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EARLY EVALUATION OF LTPP SPECIFIC PAVEMENT STUDIES – 2, COLORADO

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DEPARTMENT OF TRANSPORTATION
RESEARCH

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COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH BRANCH

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16. Abstract-

This report presents the early results of the SPS-2 experiment, "Strategic Study of Structural Factors for Rigid Pavements" documenting construction details of 13 different test sections with varying structural characteristics. The SPS-2 experiment was developed as a coordinated national experiment to address the effects of various strategic environmental and structural factors on the performance of rigid pavements. The factors studied under this experiment included concrete thickness, concrete strength, base type, lane width, drainage and environmental factors such as temperature, moisture and soil type. Pavement thicknesses were constructed at 8 and 11 inches. Alternate base types included permeable asphalt-treated base (PATB), lean concrete base (LCB), and dense-graded aggregate base (DGAB). Certain sections included a widened 14-foot slab in addition to the standard 12-foot width. Specific sections included the construction of pavement edge drains, while the remainder did not. Specific sections were constructed using high-and low-strength concrete mixes to provide a difference in performance as a paving material.

This paper discusses the performance of these test sections after being in service for four years. The results are based on monitoring data collected by the Long Term Pavement Performance Program (LTPP). The monitoring data includes deflection data collected by a falling weight deflectometer, profile data collected by a profilometer, friction data using the ASTM E 274 procedure and manually collected distress data.

Implementation

Based on the early results of the SPS-2 experiment and a supplemental study that CDOT conducted, the use of 14-foot slabs is highly recommended. The results of this study revealed that wider slabs improved the load-carrying capacity of the outside lane by keeping the trucks away from the longitudinal joint at the shoulder. Structurally speaking, their contributions were found to be equivalent to 1 inch of slab thickness. The 14-foot slab is now an option for CDOT designers, primarily in a rural setting.

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EXECUTIVE SUMMARY

This report presents the early results of the SPS-2 experiment, "Strategic Study of Structural Factors for Rigid Pavements" documenting construction details of 13 different test sections with varying structural characteristics. Included in this report is an overview of the SPS-2 experimental design, data acquisition and data analysis. The SPS-2 experiment was developed as a coordinated national experiment to address the effects of various strategic environmental and structural factors on the performance of rigid pavements. The factors studied under this experiment included concrete thickness, concrete strength, base type, lane width, drainage and environmental factors such as temperature, moisture and soil type.

Colorado Department of Transportation (CDOT) participated in this national study by constructing 13 different test sections with the following combination of structural properties:

- Concrete thickness at two levels of 8 and 11 inches;
- 14-day flexural strength of 550, 650 (state standard) and 900 psi;
- Non-draining bases- lean concrete base (LCB) and dense-graded-aggregate base (DGAB);
- Draining bases - permeable asphalt-treated base (PATB) with edge drain and transverse interceptor drain; and
- Lane width at two levels of 12 and 14 feet with untied shoulders.

In general, the intent of the SPS-2 experiment is to collect reliable data over the entire life of the pavement section to better calibrate pavement performance prediction models and to develop new design equations for incorporation into the upcoming AASHTO 2002 design guide. One of the advantages of the SPS-2 experiment is the initiation of monitoring of performance and traffic from the initial date of construction or opening to traffic. This allows the establishment of a comprehensive project–specific base line data set that can be used to monitor and compare the subsequent changes in performance for each of the pavement test sections.

This paper discusses the performance of these test sections after 4 years of performance. The results are based on monitoring data collected by the Long Term Pavement Performance Program (LTPP). The monitoring data includes deflection data collected by a falling weight deflectometer, profile data collected by a profilometer, friction data using the ASTM E 274 procedure and manually collected distress data.

Virtually no distress is evident in these pavement test sections at this time. Profile data indicates virtually no change in the ride quality of the sections. However, the evaluation of deflection data provides an early indication of anticipated variation in test section performance later in the experiment.

At present, no difference can be identified between the deflection magnitude of the widened slab sections and the state section with tied concrete shoulders. However, both of these test sections exhibited lower deflections at this time than those test sections with untied shoulders. High deflections of the thin 8-inch test sections indicate that perhaps this section was under-designed for the traffic. Performance comparisons for 11-inch pavement test sections showed that the high-strength mixes have higher deflections than the low-strength concrete mixes.

Implementation Statement

Based on the early results of the SPS-2 experiment, and a supplemental study that CDOT conducted, the use of 14-foot slab is highly recommended. The results of this study revealed that wider slabs improved the load carrying capacity of the outside lane by keeping the trucks away from the longitudinal joint at the shoulder. Structurally speaking, their contributions were found to be equivalent to 1 inch of slab thickness. The 14-foot slab is now an option for CDOT designers, primarily in a rural setting.

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1.0 INTRODUCTION

The Strategic Highway Research Program (SHRP) included the construction of specific rigid pavement sections for evaluation under the Long Term Pavement Performance (LTPP) Studies. These test sections, designated as the SPS-2 experiment, were constructed on the basis of an experiment matrix, which included pavement slab thickness, base type, widened slabs, and drainage. Pavement thicknesses were constructed at 8 and 11 inches. Alternate base types included permeable asphalt-treated base (PATB), lean concrete base (LCB), and dense-graded aggregate base (DGAB). Certain sections included a widened slab of 14 feet in addition to the standard 12-foot width. Specific sections included the construction of pavement edge drains, while the remainder did not. Specific sections were constructed using high and low concrete strength mixes to provide a difference in performance as a paving material. In addition, a standard Colorado DOT design section was constructed to provide a performance comparison.

This paper discusses the performance of these test sections after 4 years of performance. The results are based on monitoring data collected by the Long Term Pavement Performance Program (LTPP). The monitoring data includes deflection data collected by a falling-weight deflectometer, profile data collected by a profilometer, friction data using the ASTM E 274 procedure and manually-collected distress data.

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2.0 BACKGROUND

The SPS-2 experiment was developed as a coordinated national experiment to address the effects of various strategic environmental and structural factors on the performance of rigid pavements. The factors studied under this experiment included concrete thickness, concrete strength, base type, lane width, drainage and environmental factors such as temperature, moisture and soil type. Colorado Department of Transportation (CDOT) participated in this national study by constructing of 13 different test sections with the following combination of structural factors:

- Concrete thickness at two levels of 8 and 11 inches;
- 14-day flexural strength of 550, 650 (state standard) and 900 psi;
- Non-draining bases- lean concrete base (LCB) and dense-graded aggregate base (DGAB).
- Draining bases - permeable asphalt-treated base (PATB) with edge drain and transverse interceptor drain; and
- Lane width at two levels of 12 and 14 feet with untied shoulders.

With respect to environmental factors, the SPS-2 experiment is divided into 4 climatic zones: wet-freeze, wet-no-freeze, dry-freeze, and dry-no-freeze. These climatic zones are further subdivided into coarse and fine subgrades. Considering these environmental factors, Colorado's site is characterized as the zone of dry-freeze with coarse subgrade.

3.0 OBJECTIVE

The primary objective of the SPS-2 experiment is to establish relationships among strategic factors that influence concrete pavement performance. The knowledge gained from the effects of these strategic factors, in turn, will be used to improve and refine design equations for new and reconstructed concrete pavements. The ultimate goal of this experiment is to build better, safer, longer-lasting and cost-effective Portland Cement Concrete pavements.

4.0 PROJECT DESCRIPTION AND SCOPE OF WORK

The subject research site is located on I-76, "Project I 076 6-1 (138)," in the eastbound direction, approximately 18 miles east of Denver, Colorado. Altogether, a total of 13 test sections, (including a state standard section) were constructed on I-76 as part of a 3-mile reconstruction project. Each test section consisted of a 500-foot long monitoring segment with 100 feet of transition between each section. Figure 1 illustrates the layout of the SPS-2 experimental test sections in Colorado.

I-76 at this location was experiencing an average daily traffic (ADT) of 10,400 vehicles with 18 percent of that volume consisting of trucks. The 20-year design (state standard section) called for a full depth concrete pavement, Class P, with a nominal thickness of 11 inches. Colorado DOT completed construction of the test sections and opened the new roadway to traffic in November of 1994.

4.1 Base Layers

Altogether, 3 different bases were incorporated into this experiment of which two were non-drainable and one was drainable as follows:

- A 6-inch layer of dense-graded aggregate base (DGAB) compacted to 95% relative density was placed on the subgrade for 4 of the test sections (Figure 2a).
- A 6-inch layer of lean concrete base (LCB) with the following properties was installed on the subgrade for 4 of the test sections:

Lean Concrete Base

Cement..231 lbs.

