJ base prepared for the triaxial and resilient modulus tests had a lower density than the 307 IA and 304 bases, probably due to a lack of smaller particles in the mix. The 307 NJ material was difficult to compact in the molds.
2. Axial strain at failure in the triaxial tests was lower for the 307NJ base than the 307 IA and 304 bases. As traffic loads pass over PCC pavement with the 307 NJ base, heavy loads and vibrations may cause the base to consolidate, thereby resulting in a loss of support for the PCC pavement. This can have a significant impact on field performance.

5.2 Field – Cracking Observations

1. PCC test sections with a 25-foot slab length all averaged one or two transverse cracks per slab when constructed on 304, 307 NJ, 307 IA, 310 and CTFD base. Slabs on ATFD base had minimal cracking.
2. PCC test sections with 13-foot slab lengths had minimal cracking when constructed on 304, 307 IA, 310 and either ATFD or CTFD bases, while 13-foot slabs on 307 NJ base had significant transverse cracking. This cracking occurred after the sections were opened to traffic and was not believed to be associated with construction.
3. Both sections on the 307 NJ base had significant transverse and some longitudinal cracking. This may be caused by densification of this free draining material under heavy traffic loads and high stresses being induced in the slabs from the resulting loss of support. When slab ends are curled upward, significant tensile stresses from the

weight of the slab and heavy traffic passing over the cantilevered slab ends are generated away from the joints. Cores taken at the cracks show that the size of the crack opening decreases from top to bottom of the slab, which supports this hypothesis.

4. The section with 25-foot long slabs and CTFD base was the most extensively cracked section in the experiment. The rigidity of the CTFD base resists deformation during curling and warping. As a result, the separation between the slab and base becomes more pronounced, the length of unsupported slab length becomes larger, and higher stresses are introduced into the slab. The high FWD measurements on the 13-foot long slabs with CTFD base are indicative of this phenomenon.

5.3 Field – FWD Measurements

1. Slabs on ATFD base had the lowest normalized FWD deflection in June 1999 at midslab, indicating the highest pavement stiffness. Slabs on 307 NJ base had the highest midslab deflection, indicating the lowest pavement stiffness. This may be partially due to the presence of transverse cracks in the 307 NJ sections. While the subgrade can affect overall pavement stiffness, it is interesting that midslab deflections in the 13 and 25-foot long sections with the same base were similar. Higher deflections in the CTFD base section may be due to a lack of support resulting from curling and warping on a very rigid base layer.
2. The 13 and 25-foot slabs on 307 NJ base, and the 13-foot slabs on CTFD base had very high FWD deflection and very low load transfer at the joints, indicating poor joint performance. The CTFD base section with 13-foot slabs, though largely uncracked at this time, is likely to show some transverse cracking soon.

3. With high joint deflections, and joint leave readings being significantly higher than the joint approach readings, faulting is likely to occur in the 307 NJ section with 13-foot slabs.

5.4 Summary – Overall Base Performance

1. All transverse cracking and FWD parameters used to measure performance on both sections with 307 NJ base were rated poor to very poor in Table 4.6.
2. Wheelpath cores taken from the sections with ATFD base showed severe stripping of the asphalt cement from aggregate in the base.

In summary, the preponderance of data collected in the laboratory and at the ERI/LOR 2 site suggests the 307 NJ and CTFD bases are performing poorly at this time. All sections with 25-foot slabs except those with ATFD base, and the section with 13-foot slabs on 307 NJ base have significant transverse cracking. The 307 NJ/13' slabs also have some longitudinal cracking. Considering the relatively short time these pavement sections have been in service, this level of performance is unacceptable. The ATFD base appears to be performing the best at this time.

High FWD joint deflections in the wheel path of the CTFD base section may be caused by a lack of support as the pavement slabs curl and warp longitudinally on a rigid base. Higher than expected midslab readings may be caused by curling and warping in the transverse direction. This may result in some slab faulting or cracking in the CTFD base section in the near future.

Chapter 6

RECOMMENDATIONS

Based upon results obtained thus far in this project, the following recommendations are presented for consideration at this time:

