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TPF-5(291) FINAL REPORT:

EVALUATING THE IMPACT OF DESIGN FEATURES ON PAVEMENT PERFORMANCE:

Prepared On Behalf Of	Date	Project Number
State Pooled Fund Study TPF-5(291)	October 2021	56A0418-008 (TPF-5(291)) 219.03.10 (NCE)

Timin Punnackal, P.E.
Project Engineer, NCE

Kevin Senn, P.E.
Principal Engineer, NCE

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1.0 BACKGROUND

The NCE team was awarded the Transportation Pooled Fund (TPF) Study 5(291) to investigate data from the Long-Term Pavement Performance (LTPP) Specific Pavement Study (SPS)-2 experiment for concrete pavement design factors, with the Washington State Department of Transportation as the Lead State. This pooled fund study included the investigation and proposal of a pavement preservation experiment utilizing existing test site conditions. Upon completion of the initial phase of the study, several SPS-2 Tech Days were conducted to broaden the pavement community's knowledge of the SPS-2 experiment and to garner input on analyses the community would find useful. The Pooled Fund Technical Advisory Committee (TAC) also provided recommendations for additional analyses.

As a result, five additional tasks were focused on SPS-2 test sections:

- Conducting a deterioration rate analysis
- Analyzing performance data
- Investigating sources of non-LTPP data
- Analyzing joint score and area of localized roughness (ALR) impacts on performance
- Updating previous SPS-2 analyses

Upon completion of these tasks, an additional 11 tasks were proposed. The purpose of this supplementary extension of TPF-5(291) was to conduct further analyses of existing data from the LTPP SPS-2 concrete pavement experiment. The focus of this set of tasks was to investigate the impact of non-experimental factors on pavement performance. The following tasks were completed:

- Identifying agency-specific trends
- Analyzing the impact of construction and materials issues
- Reviewing early SPS-2 failures
- Identifying lessons learned from state supplemental sections
- Analyzing the impacts of climate, traffic, and overall condition on deterioration rate
- Comparing SPS-8 and SPS-2 performance
- Assessing diurnal changes in roughness
- Evaluating service life
- Comparing mix-design performance
- Conducting Mechanistic Empirical Pavement Design Guide (MEPDG) sensitivity analysis of portland cement concrete/lean concrete base (PCC/LCB) bond
- Evaluating transverse joint opening width

This report presents the results of a deterioration rate analysis conducted on SPS-2 test sections, as well as subsequent comparisons designed to evaluate the impact of design features on pavement performance.

2.0 INTRODUCTION

This analysis continued previous work that compared predicted and measured pavement performance of SPS-2 test sections. Prior analyses showed poor correlation between predicted and measured deterioration rates (TPFS5-291 study, "Comparison of PavementME and Actual Performance"). This expanded study used a deterioration rate analysis to assess the impact of five design features on pavement performance.

The five SPS-2 design features examined in this study include:

- Pavement Thickness
- Base Type
- PCC Strength
- Lane Width
- Drainage

The impact of these design features on pavement performance was evaluated using the deterioration rates of the International Roughness Index (IRI) values, faulting measurements, and the percentage of slabs that were cracked transversely.

After the initial deterioration rate analyses, additional comparisons were conducted to investigate relationships between other related design features and performance measures. These studies included:

- Impact of Initial Smoothness On Pavement Performance
- Impact of Shoulder Type on Pavement Performance
- Impact of Design Feature on Longitudinal Cracking
- Impact of Design Feature on Load Transfer Efficiency (LTE)
- Mid-Slab Deflection and Area Value Analysis
- Transverse Joint Seal Failure Analysis
- Transverse Joint Condition Index Analysis

The SPS-2 experiment was designed to study selected design factors under different climatic and subgrade conditions. Consequently, the impact of design factors on test sections may vary from agency to agency. To increase the value of the results, the comparisons for each investigation were grouped by the state in which the project was located. These states included:

- Arizona
- Arkansas
- California
- Colorado
- Delaware
- Iowa
- Kansas
- Michigan

- Nevada
- North Carolina
- North Dakota
- Ohio
- Washington
- Wisconsin

Since each project had different conditions for construction, materials, traffic and climate, test section comparisons in this study were made relative to other sections within the same project (state) in order identify trends. As a result, recommendations based on these comparisons are more generalized and less agency-specific.

2.1 Outliers

The SPS-2 experiment collected data from over 200 test sections; most test sections performed well. This investigation focused on test sections that showed significant deterioration. However, within this smaller set of test sections, Nevada and Michigan test sections were consistent outliers. Each project had several issues during construction that led many test sections to deteriorate rapidly. Notably, 14-day flexural-design-strength requirements were not met for many test sections in both projects. The deterioration rates of IRI, faulting, and transverse cracking were high on several test sections at these projects. Therefore, the average IRI at these projects was much higher than the IRI at other projects and higher than the values predicted by the MEPGD.

Eight SPS-2 test sections had deterioration rates higher than 12 inch/mile/year. Of these, two were from Nevada and five were from Michigan. These test sections typically went out of study early after recording a large spike in IRI. The Nevada project had higher deterioration rates for thick pavements, which was unusual; the MEPGD-predicted IRI had shown much lower deterioration rates for test sections in Michigan and Nevada. Additionally, Nevada, Michigan and Ohio test sections with higher deterioration rates typically had lean concrete base (LCB) and high-strength PCC. Some dense graded aggregate base (DGAB) test sections in Ohio, as well as some permeable asphalt treated base (PATB) test sections in Nevada and Ohio also had higher deterioration rates. Michigan was the only project where lane width had a definite impact on the rate of transverse cracking. Also, none of the test sections in Nevada had positive faulting rates. Negative faulting was sometimes due to reduction in faulting and sometimes due to a negative difference in elevation between the approach and leave slab.

While Ohio was not noted to have as many construction-related issues as Nevada and Michigan, the Ohio project also showed relatively high deterioration rates for transverse cracking. Several Ohio sections with high-strength PCC deteriorated much faster than their low-strength counterparts. Ohio sections also had especially high deterioration rates on several sections that went out of study soon after construction.

The data from the Nevada, Michigan, and Ohio projects are included in the plots presented herein. However, because they are considered outliers, the discussions and analyses typically exclude the information from these projects.

3.0 DETERIORATION RATE ANALYSIS OF FIVE DESIGN FEATURES

The five SPS-2 design factors include pavement thickness (either thin, nominally 8-inches, or thick, nominally 11-inches), base type (DGAB, LCB, and PATB), PCC strength (designed to low-strength, 550-psi, or high-strength, 900-psi), lane width (either standard, 12-feet wide, or widened 14-wide lanes), and drainage (drained or undrained). The design factor of drainage overlaps with base type; DGAB and LCB are undrained and PATB is drained. Thus with 24 possible combinations, the SPS-2 followed a half factorial experimental design, where half the possible combinations were designed on 12 core test section on a project and the other half on a different project.

3.1 Design Feature 1 – Pavement Thickness

Figure 1 shows the average IRI deterioration rates of test sections with thick and thin PCC pavement (nominally 11 and 8 inches thick, respectively). The average deterioration rate for SPS-2 test sections was 2.5 inch/mile/year. Typically, thick sections had lower deterioration rates than thin sections. In some cases (outliers excluded), the deterioration rates of thin pavements were 140% higher on average than that of thick sections. In three projects, thicker pavements had 30% higher deterioration rates than thinner pavements (Delaware, North Dakota, and Wisconsin). The deterioration rates from predicted IRI had fewer outliers than measured IRI; average deterioration rates did not exceed 5 inch/mile/year. On average, predicted IRI shows that thinner sections deteriorate 75% faster than thicker pavement sections.

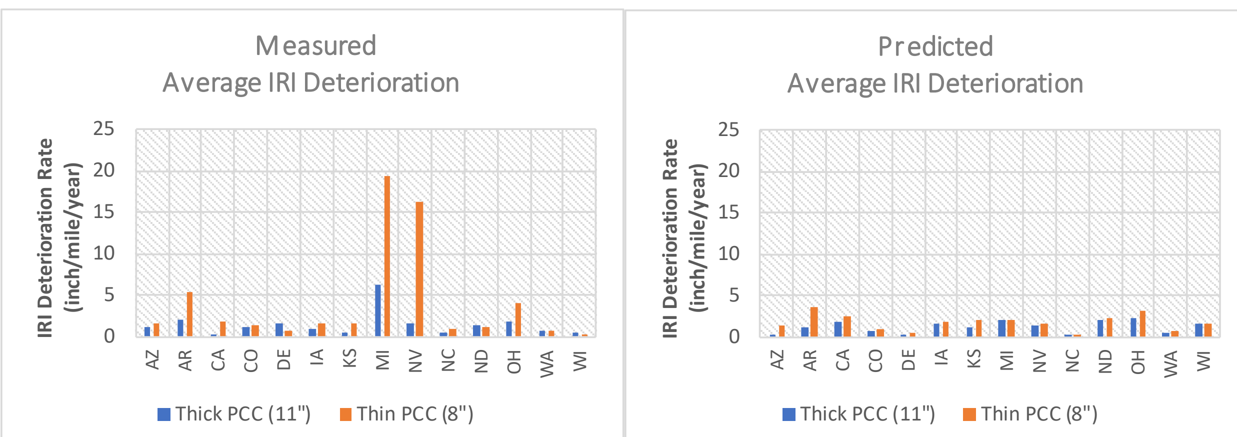


Figure 1. Deterioration Rates for Measured and Predicted IRI by PCC Design Thickness

Figure 2 shows faulting on all SPS-2 sections ranges from -0.0003 to 0.0021 inches per year. Based on the deterioration rates of thick and thin pavements, pavement thickness did not have an impact on the rate of faulting. Predicted faulting data show that there were slightly more projects where thin pavements faulted at a marginally higher rate than thick pavement sections.

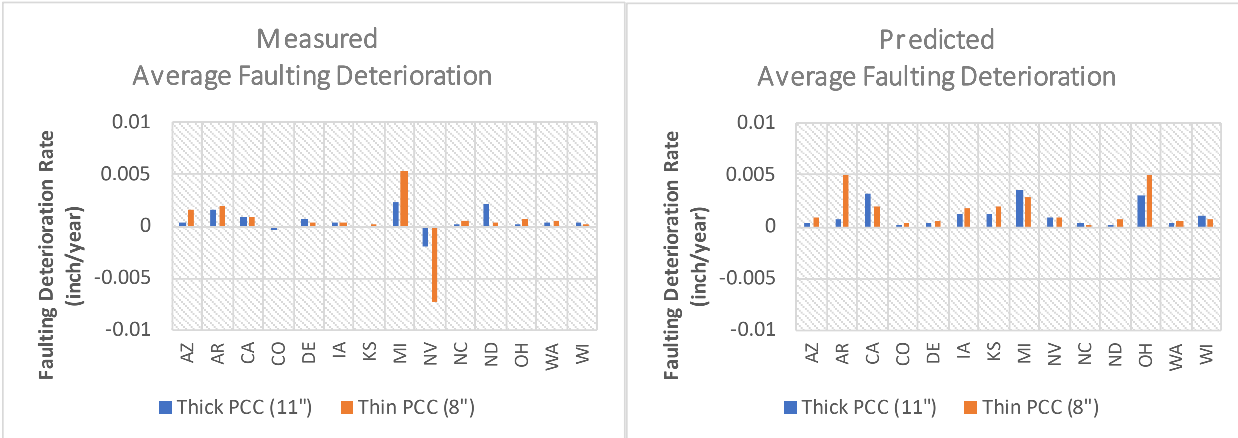


Figure 2. Deterioration Rates for Measured and Predicted Faulting by PCC Design Thickness

Figure 3 shows that there were several states with low deterioration rates for the percentage of transversely cracked slabs. Delaware, Iowa, Kansas, North Dakota, and Wisconsin are some states where most test sections showed very low deterioration rates. Typically, deterioration rates for thin pavement sections were higher than for thick pavement sections. On average, thin pavement section deteriorated 5 to 6 times faster than thick pavement sections. Among the projects where significant transverse cracking was predicted, thin pavement sections deteriorated faster than thick pavement sections.

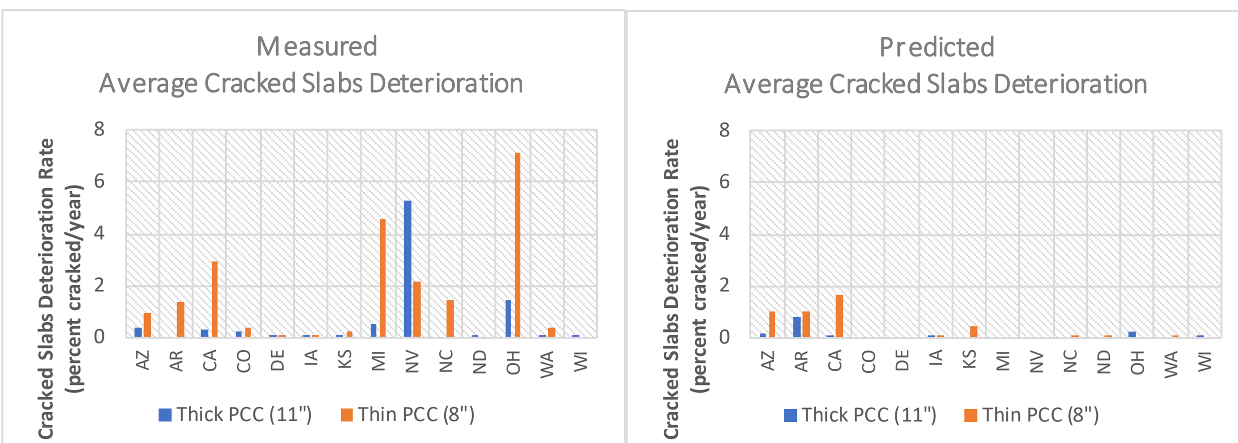


Figure 3. Deterioration Rates for Measured and Predicted Transversely Cracked Slabs by PCC Design Thickness

3.2 Design Feature 2 – Base Type

4 shows that test sections with an LCB base type typically had the highest deterioration rates for IRI, while DGAB and PATB base types typically had the lower IRI deterioration rates. For a few projects, sections with DGAB base had the higher deterioration rates (e.g., Arizona, Arkansas, and California). These states also had projects in non-freeze climates with high amounts of traffic. Overall, test sections with PATB bases were predicted to deteriorate faster

than other base types; sections with LCB bases were predicted to deteriorate slower than other base types, which was not in accordance with the measured values.

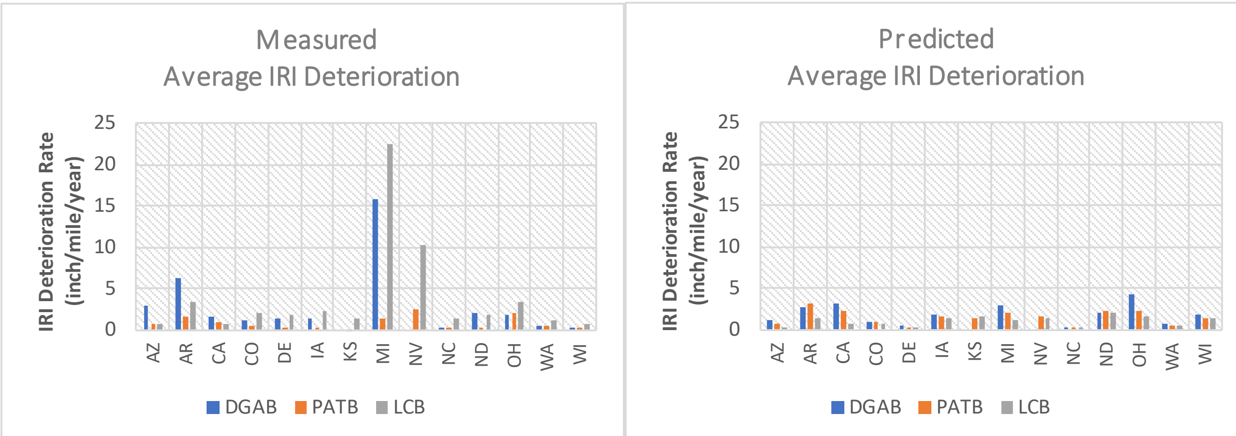


Figure 4. Deterioration Rates for Measured and Predicted IRI by Base Type

5, the deterioration rates for faulting were somewhat similar to IRI deterioration rates, where typically the sections with LCB bases had relatively higher rates and sections with PATB sections had relatively lower rates. However, in the case of faulting, this trend was not as consistent; there were several more sections where other base types were higher or lower. The largest measured deterioration rates for faulting across all SPS-2 test sections – in agreement with MEPGD – were usually found in sections with DGAB bases. Additionally, sections with LCB were predicted to have lower deterioration rates.

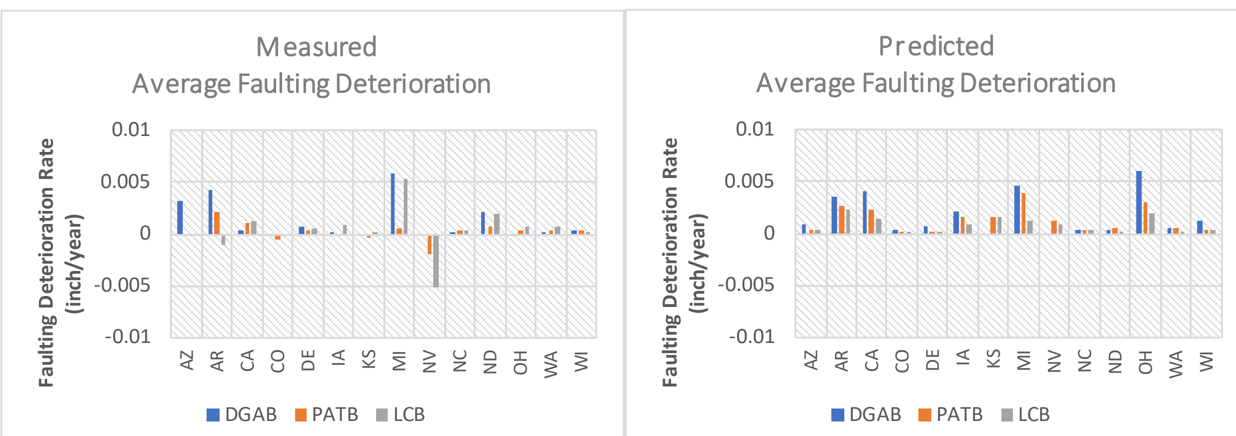


Figure 5. Deterioration Rates for Measured and Predicted Faulting by Base Type

6). California and North Carolina projects were exceptions, where test sections with DGAB had the same or slightly higher deterioration rates than those with LCB. The predicted deterioration rates did not show a definite impact on performance related to the base type of test sections.

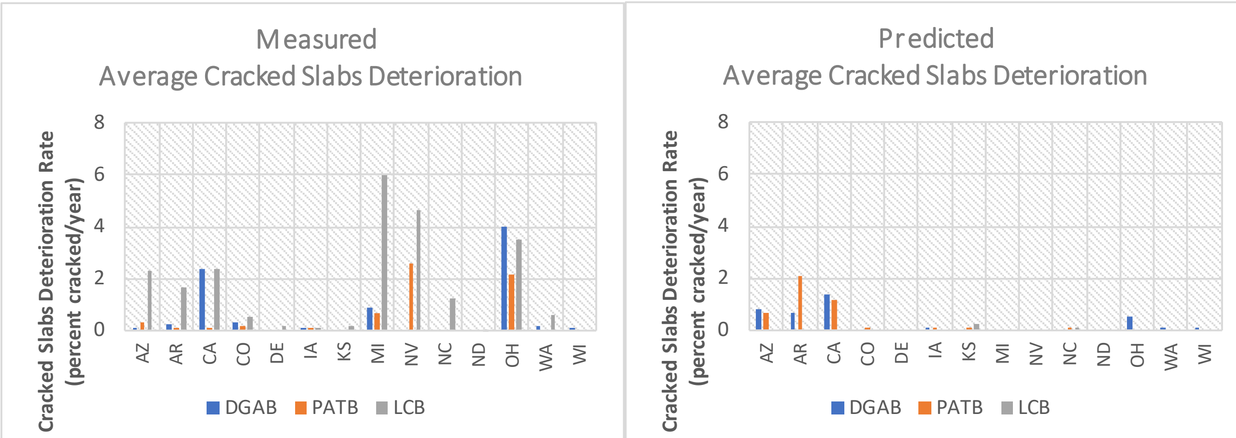


Figure 6. Deterioration Rates for Measured and Predicted Transversely Cracked Slabs by Base Type

3.3 Design Feature 3 – PCC Strength

7 shows that PCC strength did not have a definite impact on the IRI deterioration rate. In most cases, the deterioration rate of high-strength PCC sections was similar to the deterioration rate of low-strength PCC sections. Iowa and North Carolina showed slightly higher average deterioration for high-strength test sections. Arkansas was the only project that showed a significant difference in the deterioration rate of the two types of mix strengths. Predicted IRI deterioration rates showed that low-strength PCC test sections were predicted to deteriorate slightly faster than high-strength sections.