Fly Ash Class F................................69 lbs.

Water/Cementitious Ratio 0.85

Air content.......................................8.9%

Slump, (AASHTO 119).......................3.5"

Wax-base curing compound was applied immediately after LCB placement at a rate of one gallon per 100 square feet. A second coat of curing compound was applied 24 hours prior to concrete placement at the rate of 1 gallon per 150 square feet to assure separation of concrete pavement from the LCB layer. Figure 2a illustrates a typical section for non-drainable test sections, the LCB and the DGAB layers.

- A 4-inch layer of drained base, which incorporated a permeable asphalt-treated base (PATB) in conjunction with longitudinal edge drains and transverse interceptor drains was placed on top of the 4 inches of DGAB for 4 of the test sections. The DGAB was used as a filter-separator to separate the subgrade from the treated base. The main function of the DGAB layer was to prevent the migration of fines into the treated base layer. Some states used fabrics in place of the DGAB. The aggregate gradation for the PATB conformed to AASHTO No. 57 size stone, which is highly draining with a coefficient of permeability in excess of 10,000 ft/day.

4- inch perforated longitudinal edge drains were installed at the outer edge of the shoulder continuously for the entire length of the PATB test sections. Discharge outlet pipes were installed every 250 feet along the edge drains to collect and divert the water from the edge drains. A layer of fabric was wrapped around the edge drains to prevent them from clogging up. In addition to the edge drains, transverse interceptor drains were also installed at the transitions between the drained and non-drained zones. Their main purpose is to prevent the flow of water from the drained zones into the non-drained zones. Figure 2b illustrates a typical section for drainable base sections using a PATB layer.

The PATB layer was hot laid with an AC content of 2.5 percent using a truck-mounted paver with extended screed. A steel roller was used to seat the PATB. The paving operation proceeded smoothly and the PATB mix appeared to be homogenous. Dowel baskets were placed in 15-foot intervals followed by concrete paving.

4.2 Trial Batches and Mix Design Selection

Three trial batches for the 550 psi mix and three trial batches for the 900 psi mix with different cement contents and water/cement ratios were prepared to cover the proposed flexural strength ranges of 550 to 900 psi at 14 days. The tolerances required by LTPP using the third point loading were 550 ± 25 and 900 ± 40 psi. After many trial mixes, the mix proportions were established for both the 550 and 900 psi mixes. In general, the W/C ratio and air content had to be closely regulated in order to achieve the requirement set by LTPP. The following represent the final mix proportions and properties for both the 550 and 900 psi mixes:

SHRP "550" Mix Summary

Cement....................................399 lbs./yd^3

Fly Ash....................................100 lbs./yd^3

AEA..6.3 oz./yd^3

Sand.......................................1430 lbs./yd^3

Rock.......................................1720 lbs./yd^3

Air Content.......................................6.4%

WC+P Ratio.......................................0.47

Flexural Strength, 14 Days.............572 psi

SHRP "900" Mix Summary

Cement.......................................749 lbs./yd^3

Fly Ash.....................................150 lbs./yd^3

AEA..3.0 oz./yd^3

WRA..36 oz./yd^3

Sand..935 lbs./yd^3

Rock.......................................1865 lbs./yd^3

Air Content..5.7%

WC+P Ratio...0.29

Flexural Strength, 14 Days.................905psi

State Standard "650" Mix Summary

Cement.......................................565 lbs./yd^3

Fly Ash.......................................113 lbs./yd^3

AEA.. 5.6 oz./yd^3

WRA... 22.5 oz./yd^3

Sand...1200 lbs./yd^3

Rock...1730 lbs./yd^3

Air Content...............................6.24%

WC+P Ratio...............................0.36

5.0 MATERIALS SAMPLING, FIELD AND LABORATORY TESTING

Due to extensive sampling and testing required for the SPS-2 test sections, it was decided to make the materials sampling and field testing into a separate contract. A summary of material sampling and field testing on each of the test sections during and after construction is presented below:

5.1 Subgrade

- Thin-wall (Shelby) tube samples and bulk samples
- Density and moisture measurement
- Auger sampling to a depth of 6.1 m (20 feet)
- Plate bearing tests
- Base line elevation survey on prepared subgrade
- Falling weight deflectometer

5.2 Dense-graded Aggregate Base (DGAB)

- Bulk samples
- Plate bearing tests

- Density and moisture measurement
- Elevation measurements on prepared DGAB
- Falling-weight deflectometer

5.3 Permeable Asphalt-treated Base (PATB)

- Bulk samples
- Plate bearing tests
- Coring of PATB for laboratory testing
- Elevation measurement on the prepared PATB
- Falling-weight deflectometer

5.4 Lean Concrete Base (LCB)

- Compressive strength for 7 day, 28 day and 1 year (as delivered and as placed)
- Plate bearing test
- Coring of LCB for laboratory testing
- Elevation measurement on the prepared PATB
- Falling weight deflectometer

5.5 Portland Cement Concrete

- Compressive strength, splitting tensile strength and flexural strength for 7 day, 28 day and 1 year (as-delivered and as-placed)
- Slump, air content, and temperature measurements on the as-delivered PCC mix.
- Coring of the PCC for laboratory testing
- Elevation measurement on the finished PCC surface.
- Falling weight deflectometer

Table 1 shows summary of PCC flexural strengths for all the test sections. It is important to note that in order to keep all the test sections across country uniform, Colorado DOT was required not

Table 1 Summary of PCC Flexural Strengths for SPS-2 Experiment in Colorado

Test Section Identification	Flexural Strength (psi)			
	Design	Average 14-Day	Average 28-Day	Average 1-year
080213	550	520	630	710
080214	900	930	950	950
080215	550	510	580	650
080216	900	900	925	870
080217	550	495	565	680
080218	900	810	950	N/A
080219	550	515	640	N/A
080220	900	890	1025	950
080221	550	475	470	620
080222	900	950	955	1005
080223	550	625	570	N/A
080224	900	815	700	1050
808259	650	750	770	770
Average 550	550	523	576	665
Standard Dev.	----	52	61	39
Average 900	900	883	918	965
Standard Dev.	----	58	112	68

Note: 1 psi = 6.89 kPa

to tie the concrete shoulders to the mainline pavement for all the test sections. The reason for this requirement was that some states used asphalt shoulders for their concrete pavements.

The variability of the pavement thickness of the various sections is excessive, when considered in the context of good paving quality control, considering today's paving techniques and equipment. The range of thickness for the 8-inch sections was documented as being from 7.7-8.7 inches. This difference of an inch potentially will result in a large difference in pavement performance life among comparative 8-inch sections. Similarly, for the 11-inch thick sections, the variability ranged from 11.1-11.8 inches. While this variability is less severe, it is still quite large, and likely to affect the ultimate performance life of the comparison sections.

5.6 Instrumentation for Traffic Data Collection

Site-specific traffic data plays a major role in evaluation and development of pavement performance models. To design new pavement and to predict future performance requires detailed knowledge of traffic information. As part of the SPS-2 experiment, CDOT installed state-of-the-art traffic data equipment to acquire the necessary information for monitoring the performance of the test sections. Class I Piezo-electric cables were installed in all lanes and directions to acquire average daily traffic volume, axle load and vehicle classification. The design 18-K equivalent single axle load (ESAL) of 15,594,000 was considered for the design period of 20 years. The estimated 18-K ESAL for the year 1994 was 395. The monitored 18-K ESAL for the years 1995, 1996 and 1997 are 487, 346 and 226.

6.0 DATA ACQUISITION AND ANALYSIS

The data acquisition consisted of acquiring deflection data collected by a falling-weight deflectometer (FWD), profile data collected by a profilometer, frictional data using the ASTM E 274 procedure and manually collected distress data. It should be noted that the Colorado SPS-2 experiment also included a typical state section of 11 inches thickness with tied concrete shoulders and 28-day flexural strength of 650 psi. The following presents the comparative performance of all the test sections, as measured by deflection response data early in the performance life of the pavement. These data comparisons include assessment of slab deflections at corners, edges, and mid-slab locations.

6.1 Comparison of Corner Deflections

Figures 3 and 4 show corner deflection data for each of the test sections. These figures provide a comparison of deflections for the 550 and 900 psi mixes on the three different base types. The data includes 1994, 1996 and 1998 deflections. As the data indicates, the deflections are greater for the high strength mix (900 psi) than for the lower-strength (550 psi) with 14-foot slab width. The relatively smaller change in deflections measured by sensor 7, representing subgrade deflections, indicates that the increased deflection is not the result of relative changes in subgrade support, but reflects the relative response of the different pavement sections. This trend likely represents the increased corner bending experienced by the narrower lanes (12-foot. untied).