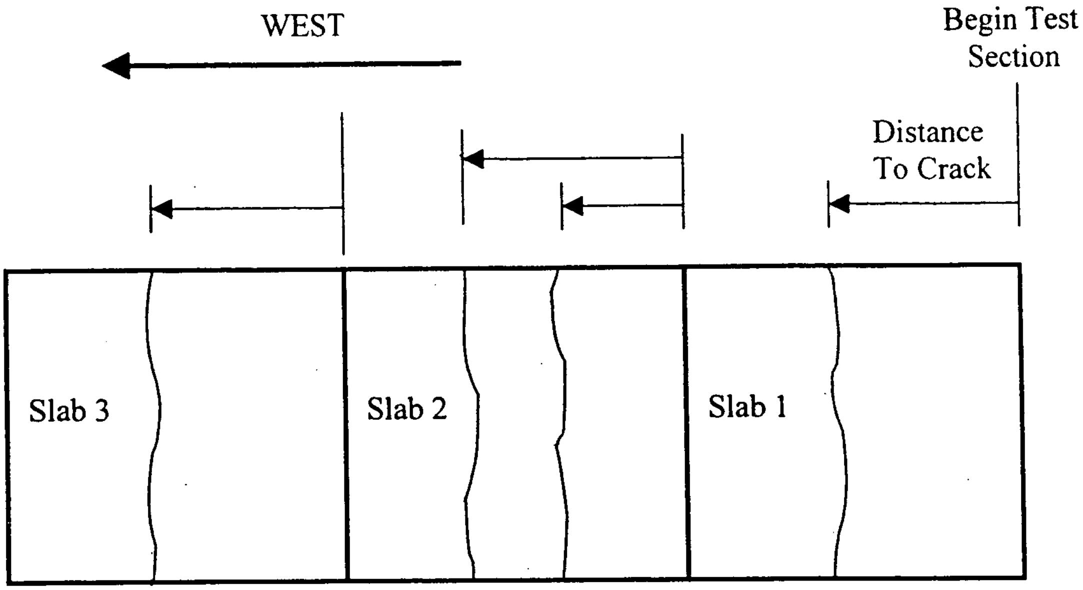
1. The 307 NJ and CTFD bases are performing poorly under the PCC pavement on SR 2. It appears the 307 NJ base may consolidate under traffic loading and lose needed support around the joints. The rigidity of CTFD base may cause high tensile stresses in the top of PCC slabs as they curl and warp, which will likely result in premature slab cracking. Since other satisfactory materials are available for use under PCC pavement, the use of 307NJ and CTFD base should be discontinued for this application.
2. The SR 2 test sections have been in service for a limited period of time. There should be continued monitoring to determine the long-term performance of 304 and 310 dense graded aggregate bases, 307 IA base and ATFD base.
3. The original objective of this installation was to observe the effect of base type on the development of D-cracking in PCC pavement constructed with D-cracking susceptible and D-cracking resistant aggregate. This is a critical consideration in the performance of PCC pavement and additional monitoring should be performed to meet this objective.

APPENDIX A

CRACK LOCATIONS IN CONCRETE SLABS

ERI/LOR 2 – Project 6000(92)

June 1999



Numbering Convention

Slabs numbered from east to west
Transverse cracks measured from east end of slab
Slabs shaded in table have longitudinal cracks

RT. 2 - CONCRETE CRACK LOCATIONS

NOTES:
Distance to crack measured from East end of slab
Slab number increases from East to West
All cracks in transverse direction unless otherwise notified
Shaded slab numbers have longitudinal cracks, see end of sheet
Picture numbers shown in brackets [#]

SLAB NUMBER	SLAB LENGTH	BASE TYPE	DISTANCE	SLAB NUMBER	SLAB LENGTH	BASE TYPE	DISTANCE
1	13	CTB	NO CRACK (NC)	10	25	ATB	NC
2	13	CTB	NC	11	25	ATB	19'-0"
3	13	CTB	NC	12	25	ATB	19'-6"
4	13	CTB	5'-9"	13	25	ATB	NC

5	13	CTB	NC
6	13	CTB	NC
7	13	CTB	NC
8	13	CTB	NC
9	13	CTB	NC
10	13	CTB	NC
11	13	CTB	NC
12	13	CTB	NC
13	13	CTB	NC
14	13	CTB	NC
15	13	CTB	NC
[illegible]	13	CTB	6'-0", 9'-0"
1	25	CTB	13'-6"
2	25	CTB	5'-5", 12'-6", 15'-5"
3	25	CTB	11'-9", 13'-2"
4	25	CTB	8'-5", 15'-1" [3-5]
[illegible]	25	CTB	9'-10", 19'-0"
[illegible]	25	CTB	5'-3", 8'-3", 13'-0", 18'-4"
7	25	CTB	9'-4"
8	25	CTB	12'-5", 15'-10"
9	25	CTB	8'-3", 11'-2", 18'-8"
10	25	CTB	7'-4", 10'-0", 16'-6", 18'-6"
[illegible]	25	CTB	13'-2" [3-6]
12	25	CTB	8'-0", 16'-6"
[illegible]	25	CTB	10'-10", 18'-8"
[illegible]	25	CTB	7'-7", 15'-1"
[illegible]	25	CTB	5'-3", 8'-6", 11'-6", 16'-8"
16	25	CTB	5'-6", 8'-4", 15'-7"
17	25	CTB	11'-6"
1	25	ATB	NC
2	25	ATB	NC
3	25	ATB	NC
4	25	ATB	NC
5	25	ATB	NC
6	25	ATB	NC
7	25	ATB	NC
8	25	ATB	NC
9	25	ATB	NC