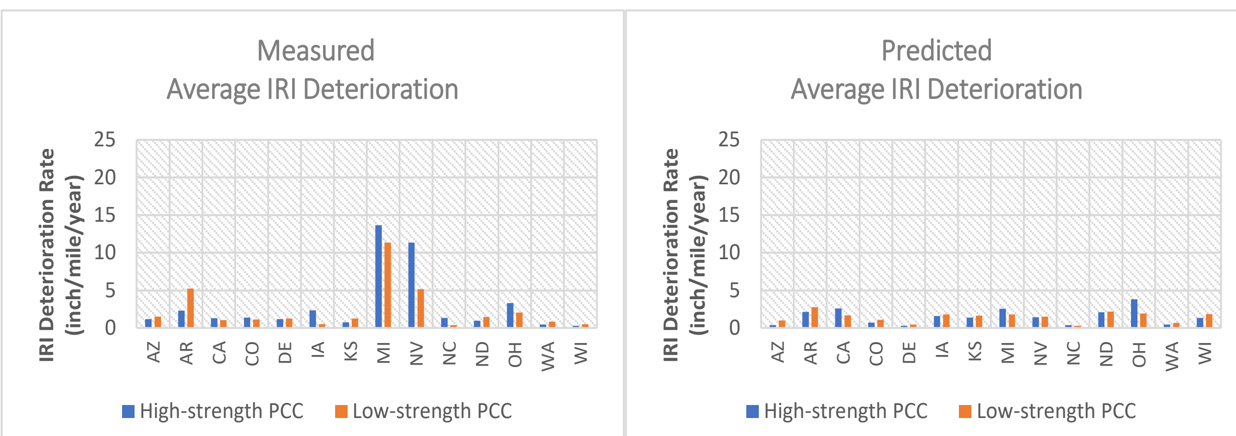


Figure 7. Deterioration Rates for Measured and Predicted IRI by PCC Design Strength

8 shows that low-strength PCC sections had a higher rate of faulting deterioration than high-strength sections. Overall, though, there was very little faulting and the differences in faulting rates were marginal between the two types of sections High-strength PCC test sections were predicted to deteriorate slightly faster than low-strength sections.

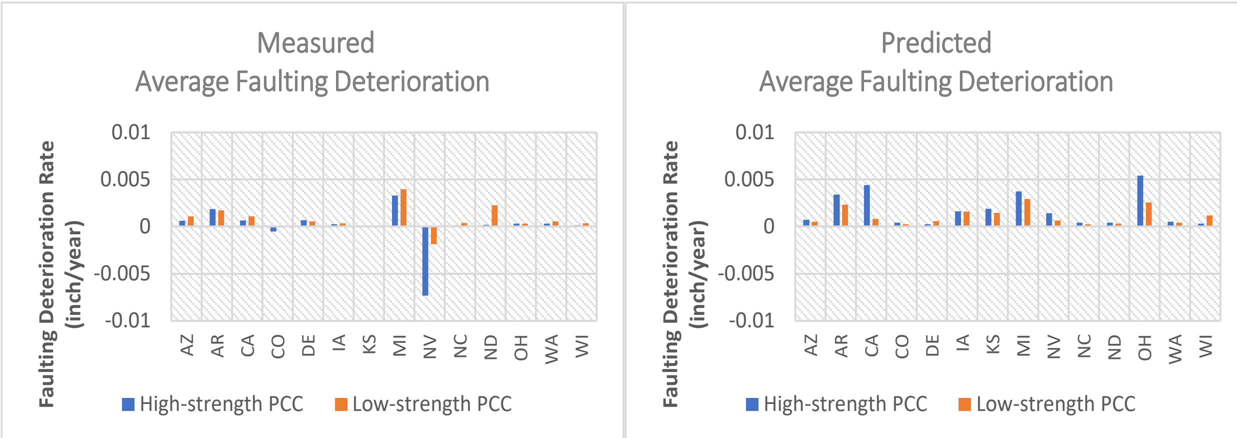


Figure 8. Deterioration Rates for Measured and Predicted Faulting by PCC Design Strength

9 shows that while the deterioration rates for transversely cracked slabs were typically higher for sections with high-strength PCC, the difference was minor in most cases. The predicted deterioration rates for transverse cracking forecasted the opposite trend: low-strength PCC test sections were predicted to deteriorate slightly faster than high-strength sections.

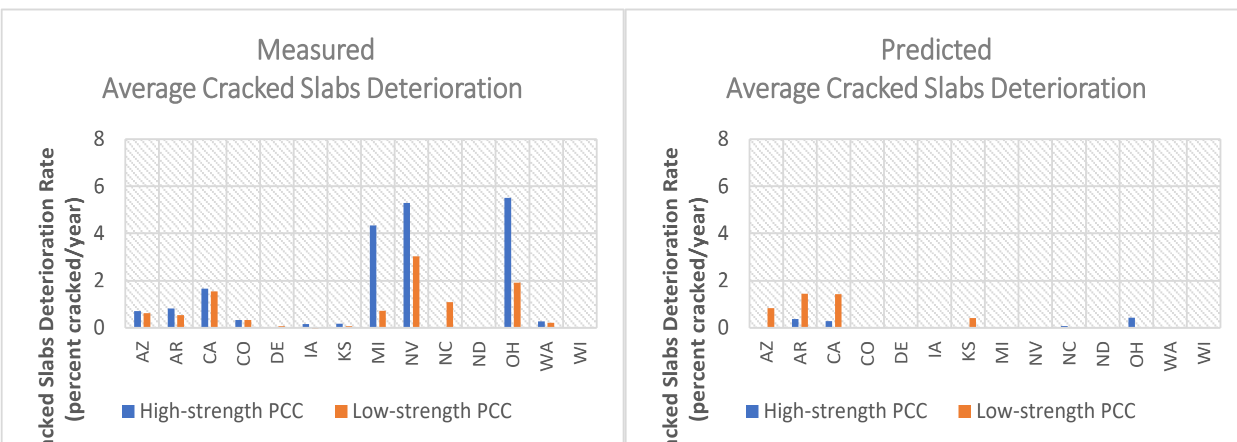


Figure 9. Deterioration Rates for Measured and Predicted Transversely Cracked Slabs by PCC Design Strength

3.4 Design Feature 4 – Lane Width

10. In eight projects, lanes had higher IRI deterioration rates; in six projects, 14-foot lanes had higher rates. Additionally, in most cases, there was not a significant difference between test sections of different lane widths on the same project. Predicted IRI deterioration rates also did not show a clear impact on pavement performance due to the lane width of test sections. On several projects, the average deterioration rate for test sections with standard (12-foot lanes) and widened lanes were close to the same.

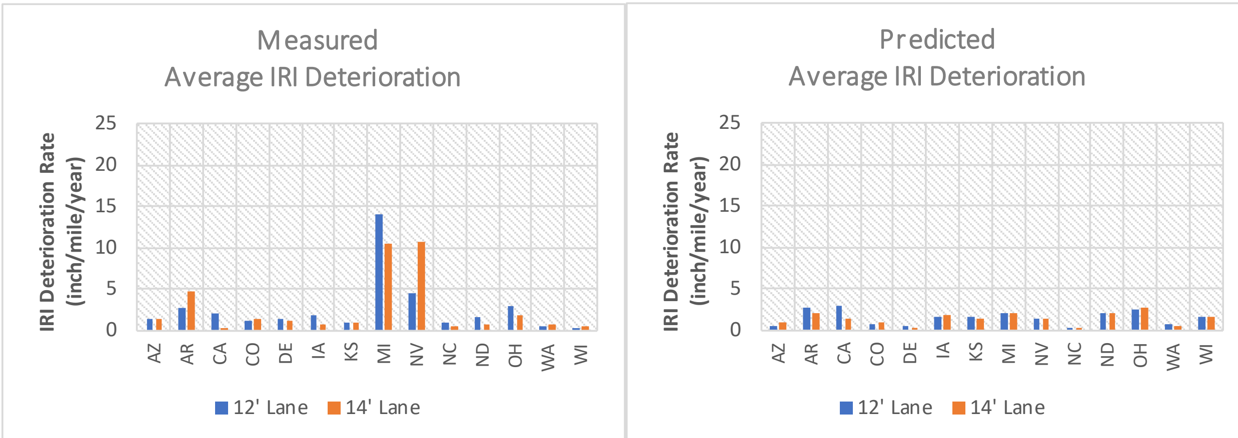


Figure 10. Deterioration Rates for Measured and Predicted IRI by Lane Width

11, faulting also showed similar deterioration rates between test sections with 12-foot and 14-foot lanes. There were a few more projects where test sections with 12-foot lanes had higher faulting deterioration rates. Predicted faulting deterioration rates did not show a clear impact on pavement performance related to the test section lane width.

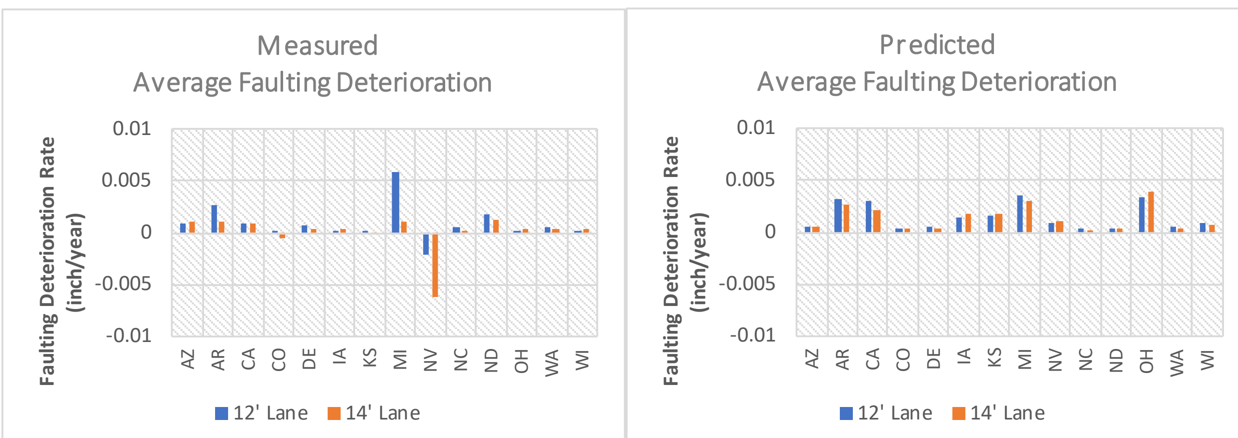


Figure 11. Deterioration Rates for Measured and Predicted Faulting by Lane Width

12 shows that in most projects, test sections with 12-foot lanes had a higher rate of transverse cracking than sections with widened lanes. However, in most cases, the difference in the rate of deterioration was slight. Predicted deterioration rates for transverse cracking did not have a clear impact on pavement performance due to the lane width of test sections. In Arizona, test sections with 14-foot lanes were predicted to deteriorate faster than sections with 12-foot lanes. Conversely, Arkansas test sections with 12-foot lanes were predicted to deteriorate faster than sections with 14-foot lanes. In California, test sections with 12-foot lanes were predicted to deteriorate faster than sections with 13-foot lanes (widened lanes in California were only 13 feet). An analysis of whether widened lanes contributed to longitudinal cracking is provided in a later section of this report.

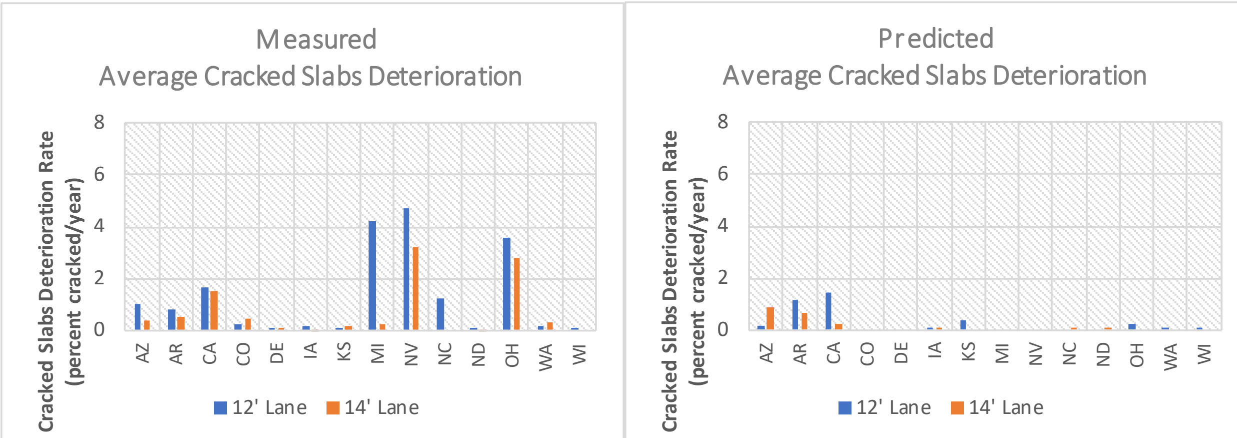


Figure 12. Deterioration Rates for Measured and Predicted Transversely Cracked Slabs by Lane Width

3.5 Design Feature 5 – Drainage Feature (or No Drainage)

Most of the SPS-2 projects have sections with either a drainage blanket (with longitudinal drains) or no subsurface drainage. Only five projects have sections with longitudinal drains and no drainage blanket. As shown in Figure 13, IRI deterioration at all projects was higher when there was no subsurface. In most cases, the difference was slight between the IRI deterioration rates of drained and undrained test sections. The projects that showed a large rate difference contained test sections that failed early. Drainage features or lack thereof did not have a clear impact on predicted IRI deterioration rates.

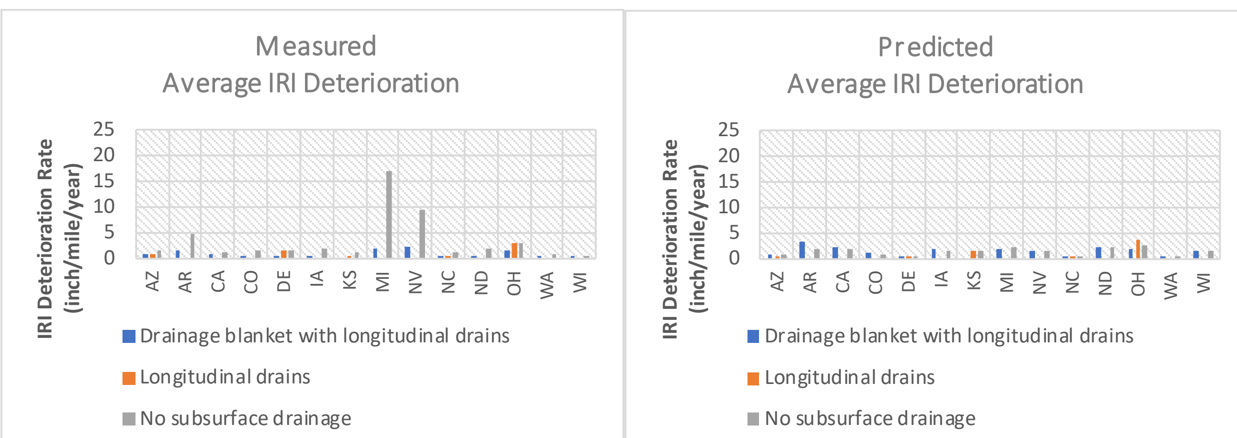


Figure 13. Deterioration Rates for Measured and Predicted IRI by Drainage Feature

14 shows that SPS-2 drainage features did not have a definite impact on the rate of faulting. In about half of SPS-2 projects, the rate of faulting was higher for sections with drainage blankets. The other half of SPS-2 projects had higher rates for sections with no subsurface drainage. In most cases, there was not a significant difference in the measured rate between sections with and without drainage features. MEPGD predictions also indicated that the presence of drainage features made no distinct impact on faulting deterioration rates.

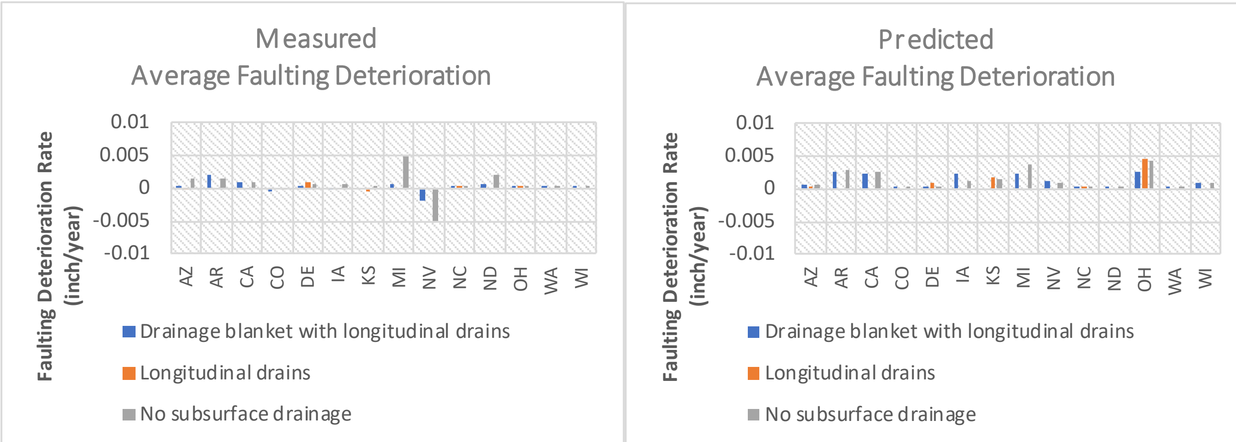


Figure 14. Deterioration Rates for Measured and Predicted Faulting by Drainage Feature

15, drainage features did have an impact on the rate of transverse cracking. Test sections without subsurface drainage had higher deterioration rates than test sections with drainage blankets and/or longitudinal drains. In most cases, the difference in the rate of deterioration was not too significant, as most SPS-2 test sections performed well and did not show significant transverse cracking. There were a few projects where the difference in deterioration rates was significant (i.e., Arkansas, California, and North Carolina). This was possibly due to the amount of traffic loading (or climate conditions) at these projects, causing undrained test sections to deteriorate faster than in other projects. Predicted deterioration rates for transverse cracking did not have a clear impact on pavement performance due to the drainage features of test sections.

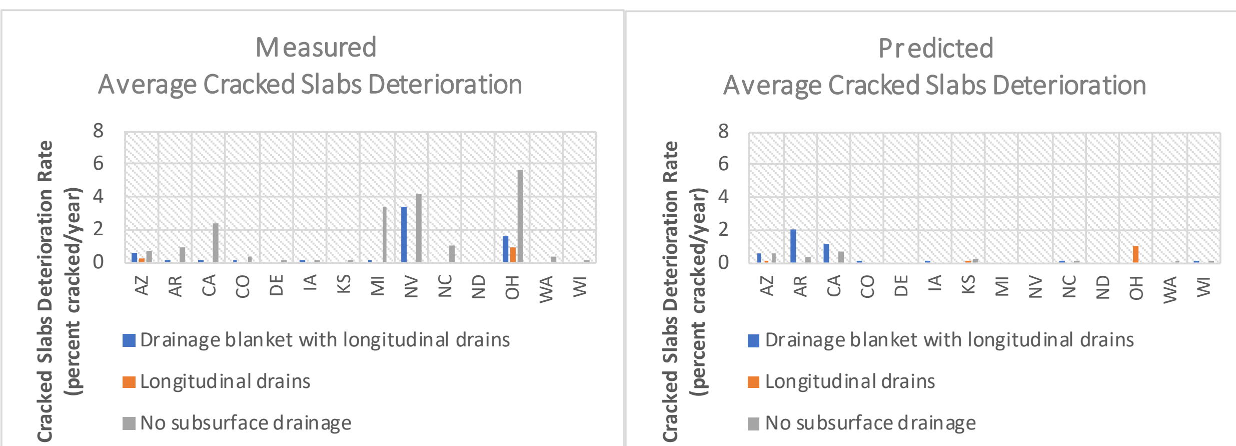


Figure 15. Deterioration Rates for Measured and Predicted Transversely Cracked Slabs by Drainage Feature

16 shows a histogram of transverse cracking deterioration rates. Measured transverse cracking rates were higher than predicted rates – in other words, the rates were typically underpredicted – and this was especially true in the case of LCB test sections.