The figures also show the deflection magnitudes for the 8-inch slabs on lean concrete base course. Once again the magnitude of deflections for the higher strength mix sections exceeded those of the lower-strength mix sections. Consistency of the sensor 7 (subgrade deflection data) again verifies that the subgrade response is consistent throughout the sections, indicating that the variability is primarily due to the pavement structural factors.

Very similar results are shown for the 8-inch slab deflections on the permeable asphalt-treated base. The corner deflections for the 11-inch thick state standard section (080259) with tied concrete shoulders placed directly on subgrade were lower than those of the untied 11-inch thick sections. For these 11-inch sections not having tied concrete shoulders, the slab deflections were greater for the 12-foot wide slabs with 550 psi mix than for the 14-foot wide slab with 900 psi mix. The exception to this case is the test section with LCB (080220). This can be seen looking at both sensor 1 and sensor 4 data in Figures 3and 4.

Subgrade deflections shown by sensor 7 showed little variation. However, the magnitude of the deflections for the 650 psi sections (state standard) was slightly lower than the other sections.

The two figures show the deflections of the 11-inch slab sections on lean concrete base course. The deflections appear to be fairly consistent, with the exception of the 12-foot wide lane with 550 psi section. At the lowest of the test temperatures, the observed response may reflect the effect of temperature change on the concrete slabs. Once again, the response of the subgrade deflections is quite consistent. The 12-foot wide, 550 psi section has slightly greater deflection than the other sections.

Similar results are seen for the 11-inch PATB test sections, again showing very little variability. The greatest deflections are at the 550 psi, 12-foot wide slab sections. In general, the magnitude of deflections for sensors 1, 4, and 7 was relatively low for the standard state mix (650 psi) with tied concrete shoulders.

6.2 Comparison of Edge Deflections

Edge deflection results are shown in Figures 5 and 6. For the 8-inch thick sections, deflections are for most part consistent. The highest deflection is associated with the 12-foot wide slabs and 900 psi section. For 8-inch slabs on lean concrete base course, deflections are slightly higher for the 900 psi sections with 12-foot slabs. The figures also show that subgrade deflections are consistent for these sections, as shown by sensor 7 response.

The 8-inch slab on permeable asphalt-treated base shows no significant difference in deflection magnitude. The figures show that very little difference exists between deflections for the 14-foot lane (untied shoulder) with 900 psi and the 12-foot lane state 650 psi sections with tied concrete shoulders. Again, the deflections of the state 650 psi section (080259) are among the lowest. The 12-foot untied shoulders show higher deflections at this time than the 12-foot tied and 14-foot untied test sections.

The deflections of the 11-inch slabs on the dense-graded aggregate base are for most part constant for all sections. The same sections on lean concrete base course show consistency of deflection except for the 12-foot lane with 550 psi section, which is slightly greater. Some difference, although smaller, is seen in the sensor 7 data. Little variation is evident among the deflection data for the 11-inch thick slab sections on permeable asphalt-treated base.

6.3 Comparison of Mid-Slab Deflections

Data for mid-slab deflections taken in March 1994, April 1996, and August 1998 for the 8-inch slabs on the various base types are shown in Figure 7. In August 1998 the highest deflections were observed for 900 psi mix on DGAB and LCB. In April 1996 the highest deflections are observed for the 550 psi mix on DGAB and PATB, and the 900 psi mix on LCB. Very different results are seen for the same sections in March 1994. Both deflections and temperatures are observably higher than those for April 1996. These observations appear to confirm the thermal sensitivity of the 900 psi mix on a rigid base. Furthermore, the lower-strength mix experiences higher deflection when placed on less-stiff base layers.

The deflection data for 11-inch slabs is shown in Figure 8. Deflections observed in August 1998 are very consistent for all sections, except for the 900 psi section on DGAB and LCB. The April 1996 deflections are again very consistent, except for the 900 psi section on the LCB. Once again the deflection magnitude of the high-strength mix shows the temperature sensitivity of this mix when used in combination with a rigid base course. By comparison, both the temperatures and deflections of the same sections are lower in March 1994.

Figures 7 and 8 show significant variation with temperature. Deflections for the 550 psi sections on DGAB are the greatest. A structural evaluation of this section is in order to determine whether this observed trend is a result of overstressing of the pavement structure in this particular case. These experimental sections were not designed for structural adequacy by the SHRP program. It was assumed they would fail earlier than the thicker slab sections. Base layer deflections for these same sections, represented by sensor 4, are fairly consistent for August 1998 and April 1996 data. The deflection magnitudes for the PATB sections are generally in the range between the DGAB and the LCB deflections.

6.4 Summary of Deflection Analysis

Overall, the deflection data reviewed provides some very interesting insights into the relative performance of the various pavement test sections. These results, discussed in detail in the preceding sections, are summarized below:

- Deflections are relatively higher for the 8-inch slab sections, reflecting the relatively lower structural capacity of these sections.
- The magnitude of deflections is generally less than 10 mils.
- LCB sections, particularly with the combination of the higher strength concrete mix, after 4 years of service are sensitive to warping at higher temperatures. At higher temperatures, deflections of the section on LCB are higher, particularly when the 900 psi mix was used, indicating the presence of greater slab warping under these conditions. A summary of climatic conditions is provided in Figures 9 and 10.
- The deflection magnitudes generally rank in the order of anticipated stiffness values of the various base materials, i.e., sections with DGAB had higher deflections than PATB sections and sections with LCB had lower deflections than the PATB sections.
- Deflections resulting from the widened slab and state section with tied concrete shoulder show significantly lower deflections than standard width sections with untied shoulders. At this time, no difference in deflections is observed between the widened slab (14-foot untied shoulder) and the 12-foot tied shoulder (state standard section).
- Deflection magnitudes for the drainable base (PATB) sections are generally between those for the other base types (DGAB and LCB).

6.5 PAVEMENT ROUGHNESS

As shown in Table 2, the roughness of the test sections remains good (International Roughness Index < 1.85 m/km or 117 inches/mile). Minimal change has occurred in the ride quality of the test sections. During the roughness data collection in 1994, 1996 and 1998 the air temperatures were measured 30, 54 and 79 °F. For some of the test sections the roughness measurements showed improvement. This may be due to the change in temperature between measurements.

Table 2 Roughness Data Summary for April 13, 1994 (30.0°F), November 8, 1997 (53.6°F), and August 14, 1998 (78.8°F)

Test Section	IRI (inches/mile)								
	Left Wheel Path			Right Wheel Path			Average		
	1994	1996	1998	1994	1996	1998	1994	1996	1998
080213	76.0	78.4	72.6	73.3	72.4	71.2	74.6	75.4	71.9
080214	62.0	59.5	59.2	67.5	60.1	60.6	64.7	59.8	59.9
080215	67.0	63.6	63.4	70.9	73.7	73.8	68.8	68.7	68.6
080216	65.7	63.6	61.8	62.2	60.9	58.4	63.9	62.2	60.1
080217	107.8	108.7	112.4	98.4	101.6	99.7	103.1	105.2	106.0
080218	87.5	84.8	85.0	90.9	90.4	85.8	89.2	87.6	85.4
080219	89.3	93.2	93.9	101.3	103.6	105.5	95.3	98.4	99.7
080220	108.5	107.7	113.9	105.0	104.1	110.9	106.7	105.9	112.4
080221	98.5	90.0	94.8	97.3	92.6	90.9	98.0	91.3	92.9
080222	94.2	92.8	98.8	77.9	72.7	73.4	86.0	82.8	86.1
080223	117.7	107.8	107.0	112.6	99.8	101.4	115.2	103.8	104.2
080224	100.4	94.6	97.6	103.8	94.2	99.4	102.1	94.4	98.5
080259	70.1	70.3	74.3	74.3	73.2	77.9	72.3	71.7	74.3

Note: 1 m/km = 63.36 in/mile; °C = (°F-32)/1.8

Table 3 Distress Data Summary (Test Date - August 1998)

Distresses	080215	080217	080218	080219	080220	080221	080222	080223	080224
	Test Sections								
Trans Crack (Numbers)	0	0	1	0	0	0	0	0	0
Trans Crack Length (m)	0	0	3.7	0	0	0	0	0	0
Long Crack (m)	0	11.7	0	0	0	1.3	0	0	0

Note: Both the transverse crack (Trans Crack) and longitudinal crack (Long Crack) had "Low" severity level of distress by the LTPP definition.

6.6 Pavement Distress Data

The distress summary data provided in Table 3 indicates virtually no distress at this time. Minor amounts of transverse cracking are identified in section 080218, with minor longitudinal cracking in sections 080217 and 080221. There is minor spalling in sections 080215, 080217, 080218, 080221, and 080224 with high spalling in section 080222.