14	25	ATB	NC
15	25	ATB	13'-3"
16	25	ATB	NC
6	13	ATB	NC
7	13	ATB	NC
8	13	ATB	NC
9	13	ATB	NC
10	13	ATB	NC
11	13	ATB	NC
12	13	ATB	NC
13	13	ATB	NC
14	13	ATB	NC
15	13	ATB	NC
16	13	ATB	NC
17	13	ATB	NC
18	13	ATB	NC
19	13	ATB	NC
20	13	ATB	NC
21	13	ATB	NC
22	13	ATB	NC
23	13	ATB	NC
24	13	ATB	NC
25	13	ATB	NC
26	13	ATB	NC
27	13	ATB	NC
28	13	ATB	NC
29	13	ATB	NC
30	13	ATB	NC
31	13	ATB	NC
32	13	ATB	NC
33	13	ATB	NC
34	13	ATB	NC
35	13	ATB	NC
36	13	ATB	NC
37	13	ATB	NC
38	13	ATB	NC

SLAB NUMBER	SLAB LENGTH	BASE TYPE	DISTANCE
1	13	NJ	NC
2	13	NJ	NC
3	13	NJ	7'-2"

SLAB NUMBER	SLAB LENGTH	BASE TYPE	DISTANCE
17	25	NJ	10'-2", 19'-0"
1	25	304	11'-6"
2	25	304	12'10"

4	13	NJ	6'-0"
5	13	NJ	7'-2"
6	13	NJ	6'-5"
7	13	NJ	6'-5", 7'-0"
8	13	NJ	6'-8"
9	13	NJ	6'-6"
10	13	NJ	6'-6"
11	13	NJ	6'-11"
12	13	NJ	6'-10"
13	13	NJ	6'-4"
14	13	NJ	6'-4"
15	13	NJ	6'-0"
16	13	NJ	7'-4"
17	13	NJ	7'-3"
18	13	NJ	6'-9"
19	13	NJ	6'-4"
20	13	NJ	6'-2"
21	13	NJ	NO TRAFFIC CONTROL
22	13	NJ	NO TRAFFIC CONTROL
23	13	NJ	NO TRAFFIC CONTROL
24	13	NJ	NO TRAFFIC CONTROL
25	13	NJ	NO TRAFFIC CONTROL
26	13	NJ	NO TRAFFIC CONTROL
27	13	NJ	NO TRAFFIC CONTROL
28	13	NJ	NO TRAFFIC CONTROL
29	13	NJ	NO TRAFFIC CONTROL
30	13	NJ	NO TRAFFIC CONTROL
31	13	NJ	NO TRAFFIC CONTROL
32	13	NJ	NO TRAFFIC CONTROL
33	13	NJ	NO TRAFFIC CONTROL
34	13	NJ	NO TRAFFIC CONTROL
35	13	NJ	NO TRAFFIC CONTROL
1	25	NJ	2 cracks
2	25	NJ	1 at midspan
3	25	NJ	2 at midspan
4	25	NJ	2 cracks
5	25	NJ	1 at midspan
6	25	NJ	3 cracks
7	25	NJ	3 cracks
8	25	NJ	2 cracks
9	25	NJ	2 cracks
10	25	NJ	2 cracks
11	25	NJ	2 cracks
12	25	NJ	2 cracks
3	25	304	12'-7"
4	25	304	14'-10"
5	25	304	9'-4"
6	25	304	9'-5"
7	25	304	10'-4"
8	25	304	11'-6"
9	25	304	13'-1"
10	25	304	11'-3"
11	25	304	11'-4"
12	25	304	9'-2"
13	25	304	13'-5"
14	25	304	13'-8"
15	25	304	11'-2"
16	25	304	13'-8"
17	25	304	11'-4"
1	13	304	NC
2	13	304	NC
3	13	304	NC
4	13	304	NC
5	13	304	NC
6	13	304	NC
7	13	304	NC
8	13	304	NC
9	13	304	NC
10	13	304	NC
11	13	304	NC
12	13	304	NC
13	13	304	NC
14	13	304	NC
15	13	304	NC
16	13	304	NC
17	13	304	NC
18	13	304	NC
19	13	304	NC
20	13	304	NC
21	13	304	NC
22	13	304	NC
23	13	304	NC
24	13	304	NC
25	13	304	NC
26	13	304	5'-6"
27	13	304	NC
28	13	304	NC
29	13	304	NC

13	25	NJ	8'-5", 17'-6"
14	25	NJ	10'-6", 18'-10"
15	25	NJ	9'-4", 18'-4"
16	25	NJ	9'-10", 18'-0"

SLAB NUMBER	SLAB LENGTH	BASE TYPE	DISTANCE
1	13	IA	NC
2	13	IA	NC
3	13	IA	NC
4	13	IA	NC
5	13	IA	NC
6	13	IA	NC
7	13	IA	NC
8	13	IA	NC
9	13	IA	NC
10	13	IA	NC
11	13	IA	NC
12	13	IA	NC
13	13	IA	NC
14	13	IA	NC
15	13	IA	NC
16	13	IA	NC
17	13	IA	NC
18	13	IA	6'-8"
19	13	IA	6'-3"
20	13	IA	6'-9"
21	13	IA	6'-8"
22	13	IA	NC
23	13	IA	NC
24	13	IA	NC
25	13	IA	NC
26	13	IA	NC
27	13	IA	NC
28	13	IA	NC
29	13	IA	6'-11"
30	13	IA	NC
31	13	IA	6'-9"
32	13	IA	NC
33	13	IA	NC
34	13	IA	NC
35	13	IA	NC
36	13	IA	5'-8"
1	25	IA	6'-4", 13'-0"