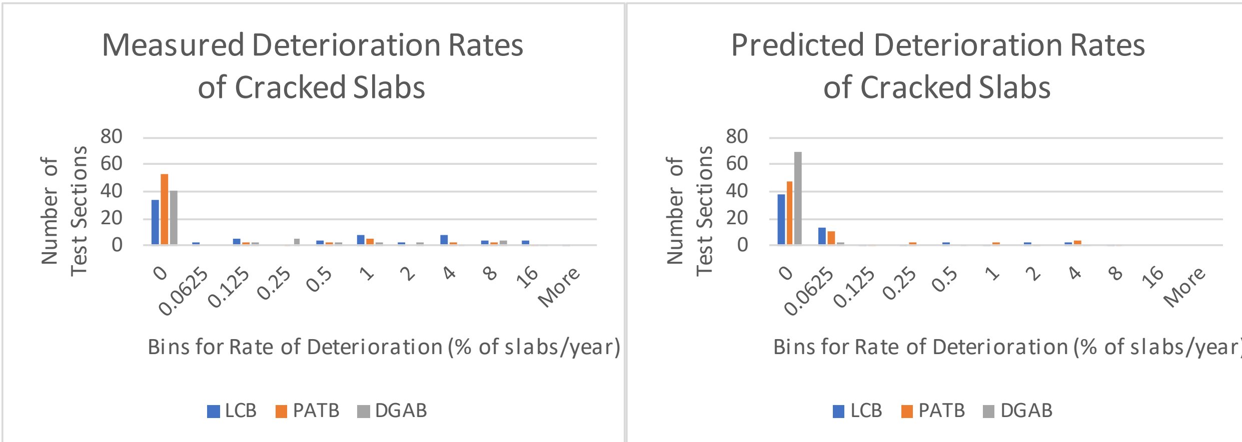


Figure 16. Histogram of Deterioration Rates for Transversely Cracked Slabs

3.6 Accuracy of MEPGD Predictions

Table 1 summarizes the accuracy of the MEPGD in predicting the slab-cracking deterioration rate of SPS-2 test sections by design feature. The accuracy is presented as a percent of well-predicted, underpredicted, and overpredicted performance. Prediction ratings include:

- Well-predicted – the difference between the predicted and measured deterioration rates was no more than 0.25% cracked slabs per year; measured rate of transverse cracking approximately equal to predicted rate of transverse cracking.
- Underpredicted – the test section performed worse than predicted; measured rate of transverse cracking greater than predicted rate of transverse cracking.
- Overpredicted – the section performed better than predicted; measured rate of transverse cracking less than predicted rate of transverse cracking.

Table 1. Quality of Performance Prediction of SPS-2 Test Sections by Design Factor

SPS-2 Design Feature	Design Feature Type	Percent of Test Sections by Design Factor		
		Well-Predicted	Under-Predicted	Over-Predicted
PCC Thickness	Thick (11”)	78%	17%	5%
	Thin (8”)	48%	38%	13%
Base Type	DGAB	71%	19%	10%
	PATB	73%	16%	11%
	LCB	52%	42%	5%
PCC Strength	High	63%	31%	6%
	Low	66%	23%	11%
Lane Width	12’	62%	30%	8%
	14’	72%	20%	8%

SPS-2 Design Feature	Design Feature Type	Percent of Test Sections by Design Factor		
		Well-Predicted	Under-Predicted	Over-Predicted
Drainage	Drainage blanket with longitudinal drains	74%	16%	10%
	Longitudinal drains only	73%	9%	18%
	No subsurface drainage	60%	33%	8%

As shown in Table 1, 48% to 78% of test sections fall into the category of well-predicted. Well-predicted test sections typically had very low to no deterioration during the monitoring period. Except for Section 060201, the deterioration rate of test sections in the well-predicted category did not exceed 0.35% of transversely cracked slabs per year.

The MEPDG typically underpredicted performance 2 to 3 times more frequently than it overpredicted performance. This ratio of underpredicted to overpredicted represents the general mismatch between the measured and predicted deterioration rates (on average) for the SPS-2 experiment. Therefore, deviations from this ratio, with respect to design feature, represent the impact that the design feature may have had on the prediction.

The ratio of underpredicted to overpredicted deviated significantly from the norm for the following design features:

- LCB test sections, which were 8 times more underpredicted than overpredicted (43% vs. 5%)
- Sections with high-strength PCC, which were 5 times more underpredicted than overpredicted (31% vs. 6%).

This suggests that something in the MEPGD model concerning LCB base and PCC mix strength contributed substantially to underpredictions relative to other design features.

Conversely, sections with longitudinal drains tended to be less frequently underpredicted than overpredicted (9% vs. 18%). However, this drainage feature was not as common as the variant with drainage blanket and longitudinal drains. Since the more common design feature (or lack thereof) did not deviate significantly from the typical ratio of underpredicted to overpredicted sections, it can be construed that drainage features did not additionally contribute to the poor predictions – at least no more so than most other design features (i.e., pavement thickness, DGAB and PATB base, low-strength PCC, and lane width).

3.7 Summary

In summary, the SPS-2 design features that typically provided better performance included:

- Thicker pavements
- PATB bases
- Low-strength PCC

- Widened lanes (not a significant improvement)
- Drainage blanket with longitudinal drains (characteristic of PATB base type)

Predicted deterioration rates agreed that sections with thicker pavements and widened lanes had better performance, but the MEPGD was incorrect in its predictions that sections with LCB bases and high-strength PCC would have better performance or that drainage features would have no clear impact. Based on deterioration rates, the MEPGD underpredicted the performance of test sections with LCB bases, high-strength PCC, and/or drainage features.

4.0 IMPACT OF INITIAL SMOOTHNESS ON PAVEMENT PERFORMANCE

Past studies have shown that initial smoothness significantly impacts future smoothness. Thus, initial IRI is important input of roughness prediction models. However, determining the impact of "initial" smoothness on pavement performance of an SPS-2 test section is difficult for a number of reasons:

- In order to fairly assess the impact of initial smoothness, the comparison should be drawn between test sections with different initial IRI values and similar pavement structure. However, initial IRI was not a design feature in the SPS-2 experiment. Even if test sections within a project had different initial smoothness, they also had at least one other design factor that varied, potentially biasing the comparison.
- LTPP profile measurements do not account for the curl and warp of the concrete during the time of testing. Seasonal and diurnal fluctuations in temperature and moisture can cause significant variations in curl and warp of the pavement at the time of profile measurement. Because it is difficult to account for curl and warp, it is also difficult to accurately assess the initial smoothness and the progression of roughness over the monitoring period. For example, diurnal profile testing on Arizona test sections in 2014 determined mean roughness varied by 10 to 29 inch/mile between profile measurements taken at about 6:00 AM and 2:00 PM on the same day.
- Another issue is that, on average, the first profile of SPS-2 test sections took place 9 months after construction. The first profile may have occurred as soon as 17 days after construction (Washington SPS-2) or as late as 31 months after construction (North Dakota SPS-2). Also, SPS-2 sites typically opened to traffic 2 months after construction. While roughness may start to increase under traffic loading, it could be argued that initial smoothness should be represented by the IRI at the time of construction, since agencies base their specifications on pavement at time of construction. Additionally, the performance of SPS-2 test sections was not comprehensively monitored in the first year after construction and it is unclear exactly how the smoothness of the pavement behaves in this early period.
- While the changes in profile data collection technologies and equipment over time is a potential source of variability, each time the equipment was changed, LTPP conducted a thorough study and determined the data were substantially equivalent for the old and the new equipment. The K.J. Law DNC690 profile equipment changed to the K.J. Law T-6600 in 1996, then changed to the ICC inertial profiler in 2002, and most recently changed to the Ames inertial profiler in 2013. The comparison in 2002 between the K.J. Law and ICC profilers found that in 70% of cases, the differences in IRI were within ±6.3 inch/mile[1].

For the initial IRI input, MEPDG predictions used the intercept from the linear regression of profile measurements taken within the first 3 years after the sites were opened to traffic. This method was selected in order to provide an initial IRI at the time the section was opened to

[1] Simpson, A. L., & Elkins, G. E. (2013). *LTPP Profiler Comparaison – 2013*. Federal Highway Administration.

traffic, but to exclude the regression influenced by non-linear IRI measurements that may appear as the pavement ages. In most cases, this provided an initial IRI input that was very similar to the IRI measurement from the first profile visit. Figure 17 confirms that the linear regression intercept of IRI measurements from the first 3 years has a stronger correlation with the first profile visit measurement than the linear regression intercept of measurements from all years of profiling. Because the first 3 years have a stronger linear correlation, this suggests that the progression of roughness measurements throughout the performance period tends to be nonlinear or variable. As discussed previously, there are several potential sources for variability in profile measurement; most notably, curl and warp. However, the progression of IRI is assumed to be a linear relationship for calculation purposes and the first profile measurement was used to represent initial smoothness in the early life of the pavement.

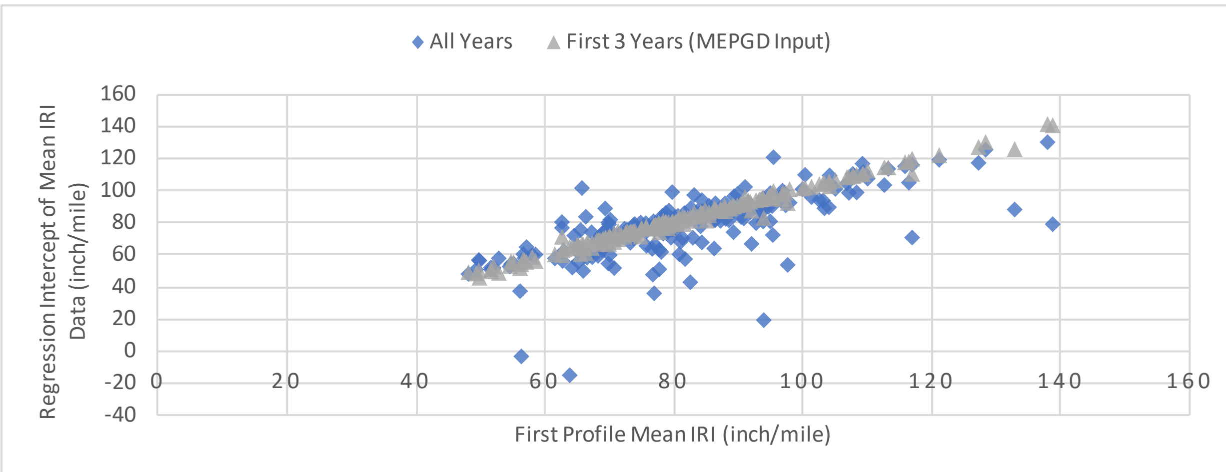


Figure 17. Comparison of First Profile Mean IRI and the Linear Regression Intercept of Profile Data.

This does not resolve the issue of curl and warp when using the first profile measurement to represent initial smoothness. Figure 18 shows that the first profile mean IRI does not correlate with the deterioration rate (linear regression slope) of IRI. Several sites had negative deterioration rates based on the first 3 years of profiling, which implied that IRI was improving on these sites. Typically, the IRI would drop after the first profile measurement; Figure 19 shows an example of this, where there was a drop of 25 inch/mile between the first and second IRI measurement of Section 040214. For sections like 040214, an initial IRI based on the second profile measurement appears to be more reasonable as an MEPGD input than an initial IRI based on the first profile mean IRI. However, that may not be case if the profile measurement could be adjusted for curl and warp. Test sections where the second profile measurement was less than the first profile were most commonly found in the Arizona and Kansas projects. These inconsistencies in IRI may not necessarily be due to an initial curl in the pavement slab flattening out over time, but could be the result of curl and warp effects on profile measurements subsequent to the first profile.

Figure 18 also shows, in some test sections, the linear regression of mean IRI data results in larger regression slopes (in the magnitude of 20 to 40 inch/mile/year). These test sections were almost entirely from Nevada and Michigan sites. Test sections with mean IRI regression slopes of 9 to 20 inch/mile/year include 052017, 050213, 260213, 260214, and 320201. Test sections with mean IRI regression slopes greater than 20 inch/mile/year included 260215, 260217, 260218, and 320202.

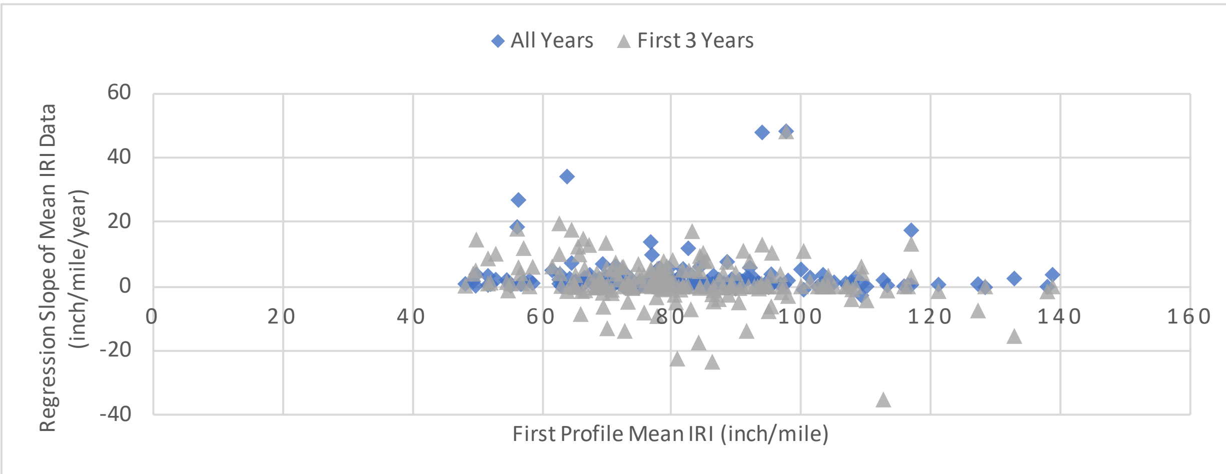


Figure 18. Comparison of First Profile Mean IRI and the Linear Regression Slope of Profile Data (IRI Deterioration Rate).

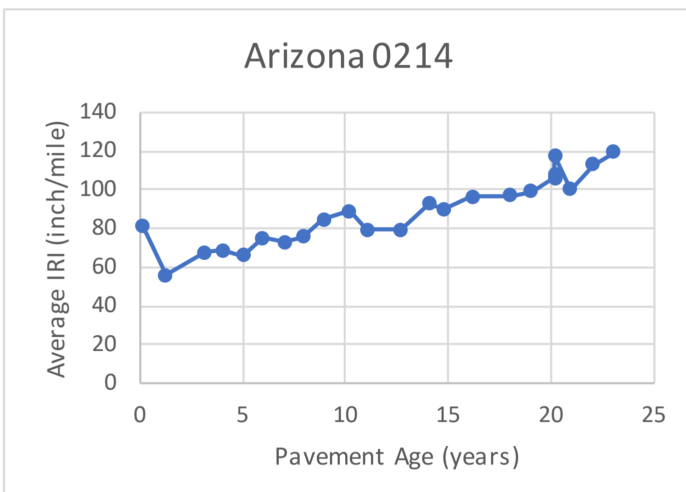


Figure 19. Time Series of Mean IRI for Section 040214.

In MEPGD predictions, a change in initial IRI resulted in a proportional change in the IRI deterioration rate. However, in the SPS-2 experiment, it was difficult to determine how changes in initial IRI may have affected the IRI deterioration rate, as test sections with different initial IRI values also had different design features. Table 2 summarizes the data in Figure 18 and shows average IRI deterioration rates for incremental ranges of initial IRI.

Table 2. Average IRI Deterioration Rates (inch/mile/year) by Bins (range of values) for Initial Mean IRI of SPS-2 Test Sections

SPS-2 Project	Initial IRI (inch/mile)					
	<60	**60-70**	**70-80**	**80-90**	**90-100**	**>100**
AZ		2.4	0.8	1.1	1.4	1.3
AR	1.8	2.1	4.7	6.2	2.9	1.9
CA	1.5	2.1	2.7	0.7	1.4	-1
CO		1.9	0.2	1.3	0.9	1.4
DE	0.6	1.6	1.3		1.1	2.7
IA		2.7	1.9	1.6	0.2	0.2
KS			1	1	1.2	1
MI	26.8	7.7	6.3	6.1	26.8	17.4
NV	6.8	2.5		7.6	24.4	-1.1
NC		0.8	0.9	0.8	0.5	0.8
ND					1	1.3
OH	1.7	3.4	2.6	1	3.7	
WA	0.2	0.5	0.8			
WI	0.8	0.6	0.2	0.4	0.7	0

There were no projects where the average deterioration rate consistently increased with initial IRI. However, the highlighted values in Table 2 show portions of the data where relative increases in initial roughness correspond to relative increases in the IRI deterioration rate. For example, in Arizona, as initial IRI increased from 70 to 100 inch/mile, the IRI deterioration rate also increased from 0.8 to 1.1 to 1.4 inch/mile/year. Table 2 shows that similar trends occur in other projects, although not consistently.

It is difficult to determine how meaningful these trends are, as many outliers were compounded into the averages. In several projects, a decrease in the IRI deterioration rate was observed when the initial IRI was in the range of 90 to 100 inch/mile or more. For example, in Arkansas, the IRI deterioration rate dropped from 6.2 to 2.9 inch/mile/year as the initial IRI increased from 80 to 90 inch/mile to 90 to 100 inch/mile. This implies some sections with high initial IRI had a lower IRI deterioration rate than test sections with a lower initial IRI. In some cases, the low IRI deterioration rates resulted because the regression of IRI data with curl and warp or surface grinding produced a linear trend with very little slope (e.g., 380218). In other cases, the high initial IRI resulted from a coarse pavement surface texture that persisted throughout its performance period (e.g., 190223). Several test sections having high deterioration rates in Michigan and Nevada went out-of-study early in the program and these sections typically started out with initial IRI values over 90 inch/mile except for 260215, which started out with 56 inch/mile. North Dakota test sections showed an initial mean IRI greater than 90 inch/mile, likely because the first profile measurement at these sections occurred 31 months after construction. The deterioration rates for the slabs with transverse cracking show less correlation to initial IRI than the IRI deterioration rate. Table 3 shows increases in transverse cracking deterioration rates were few and minor.

However, this was expected since most SPS-2 test sections did not exhibit significant transverse cracking while in study.

Figure 20 shows the relationship between the initial roughness and projected roughness after 20 years (based on the IRI deterioration rate). This figure shows that the distribution of projected IRI is relative to the initial IRI. In other words, as initial IRI increases, the frequency of high IRI deterioration rates also increases – especially in the initial IRI range of 50 to 90 inch/mile – resulting in higher 20-year IRI projections. In addition, the profile data indicate that projects with low initial IRI typically had lower levels of roughness during the last round of data collection.

Table 3. Average Transverse Cracking Deterioration Rates (percent of slabs/year) by Bins for Initial IRI of SPS-2 Test Sections

SPS-2 Project	Initial IRI (inch/mile)					
	<60	**60-70**	**70-80**	**80-90**	**90-100**	**>100**
AZ		0.7	0	1.1	0.1	0.1
AR	0.5	0	0.4	2.8	0.1	0
CA	0	5.1	2.9	1.8	0	-0.1
CO		0.5	0	0.3	0	0.6
DE	0	0	0.2		0	0
IA		0.1	0.1	0	0	0
KS			0.3	0	0	0
MI	0.7	0.6	0.7	0	12	1.3
NV	2.5	5		0	3.1	11.5
NC		0	0	0.1	0	2.1
ND				0	0	0
OH	4.9	2.1	4.5	0.3	2.4	
WA	0	0.4	0.2			
WI	0	0	0	0	0	0

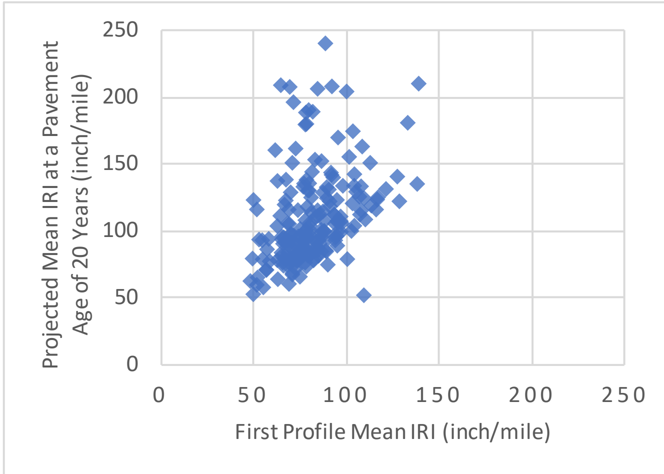


Figure 20. Comparison of First Profile Mean IRI and the Projected IRI after 20 Years.

Although there was not a direct correlation, the trend in Figure 20 illustrates initial roughness is a significant factor in the roughness after 20 years. Other factors such as traffic, climate, pavement structure, maintenance treatments, and curl and warp also had influence and created variability in the projected roughness. For example, Section 060203 experienced steady decreases in mean IRI from 120 inch/mile in 2002 to 75 inch/mile in 2010. This decrease in mean IRI may be because of surface-grinding activities. The first profile at Section 060203 was 109 inch/mile in 2000 and the last profile was 75 inch/mile in 2016. Linear regression projected the 20-year IRI to 50 inch/mile, but the IRI was steady at 75 inch/mile from the period of 2010 to 2016. This example also shows that projecting IRI using linear regression adds another layer of variability because measured roughness is not necessarily linear, and the monitoring period varied from site to site – especially for test sections that went out-of-study early.

5.0 IMPACT OF SHOULDER TYPE ON PAVEMENT PERFORMANCE

In order to properly compare the difference in performance between test sections with different shoulder types, all other variables must remain the same. Drawing comparisons between test sections within the same project eliminates state-specific variables such as climate, traffic, material, and construction. This direct comparison was limited because the core test sections for the SPS-2 projects exclusively used either asphalt concrete (AC) or PCC shoulder types. Table 4 shows the distribution of shoulder type by project.