6.7 Friction Data

Friction data collected by the CDOT indicated a significant difference between the 550 and 900 psi concrete sections. The average friction number for the 550 psi sections collected in June of 1998 was 52, while the average for the 900 psi sections collected at same date was 42. Visual examination of the section revealed that the 550 psi sections exhibited surface wear exposing the aggregate, while the 900 psi sections showed very little surface wear and very little aggregate exposure. The wear on the surface correlates well with the friction measurements. Future evaluations will determine if the 550 mix results in a shorter performance life or improved friction quality.

7.0 CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

The evaluation of the SPS-2 pavement test sections in Colorado provides a measure of the performance of the pavement early in its service life. The functional aspects of the performance are virtually unchanged. Responsive structural performance evidenced as distress cracking provides very little difference between the sections at this early pavement age. However, the structural response of the sections evaluated by FWD does provide early indications of differences in load-carrying capacity of different sections. The construction variability of the pavement thickness is somewhat severe and it may affect the ultimate performance life of the sections.

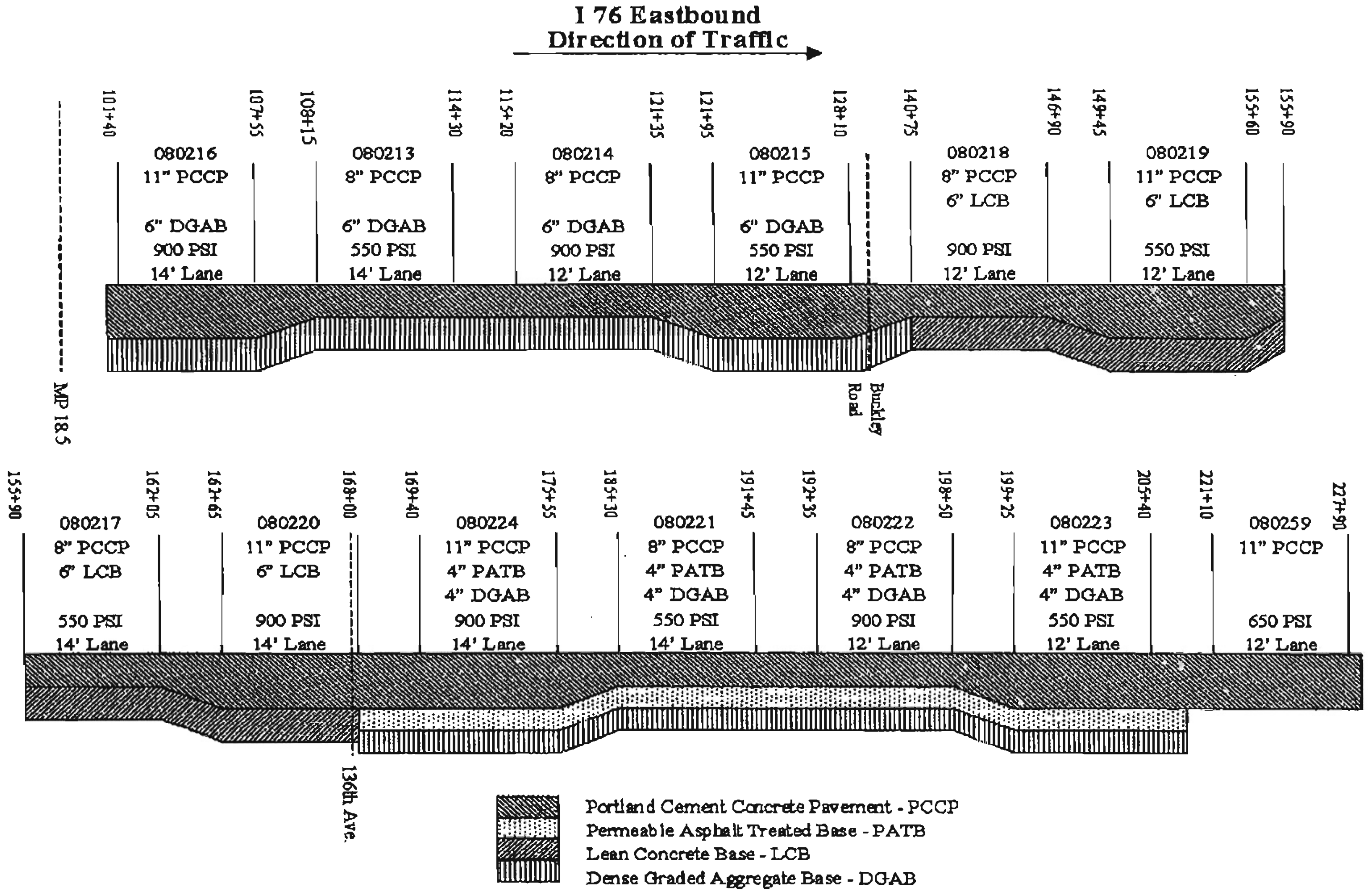
From structural evaluation responses, it is evident that both the widened-slab design and the tied-concrete shoulder design provide additional support as compared with the untied standard width lanes. Evidence of slab warping is indicated by the relative increase in deflections of the higher strength mixes on LCB.

The thinner sections are showing higher deflections after the same traffic history, which is likely a sign, that earlier fatigue failure will occur, as anticipated. At present, the state designed standard section placed directly on subgrade with a tied concrete shoulder, shows a good structural response in the form of low deflections. No difference can be seen at this time in the performance of the drainable bases as compared to other bases, in this relatively dry climate. The DGAB sections consistently show the highest deflections within the individual structural experiment cells. This agrees with the relative stiffness of the base materials.

In addition, some early evidence of relative pavement durability is observed by the fact that greater wear is evident in the 550 psi sections than in the 900 psi sections. At the present time, this increased wear has evidenced itself in the form of increased pavement friction characteristics. Future evaluation will determine if this in fact results in a shorter performance life, or improved friction quality.

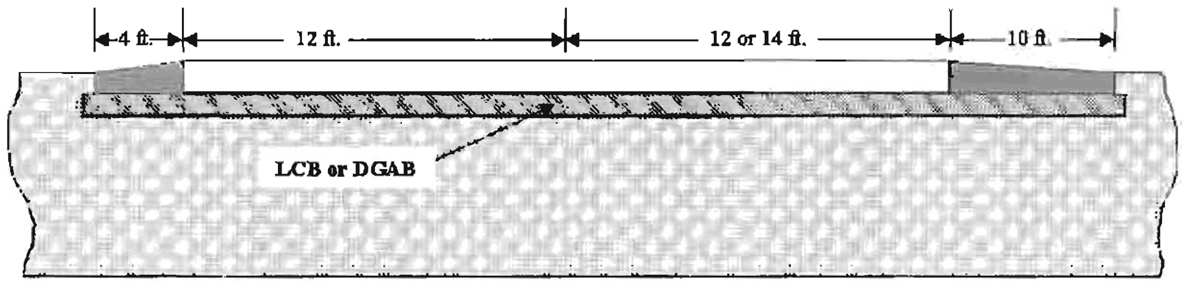
7.2 Recommendations

Based on a supplemental study that CDOT conducted on the merits of widened-slabs (14-foot slab), the use of 14-foot slab is highly recommended. The results of this study revealed that wider slabs, by keeping the trucks away from the longitudinal joint at the shoulder, improved the load-carrying capacity of the outside lane. Structurally speaking, their contributions were found to be equivalent to 1 inch of slab thickness. The 14-foot slab is now an option for CDOT designers, primarily in a rural setting.