30	13	304	NC
31	13	304	NC
32	13	304	NC
33	13	304	NC

SLAB NUMBER	SLAB LENGTH	BASE TYPE	DISTANCE
16	25	IA	12'-10"
17	25	IA	12'-8"
18	25	IA	12'-0"
19	25	IA	14'-2"
1	25	310	14'-5"
2	25	310	14'-0"
3	25	310	12'-4"
4	25	310	7'-8"
5	25	310	8'-0", 16'-0"
6	25	310	13'-2"
7	25	310	11'-8"
8	25	310	13'-7"
9	25	310	14'-4"
10	25	310	9'-0"
11	25	310	12'-9"
12	25	310	8'-10"
13	25	310	16'-4"
14	25	310	10'-9", 13'-7"
15	25	310	15'-4"
16	25	310	10'-10"
17	25	310	8'-5"
18	25	310	15'-3"
19	25	310	12'-9"
20	25	310	7'-0"
1	13	310	NC
2	13	310	NC
3	13	310	NC
4	13	310	NC
5	13	310	NC
6	13	310	NC
7	13	310	NC
8	13	310	NC
9	13	310	NC
10	13	310	NC
11	13	310	NC
12	13	310	NC
13	13	310	NC

2	25	IA	11'-0"
3	25	IA	12'-9"
4	25	IA	14'-8"
5	25	IA	8'-5", 15'-6"
6	25	IA	13'-8"
7	25	IA	11'-8"
8	25	IA	7'-0", 7'-11", 16'-6"
9	25	IA	13'-6"
10	25	IA	10'-4"
11	25	IA	10'-9"
12	25	IA	14'-7"
13	25	IA	9'-10"
14	25	IA	12'-10"
15	25	IA	12'-0"

14	13	310	NC
15	13	310	NC
16	13	310	6'-5"
17	13	310	NC
18	13	310	7'-0"
19	13	310	NC
20	13	310	NC
21	13	310	NC
22	13	310	NC
23	13	310	NC

LONGITUDINAL CRACKS

NOTES:

Longitudinal cracks measured from edge line of road, length given in parentheses.

SLAB NUMBER	SLAB LENGTH	BASE TYPE	DISTANCE
	13	CTB	5'-7" (13')
	25	CTB	5'-6" (13'-2")
	25	CTB	5'-0" (13'-1")
	25	CTB	5'-5" (5'-10")
	25	CTB	7'-0" (13'-1")
	25	CTB	3'-6" (7'-1")
	25	CTB	7'-1" (5'-3")

Appendix B

FALLING WEIGHT DEFLECTOMETER DATA

ERI/LOR 2 - Project 6000(92)

June 29, 1999

FALLING WEIGHT DEFLECTOMETER DATA
LOR 2; Load ~ 9,000 lbs.
6/29/99

File	Station	Type Reading	Normalized Df1 (mils/kip)	LT (%) (Df3/Df1)	Station	Type Reading	Normalized Df1 (mils/kip)	LT (%) (Df3/Df1)
NJ99a.FWD	NJ Base-13 Foot Slabs				NJ Base-25 Foot Slabs			
	72+53	JL	3.95		65+50	JL	1.29	
	72+51	M	1.49	75.3	65+45	M	0.65	103.2*
	72+49	M	0.91	113.0*	65+40	M	1.26	80.3
	72+47	M	1.11	58.7*	65+35	M	0.49	70.9
	72+44	JA	1.47	2.4	65+28	JA	0.81	11.8
	72+42	JL	1.76		65+26	JL	0.89	
	72+39	M	0.60	84.8	65+21	M	0.33	104.5*
	72+37	M	0.62	73.8	65+15	M	0.68	68.4
	72+35	M	0.45	98.8*	65+03	JA	2.11	5.7
	72+33	JA	1.26	6.2	65+01	JL	1.66	
	72+32	JL	1.26		64+96	M	0.39	110.7*
	72+30	M	0.66	76.4	64+91	M	1.48	78.2
	72+28	M	0.38	90.6	64+86	M	0.25	99.1*
	72+26	M	0.39	91.4	64+80	JA	1.03	3.7
	72+23	JA	1.53	7.8				
	Average	JL (3)	2.32		Average	JL (3)	1.28	
		M (9)	0.73	84.8		M (8)	0.69	89.4
		JA (3)	1.42	5.5		JA (3)	1.32	7.1
IA99a.FWD	IA Base-13 Foot Slabs				IA Base-25 Foot Slabs			
	13+01	JL	0.65		8+15	JL	0.57	
	12+96	M	0.29	85.3	8+10	M	0.33	83.8
	12+90	JA	0.50	100.2	8+05	M	0.28	89.2
	12+88	JL	0.54		7+99	M	0.29	86.1
	12+83	M	0.30	86.0	7+94	JA	0.49	70.8
	12+77	JA	0.42	97.4	7+92	JL	0.71	
	12+75	JL	0.39		7+87	M	0.27	89.4
	12+71	M	0.30	85.8	7+82	M	0.80	45.3*
	12+65	JA	0.60	112.1**	7+77	M	0.27	86.2
					7+72	JA	0.44	83.4
					7+70	JL	0.40	
					7+65	M	0.29	92.5
					7+60	M	0.41	81.6
					7+55	M	0.26	85.9
					7+49	JA	0.61	32.3
	Average	JL (3)	0.53		Average	JL (3)	0.56	
		M (3)	0.30	85.7		M (9)	0.36	82.2
		JA (3)	0.51	103.2		JA (3)	0.51	62.2