Three projects (Michigan, North Dakota, and Wisconsin) had a total of five supplemental sections with a shoulder type different than the project's core test sections (highlighted in Table 4): 260259, 380259, 380260, 380264, and 550262. These allow for more useful comparison, but the limited number of sections means the results of this analysis may not be representative of the entire SPS-2 project. A more general comparison was also considered in this analysis based on the frequency of shoulder rehabilitation for each shoulder type.

Table 4. Number of SPS-2 Test Sections by Shoulder Type

SPS-2 Project	Count of Test Sections by Shoulder Type			
	Core Test Sections		Supplemental Test Sections	
	AC	**PCC**	**AC**	**PCC**
AZ	-	12	-	7
AR	12	-	-	-
CA	-	12	-	-
CO	-	12	-	1
DE	12	-	2	-
IA	12	-	1	-
KS	-	12	-	1
MI	12	-	-	1
NV	-	11	-	1
NC	-	12	-	2
ND	12	-	3	3
OH	12	-	7	-
WA	12	-	1	-
WI	12	-	7	1

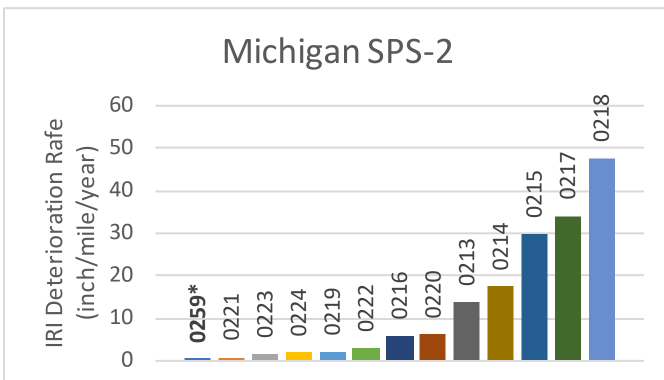
- indicates no test sections

Figures 21 through 23 show that, based solely on IRI deterioration rates, sections with PCC shoulders performed relatively better than sections with AC shoulders within the same project. This was especially true in Michigan and Wisconsin, where the sections with the best performance were the supplemental sections with PCC shoulders (Michigan 0259 and Wisconsin 0262).

Michigan, North Dakota, and Wisconsin have similar climatic regions, but traffic loading at the Michigan SPS-2 was several times higher than traffic loading at either the North Dakota or

Wisconsin sites. Traffic may have contributed to the high transverse cracking deterioration rate at Michigan 0259 (2.9 percent of slabs cracked transversely per year). This analysis did not determine the impact of shoulder type on transverse cracking. Transverse cracking performance may provide additional insight into the impact of shoulder type, but as with roughness, a one-to-one comparison deviating only in shoulder type as a design factor would not be available.

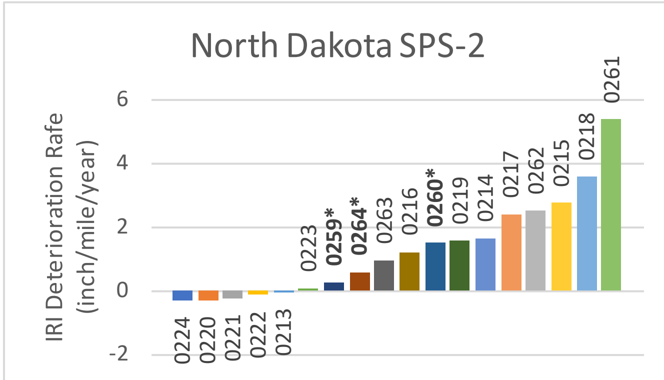
The layer structure of Michigan 0259 was most similar to the layer structure of Michigan 0223; both were 11-inch, low-strength PCC pavement over an asphalt-treated base having a 12-foot-wide travel lane. Both Michigan 0259 and 0223 had low IRI deterioration rates, but Michigan 0223 also had no transverse cracking. However, Michigan 0259 and 0223 specifically differed in the type of asphalt-treated base; Michigan 0259 had an open-graded drainage course base, whereas Michigan 0223 had a PATB base. This difference in base type may be related to the difference in transverse cracking performance–possibly in tandem with drainage functionality.



* indicates test section has a different shoulder type.

Figure 21. IRI Deterioration Rates for SPS-2 Test Sections in Michigan.

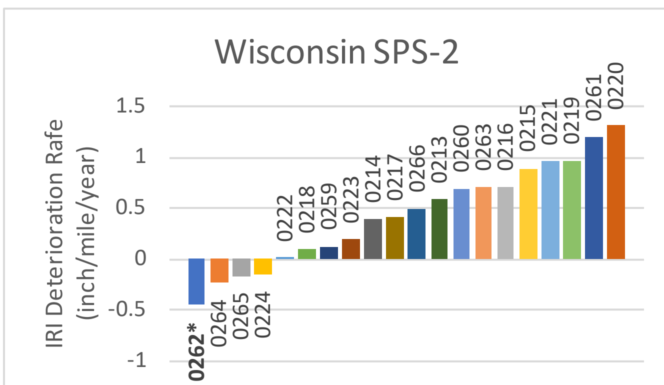
North Dakota test sections 0259, 0260, and 0264 were most like North Dakota 0222, 0215, and 0223, respectively, in layer structure. None of these six test sections showed transverse cracking. North Dakota 0215 had a high IRI deterioration rate, but so did its counterpart, 0260. Although there are other variables by which North Dakota 0259, 0260, and 0264 differed from their counterparts, the performance of these test sections did not distinguish an impact on performance due to shoulder type.



* indicates test section has a different shoulder type.

Figure 22. IRI Deterioration Rates for SPS-2 Test Sections in North Dakota.

Wisconsin 0262 was most like Wisconsin 0214 in layer structure. While Wisconsin 0262 had the best performance in IRI deterioration, overall, IRI deterioration rates for all Wisconsin test sections were low (less than 1.5 inch/mile/year). Since Wisconsin test sections 0214 and 0262 did not deteriorate at significantly different rates, it is difficult to determine the impact of shoulder type on these test sections.



* indicates test section has a different shoulder type

Figure 23. IRI Deterioration Rates for SPS-2 Test Sections in Wisconsin.

There were also a number of projects where shoulder restoration (resurfacing) was performed on all test sections. All Iowa test sections had AC shoulder restoration in 2013. North Dakota had multiple project-wide AC shoulder restorations in the years 1997, 2001, 2006, 2009, and 2016. Ohio had 10 test sections that received AC shoulder restoration in 2013. While AC shoulder restoration was not commonplace for all SPS-2 projects, none of the test sections with PCC shoulders had shoulder restoration. In terms of maintenance and rehabilitation cost, PCC shoulders performed better than AC shoulders within the SPS-2 experiment.

Figure 24 shows the rate of shoulder drop-off, shoulder separation, and corner breaks, and the average of age when the shoulder joint was no longer considered "well sealed." In general, PCC shoulders appeared to perform better in most categories. For Michigan and Wisconsin, test sections with PCC shoulders had less shoulder drop-off and separation than sections with

AC shoulders. For North Dakota, PCC shoulder test sections had more separation than the asphalt shoulder test sections. The negative shoulder separation deterioration rate in Washington was due to a comparatively large shoulder separation measurement in 1997. Shoulder separation measurements following 1997 were consistently lower, resulting in a negative deterioration rate.

The impact of shoulder type on corner breaks could not be determined as only Arkansas and Michigan projects had a significant number of corner breaks. Figure 24(d) shows that shoulder joint seals on sections with a PCC shoulder lasted longer in most cases, but North Dakota was the only project where a significant difference in the average age of the shoulder joint seal was observed between the two shoulder types. In Michigan and Wisconsin, the average age before shoulder joint seal failure was short, and the difference between the two shoulder types was not significant.

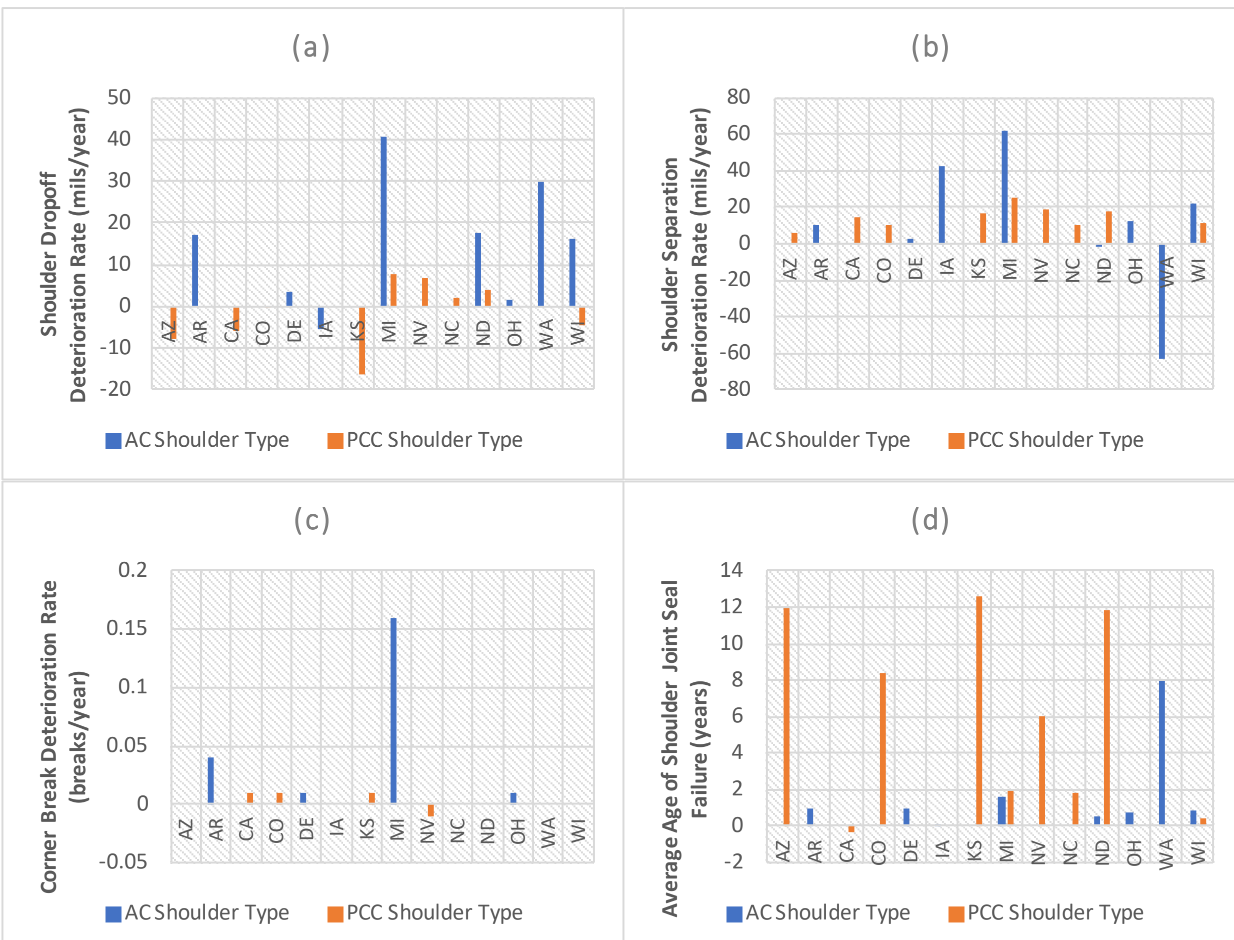


Figure 24. Deterioration Rates for Shoulder Dropoff (a), Shoulder Separation (b), Corner Breaks (c), and the Average Age at Shoulder Joint Seal Failure (d) by Shoulder Type

6.0 IMPACT OF DESIGN FEATURE ON LONGITUDINAL CRACKING

Figure 25 shows that the majority (about 85%) of SPS-2 test sections had no longitudinal cracking. Test sections that did have longitudinal cracking tended to have thin PCC pavements, widened lanes, and no subsurface drainage. Test sections with deterioration rates higher than 20 feet/year were all in Nevada and were considered outliers. However, other test sections with higher deterioration rates typically had LCB base types and PCC shoulders. Overall, widened lanes were consistently present in test sections with longitudinal cracking. Other design features that may have added to the impact of widened lanes on longitudinal cracking include (in the order of most- to least-influential): the lack of subsurface drainage, thinner PCC pavements, and LCB base type.

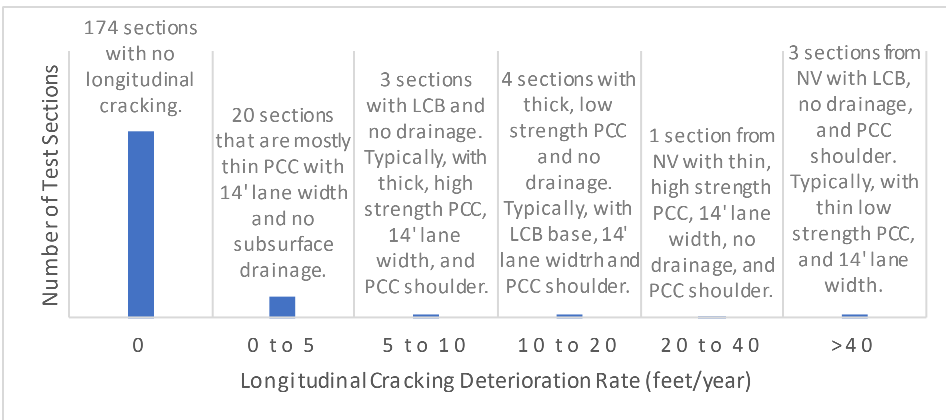


Figure 25. Histogram of SPS-2 Test Sections by Bins Longitudinal Cracking Deterioration Rate

Figure 26 shows the average rate of longitudinal cracking (feet/year) by SPS-2 project and design feature (including shoulder type). The figure compares the impact of design features within a project to control the effect of traffic, climate, materials, construction, and other variables on pavement performance. The figure caps the deterioration rate at 15 feet per year. Although averages from Nevada test sections often exceeded this amount, as mentioned, Nevada is considered an outlier. Test sections in Delaware, Iowa, Kansas, North Carolina, and Wisconsin had very little to no longitudinal cracking.

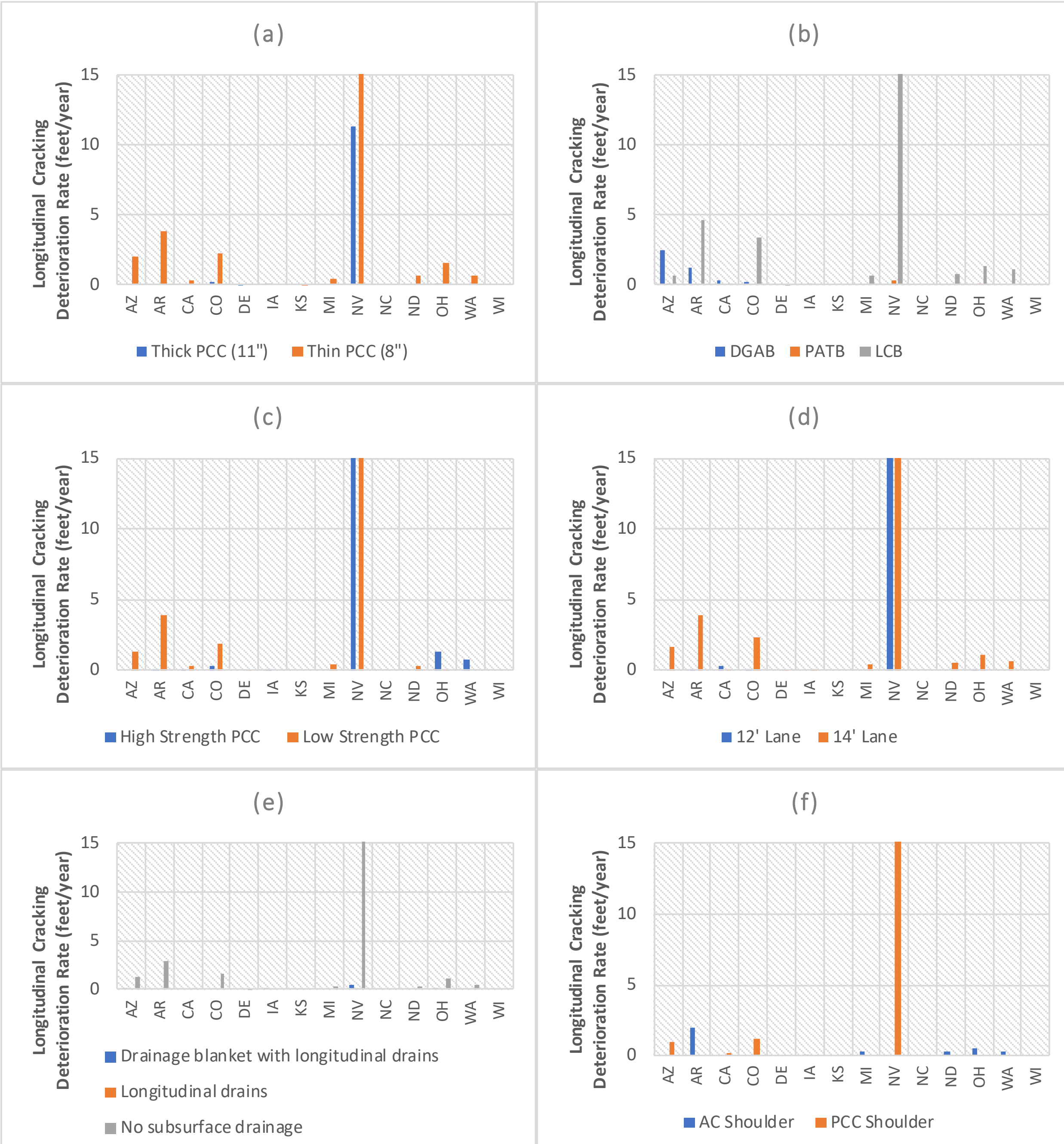


Figure 26. Average Longitudinal Cracking by SPS-2 Project and Design Feature: (a) PCC Thickness, (b) Base Type, (c) PCC Strength, (d) Lane Width, (e) Drainage Feature, and (f) Shoulder Type.

In most cases where longitudinal cracking was present, design features had a clear impact (see Figure 26):

- Thinner pavements had higher rates of longitudinal cracking.

- Sections with LCB base had higher deterioration rates (except for Arizona).
- In most cases, low-strength PCC sections had higher deterioration rates, although results were mixed.
- Widened lanes had a clear impact on increased longitudinal cracking – the only exception was in California, where the widened lanes were only 13 feet wide rather than the usual 14 feet.
- Nearly all sections with longitudinal cracking had no subsurface drainage.
- Shoulder type was the one design feature that showed little or no impact on the rate of longitudinal cracking.

When considering only projects in Arizona, Arkansas, Colorado, Michigan, North Dakota, Ohio, and Washington (non-outlier projects with longitudinal cracking), longitudinal cracking was not found in any test section with thick PCC, PATB base, 12-foot lanes, or longitudinal drains. The presence of any of these design features on an SPS-2 test section provided for better performance in longitudinal cracking.

7.0 IMPACT OF DESIGN FEATURE ON LTE

LTE at the joint is a computed parameter, where falling weight deflectometer (FWD) testing is performed with the load plate placed on either the leave or approach side of a joint. Figure 27 shows the average change in LTE per year for SPS-2 test sections at the wheel-path of joints. This figure shows that the LTE for most test sections deteriorated less than 1.5% per year. LTE typically decreased over time, but some sections showed a minor increase in LTE over time. This increase was likely due to the variability of the LTE data; therefore, sections typically maintained their initial LTE.

Eight sections showed an improvement in LTE of 1.5% per year or greater. Five of these were Nevada SPS-2 test sections; these sections were also found to have a negative rate of change in faulting. This suggests subsurface support was deteriorating faster at the approach side of joints rather than the leave side. The unusual pattern of LTE and faulting at these Nevada sections was likely a result of the extensive transverse and longitudinal cracking, and as noted above, the Nevada sections are considered to be outliers due to materials and construction issues.

The other three were Michigan 0217 and 0218 (also outliers) and Arizona 0218 (a thin pavement test section with LCB, high-strength PCC, and standard lane width).