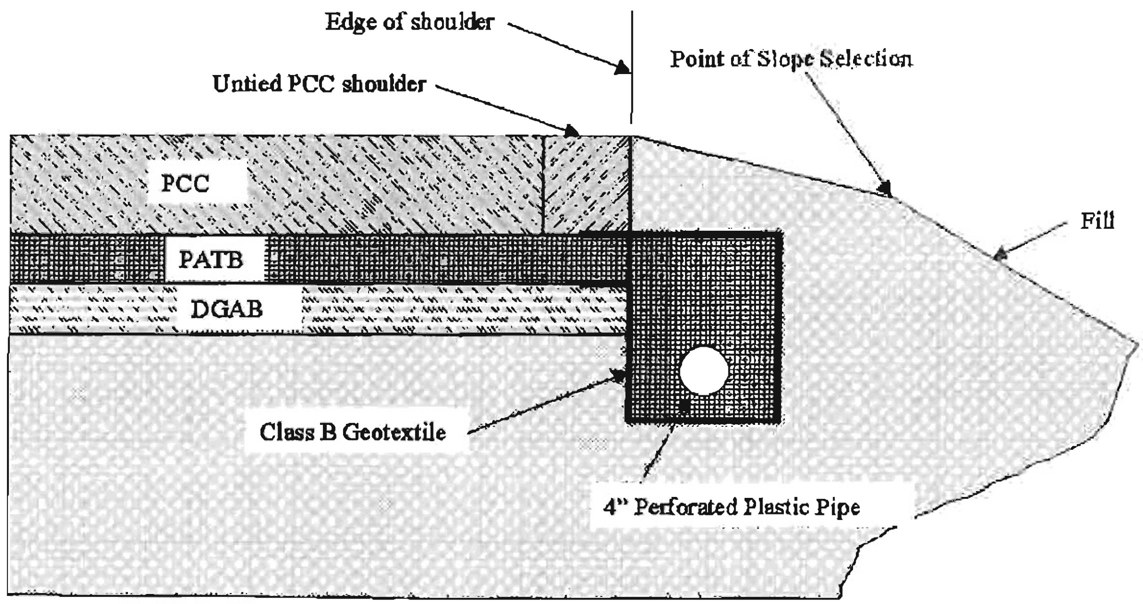


Note: 1 in = 25.4 mm; 1 ft = 0.305 m; 1 psi = 6.89 kPa

Figure 1. Layout of the SPS-2 Experimental Test Sections.



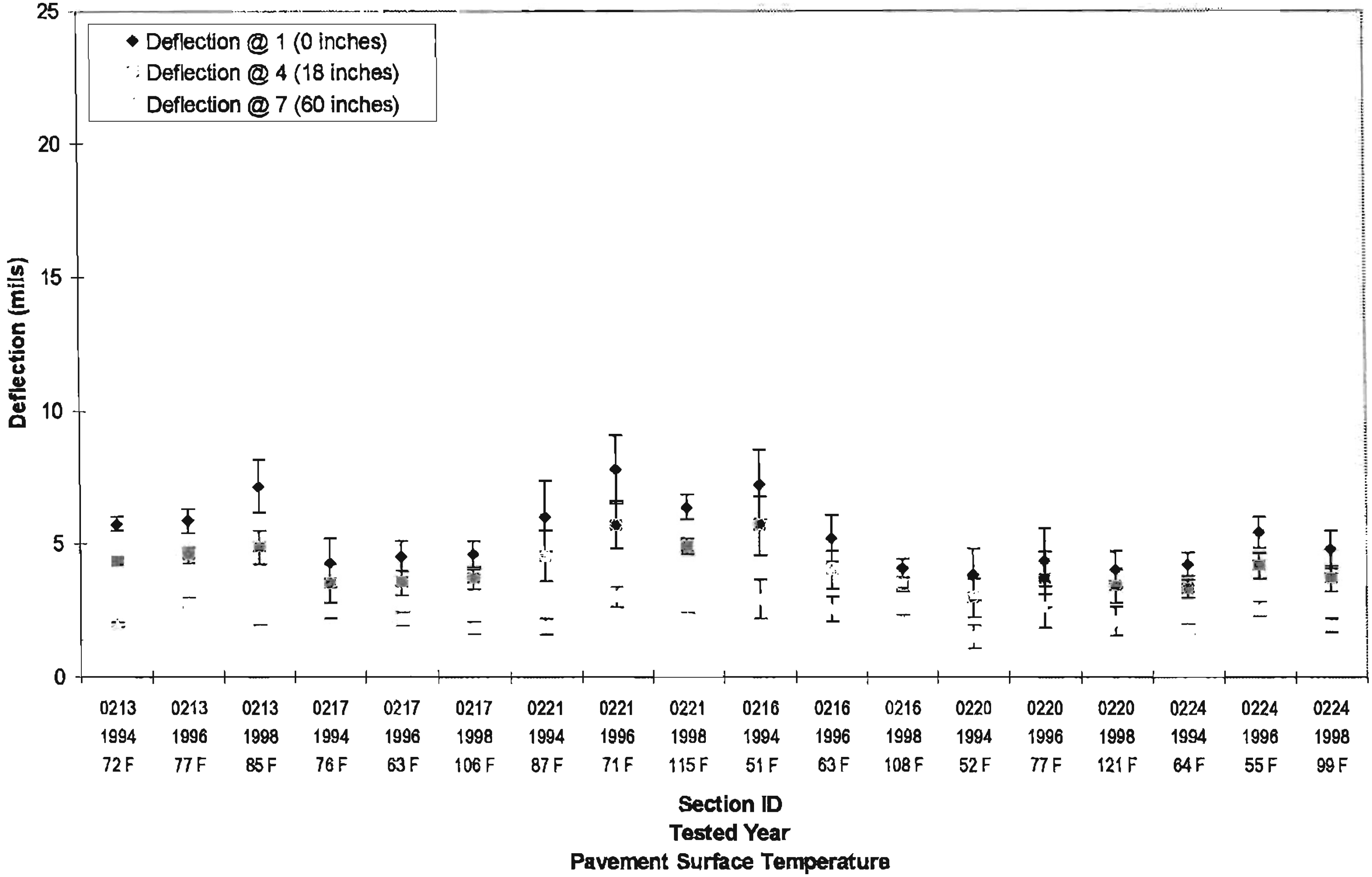
(a)



(b)

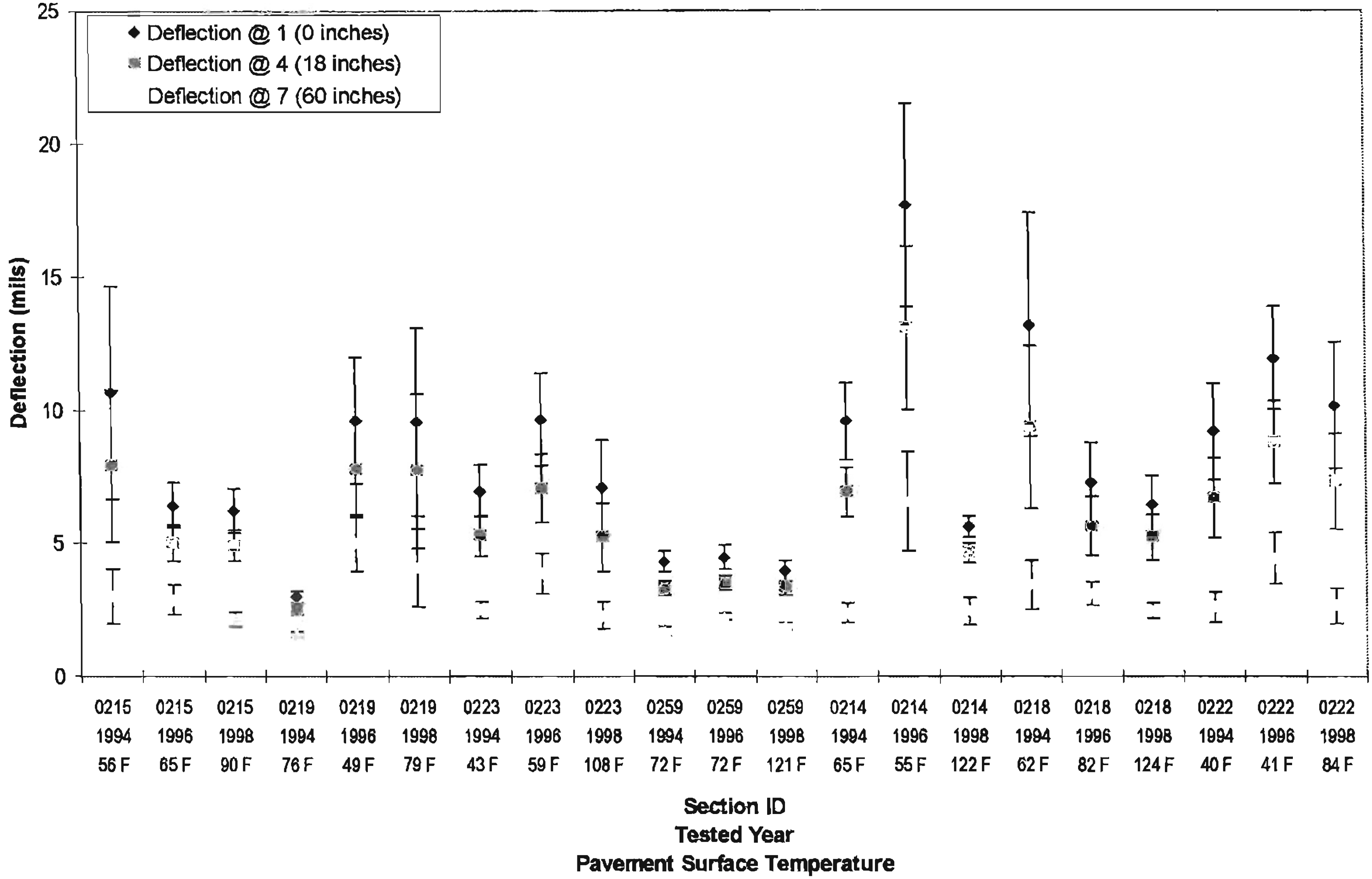
Note: 1 in = 25.4 mm; 1 ft = 0.305 m

Figure 2. Typical Section for (a) Non-Drainable Base Layer and (b) Drainable Base Layer.