* Crack or joint probably in deflection basin

** Joint probably between Df3 and Df4 instead of between Df1 and Df3

FALLING WEIGHT DEFLECTOMETER DATA
LOR 2; Load ~ 9,000 lbs.
6/29/99

File	Station	Type Reading	Normalized Df1 (mils/kip)	LT (%) (Df3/Df1)	Station	Type Reading	Normalized Df1 (mils/kip)	LT (%) (Df3/Df1)
30499a.FWD	304 Base-13 Foot Slabs				304 Base-25 Foot Slabs			
	60+06	JL	0.74		63+16	JL	1.24	
	60+02	M	0.25	74.8	63+11	M	0.28	84.6
	59+95	JA	0.49	23.5	63+06	M	1.08	76.6
	59+93	JL	0.99		63+01	M	0.20	78.2
	98+93	M	0.32	76.8	62+94	JA	0.63	14.9
	59+83	JA	0.47	73.2	62+92	JL	1.54	
	59+81	JL	0.37		62+87	M	0.43	88.0
	59+77	M	0.17	79.7	62+82	M	0.36	76.1
	59+71	JA	0.57	28.2	62+77	M	0.18	79.8
					62+71	JA	0.56	85.3
					62+69	JL	0.50	
					62+64	M	0.21	81.0
					62+59	M	0.28	96.9
					62+54	M	0.26	76.6
					62+48	JA	0.53	46.2
	Average	JL (3)	0.70		Average	JL (3)	1.09	
		M (3)	0.25	77.1		M (9)	0.36	82.0
		JA (3)	0.51	41.6		JA (3)	0.57	48.8
31099a.FWD	310 Base-13 Foot Slabs				310 Base-25 Foot Slabs			
	1836+50	JL	0.64		4+24	JA	0.91	22.2
	1836+44	M	0.32	85.7	4+22	JL	0.52	
	1836+38	JA	0.55	64.6	4+17	M	0.36	80.4
	1836+36	JL	0.52		4+12	M	0.33	97.9
	1836+32	M	0.32	89.7	4+07	M	0.30	87.2
	1836+26	JA	0.75	32.4	4+03	JA	0.55	33.9
	1836+24	JL	0.64					
	1836+21	M	0.40	86.6				
	1836+14	JA	0.69	50.5				
	Average	JL (3)	0.60		Average	JL (1)	0.52	
		M (3)	0.35	87.3		M (3)	0.33	88.5
		JA (3)	0.66	49.2		JA (2)	0.73	28.1

FALLING WEIGHT DEFLECTOMETER DATA
LOR 2; Load ~ 9,000 lbs.
6/29/99

File	Station	Type Reading	Normalized Df1 (mils/kip)	LT (%) (Df3/Df1)	Station	Type Reading	Normalized Df1 (mils/kip)	LT (%) (Df3/Df1)
CTB99a.FWD	CTB Base-13 Foot Slabs				CTB Base-25 Foot Slabs			
	87+98	JL	0.64		85+49	JL	0.51	
	87+96	M	0.32	81.8	85+44	M	0.30	88.1
	87+94	M	0.29	85.7	85+40	M	0.27	93.3
	87+92	M	0.32	99.7*	85+35	M	0.24	85.1
	87+90	JA	1.33	9.5	85+27	JA	0.30	100.0
	87+88	JL	1.54		85+25	JL	0.26	
	87+86	M	0.72	84.2	85+19	M	0.20	86.7
	87+84	M	0.47	96.2	85+15	M	0.20	85.9
	87+82	M	0.74	113.4*	85+10	M	0.28	81.1
	87+79	JA	2.52	4.5	85+03	JA	0.50	104.5
	87+77	JL	1.33		85+01	JL	0.51	
	87+75	M	0.59	82.1	84+96	M	0.33	94.6
	87+73	M	0.44	99.3*	84+91	M	0.43	81.4
	87+69	JA	2.43	5.7	84+85	M	0.16	77.6
					84+78	JA	0.32	71.2
	Average	JL (3)	1.17		Average	JL (3)	0.43	
		M (8)	0.49	92.8		M (9)	0.27	86.0
		JA (3)	2.09	6.6		JA (3)	0.37	91.9
ATB99a.FWD	ATB Base-13 Foot Slabs				ATB Base-25 Foot Slabs			
	76+49	JL	0.30		80+78	JL	0.32	
	76+47	M	0.20	77.5	80+72	M	0.11	77.9
	76+45	M	0.17	79.2	80+67	M	0.11	76.0
	76+43	M	0.17	81.9	80+62	M	0.10	73.5
	76+40	JA	0.30	80.9	80+54	JA	0.23	65.6
	76+38	JL	0.30		80+53	JL	0.23	
	76+36	M	0.21	82.7	80+48	M	0.12	75.7
	76+34	M	0.20	81.5	80+43	M	0.12	79.5
	76+32	M	0.20	86.4	80+37	M	0.12	76.7
	76+29	JA	0.58	25.7	80+29	JA	0.24	57.5
	76+27	JL	0.35					
	76+25	M	0.21	80.7				
	76+23	M	0.20	84.1				
	76+21	M	0.22	88.2				
	76+17	JA	0.78	23.1				
	Average	JL (3)	0.32		Average	JL (2)	0.28	
		M (9)	0.20	82.5		M (6)	0.11	76.6
		JA (3)	0.55	43.2		JA (2)	0.24	61.6