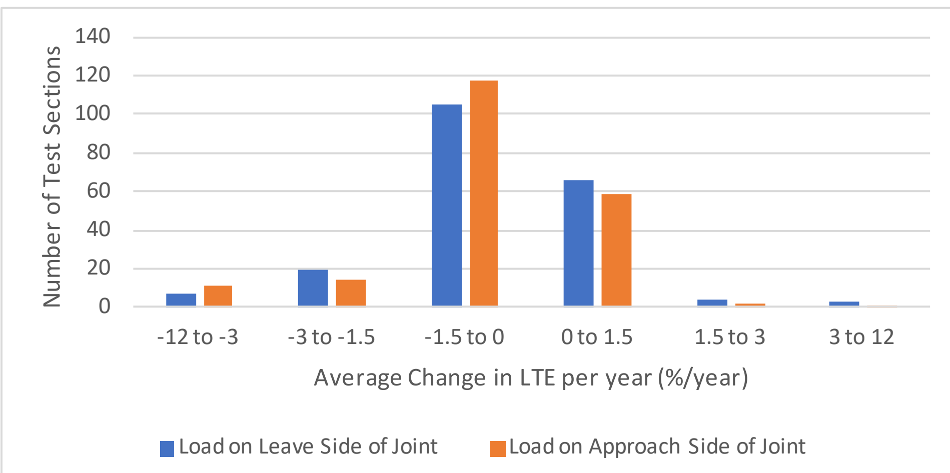


Figure 27. Histogram of Change in LTE per Year

Figure 28 shows the impact of SPS-2 design features on the deterioration rate of LTE.

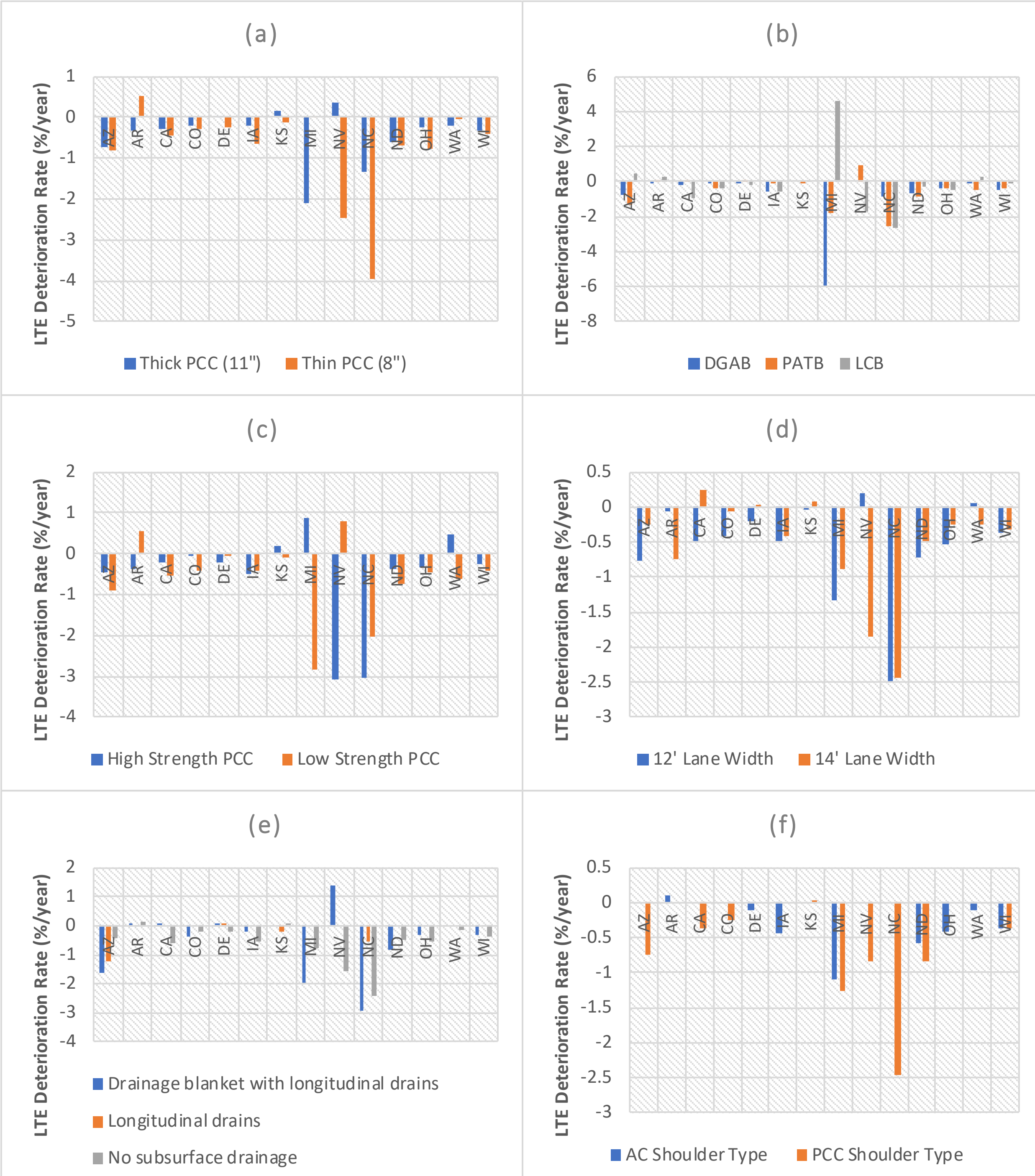


Figure 28. Average Leave Slab LTE by SPS-2 Project and Design Feature: (a) PCC thickness, (b) Base type, (c) PCC strength, (d) Lane width, (e) drainage feature, and (f) shoulder type.

As shown in Figure 28,

- Test sections with thin pavements had higher LTE deterioration than thick pavement sections. The sections with the highest rate of deterioration were in Michigan, Nevada, and North Carolina. Several North Carolina sections, although steadily decreasing in LTE over time, performed well in IRI and transverse cracking. In Michigan there were several sections with thick pavements where larger changes in LTE also correlated with a high deterioration rate in transverse cracking.
- Base type did not make a clear impact on LTE deterioration. Except for Michigan, each base type performed similarly in LTE deterioration and the differences in performance are not consistent from project to project.
- Low-strength PCC sections generally had higher LTE deterioration rates, but there were also projects where high-strength PCC sections decreased in LTE faster than low-strength sections. North Carolina had especially high LTE deterioration rates for high-strength PCC sections. These inconsistencies suggest that PCC strength has little impact on LTE.
- Lane width had a minor impact on the LTE deterioration rate. On most projects (except for Arkansas, Nevada, and Washington), test sections with a 12-foot lane width had a slightly faster LTE deterioration than test sections with widened lanes. Because the impact was small, the inconsistencies in this trend are likely due to the influence of other design factors. Nevertheless, the impact of lane width was as significant as pavement thickness and more significant than base type or PCC strength.
- Drainage features did not have an impact on the LTE deterioration rate. In most projects, test sections with drainage had close to the same LTE deterioration rates as sections without drainage. Similar to base type and PCC strength, the average deterioration rates from project-to-project were too inconsistent to imply that drainage had a clear impact on LTE. The LTPP database indicated that the following test sections had longitudinal drains but no drainage blanket: 040263, 040264, 100259, 100260, 200209, 200210, 200211, 370260, 390259, 390263, and 390264.
- Shoulder type may have had an impact on LTE deterioration. Test sections with PCC shoulders tended to decrease in LTE slightly faster than sections with AC shoulders. However, there were too few projects where a relative comparison between shoulder type could be made. Therefore, the results of the available comparisons may not be representative of concrete pavements in general or even pavements within the context of the SPS-2 experiment. Additionally, because PCC shoulders of SPS-2 test sections were not tied to the pavement – as is typical in standard construction practice – PCC shoulders may not have contributed additional support to the pavement.

In summary, pavement thickness and lane width had the most impact on the deterioration of LTE. Other SPS-2 design factors did not have a significant impact by comparison. Factors outside of the experimental design may have influenced these results, such as properties of materials, quality of construction, traffic loading, climate, maintenance of joint seals, and length of the monitoring period.

8.0 MID-SLAB DEFLECTION AND AREA VALUE ANALYSIS

In linear elastic theory, mid-slab deflection is proportional to the stiffness of the pavement structure and the applied load. Therefore, under the same load, a change in deflection of the pavement structure is typically indicative of a change in material stiffness. This change in material properties may have occurred permanently through continual erosion or hardening of the material or temporarily in response to seasonal or diurnal changes in climate. For example, unbound layers tend to be stiffer in colder winter months than in the hotter summer months. The time of FWD testing would influence the linear regression of deflection measurements and partly contribute to the calculated deterioration rate. When the deterioration rate is low, it is less clear whether changes in mid-slab deflection are due to permanent or temporary changes in the material. Pavements in good condition tend to erode more slowly than pavements in poorer condition. Additionally, concrete naturally tends to gain strength over time. Therefore, it is difficult to assess the impact of a design feature on deterioration rate when the difference between deterioration rates is marginal.

Figure 29 shows the effect of design features on mid-slab deflection over time. The figure shows mid-slab deflections increased over time, suggesting the pavement structure weakened. Design features did seem to have a minor effect on the rate of deterioration of mid-slab deflections. As seen in previous analyses, the Nevada, Michigan, and Ohio projects were outliers and typically had higher rates of deterioration than other projects.

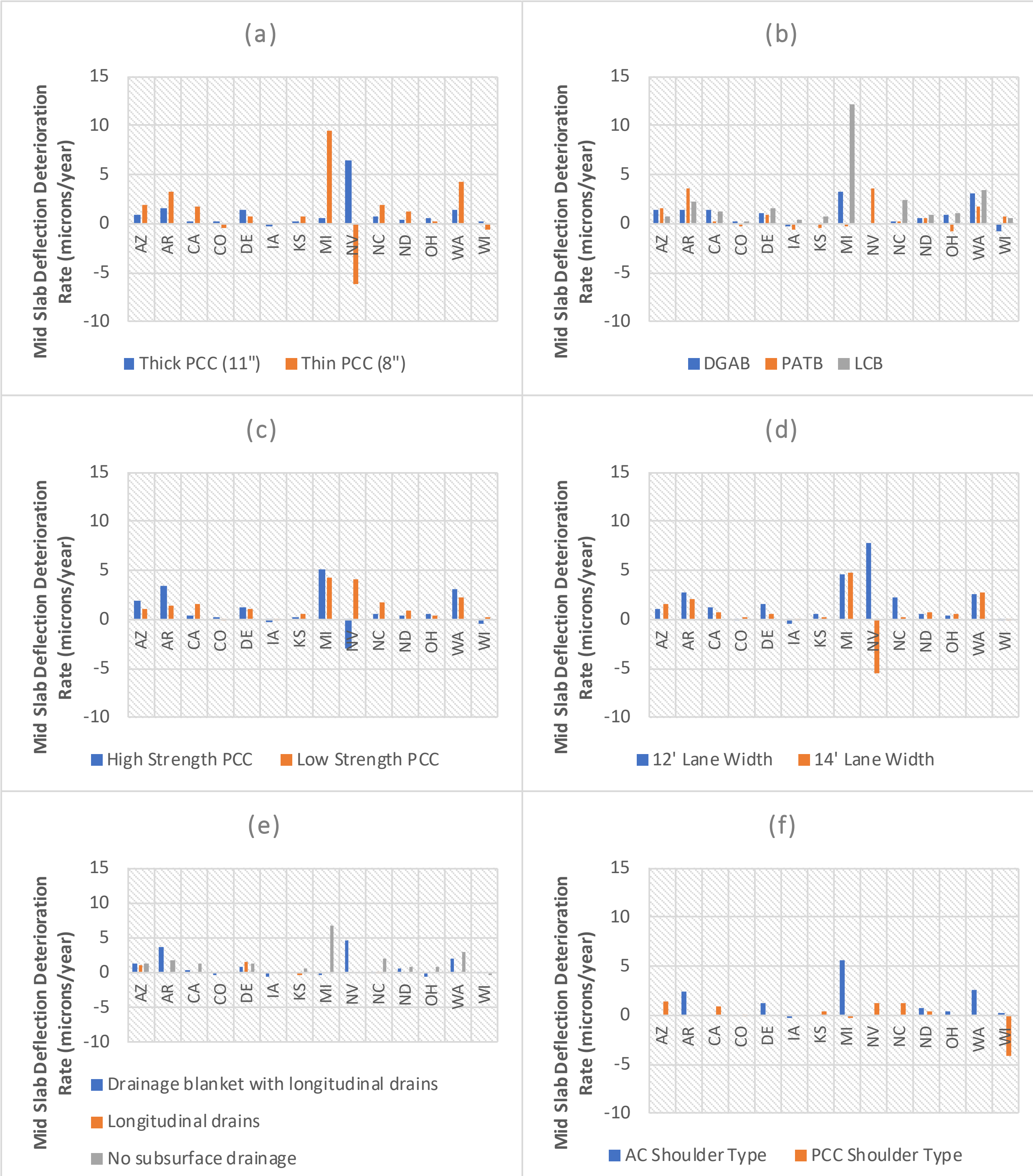


Figure 29. Average Mid Slab Deflection by SPS-2 Project and Design Feature: (a) PCC Thickness, (b) Base Type, (c) PCC Strength, (d) Lane Width, (e) Drainage Feature, and (f) Shoulder Type.

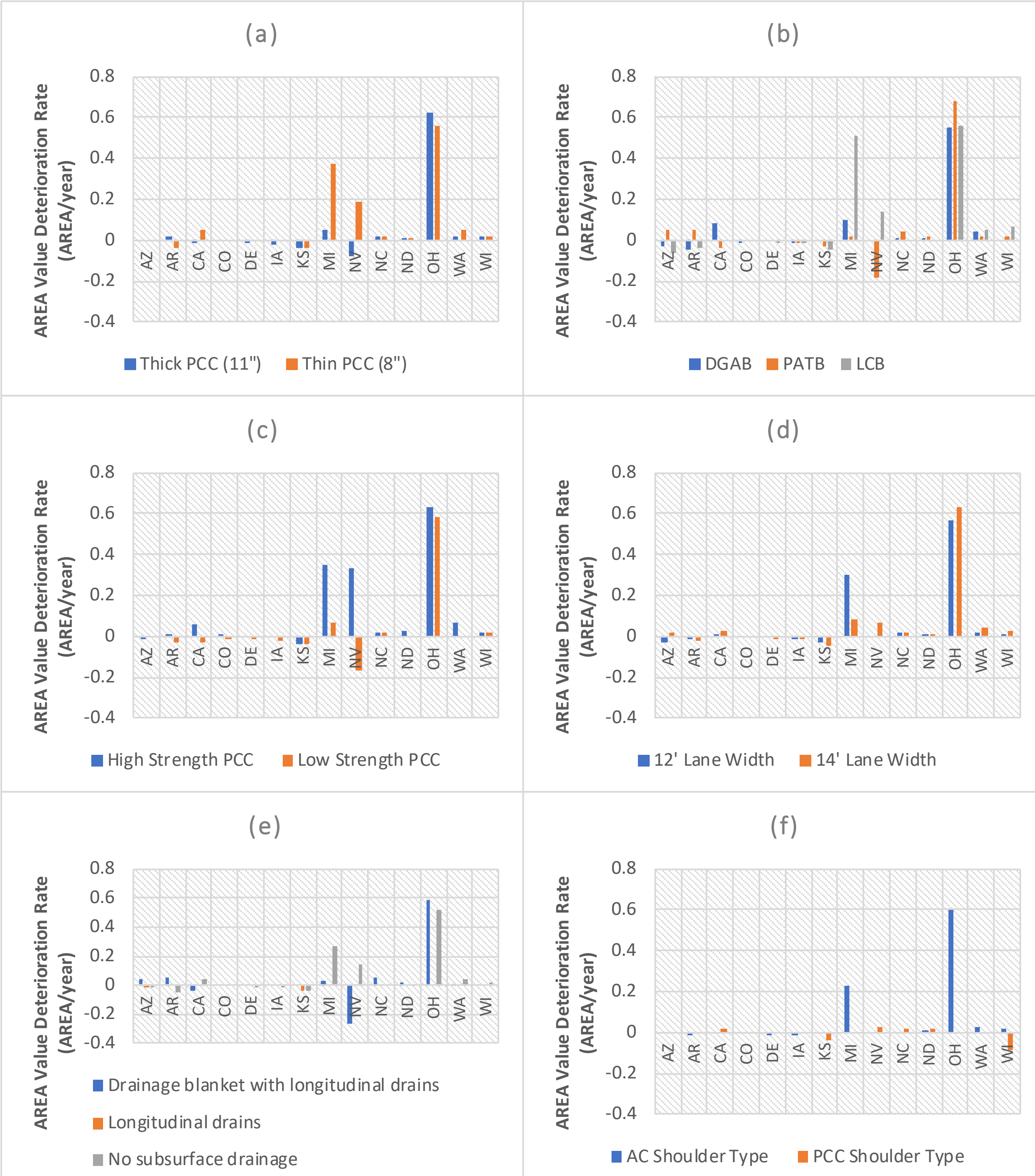


Figure 30. Average Area Value by SPS-2 Project and Design Feature: (a) PCC thickness, (b) Base type, (c) PCC strength, (d) Lane width, (e) drainage feature, and (f) shoulder type.

The mid-slab deflection after construction typically showed that thinner pavements initially had about 50% higher deflection than thicker pavements. Base type and PCC strength also had some influence on initial mid-slab deflection. In most cases, test sections with DGAB base

deflected more than sections with bound (i.e., PATB and LCB) base. Low-strength PCC sections had slightly more initial deflection than high-strength PCC sections. These trends indicated mid-slab deflection was proportional to the stiffness of the pavement structure.
Figure 29a shows that thinner pavements typically deteriorated faster than thicker pavements. Figure 29b shows that base type did not have a clear impact on the deflection deterioration rate. The other selected design features did not show a clear impact from on mid-slab deflection (Figure 29c to 29e). Because the deterioration rates were generally low, it could be that mid-slab deflections were influenced by variations in climate rather than design features.

The other value evaluated for this part of the study was AREA. The AREA value is a parameter that is used to describe the shape of the deflection basin:

$$AREA = \left[4 + 6\left(\frac{d_8}{d_0}\right) + 5\left(\frac{d_{12}}{d_0}\right) + 9\left(\frac{d_{24}}{d_0}\right) + 18\left(\frac{d_{36}}{d_0}\right) + 12\left(\frac{d_{60}}{d_0}\right)\right]$$

Where, d_x (e.g., d_0, d_8, d_{12}, etc.) is the deflection of the FWD sensor at a distance of x inches from the loading plate.

Initial AREA values (post-construction) showed no significant impacts from the design features. The AREA value grouped by the design feature usually amounted to the same average value within the same project. The minor changes in AREA value over time were mostly due to seasonal variation. As shown in Figure 30, the AREA value did not change significantly as the pavement aged, regardless of the design feature for most SPS-2 projects. The data indicate that the shape of the deflection basin stayed the same, except on the outlier projects of Nevada, Michigan, and Ohio.

9.0 TRANSVERSE JOINT SEAL FAILURE ANALYSIS

The LTPP distress identification manual defines joint seal damage as any type of condition that allows incompressible material and water to infiltrate the joint. This condition includes several types of joint seal damage, such as extrusion, hardening, adhesive failure, cohesive failure, complete loss of material, intrusion of foreign material, and vegetation growth. While these failure types are considered, the exact failure mode is not recorded. LTPP also uses different methods for evaluating transverse and longitudinal joints. Transverse joints are rated by severity levels of low, medium, and high. Low-, medium-, and high-severity ratings indicate that the joint seal damage exists in less than 10%, between 10 and 50%, and more than 50% of the joint, respectively. Longitudinal joints do not have severity level; instead the total length of joint seal damage is recorded.

This analysis looks at the age when transverse joints begin to fail, the failure rate, and the impact of the design features on this rate. It was assumed that the failure condition for a transverse joint seal was a rating of high severity (50% or more of the transverse joint seal was damaged).

Figure 31 shows the age at which transverse joints seals at core test sections began to fail (start to show high severity) versus the rate at which transverse joint seals with high severity accumulate. Twenty-eight SPS-2 test sections had sealed transverse joints that never reached high severity during the monitoring period. The figure shows that sometimes a larger portion of transverse joint seals failed simultaneously, resulting in a high rate; other times, the seals failed at different times, resulting in a more gradual rate. On average, transverse joint seals started failing in their seventh year at rate of 11% per year thereafter.

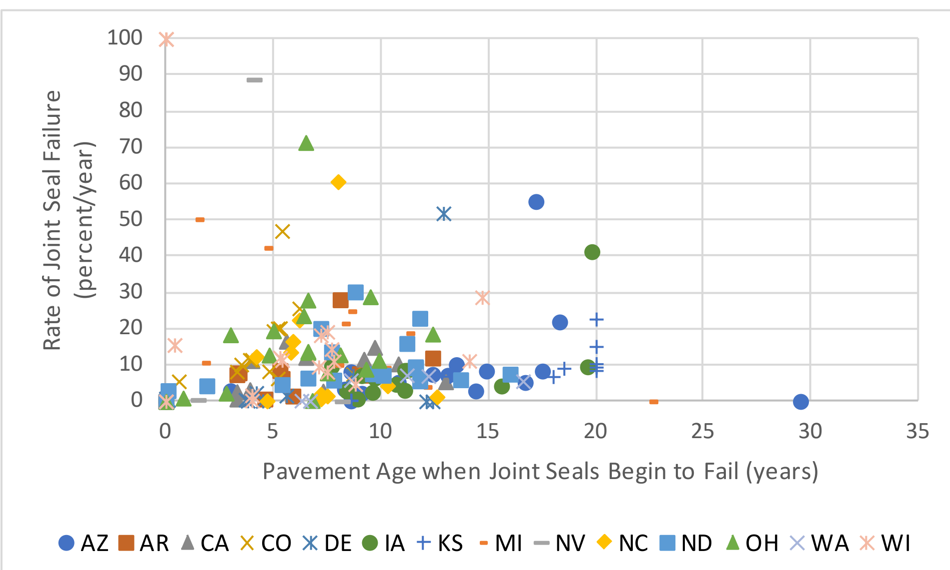


Figure 31. Start and Rate of Joint Seal Failure on SPS-2 Core Test Sections.