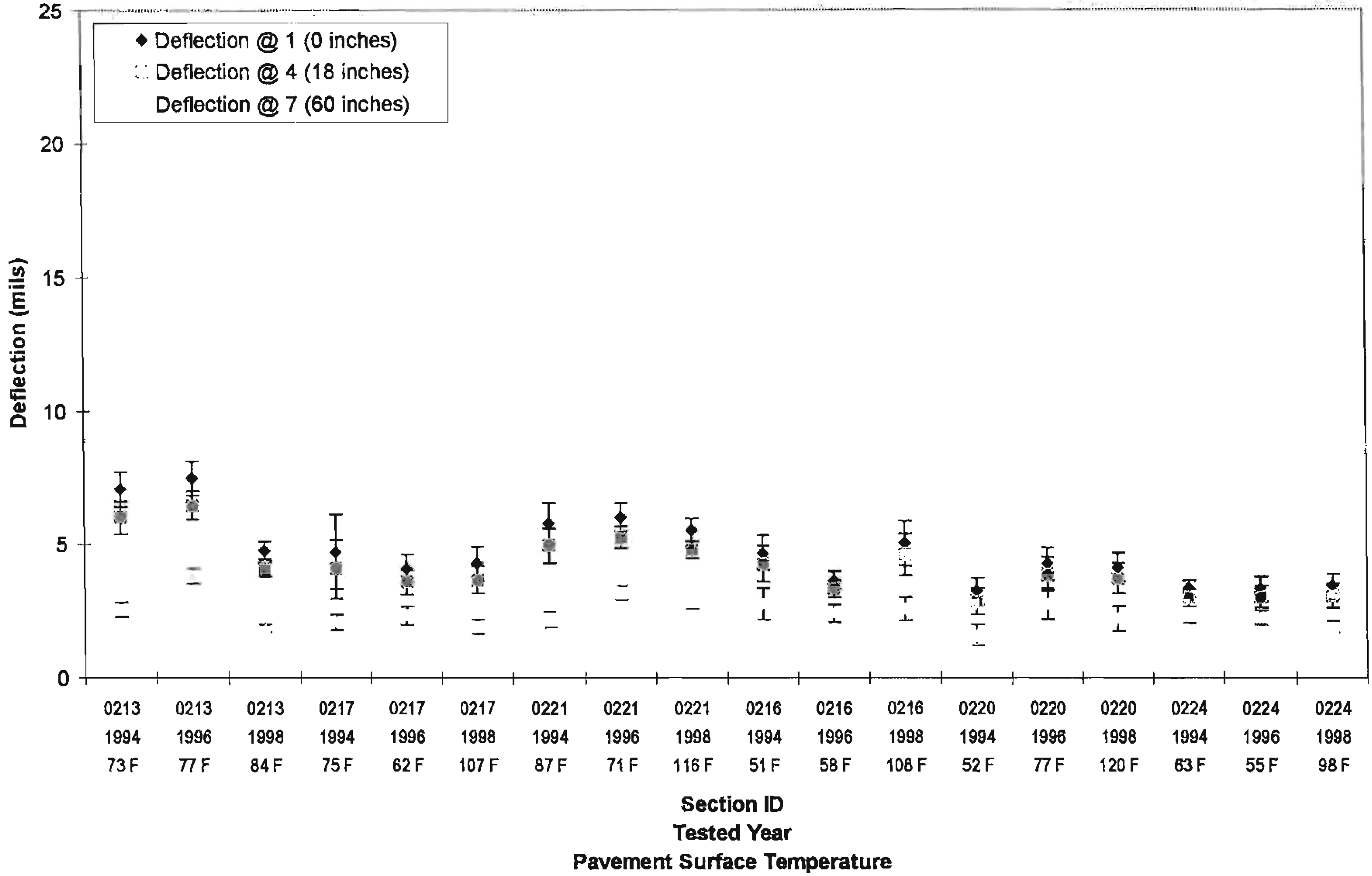
Note: 1 mil = 25.4 µm; 1 in = 25.4 mm; 1 ft = 0.305 m; °C = (°F-32)/1.8

Figure 3. Corner Deflections for 14-foot Wide Slab.



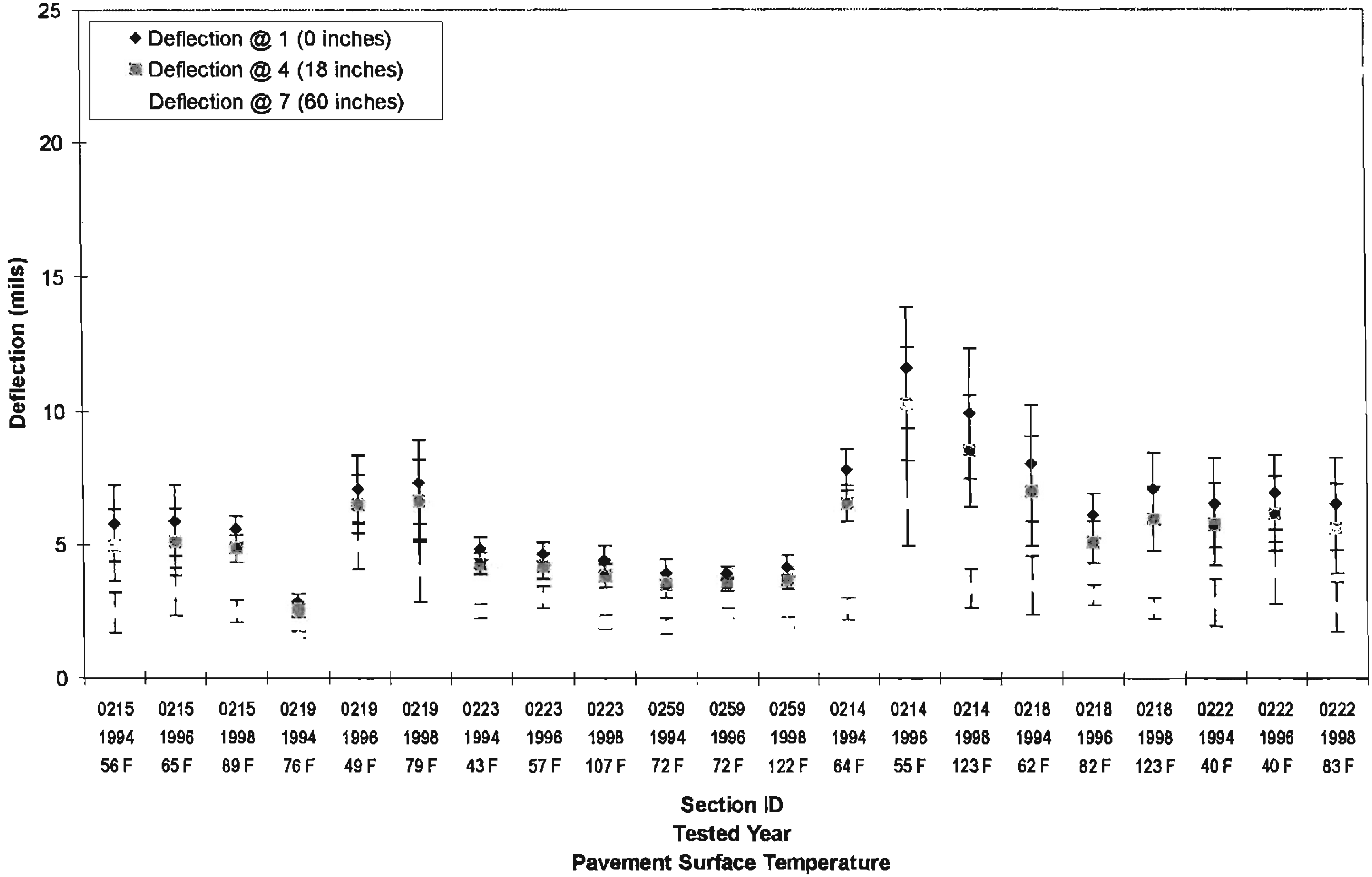
Note: 1 mil = 25.4 µm; 1 in = 25.4 mm; 1 ft = 0.305 m; °C = (°F-32)/1.8

Figure 4. Corner Deflections for 12-foot Wide Slab.