* Reading taken close to joint with high deflection and low load transfer

SUMMARY
FALLING WEIGHT DEFLECTOMETER DATA
LOR 2; Load ~ 9,000 lbs.
6/29/99

Base Type	Slab Length (ft.)	Normalized Df1 (mils/kip)			% Load Transfer (Df3/Df1)	
		JL	M	JA	M	JA
304	13	0.70	0.25	0.51	77.1	41.6
	25	1.09	0.36	0.57	82.0	48.8
310	13	0.60	0.35	0.66	87.3	49.2
	25	0.52	0.33	0.73	88.5	28.1
NJ	13	2.32	0.73	1.42	84.8	5.5
	25	1.28	0.69	1.32	89.4	7.1
IA	13	0.53	0.30	0.51	85.7	103.2
	25	0.56	0.36	0.51	82.2	62.2
CTB	13	1.17	0.49	2.09	92.8	6.6
	25	0.43	0.27	0.37	86.0	91.9
ATB	13	0.32	0.20	0.55	82.5	43.2
	25	0.28	0.11	0.24	76.6	61.6

JL = Joint Leave; M = Midslab; JA = Joint Approach
Df1 = Deflection under FWD load plate
Df3 = Deflection @ R=12 inches
Joint between Df1 and Df3 in JA position

ANALYSIS

Df1 @ midslab (M) indicative of pavement stiffness (no midslab cracks)

Df1 @ JA and JL indicative of stiffness at slab ends - usually higher deflection than Df1 @ midslab and lower stiffness, especially when joint in poor condition

Df3/Df1 @ midslab indicative of how pavement structure (mostly the slab) distributes the load
Should be relatively constant on a given pavement if there are no midslab cracks
May be erratic if there are midslab cracks and deviation from norm (high or low);
depends upon relative position of crack, load plate and sensors

Df3/Df1 @ JA indicative of how well the joint between the load plate and Df3 transfers the load
If close to Df3/Df1 @ midslab, the joint has excellent load transfer
If significantly lower than Df3/Df1 @ midslab, effectiveness is (Df3/Df1 @ JA)/(Df3/Df1 @ M)

OBSERVATIONS

General - Df1 at joints and load transfer tend to be inversely proportionally
304 - Relatively high Df1 @ slab ends and moderate load transfer across joints
310 - Elevated Df1 @ slab ends and moderate load transfer across joints
NJ - Highest Df1 @ midslab, high Df1 @ slab ends and very low load transfer across joints
Data also suggest cracking in the 13 foot and 25 foot long slabs
IA - Good overall FWD response with low load transfer at one joint and one midslab crack
CTB - 13 foot slabs have high deflection at slab ends and poor load transfer; 25 foot slabs OK
ATB - Df1 OK, but some loss of load transfer; 25 foot slabs better than 13 foot slabs

Appendix C

FALLING WEIGHT DEFLECTOMETER DATA

ERI/LOR 2 - Project 6000(92)