Figure 32 shows the average start of deterioration and the rate of deterioration of transverse joint seals by state. The intention in Figure 32 is not to show when the majority of transverse joint seals fail, but how soon after construction they start to fail.

Transverse joint seal deterioration started the soonest after construction in Nevada, Delaware, and Washington. However, the deterioration rates of transverse joint seals in Washington and Delaware were the most gradual. Arizona, North Dakota, California, Arkansas, and North Carolina had transverse joint seal performances that were more middle-of-the-pack. The best performance was seen in test sections in Kansas and Iowa, where transverse joint seals lasted 11 to 12 years on average before they began to fail. Michigan, Ohio, and Colorado test sections had transverse joint seals that deteriorated more suddenly after 4 to 8 years. A high rate of transverse joint seal failure was seen in test sections in Wisconsin. While Wisconsin test sections showed transverse joint seal failure after 5 years on average, some sections had high-severity transverse joint ratings immediately after construction.

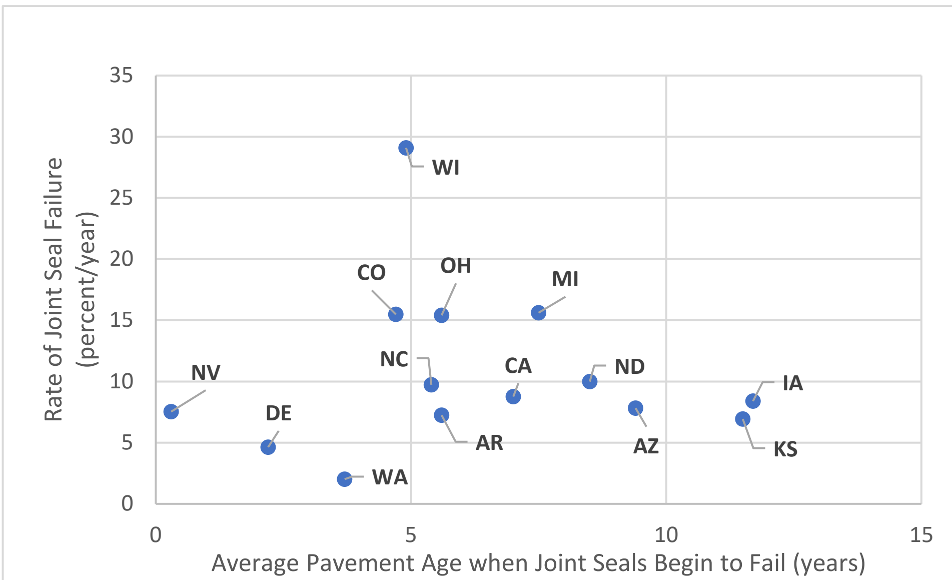
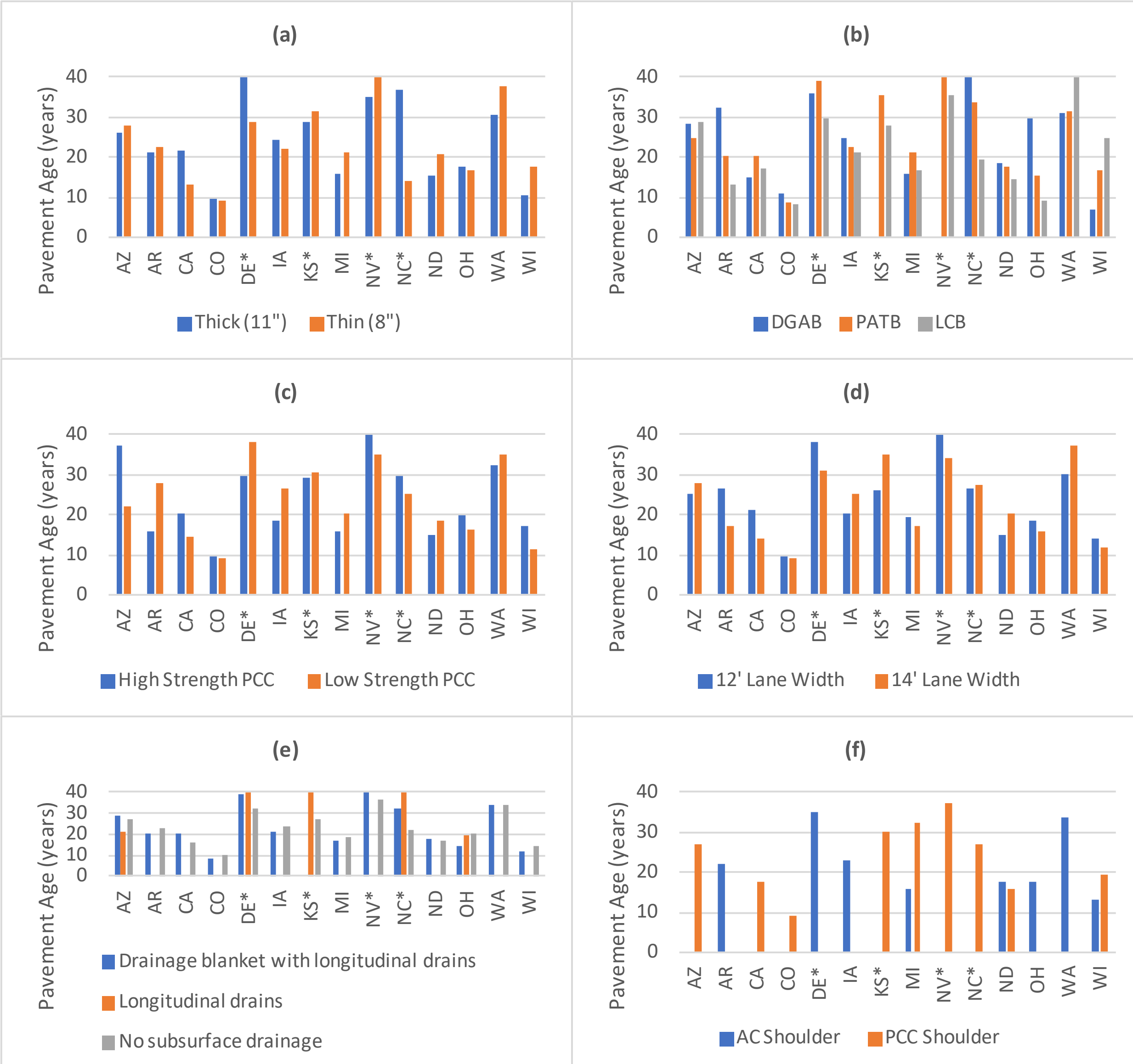


Figure 32. Average Start and Rate Of Transverse Joint Seal Failure on SPS-2 Test Sections by State.

Figure 33 shows the average age of test sections when approximately 50% of the transverse joint seals have failed (reached high severity). In contrast to Figure 32, Figure 33 shows when a section-wide failure criterion has been achieved; the majority of transverse joint seals have failed. Based on the monitoring data available, some test sections have transverse joints seals that maintain low severity and do not trend toward high severity during the monitoring period. For these sections, the age at which 50% of transverse joint seals fail was assumed not to exceed 40 years. For sections that have 100% high-severity transverse joint seals starting from the first survey, 50% transverse joint seals failure is assumed to have occurred at 6 months. These assumptions were made for the benefit of calculating averages that sufficiently weighed the performance of test sections with transverse joints that did not seem to fail, failed immediately, or began to fail during the monitoring period. The age was determined using trend lines; these are provided in Appendix A.



*Indicates that at these projects average pavement age was based mostly on data projected past the maximum percent of transverse joint seal failure evident at these test sections; 50% or more of test sections at these projects had a percent of transverse joint seal failure of less than 50%.

Figure 33. Average Pavement Age at 50% Transverse Joint Seal Failure by SPS-2 Project and Design Feature: (a) PCC Thickness, (b) Base Type, (c) PCC Strength, (d) Lane Width, (e) Drainage Feature, and (f) Shoulder Type.

Figure 33 shows that there was no specific design feature that caused transverse joint seals to fail. The average transverse joint seal performance of test sections with different design features was similar on the same project. The minor differences typically present did not provide any consistent trends from project to project. About half of the projects had thick pavements with better transverse joint seal performance and the other half had thin pavements with better performance. The same could be said about base type, PCC strength, lane width, drainage feature, and shoulder type. However, the average pavement age in these figures was based on a linear regression model of the transverse joint seal failure data and, in some cases, this linear regression model was not the best representation of transverse joint seal failure trends. Several test sections did not achieve a condition where 50% or more of transverse joints seals had failed. However – for comparison purposes – joint seal failure at these test sections was projected to 50% in order to compute the average age when a 50% failure would occur. Actual data trends observed at some test sections showed that the transverse joint seal failure percentage may plateau at a given point. Delaware, Kansas, Nevada, and North Carolina projects never achieved 50% transverse joint seal failure.

10.0 TRANSVERSE JOINT CONDITION INDEX ANALYSIS

Joint condition index (JCI) was a tool developed exclusively for this study as possible measure of joint performance using LTPP's joint rating procedure. The intention in developing JCI was to provide a quantifiable index to assess and compare the condition of joint seals. Transverse joint seal performance is measured as in terms of the number of joints in low, medium, and high severity condition. Because severity and quantity were used in collecting field performance data, there was a need to combine the two metrics into one for comparison purposes. The JCI analysis is a supplement to the preceding joint seal failure analysis that specifically focused on the high severity condition. However, it was unclear whether JCI would relate to transverse joint seal performance in a meaningful way.

JCI ranges from 0 to 100 for transversely sealed joints. A JCI of 0 indicates that all joints are at high severity and a JCI of 100 indicates that all joints are at low severity. In other words, a decreasing JCI indicates worsening joint condition. A JCI of 50 could indicate a combination of conditions, such as all joints are at medium severity, or only half the joints are high severity and the other half are at low severity.

JCI is calculated as follows:

$$JCI = 100 \times \frac{2(count\ of\ low\ severity\ joints) + (count\ of\ medium\ severity\ joints)}{2(total\ number\ of\ joints)}$$

Figure 34. Equation for JCI.

JCI was calculated for all SPS-2 sections in each state and compared against average IRI, average wheel-path faulting, and percent of slabs cracked transversely. Appendix A provides plots of the results. The confidence level of the results was calculated, where appropriate, using a T-test.

The following analysis compares the calculated JCI values with SPS-2 factors and performance measures, followed by a discussion of the confidence level for the JCI.

Figure 35 shows a histogram of test sections by the change in JCI per year. This figure shows that for most test sections, JCI changed from 0 to -7 per year. A positive change in JCI indicates in an improvement in overall joint condition. The change of more than -8 JCI per year indicates more rapid joint seal deterioration.

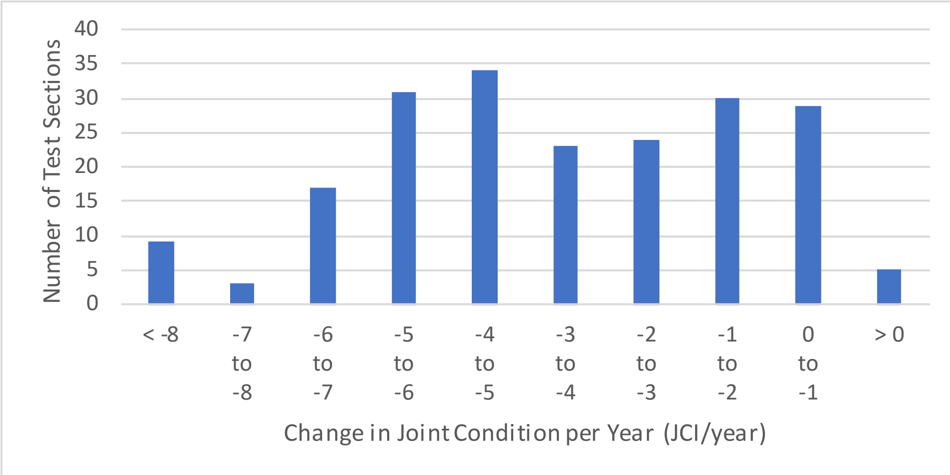


Figure 35. Histogram of Transverse JCI Deterioration Rates

10.1 Impact of Design Factor on JCI

Table 5 shows the average change in JCI per year by SPS-2 experimental factor.

Table 5. Average Transverse JCI Deterioration Rate by Experimental Factor

SPS-2 Factor	Factor Type	Average JCI/year
PCC Thickness	Thick (11”)	-3.2
	Thin (8”)	-4.5
Base Type	DGAB	-3.3
	PATB	-3.5
	LCB	-4.5
PCC Strength	High	-3.9
	Low	-3.7
Lane Width	12’	-3.6
	14’	-4.1
Drainage	Drainage blanket with longitudinal drains	-3.7
	Longitudinal drains	-2.2
	No subsurface drainage	-4.0

The table indicates the following:

- Thin (nominally 8”) pavements had higher joint seal deterioration rates than thick”(nominally 11”) pavements.
- Test sections with an LCB base type had joint seals that deteriorated faster than sections with other base types.
- High-strength PCC had slightly higher joint seal deterioration than test sections with low-strength PCC.
- Joint seal deterioration was higher for widened (14-foot) lanes than 12-foot lanes.

- Test sections with no drainage had joints seals that deteriorated faster than sections with drainage. The highest joint seal deterioration rates were found among thin pavement test sections with LCB base.

10.2 Comparing JCI to IRI, Faulting, and Cracked Slab

Next, the age at which each test section reached a JCI of 99, 75, 50, 25, and 0 was compared with and the average IRI, faulting, and transversely cracked slab percent for each test section at this age. The results are presented in Appendix B and summarized in Table 6. In some cases, the JCI improved on a test section and thus certain JCI values could appear more than once throughout the life the pavement. In most cases, this slight improvement was due to the variability in the distress rater’s judgement regarding the percent of the joint that was damaged.

Table 6. JCI vs. Average Age, IRI, Faulting, and Transversely Cracked Slabs

Target JCI	Average Age (years)	Average IRI (inch/mile)	Average Faulting (inch)	Average Transversely Cracked Slabs (%)
99	6.8	88.8	0.008	4.3
75	10.0	93.5	0.009	4.4
50	11.5	97.9	0.011	5.6
25	12.9	101.1	0.011	7.7
0	13.1	99.7	0.004	9.1

As shown in Table 6, the average age, IRI, and percent of transversely cracked slabs generally increased as JCI decreased. There was no significant difference in age and IRI values between the JCIs of 25 and 0. Faulting increased from JCI 99 to 50, but then decreased. The percent of transversely cracked slabs steadily increased after a JCI of 75.

Table 7 excludes test sections that did not show any transverse cracking throughout the course of the monitoring period. Ergo, the average percent of transversely cracked slabs is much higher than in Table 6, despite average age, IRI and faulting showing similar values. Average age and IRI decreased from JCI 25 to 0, because the 45 test sections that reached a JCI of 0 typically had joint seals that deteriorated faster than others.

Table 7. JCI vs. Average Age, IRI, Faulting, and Transversely Cracked Slabs (excluding test section with no cracked slabs)

Target JCI	Average Age (years)	Average IRI (inch/mile)	Average Faulting (inch)	Average Transversely Cracked Slabs (%)
99	6.3	88.6	0.008	10.9
75	9.3	95	0.009	11.3
50	10.7	101.6	0.011	14.1
25	12.7	108.7	0.012	19.2
0	11.4	96	0.005	24

Table 8 shows that the rate of IRI deterioration also increased as the JCI increased past 75. This relationship was not as evident in the deterioration rate of slabs cracked transversely. The deterioration rate of transverse cracking did not significantly increase until JCI reached a value of 0.

Table 8. JCI vs. Deterioration Rate in IRI and Transversely Cracked Slabs

Target JCI	Change in IRI (inch/mile/year)	Change in Transversely Cracked Slabs (%/year)
99	1.51	0.73
75	1.51	0.66
50	1.72	0.71
25	1.92	0.67
0	2.11	0.84

Figure 36 shows the average age of pavements at a given JCI to illustrate the deteriorate trends pavements age.

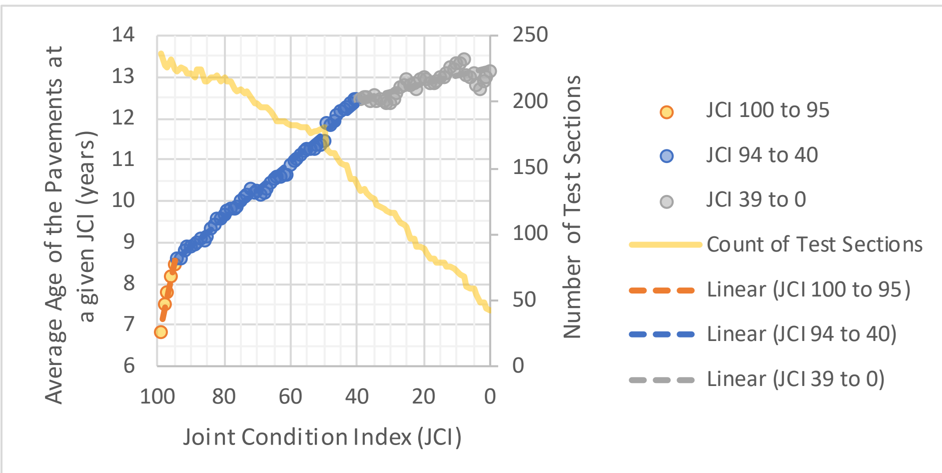


Figure 36. Average Age of SPS-2 Test Sections by JCI

JCI typically appeared to deteriorate in three stages. JCI deterioration typically started at age 6.5 and slightly dropped from a JCI of 100 to 95 by an age of 8.5 years (an average of 2.4 JCI per year). JCI then steadily decreased at a rate of 14.2 JCI per year until it reached a value of 40 JCI. In the third stage, JCI deteriorated at a higher rate of 31.5 JCI per year from 40 to 0 JCI. The number of test sections used in the average varied because some sections did not deteriorate past certain JCI values during the monitoring period. This resulted in a lot of fluctuation in the average age, especially in the third stage (JCI 39 to 0). Joint deterioration appeared to be in stages because joint severity was recorded by levels (i.e., low, medium, and high). Had joint severity been measured by a more quantifiable value (e.g., percent of joint damaged), the joint deterioration curve would likely look more parabolic.

10.3 JCI at Time of Maintenance

Table 9 shows the average JCI for test sections when maintenance treatments were performed.

Table 9. Average JCI at the Time of Maintenance Treatment

Maintenance Treatment	Average JCI
Crack Sealing	86.8
Hand Spread/Truck Compacted Flexible Patch	51.0
Transverse Joint Sealing	77.1
Lane-Shoulder Longitudinal Sealing	81.6
Partial-depth Patching of PCC Pavement other than at Joints	54.3
Partial-depth Patching of PCC Pavements at Joints	41.5
Full-depth Patching of PCC Pavement other than at Joints	61.9
Full-depth Transverse Joint Repair Patch	60.6
PCC Slab Replacement	59.6
Grinding Surface	61.9

Average JCI was lower at the time of patching (partial-depth, full-depth, or slab replacement) and grinding than at the time of crack sealing or joint sealing. However, this trend may be a consequence of the maintenance strategy rather than a correlation between maintenance treatments and joint condition. Transverse joint sealing typically occurred at JCI 77, which in Figure 36 correlated with an average pavement age of 9.8 years.

10.4 Inverse Correlation of JCI to Cracked Slabs

To understand the relationship between JCI and pavement performance—percent of slabs cracked transversely—the plots in Appendix A show the confidence level of each test section based on the T-test statistic between the correlation of JCI and the percent of slabs cracked transversely. To summarize, Figure 37 shows that, of the test sections with transverse cracking, there was typically a negative correlation between JCI and the percent of slabs cracked transversely.

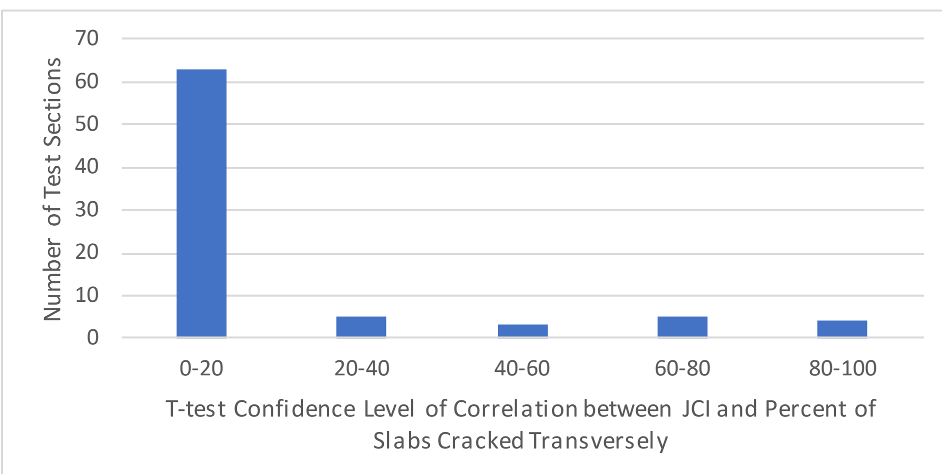


Figure 37.Histogram of Confidence Level from T-test Between Joint Severity and Transversely Cracked Slabs

Of the 80 test sections where confidence level could be calculated, Table 10 shows average confidence level by the SPS-2 experimental factor.