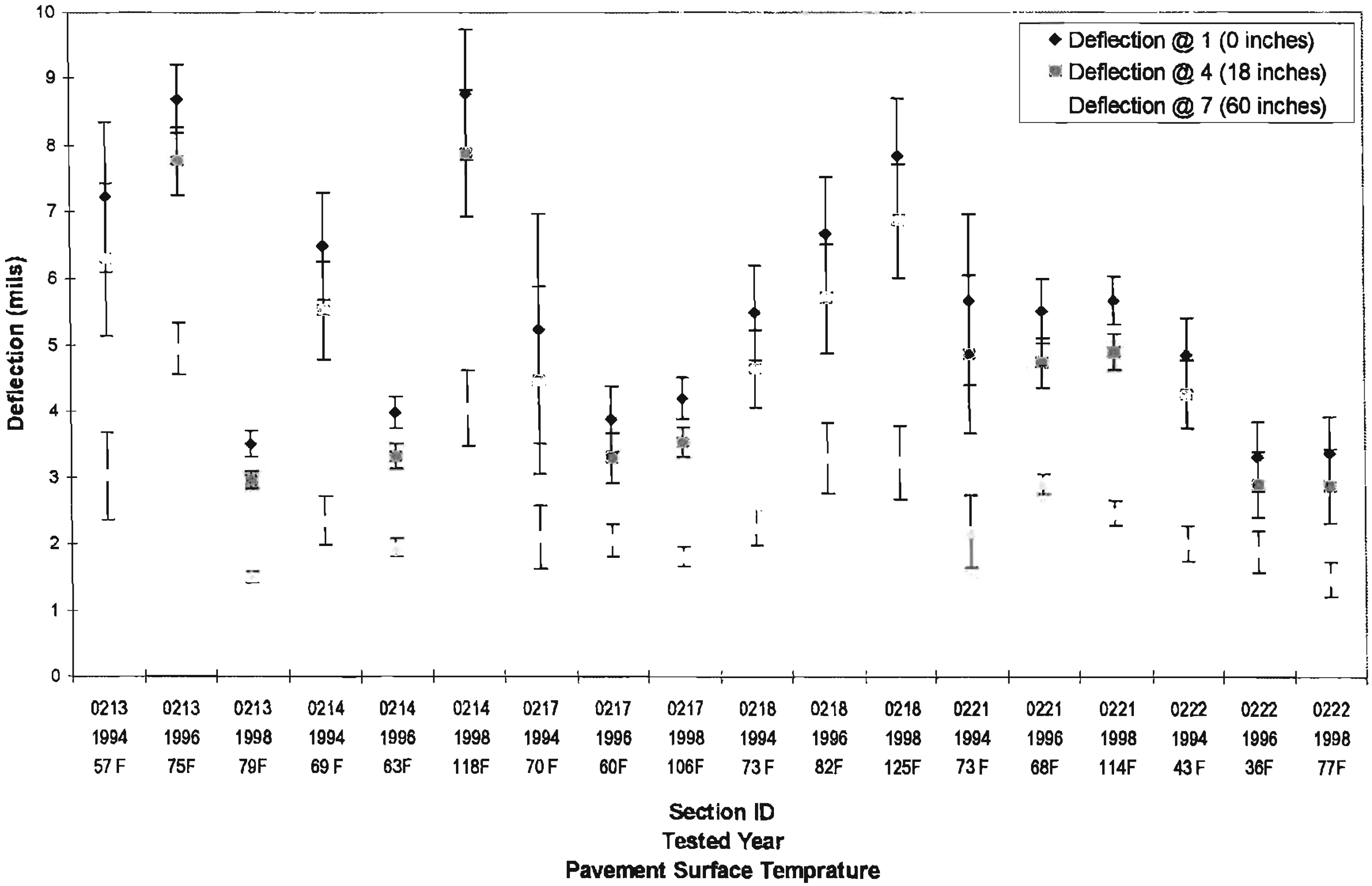
Note: 1 mil = 25.4 µm; 1 in = 25.4 mm; 1 ft = 0.305 m; °C = (°F-32)/1.8

Figure 5. Edge Deflections for 14-foot Wide Slab.



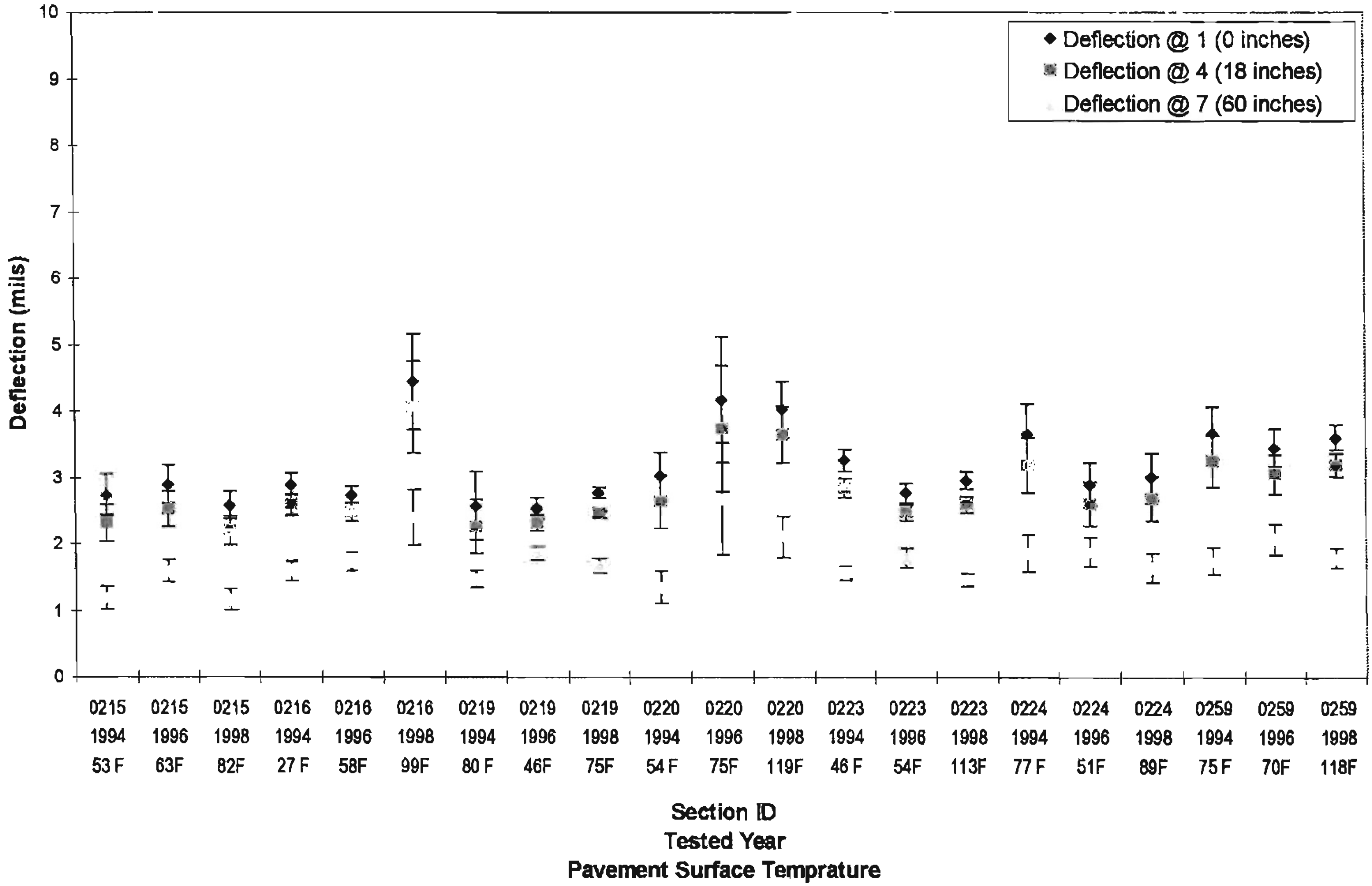
Note: 1 mil = 25.4 µm; 1 in = 25.4 mm; 1 ft = 0.305 m; °C = (°F-32)/1.8

Figure 6. Edge Deflections for 12-foot Wide Slab.