June 29, 1999

FALLING WEIGHT DEFLECTOMETER DATA
LOR 2; Load ~ 9,000 lbs.
6/29/99

File	Station	Type Reading	Normalized Df1 (mils/kip)	LT (%) (Df3/Df1)	Station	Type Reading	Normalized Df1 (mils/kip)	LT (%) (Df3/Df1)
NJ99a.FWD	NJ Base-13 Foot Slabs				NJ Base-25 Foot Slabs			
	72+53	JL	3.95		65+50	JL	1.29	
	72+51	M	1.49	75.3	65+45	M	0.65	103.2*
	72+49	M	0.91	113.0*	65+40	M	1.26	80.3
	72+47	M	1.11	58.7*	65+35	M	0.49	70.9
	72+44	JA	1.47	2.4	65+28	JA	0.81	11.8
	72+42	JL	1.76		65+26	JL	0.89	
	72+39	M	0.60	84.8	65+21	M	0.33	104.5*
	72+37	M	0.62	73.8	65+15	M	0.68	68.4
	72+35	M	0.45	98.8*	65+03	JA	2.11	5.7
	72+33	JA	1.26	6.2	65+01	JL	1.66	
	72+32	JL	1.26		64+96	M	0.39	110.7*
	72+30	M	0.66	76.4	64+91	M	1.48	78.2
	72+28	M	0.38	90.6	64+86	M	0.25	99.1*
	72+26	M	0.39	91.4	64+80	JA	1.03	3.7
	72+23	JA	1.53	7.8				
	Average	JL (3)	2.32		Average	JL (3)	1.28	
		M (9)	0.73	84.8		M (8)	0.69	89.4
		JA (3)	1.42	5.5		JA (3)	1.32	7.1
IA99a.FWD	IA Base-13 Foot Slabs				IA Base-25 Foot Slabs			
	13+01	JL	0.65		8+15	JL	0.57	
	12+96	M	0.29	85.3	8+10	M	0.33	83.8
	12+90	JA	0.50	100.2	8+05	M	0.28	89.2
	12+88	JL	0.54		7+99	M	0.29	86.1
	12+83	M	0.30	86.0	7+94	JA	0.49	70.8
	12+77	JA	0.42	97.4	7+92	JL	0.71	
	12+75	JL	0.39		7+87	M	0.27	89.4
	12+71	M	0.30	85.8	7+82	M	0.80	45.3*
	12+65	JA	0.60	112.1**	7+77	M	0.27	86.2
					7+72	JA	0.44	83.4
					7+70	JL	0.40	
					7+65	M	0.29	92.5
					7+60	M	0.41	81.6
					7+55	M	0.26	85.9
					7+49	JA	0.61	32.3
	Average	JL (3)	0.53		Average	JL (3)	0.56	
		M (3)	0.30	85.7		M (9)	0.36	82.2
		JA (3)	0.51	103.2		JA (3)	0.51	62.2

* Crack or joint probably in deflection basin

** Joint probably between Df3 and Df4 instead of between Df1 and Df3

FALLING WEIGHT DEFLECTOMETER DATA
LOR 2; Load ~ 9,000 lbs.
6/29/99

File	Station	Type Reading	Normalized Df1 (mils/kip)	LT (%) (Df3/Df1)	Station	Type Reading	Normalized Df1 (mils/kip)	LT (%) (Df3/Df1)
30499a.FWD	304 Base-13 Foot Slabs				304 Base-25 Foot Slabs			
	60+06	JL	0.74		63+16	JL	1.24	
	60+02	M	0.25	74.8	63+11	M	0.28	84.6
	59+95	JA	0.49	23.5	63+06	M	1.08	76.6
	59+93	JL	0.99		63+01	M	0.20	78.2
	98+93	M	0.32	76.8	62+94	JA	0.63	14.9
	59+83	JA	0.47	73.2	62+92	JL	1.54	
	59+81	JL	0.37		62+87	M	0.43	88.0
	59+77	M	0.17	79.7	62+82	M	0.36	76.1
	59+71	JA	0.57	28.2	62+77	M	0.18	79.8
					62+71	JA	0.56	85.3
					62+69	JL	0.50	
					62+64	M	0.21	81.0
					62+59	M	0.28	96.9
					62+54	M	0.26	76.6
					62+48	JA	0.53	46.2
	Average	JL (3)	0.70		Average	JL (3)	1.09	
		M (3)	0.25	77.1		M (9)	0.36	82.0
		JA (3)	0.51	41.6		JA (3)	0.57	48.8
31099a.FWD	310 Base-13 Foot Slabs				310 Base-25 Foot Slabs			
	1836+50	JL	0.64		4+24	JA	0.91	22.2
	1836+44	M	0.32	85.7	4+22	JL	0.52	
	1836+38	JA	0.55	64.6	4+17	M	0.36	80.4
	1836+36	JL	0.52		4+12	M	0.33	97.9
	1836+32	M	0.32	89.7	4+07	M	0.30	87.2
	1836+26	JA	0.75	32.4	4+03	JA	0.55	33.9
	1836+24	JL	0.64					
	1836+21	M	0.40	86.6				
	1836+14	JA	0.69	50.5				
	Average	JL (3)	0.60		Average	JL (1)	0.52	
		M (3)	0.35	87.3		M (3)	0.33	88.5
		JA (3)	0.66	49.2		JA (2)	0.73	28.1