Table 10. Average T-test Confidence Level by Experimental Factor

SPS-2 Factor	Factor Type	Average T-test Confidence Level
PCC Thickness	Thick (11”)	19.2
	Thin (8”)	13.6
Base Type	DGAB	18.9
	PATB	12.0
	LCB	16.1
PCC Strength	High	10.8
	Low	20.0
Lane Width	12’	12.2
	14’	20.8
Drainage	Drainage blanket with longitudinal drains	9.1
	Longitudinal drains	3.2
	No subsurface drainage	18.3

Confidence levels closer to 0 indicate a stronger negative correlation between JCI and the percent of slab cracked transversely. The table shows that the negative correlation is strongest in thin, high-strength PCC pavements with treated bases, 12-foot-wide slabs, and some subsurface drainage.

10.5 Summary

As an invented metric, JCI provided a conceptual normalized measure of the overall condition of transverse joint seals during the performance period of a test section. The transverse joint seal analysis, which assumed the failure condition of a joint seal as high severity, had found that the following design factors had better joint seal performance: thick pavements, DGAB or PATB bases, standard lane width, and drained pavement. The JCI analysis was able to reinforce these findings.

Additionally, JCI indicated that joint condition typically was inversely correlated to the precent of slab cracked transversely. Several of the design factors impacted transverse cracking in the same way that joint condition was impacted. The only exception being widened lanes that provide better performance in transverse cracking, but not in joint seal condition.

Outside of showing the inverse relationship between joint seal condition and transverse cracking, JCI may not have practical value as a performance indicator.

11.0 CONCLUSIONS AND RECOMMENDATIONS

These analyses succeeded in providing new findings as well as supporting previous work. As in prior evaluations, most of the SPS-2 test sections performed well. Also as in previous studies, the analysis of SPS-2 data was limited by the length of the monitoring period – monitoring was not conducted long enough to measure when some distresses would appear or significantly deteriorate. For this reason, comparisons were only possible with test sections that did show substantial deterioration. This group of test sections also included several projects that were outliers (i.e., Nevada, Michigan, and Ohio), which had test sections that deteriorated rapidly and were out-of-study early for materials- and/or construction-related issues. Despite these limitations, the analyses found that all features of the SPS-2 experimental design had varying impact on some aspect of test section performance.

Table 1 summarizes the impact of design features on pavement performance measures. In some cases, the impact of a design feature was more significant than in other cases. However, the key conclusions are that pavement thickness, base type, and drainage had clear impacts, while PCC strength and lane width had mixed results, and shoulder type was inconclusive.

Table 11. Summary of Analyses on the Impact of SPS-2 Design Features

SPS-2 Design Feature	Design Feature Type	Pavement Performance Measure Deterioration Over Time								
		IRI	Faulting	Transverse Cracking	Longitudinal Cracking	Shoulder Dropoff	LTE	Mid-slab Deflection	AREA Value	Joint Condition
PCC Thickness	Thick (11″)	👍	👍	👍	👍	NA	👍	👍	×	👍
	Thin (8″)	👎	👎	👎	👎	NA	👎	👎	×	👎
Base Type	DGAB	×	×	×	👍	NA	×	×	×	👍
	PATB	👍	👍	👍	👍	NA	×	×	×	👍
	LCB	👎	👎	👎	👎	NA	×	×	×	👎
PCC Strength	High	×	👍	👎	👍	NA	👍	×	×	×
	Low	×	👎	👍	👎	NA	👎	×	×	×
Lane Width	12′	×	👎	👎	👍	NA	👎	×	×	👍
	14′	×	👍	👍	👎	NA	👍	×	×	👎
Drainage	Drainage blanket / longitudinal drains	👍	×	👍	👍	NA	×	×	×	👍
	No subsurface drainage	👎	×	👎	👎	NA	×	×	×	👎
Shoulder Type	AC	👎	NA	NA	×	👎	×	NA	NA	NA
	PCC	👍	NA	NA	×	👍	×	NA	NA	NA

👍 – relatively positive impact on deterioration rate or performance measure
👎 – relatively negative impact on deterioration rate or performance measure
× – no clearly observable impact or impact varies significantly from project to project
NA – impact on performance measure was not applicable to design feature

While the analyses conducted so far have shed light on the impact of SPS-2 design features on actual pavement performance, the SPS-2 experiment can offer answers to further questions about jointed concrete pavement performance. Now that a baseline has been set, the following research is recommended using SPS-2 data.

- Determine the impact on pavement performance (deterioration rate) from changes over time in climate (annual precipitation/temperature), traffic, and distresses. Seasonal monitoring program (SMP) sites could be used to determine seasonal variations. As pavement thickness, base type, and drainage have been identified as influential factors, there is a need to determine how these factors responded to various structural and environmental conditions at each SPS-2 project.

- Determine the impact of construction issues (as identified by the SPS-2 construction and deviation reports) on pavement performance and material testing results. Material- or construction-related issues were likely the cause of poor performance in projects such as Nevada, Michigan, and Ohio. However, even outside these projects, deviations in test sections may have biased the influence that their design features had on pavement performance.
- Determine the impact of grinding on IRI and faulting, and changes in their rate of deterioration. For the small set of sections that received grinding, this can be achieved by comparing both the changes in IRI and faulting pre- and post-treatment, as well as the trends in changes over time pre- and post-treatment.
- Estimate the age of pavement at time of failure, and the impact of design features on service life. Service life would represent the time at which the section was placed out-of-study rather than by projecting (or interpolating) performance to a failure criterion. The deterioration rate of individual performance measures does not equate to the expected service life of the test section. Using failure criteria, the expected service life of test sections might be estimated and the effect of design features on service life could be compared.
- Summarize agency-specific lessons learned from each SPS-2 project. While analyses so far have been made to generalize the trends in the SPS-2 experiment, the outliers and exceptions have shown that individual SPS-2 projects may have experienced trends outside the norm. There may be insights to be gained in investigating the cause of unique trends at these projects.
- Conduct a forensic investigation analyze agency-specific data. There would be synergy in working with the Forensic Pooled Fund study to identify priority projects for additional investigation or areas to investigate. Coring also could be considered on as many projects as practical to measure changes in material properties over time and to determine whether the LCB/PCC layer is bonded.
- Check if MEPDG predictions improve by assuming unbonded jointed plain concrete pavement (JPCP) instead of the default value of full friction loss at 240 months. The reason why the performance of test sections with LCB bases were overpredicted may rest in the assumption that the pavement layer bonded well to the base layer. Also, updates to the MEPGD software since the initial run of SPS-2 performance predictions may contribute to more accurate predictions.

APPENDIX A

PLOTS – HIGH SEVERITY JOINT SEALS AND JCI

APPENDIX B

TABLE – AGE AND PERCENT FAILED AT TARGET JCI

State Code	SHRP ID	Age (years)	Target JCI	Failed Joint Seals (%)	Average IRI (inch/mile)	Average Faulting (inch)	Average Transversely Cracked Slabs (%)
4	0213	6.57	99	0	115	0.0085	0
4	0213	9.42	75	0	113.3	-0.0032	0
4	0213	10.05	50	0	106.5	0.0039	0
4	0213	16.14	50	0	143.7	0	0
4	0214	3.01	99	0	66.7	0.0081	0
4	0214	8.05	99	0	76.6	-0.0006	0
4	0214	9.22	75	0	85.5	-0.0077	0
4	0214	17.51	99	0	96.7	0.0432	1.9
4	0215	6.48	99	0.3	112.2	0.014	0
4	0215	10.86	99	0	126.4	0.0351	0
4	0215	10.97	75	0	116.6	0.0275	0
4	0215	13.61	50	4.9	123.8	0.0457	0
4	0215	20.75	25	50	128	0.0236	0
4	0216	3.01	99	0	83.2	0.0002	0
4	0216	7.42	99	0	83.2	0.0027	0
4	0217	1.6	99	0	66.9	0.0205	2
4	0217	9.3	75	11.2	76.4	-0.0028	44.5
4	0217	9.72	50	27	75.4	-0.0012	49.2
4	0217	17.85	25	50	82.7	0.0109	66.6
4	0218	8.05	99	0	64.7	-0.0006	41.4
4	0218	8.98	75	0	69.9	-0.0153	46.9
4	0218	15.49	99	0	72.9	-0.0002	45
4	0219	2.13	99	1	78.5	0.0184	0
4	0219	6.51	99	0.4	89.7	0.0064	0.4
4	0219	8.28	75	14.4	95	-0.0092	3.7
4	0219	8.66	50	30.7	95.5	-0.0168	4.9
4	0219	9.4	25	50.1	95.7	-0.0162	9.2
4	0219	15.46	25	51.2	111.4	-0.0072	43.1
4	0220	9.02	99	0.3	73.8	-0.0077	2.9
4	0220	9.46	75	6.6	75.8	-0.0044	2.9
4	0220	9.91	50	13.2	77.8	-0.001	2.9
4	0220	16.67	75	0	83.4	-0.0059	0
4	0221	1.61	99	0	60.8	0.0227	0
4	0221	8.36	75	9.1	81.9	-0.0028	0
4	0221	8.82	50	17.3	81.9	-0.0064	0
4	0221	10.05	25	50	74.2	0	0
4	0221	15.39	50	12.3	86.4	0.0149	0
4	0222	9.02	99	0.8	68	-0.0078	0

NA – Data not available

State Code	SHRP ID	Age (years)	Target JCI	Failed Joint Seals (%)	Average IRI (inch/mile)	Average Faulting (inch)	Average Transversely Cracked Slabs (%)
4	0222	9.33	75	19	67.9	-0.0054	0
4	0222	9.65	50	37.8	67.9	-0.003	0
4	0222	9.97	25	56.7	67.8	-0.0005	0
4	0223	6.86	99	0	84.8	0.0013	0
4	0223	8.48	75	0	90.8	-0.0113	0
4	0223	9.01	50	0	91.2	-0.0197	0
4	0223	16.14	50	9.1	98	0	0
4	0223	19.42	50	24.5	103.7	-0.0086	0
4	0223	20.81	25	53.3	107.9	0.0091	0
4	0224	2.13	99	0	66.2	0.0105	0
4	0224	17	75	0	89.7	-0.0051	0
4	0262	1.74	99	0	77.6	0.0506	0
4	0262	5.98	99	0	143	0.0993	0
4	0262	8.1	99	0	160.5	0.1159	0
4	0262	10.09	75	0	159.2	0.1574	0
4	0262	16.31	50	11.5	206	0.1969	0
4	0262	16.95	25	53.4	212.5	0.1828	0
4	0263	8.14	99	0	82.5	0.001	0
4	0263	12.65	75	0	97.6	0.0098	1.4
4	0263	17.26	50	2.7	88.3	-0.0075	2.8
4	0263	18.13	25	50.5	93.1	-0.0009	5.1
4	0264	8.21	99	0	123.5	0.0052	0
4	0264	14.8	75	0	144.2	0.0495	0
4	0264	17.21	50	2.7	135.5	0.0039	0
4	0264	22	25	52.8	128.8	0.0087	0
4	0265	1.74	99	0	88.5	0.0558	0
4	0265	6.72	99	0	115.6	0.0885	0
4	0265	10.62	75	0	126.8	0.1351	0
4	0265	15.81	50	10.3	152.6	0.1403	0
4	0265	18.03	25	50.1	156	0.1032	0
4	0266	4.33	99	0	91	0.0065	0
4	0266	9.46	75	5.7	104.3	0.0174	0
4	0266	13.8	50	8.8	110.1	0.0304	0
4	0266	17.73	25	50	115.6	-0.0098	0
4	0267	8.17	99	0	98.9	0.0122	0
4	0267	14.49	75	5.9	87.8	0.0033	0
4	0267	16.02	50	24.6	82.7	-0.0007	0
4	0267	17.82	25	50	83.6	-0.0016	0

NA – Data not available

State Code	SHRP ID	Age (years)	Target JCI	Failed Joint Seals (%)	Average IRI (inch/mile)	Average Faulting (inch)	Average Transversely Cracked Slabs (%)
4	0268	7.43	99	0	93	0.0197	0
4	0268	9.83	75	0	93.7	0.0267	0
4	0268	16.73	50	3	94.1	0.0072	0
5	0213	3.43	99	0	96	0.0268	0
5	0214	6.89	99	0	140.8	0.0349	0
5	0214	13.28	75	3	176.8	0.0427	0
5	0214	16.38	50	21.2	180.1	0.0945	2.9
5	0215	10.55	99	0	116.1	0.0711	0
5	0216	1.45	99	0	82	0.0021	0
5	0216	5.62	75	5.9	121.2	0.0082	0
5	0216	8.34	75	4.8	114.8	0.0236	0
5	0216	9.16	50	21	126.9	0.0226	0
5	0216	10.35	25	60.2	140.3	0.019	0
5	0216	15.04	0	100	148.1	0.0157	0
5	0217	1.75	99	0.7	78.1	0.0009	0
5	0217	6.01	99	0	101	0.0092	3
5	0217	9.71	75	9.3	117.3	-0.0117	6.1
5	0217	11.47	50	27.3	158.1	-0.0039	6.1
5	0217	16.09	25	56.6	236.9	NA	23.6
5	0218	2.83	75	14.2	82.6	0.012	22
5	0218	5.22	50	29.1	87.8	0.0063	64.3
5	0218	8.79	50	18.2	85.7	0.0039	90.9
5	0218	11.01	25	53.2	95.2	-0.0156	98.4
5	0218	15.03	0	100	101.9	-0.0197	100
5	0219	6.01	99	0	94.2	0.0091	0
5	0219	10.75	75	2.2	91.3	0.0061	0
5	0219	13.71	50	21.8	101.2	-0.0014	0
5	0219	15	25	50.6	95.2	-0.0039	0
5	0220	2.77	75	10.6	112.5	0.0039	0
5	0220	5.89	50	29.6	121.9	-0.0022	0
5	0220	9.19	50	23.8	128.3	0.0173	0
5	0220	10.83	25	58.9	139.5	0.0077	0
5	0220	15.04	0	100	145.5	0.0079	0
5	0221	6.21	75	22.7	87.4	0.0257	0
5	0221	9.95	75	5.4	74.3	0.0309	2.5
5	0221	13.43	50	22.2	100.1	0.0174	5.9
5	0221	17.37	25	50.7	87.7	0.0463	5.9
5	0222	1.54	99	0	69.3	-0.0007	0

NA – Data not available

State Code	SHRP ID	Age (years)	Target JCI	Failed Joint Seals (%)	Average IRI (inch/mile)	Average Faulting (inch)	Average Transversely Cracked Slabs (%)
5	0222	7.16	75	9.9	70.3	0.0389	0
5	0222	8.79	50	27.3	75.1	0.0472	0
5	0222	14.46	25	55.6	105.2	0.0501	0
5	0223	8.49	99	0	84.1	0.0159	0
5	0224	5.43	75	7	105.6	0.0174	0
5	0224	9.94	50	29.4	102.3	0.0354	0
5	0224	12.24	25	55.8	113.2	0.0315	0
6	0201	3.12	99	0	95.4	0.0039	55.5
6	0201	6.45	75	0	105.3	0.0076	72.4
6	0201	9.29	50	17.1	128.5	0.0093	75.8
6	0201	11.51	25	56.1	143.4	-0.0043	75.8
6	0202	3.68	99	0	94.2	-0.0052	49.6
6	0202	5.92	75	0	93.3	-0.0021	65.6
6	0202	10.04	50	9.1	102.8	0.0039	78.8
6	0202	11.71	25	52	110.6	0.0066	81.8
6	0203	9.16	99	0	76.9	0.0307	0
6	0203	10.54	75	0	77.2	0.0039	0
6	0203	13.6	50	31.6	83.5	-0.0072	0
6	0204	3.26	99	0	109.7	-0.0017	0
6	0204	6.08	75	7.2	106.7	-0.0016	0
6	0204	9.72	50	24.9	115.2	0.0079	0
6	0205	3.14	99	0.3	71.9	-0.0011	46.3
6	0205	9.63	75	13.8	85.2	0.0079	72.7
6	0205	11.75	50	25.9	94	-0.001	72.7
6	0206	4.86	99	0	92.5	0.0145	42.4
6	0206	9.16	75	0.1	89.1	0.0043	51.5
6	0206	11.16	50	15.9	91.4	-0.0034	63.6
6	0206	11.89	25	52.9	95.6	-0.0006	63.6
6	0207	3.21	99	0	88	0.0034	3.5
6	0207	6.96	75	16.3	91.4	0.0042	9.1
6	0207	7.49	50	35.2	91.7	0.0102	9.1
6	0207	8.27	25	55.1	91	0.0148	9.1
6	0207	12.03	0	100	97.2	0.0276	9.1
6	0208	3.21	99	1	106	0.0026	6.1
6	0208	9.95	75	6.1	106.5	0.0166	12.1
6	0208	12.91	50	18.2	123.4	0.0104	13.5
6	0209	3.09	99	0.2	86	0.0001	0
6	0209	3.84	75	5	86	0.0033	0

NA – Data not available

State Code	SHRP ID	Age (years)	Target JCI	Failed Joint Seals (%)	Average IRI (inch/mile)	Average Faulting (inch)	Average Transversely Cracked Slabs (%)
6	0209	7.22	50	19.9	82.9	0.0035	3
6	0209	8.81	25	53.1	84.1	0.005	3
6	0210	3.12	99	0	74.6	-0.0006	0
6	0210	5.77	75	0	71.5	-0.0025	0
6	0210	8.7	50	26.9	73.5	0.0015	0
6	0210	10.34	25	50	80.7	0.0067	0
6	0211	3.7	99	0	113.8	0.0081	0
6	0211	10.61	75	0	122.3	0.0124	0
6	0211	14.43	50	7.8	119.6	0.0214	0
6	0212	0.48	99	0	78	0.004	0
6	0212	12.61	75	6.1	104.8	0.0083	0
8	0213	2.47	99	0.3	74.6	0.0041	0
8	0213	4.34	75	7.5	73.5	0.0073	0
8	0213	6.56	50	37.1	72.8	0.0074	0
8	0213	8.13	25	67.4	73.5	-0.0007	0
8	0213	10.54	0	100	79.3	0	0
8	0214	3.95	99	0	59.9	0.0023	0
8	0214	5.84	99	0	62.5	0	0
8	0214	7.84	75	11.9	60.5	0.0018	0
8	0214	9.62	50	28.1	72.2	0.0036	0
8	0214	13.42	25	59.9	78.3	NA	2.5
8	0215	2.46	99	0.2	68.6	0.0076	0
8	0215	4.04	75	4.4	68.3	0.0022	0
8	0215	6.2	50	27.6	71.9	0.0065	0
8	0215	7.67	25	62.8	76.3	0.0048	0
8	0215	10.55	0	100	85.8	0	0
8	0216	3.17	99	0	63.9	0.0104	0
8	0216	5.84	99	0.5	64.7	0.0007	0
8	0216	7.64	75	13.1	65.5	0.0009	4.6
8	0216	9.16	50	26.3	70.7	-0.003	10.7
8	0216	10.08	25	58.2	78	0.0003	12.1
8	0216	14.7	0	100	89.7	0	15.2
8	0216	17.8	0	100	112.8	0.0118	18.2
8	0217	2.48	99	0.4	104.6	-0.0073	0
8	0217	4.5	75	11.1	108.5	0.0066	0
8	0217	5.88	75	7.4	109.3	0.0102	0
8	0217	8.08	50	27.6	111.1	0.0063	0
8	0217	8.53	25	54.8	111.3	0.0044	0