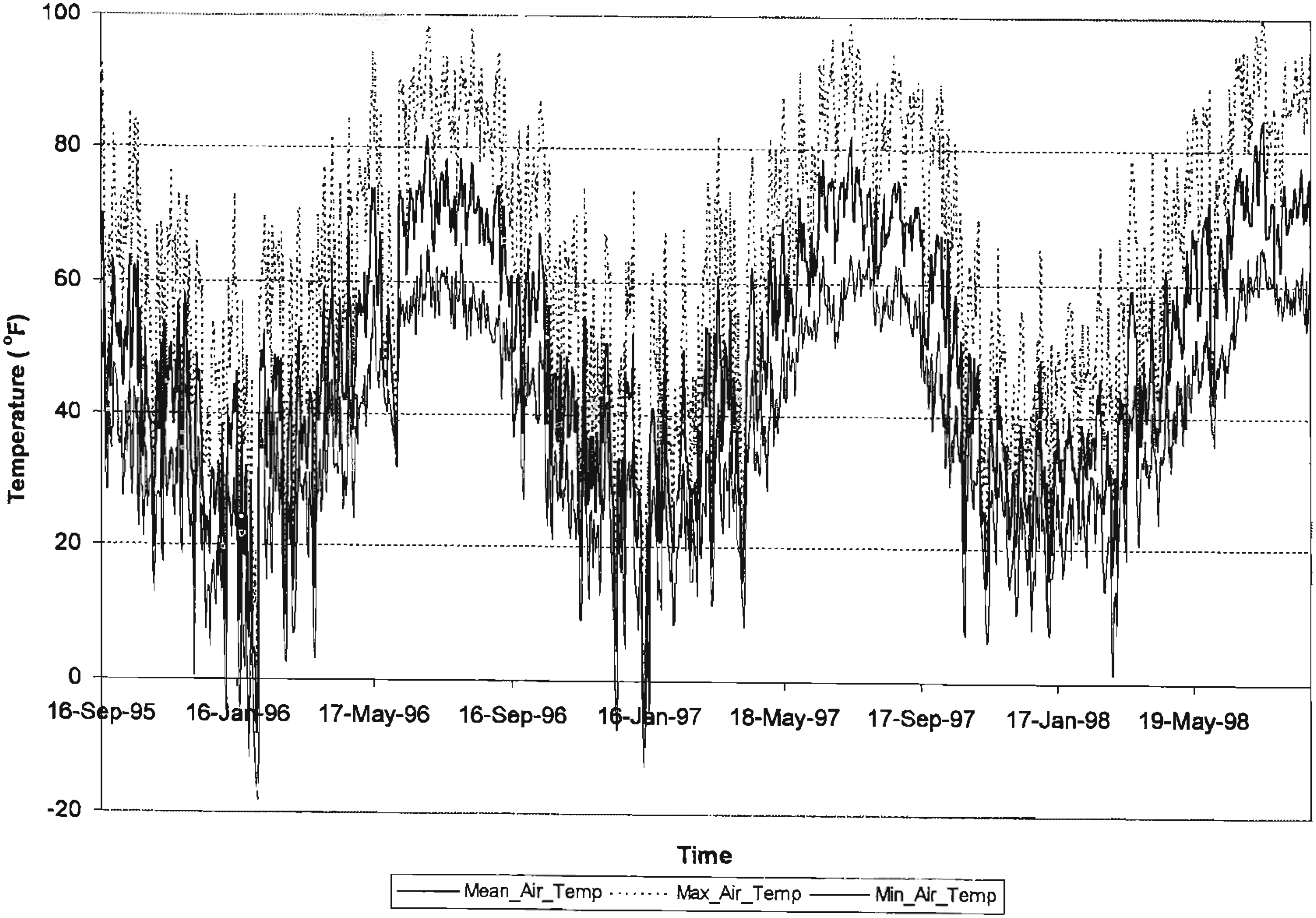
Note: 1 mil = 25.4 µm; 1 in = 25.4 mm; 1 ft = 0.305 m; °C = (°F-32)/1.8

Figure 7. Mid Panel Deflections for 8-inch Thick Slab.



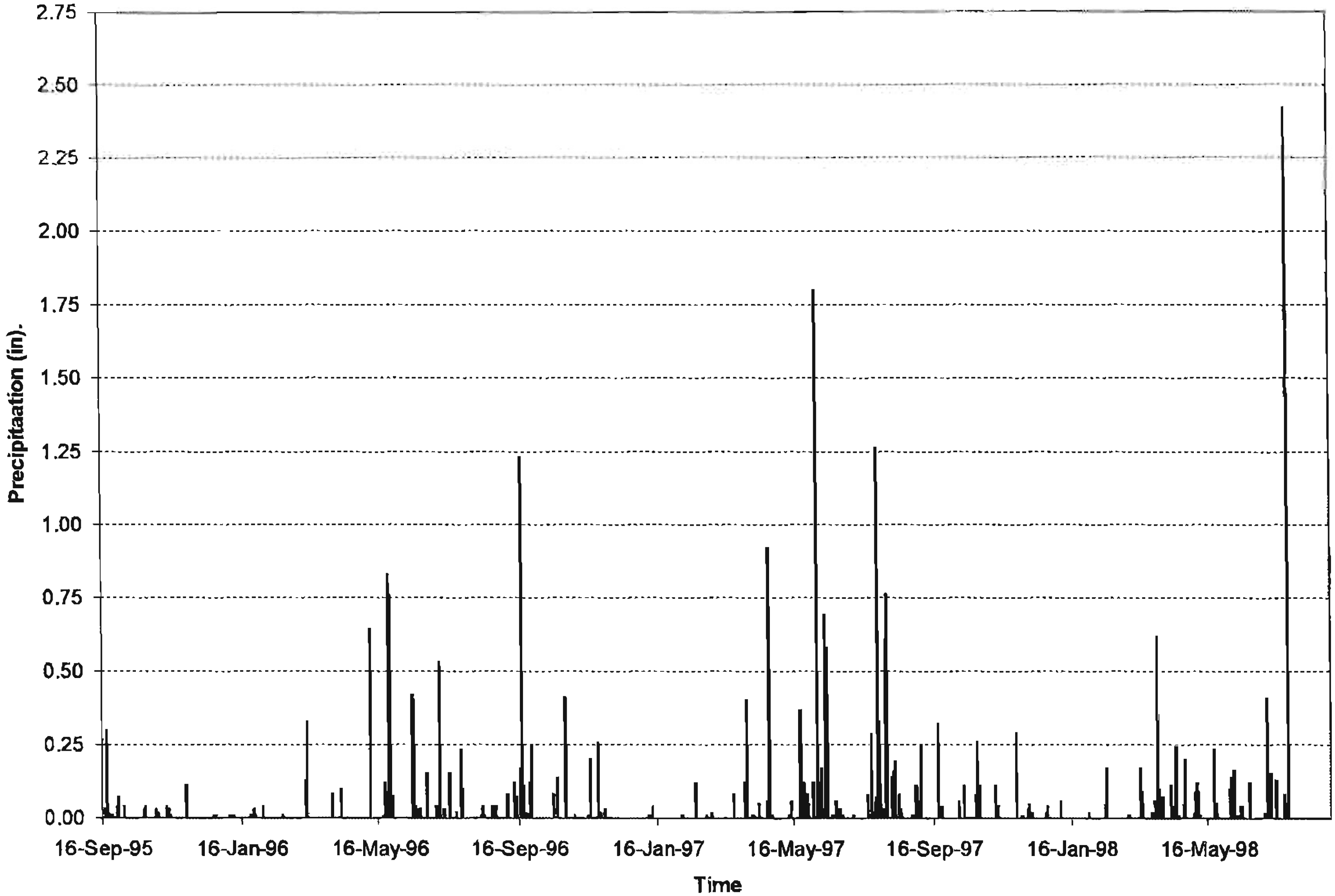
Note: 1 mil = 25.4 μm; 1 in = 25.4 mm; 1 ft = 0.305 m; °C = (°F-32)/1.8

Figure 8. Mid Panel Deflections for 11-inch Thick Slab.



Note: °C = (°F-32)/1.8

Figure 9. Daily Air Temperature



Note: 1 in = 25.4 mm

Figure 10. Daily Precipitation

REFERENCES

1. Strategic Highway Research Program. "Specific Pavement Studies Experimental Design and Research Plan for Experiment SPS-2 Strategic Study of Structural Factors for Rigid Pavements." National Research Council, Washington, D.C., April 1990.

2. Nichols, Reno Consulting Engineers, Chtd. "SPS-2 Construction Report SHRP 080200." Western Region LTPP Contractor, NV, September 1998.

3. Long Term Pavement Performance. "Information Management System, Data Users Guide." Science Applications International Corporation, TN, July 1993.