FALLING WEIGHT DEFLECTOMETER DATA
LOR 2; Load ~ 9,000 lbs.
6/29/99

File	Station	Type Reading	Normalized Df1 (mils/kip)	LT (%) (Df3/Df1)	Station	Type Reading	Normalized Df1 (mils/kip)	LT (%) (Df3/Df1)
CTB99a.FWD	CTB Base-13 Foot Slabs				CTB Base-25 Foot Slabs			
	87+98	JL	0.64		85+49	JL	0.51	
	87+96	M	0.32	81.8	85+44	M	0.30	88.1
	87+94	M	0.29	85.7	85+40	M	0.27	93.3
	87+92	M	0.32	99.7*	85+35	M	0.24	85.1
	87+90	JA	1.33	9.5	85+27	JA	0.30	100.0
	87+88	JL	1.54		85+25	JL	0.26	
	87+86	M	0.72	84.2	85+19	M	0.20	86.7
	87+84	M	0.47	96.2	85+15	M	0.20	85.9
	87+82	M	0.74	113.4*	85+10	M	0.28	81.1
	87+79	JA	2.52	4.5	85+03	JA	0.50	104.5
	87+77	JL	1.33		85+01	JL	0.51	
	87+75	M	0.59	82.1	84+96	M	0.33	94.6
	87+73	M	0.44	99.3*	84+91	M	0.43	81.4
	87+69	JA	2.43	5.7	84+85	M	0.16	77.6
					84+78	JA	0.32	71.2
	Average	JL (3)	1.17		Average	JL (3)	0.43	
		M (8)	0.49	92.8		M (9)	0.27	86.0
		JA (3)	2.09	6.6		JA (3)	0.37	91.9
ATB99a.FWD	ATB Base-13 Foot Slabs				ATB Base-25 Foot Slabs			
	76+49	JL	0.30		80+78	JL	0.32	
	76+47	M	0.20	77.5	80+72	M	0.11	77.9
	76+45	M	0.17	79.2	80+67	M	0.11	76.0
	76+43	M	0.17	81.9	80+62	M	0.10	73.5
	76+40	JA	0.30	80.9	80+54	JA	0.23	65.6
	76+38	JL	0.30		80+53	JL	0.23	
	76+36	M	0.21	82.7	80+48	M	0.12	75.7
	76+34	M	0.20	81.5	80+43	M	0.12	79.5
	76+32	M	0.20	86.4	80+37	M	0.12	76.7
	76+29	JA	0.58	25.7	80+29	JA	0.24	57.5
	76+27	JL	0.35					
	76+25	M	0.21	80.7				
	76+23	M	0.20	84.1				
	76+21	M	0.22	88.2				
	76+17	JA	0.78	23.1				
	Average	JL (3)	0.32		Average	JL (2)	0.28	
		M (9)	0.20	82.5		M (6)	0.11	76.6
		JA (3)	0.55	43.2		JA (2)	0.24	61.6

* Reading taken close to joint with high deflection and low load transfer

SUMMARY
FALLING WEIGHT DEFLECTOMETER DATA
LOR 2; Load ~ 9,000 lbs.
6/29/99

Base Type	Slab Length (ft.)	Normalized Df1 (mils/kip)			% Load Transfer (Df3/Df1)	
		JL	M	JA	M	JA
304	13	0.70	0.25	0.51	77.1	41.6
	25	1.09	0.36	0.57	82.0	48.8
310	13	0.60	0.35	0.66	87.3	49.2
	25	0.52	0.33	0.73	88.5	28.1
NJ	13	2.32	0.73	1.42	84.8	5.5
	25	1.28	0.69	1.32	89.4	7.1
IA	13	0.53	0.30	0.51	85.7	103.2
	25	0.56	0.36	0.51	82.2	62.2
CTB	13	1.17	0.49	2.09	92.8	6.6
	25	0.43	0.27	0.37	86.0	91.9
ATB	13	0.32	0.20	0.55	82.5	43.2
	25	0.28	0.11	0.24	76.6	61.6

JL = Joint Leave; M = Midslab; JA = Joint Approach
Df1 = Deflection under FWD load plate
Df3 = Deflection @ R=12 inches
Joint between Df1 and Df3 in JA position

ANALYSIS

Df1 @ midslab (M) indicative of pavement stiffness (no midslab cracks)

Df1 @ JA and JL indicative of stiffness at slab ends - usually higher deflection than Df1 @ midslab
and lower stiffness, especially when joint in poor condition

Df3/Df1 @ midslab indicative of how pavement structure (mostly the slab) distributes the load
Should be relatively constant on a given pavement if there are no midslab cracks
May be erratic if there are midslab cracks and deviation from norm (high or low);
depends upon relative position of crack, load plate and sensors

Df3/Df1 @ JA indicative of how well the joint between the load plate and Df3 transfers the load
If close to Df3/Df1 @ midslab, the joint has excellent load transfer
If significantly lower than Df3/Df1 @ midslab, effectiveness is (Df3/Df1 @ JA)/(Df3/Df1 @ M)

OBSERVATIONS

General - Df1 at joints and load transfer tend to be inversely proportionally
304 - Relatively high Df1 @ slab ends and moderate load transfer across joints
310 - Elevated Df1 @ slab ends and moderate load transfer across joints
NJ - Highest Df1 @ midslab, high Df1 @ slab ends and very low load transfer across joints
Data also suggest cracking in the 13 foot and 25 foot long slabs
IA - Good overall FWD response with low load transfer at one joint and one midslab crack
CTB - 13 foot slabs have high deflection at slab ends and poor load transfer; 25 foot slabs OK
ATB - Df1 OK, but some loss of load transfer; 25 foot slabs better than 13 foot slabs