NA – Data not available

State Code	SHRP ID	Age (years)	Target JCI	Failed Joint Seals (%)	Average IRI (inch/mile)	Average Faulting (inch)	Average Transversely Cracked Slabs (%)
8	0217	11.72	0	100	122.5	-0.0039	0
8	0218	2.46	99	0.2	87	-0.0153	3
8	0218	4.09	75	4.4	85.8	-0.0041	3
8	0218	6.04	50	30.2	87.8	0.0056	3
8	0218	6.43	25	66.5	85.8	0.0076	3
8	0218	7.73	0	100	88.9	0.0197	3
8	0219	2.47	99	0.7	97.1	-0.0074	0
8	0219	4.2	75	16.7	99.2	0.0045	0
8	0219	5.97	75	11.9	100.3	0.0092	0
8	0219	7	50	37.7	99.5	0.0056	0
8	0219	8.2	25	58.6	101.1	0.0037	0
8	0219	10.56	0	100	108.4	0.0039	0
8	0220	2.48	99	0.6	106.1	0	0
8	0220	4.5	75	13.9	109.3	0	0
8	0220	5.91	75	7.6	107.4	0.001	0
8	0220	7.84	50	43.4	111.3	-0.0035	0
8	0220	9.65	25	58	112.9	0.0034	0
8	0220	20.78	0	100	130.1	NA	0
8	0221	2.45	99	0.4	94.1	0.0079	0
8	0221	3.55	75	10.6	92.5	0.0079	0
8	0221	4.69	50	21.2	92.6	0.0079	0
8	0221	5.92	75	7.7	93.3	0.0079	0
8	0221	6.48	50	30.3	93.1	0.0079	0
8	0221	7.89	50	22.3	92.5	0.0098	0
8	0221	8.79	25	59.9	92.6	0.0007	0
8	0221	16.85	0	100	101.1	-0.0079	0
8	0222	2.49	99	0.4	84.8	0.0039	0
8	0222	4.5	75	11.1	86.2	0.0039	0
8	0222	6.13	75	11.1	82.9	0.0021	0
8	0222	7.87	50	29	82.2	-0.0022	0
8	0222	8.39	25	61.2	83.8	0.0047	0
8	0222	13.79	0	100	88.4	-0.0157	0
8	0223	2.46	99	0.4	108.7	0.012	0
8	0223	3.86	75	9.7	103.6	0.0168	0
8	0223	6.38	50	28.9	106.3	0.027	0
8	0223	7.78	50	11.9	104.5	0.0192	0
8	0223	8.34	25	56.1	108	0.0117	0
8	0223	13.79	0	100	103.8	0.0079	0

NA – Data not available

State Code	SHRP ID	Age (years)	Target JCI	Failed Joint Seals (%)	Average IRI (inch/mile)	Average Faulting (inch)	Average Transversely Cracked Slabs (%)
8	0224	2.47	99	0.5	99.6	0.0155	0
8	0224	4.12	75	11.4	98	0.0098	0
8	0224	5.87	75	8.7	96.9	0.0086	0
8	0224	6.29	50	34.6	98.9	0.0109	0
8	0224	7.93	25	53.2	100.1	0.0048	0
8	0224	14.7	0	100	105	0.0197	0
8	0259	3.97	99	0	71.3	0.009	0
8	0259	5.99	99	1	72.8	0.0039	0
8	0259	9.89	75	10	71.1	0.0065	0
8	0259	10.96	50	19.6	72.5	0.0039	0
8	0259	16.24	25	51.7	71	-0.0037	0
8	0259	21.87	0	100	73	-0.0118	0
10	0201	1.09	99	1	65.7	-0.0043	0
10	0201	4.04	99	0.8	86.5	-0.0108	0
10	0201	17.54	75	15.4	100.4	0.0035	0
10	0202	4.03	99	0	59.8	0.0107	0
10	0202	5.6	75	0	53	-0.0039	0
10	0202	8.68	50	2.1	58.5	-0.0039	0
10	0202	14.08	50	34.3	66.7	-0.0079	0
10	0203	13.27	99	0	74.8	0.0188	0
10	0204	13.1	99	0.4	107.5	0.0318	0
10	0205	4.01	99	0.9	80	0.012	15
10	0205	5.56	75	22.7	75.9	0.0115	17
10	0205	13.02	75	17.9	79.8	0.0288	16.8
10	0206	4	99	0.1	59.6	-0.0117	0
10	0206	5.11	75	2.5	45.9	-0.0086	0
10	0206	6.31	50	0	50.7	0.0039	0
10	0206	8.36	50	0	56	0	0
10	0206	12.93	50	3.3	50.2	0.0115	0
10	0206	13.93	25	54.9	54.4	0.0072	0
10	0207	4.26	99	0	69.5	-0.0013	0
10	0207	8.01	99	0	80.2	0.0079	2
10	0207	13.6	75	4.3	103.7	0.0188	1.2
10	0207	14.57	50	5.9	100.6	0.002	2.8
10	0208	13.07	99	0.3	128.2	0.0293	0
10	0209	4.2	99	0.5	52.3	0.0047	0
10	0210	0.64	99	0	59.3	0	0
10	0210	4.06	99	0.4	64.8	0.0003	0

NA – Data not available

State Code	SHRP ID	Age (years)	Target JCI	Failed Joint Seals (%)	Average IRI (inch/mile)	Average Faulting (inch)	Average Transversely Cracked Slabs (%)
10	0210	5.78	75	7	63.9	0.0075	0
10	0210	12.45	75	1	69.6	0.0092	0
10	0210	16.34	50	7.3	73.4	0.0139	0
10	0212	4.86	99	0	97	0.0065	0
10	0260	4.42	99	0	79.7	0.0117	0
10	0260	17.88	99	0	116	NA	0
19	0213	6.47	99	0	69.1	0.0052	0
19	0213	9.6	75	20.4	70.6	0.0026	0
19	0214	5.64	99	0	82.9	-0.0027	0
19	0214	11.06	75	16.8	117.3	0.0048	0
19	0214	11.8	50	45.9	121.7	0.0063	0
19	0214	12.55	25	74.9	126	0.0078	0
19	0214	21.24	25	50	150.3	0.001	5.9
19	0215	1.38	75	0	111.8	0	0
19	0215	2.71	50	0	113.2	0	0
19	0215	7.69	99	0	114	0.0234	0
19	0215	11	75	12.8	119.4	0.0204	0
19	0215	11.94	50	45.2	119.1	0.0224	0
19	0215	15.67	50	24.2	123.1	0.0217	0
19	0216	1.38	75	0	79.5	0	0
19	0216	2.71	50	0	77.9	0	0
19	0216	5.91	99	0	82.2	0.0052	0
19	0216	11.26	75	20.9	114.6	0.0197	0
19	0216	12.27	50	49.1	120.2	0.0197	0
19	0216	17.67	25	54.1	113.8	0.0133	1
19	0217	5.07	99	0	102.9	0.0001	5.9
19	0217	11.49	75	20.8	123.7	0.0092	3.2
19	0217	15.71	75	11.9	149.6	0.0141	0
19	0217	21.31	50	17.2	98.3	0.0328	0
19	0218	1.38	75	0	83.1	0	0
19	0218	2.71	50	0	80.9	0	0
19	0218	10.74	75	10.8	120.4	-0.0109	0.2
19	0218	11.46	50	41.5	128.1	-0.005	1.3
19	0218	12.19	25	72.1	135.8	0.0009	2.4
19	0219	1.38	75	0	98.4	0	0
19	0219	2.71	50	0	89.4	0	0
19	0219	11.3	75	23	92.5	0.0146	0
19	0219	12.19	50	49.4	91.6	0.0182	0

NA – Data not available

State Code	SHRP ID	Age (years)	Target JCI	Failed Joint Seals (%)	Average IRI (inch/mile)	Average Faulting (inch)	Average Transversely Cracked Slabs (%)
19	0220	1.38	75	0	71.9	0	0
19	0220	2.71	50	0	72	0	0
19	0220	8.41	75	9	81.5	0.0055	0
19	0220	10.68	50	32.4	82.1	0.0002	0
19	0220	11.62	25	66.2	89.2	0.0041	0
19	0220	12.57	0	100	96.3	0.0079	0
19	0220	15.23	50	18.8	88.3	0.0018	0
19	0220	16.27	25	53.3	92.7	0.0068	0
19	0221	7.12	99	0	87.5	0.0092	0
19	0221	13.75	75	6.2	97.3	0.0114	0
19	0221	18.92	50	11.1	94.3	0.0039	0
19	0221	21.15	25	53.9	98.8	0.0068	1.7
19	0222	5.1	99	0	118.1	0.0027	0
19	0222	10.73	75	10.7	126.8	0.0041	0
19	0222	11.34	50	40.4	126.8	0.0054	0
19	0222	11.96	25	70.3	126.7	0.0066	0
19	0222	12.58	0	100	126.7	0.0079	0
19	0222	14.93	25	50.1	120.9	0.0004	0
19	0223	6.47	99	0	126.3	0.0026	0
19	0223	13.81	75	11.9	127	0.0072	0
19	0223	20.38	50	18.3	128.5	-0.0034	0
19	0224	7.6	99	0.6	79	0.0079	0
19	0224	10.37	75	13.9	78.8	0.0079	0
19	0224	14.92	75	0.4	80.6	0.0003	0
19	0224	20.79	50	17.3	81.1	0.0015	0
19	0259	6.2	99	0	75.6	-0.002	0
19	0259	13.26	75	15.3	76.7	0.0098	0
19	0259	14.28	50	26	78.8	0.001	0
19	0259	15.75	25	51.8	84.8	0.0026	0
20	0201	4.93	99	0.9	91.9	NA	3.4
20	0201	12.39	99	1	117.1	-0.0053	4.9
20	0201	14.89	75	9.1	121.2	0.002	7.4
20	0201	20.16	50	38.2	134.9	0.0115	11.9
20	0201	21.98	25	67.5	139.1	0.0071	13.5
20	0202	12.94	99	0	61.9	0.0077	8.9
20	0202	14.95	75	0	66.3	0.0038	11.9
20	0202	20.11	99	0.2	81.7	0.0039	19.2
20	0202	21.52	75	4	88.4	0.0039	14.3

NA – Data not available

State Code	SHRP ID	Age (years)	Target JCI	Failed Joint Seals (%)	Average IRI (inch/mile)	Average Faulting (inch)	Average Transversely Cracked Slabs (%)
20	0202	23	50	7.9	93.5	0.0039	9.2
20	0203	10.55	99	0	96.2	0.0117	0
20	0203	13.55	99	0	97.3	-0.0033	0
20	0203	22.72	75	12.7	103.6	0	0
20	0204	9.87	99	0	102.8	0.007	0
20	0204	13.16	99	0	84.5	0.0003	0
20	0204	21.22	75	17.8	81.3	0.0108	1.9
20	0204	22.78	50	41.4	85	0.0146	0.4
20	0205	11.11	99	0	96.8	0.0079	0
20	0205	11.72	75	0	97.4	0.0079	0
20	0205	12.94	99	0.1	105.6	0.008	0
20	0205	14.83	75	1.5	112.8	0.0098	0
20	0205	16.81	50	2.9	119.5	0.0117	0
20	0205	20.52	75	17.7	126.2	0.0124	0
20	0205	22.12	50	28	149.4	0.0144	0
20	0206	10.55	99	0	101	0.0118	0
20	0206	13.04	99	0	109.7	0.0043	0
20	0206	20.79	75	17.5	138.2	0.0288	0
20	0206	22.21	50	33.7	151.3	0.0235	0
20	0207	12.94	99	0	114.9	-0.0038	0
20	0207	14.89	75	0	116.3	0	0
20	0207	16.93	50	0	128.9	0.0039	0
20	0207	21.23	75	11.2	125.6	0.0068	0
20	0207	22.49	50	23.1	132.1	0.0099	0
20	0208	14.2	99	0	121.7	-0.0105	3
20	0208	20.1	99	0.4	128.8	0.0078	0
20	0208	21.31	75	10.7	130.5	0.0063	0
20	0208	22.57	50	21.5	131.7	0.0048	0
20	0209	10.68	99	0	69	0	0
20	0209	13	99	0	65.8	0	0
20	0209	16.22	75	0	68.4	0	0
20	0209	20.11	99	0.3	67.7	0.004	0
20	0209	21.56	75	7.2	73.4	0.0058	0
20	0209	23.07	50	14.3	69.5	0.0077	0
20	0210	9.68	99	0.6	106.4	0.0015	0
20	0210	13.05	99	0	88.9	-0.0041	0
20	0210	20.23	99	0.2	86.4	-0.0002	0
20	0211	9.65	99	0	80.6	0.0042	0

NA – Data not available

State Code	SHRP ID	Age (years)	Target JCI	Failed Joint Seals (%)	Average IRI (inch/mile)	Average Faulting (inch)	Average Transversely Cracked Slabs (%)
20	0211	20.17	99	0	76.6	0.0038	0
20	0211	22.92	75	0	75.9	0.0004	0
20	0212	9.64	99	0.2	117.1	0.0082	0
20	0212	13.16	99	0	101.8	0	0
20	0212	19.39	99	0	104.5	0.0104	0
20	0212	20.94	75	20.1	105	0.0147	0
20	0212	21.88	50	41.6	108.6	0.0135	0
20	0212	22.82	25	63	108.1	0.0123	0
20	0259	9.73	99	0	87.6	0.0052	0
20	0259	13.07	99	0	87	0.0077	0
20	0259	21.21	75	12.1	90.5	0.0104	0
20	0259	22.53	50	25.8	95	0.0088	0
26	0213	2.23	75	6.4	85.9	0.0092	0
26	0213	3.12	50	13.2	74.4	0.0021	0
26	0214	3.36	75	15.4	101.7	0.0268	0
26	0214	5.33	50	38	134.7	0.0156	0
26	0214	7.5	25	53.6	189.1	0.0055	6.6
26	0215	1.5	99	0.2	54.2	0.0136	0
26	0215	3.31	75	5	64.7	0.0551	0
26	0215	5.02	50	16.1	101.2	0.0891	1
26	0216	1.02	99	0	80.1	0.0199	0
26	0216	4.87	99	0.7	119.9	0.027	0
26	0216	5.28	75	16.7	84.4	0.0149	0
26	0216	5.72	50	33.5	96	0.0022	0
26	0216	8.65	75	0.9	115.2	0	0
26	0216	9.16	50	28.6	141	0	0
26	0216	9.66	25	56.1	139.4	0	0
26	0216	12.81	0	100	130	0.0079	0
26	0217	1.41	99	1.1	57.3	0.0071	0
26	0217	1.89	75	25.1	57.5	0.0063	0
26	0217	2.38	50	50	61.7	0.0055	0
26	0217	2.89	25	75.1	55.9	0.0047	0
26	0217	3.38	0	100	57.8	0.0039	0
26	0219	4.92	99	0.2	78.9	0.0148	0
26	0219	8.68	75	2.8	86.8	0.0003	0
26	0219	9.11	50	32.3	87.1	0.0032	0
26	0219	9.55	25	61.8	87.4	0.0062	0
26	0219	11.79	50	11.6	101.6	NA	0

NA – Data not available

State Code	SHRP ID	Age (years)	Target JCI	Failed Joint Seals (%)	Average IRI (inch/mile)	Average Faulting (inch)	Average Transversely Cracked Slabs (%)
26	0219	12.32	25	55.8	100.4	NA	0
26	0219	16.05	25	50	106	NA	0
26	0220	4.87	99	0.8	124.2	0.0309	0
26	0220	5.19	75	19.2	94.3	0.0162	0
26	0220	5.51	50	38.3	91.8	0.0011	0
26	0220	8.94	75	13.1	132.2	0	0
26	0220	9.46	50	25.2	143.9	0	0
26	0220	11.08	25	50	109.7	0.0037	0
26	0220	12.81	0	100	142.8	-0.0079	0
26	0221	1.43	99	0	67.5	0.0031	0
26	0221	2.39	75	0	69.9	0.0016	0
26	0221	3.39	50	0	68.5	0	0
26	0221	7.08	99	0	69.2	0.0104	0
26	0221	9.76	75	11.8	69.5	0.0037	0
26	0221	11.91	75	2.7	76.5	0.0202	0
26	0221	12.6	50	12.3	73.7	0.0077	0
26	0221	17.95	50	23.5	81.2	0.0143	0
26	0222	1	99	1	73.5	0.0092	0
26	0222	5.23	75	13.8	75.1	0.0216	0
26	0222	5.8	50	21.2	81.1	0	0
26	0222	9.28	75	15.5	100.4	0.0087	0
26	0222	11.6	50	33.8	99.7	0.0174	7.6
26	0223	4.94	99	0	64.5	0.018	0
26	0223	8.34	99	0	61.9	0.0107	0
26	0223	12.03	75	6.5	78.2	0.0163	0
26	0223	12.63	50	13.2	78.7	0.0098	0
26	0223	16.14	25	55.1	87.3	0.0248	0
26	0224	1.07	99	1	64.5	0.0118	0
26	0224	5.98	99	0	72.4	0.003	0
26	0224	9.56	75	0	83.2	0	0
26	0224	12.03	50	13	76.1	0.0163	0
26	0224	14.17	25	50	84.9	0.0061	0
26	0259	1.46	99	1	69.1	0.0118	0
26	0259	2.29	75	25	69	0.0118	0
26	0259	3.15	50	50	73.3	0.0118	0
26	0259	4.01	25	75.1	70	0.0118	0
26	0259	4.86	0	100	67	0.0118	0
26	0259	11.17	99	0	76.8	0.0014	12.9

NA – Data not available

State Code	SHRP ID	Age (years)	Target JCI	Failed Joint Seals (%)	Average IRI (inch/mile)	Average Faulting (inch)	Average Transversely Cracked Slabs (%)
26	0259	18.36	75	12.5	74.4	0.0059	55.3
32	0201	3.25	99	0.5	100.4	-0.0077	90.5
32	0203	3.52	99	1	73	NA	89.9
32	0204	1.07	99	0	121.4	0.0447	27.3
32	0204	1.79	99	0.3	117.7	-0.0117	21
32	0204	1.86	75	4.3	120.5	-0.0099	26.6
32	0204	1.93	50	8.6	124.9	-0.0081	32.7
32	0205	1.38	99	1	60.1	0.0237	77.4
32	0205	6.33	99	0	85.2	0.0028	100
32	0207	3.31	99	0	94.1	-0.0175	4.1
32	0207	4.28	75	13	95.9	-0.0206	12
32	0207	4.5	50	33.1	86	-0.0037	11.9
32	0208	3.41	99	0.7	112.8	-0.0039	34.3
32	0208	4.41	75	1.5	110.6	0.0037	69.2
32	0208	5.57	50	0	101.4	0.0079	90.9
32	0209	3.26	99	0	77	-0.0083	0.2
32	0210	3.52	99	0	101.9	-0.0052	40.4
32	0211	3.81	99	0	87.5	-0.0119	7
32	0211	5.95	99	0	72.3	0.004	8.1
32	0259	3.36	99	0	97.1	-0.0046	0
37	0201	3.38	99	0	85.7	0.0079	0
37	0201	3.92	99	0	87.5	0.0057	0
37	0201	5.58	99	0	94.4	0.0199	0
37	0201	6.3	75	4.6	96.5	0.0207	0
37	0201	6.88	50	38	94.3	0.0264	0
37	0201	8.4	50	21	95.6	0.0184	4.5
37	0202	5.24	99	0	97.7	-0.0076	0
37	0202	6.06	75	0	98.3	-0.0002	0
37	0202	7.03	50	25.7	115.9	0.0186	0
37	0203	6.31	99	0	112.1	0.0123	0
37	0203	12.07	99	0.5	113.6	0.002	0
37	0203	18.72	75	0	121.5	0.0089	0
37	0204	6.75	99	0	83.9	0.0106	0
37	0204	10.6	99	0	96	0.0101	0
37	0204	18.46	75	6.9	115.3	0.0252	0
37	0205	5.2	99	0.7	118	-0.0036	0.1
37	0205	5.57	75	16.8	121.9	0.0028	2.6
37	0205	5.95	50	33.4	122.2	0.0094	5.1

NA – Data not available

State Code	SHRP ID	Age (years)	Target JCI	Failed Joint Seals (%)	Average IRI (inch/mile)	Average Faulting (inch)	Average Transversely Cracked Slabs (%)
37	0205	8.1	50	45.5	127.1	0.0039	30.3
37	0206	5.5	99	0	94	-0.0026	0
37	0206	6.72	75	15.3	100.4	0.0025	0
37	0206	7.67	50	26	94.8	-0.0028	0
37	0207	6.26	99	1	113.2	0.0046	0
37	0207	7.93	75	3.5	114.8	0.0013	0
37	0207	9.93	75	0	117.9	0.0032	0
37	0207	12.03	99	0.1	115.2	-0.0076	0
37	0207	13.66	75	2	114	-0.0001	0
37	0207	18.37	50	19.2	116.7	0.0035	0
37	0207	20.34	25	51.6	114.7	0.0003	0
37	0208	7.26	99	0	127.6	0.0065	0
37	0208	18.21	99	0	138.2	0.0038	0
37	0208	20.16	75	0	151.2	0.0006	0
37	0209	5.23	99	0	82	0.0005	0
37	0209	6.11	75	0.9	82	0.0117	0
37	0209	6.59	50	28.8	82.7	0.0098	0
37	0209	7.07	25	56.8	85.6	0.0079	0
37	0209	8.6	25	53.5	83.7	0.0073	0
37	0210	5.22	99	0.2	85	0.0003	0
37	0210	5.61	75	5.6	89.7	0.0072	0
37	0210	6.02	50	11.1	87.2	0.0145	0
37	0211	2.78	99	0	84.2	0.0071	0
37	0211	7.57	75	8.9	81.2	0.0063	0
37	0211	10.06	75	5.6	80.4	0.0006	0
37	0211	13.95	75	8.4	80.4	0.0052	0
37	0211	18.73	50	27.3	79	0.0069	0
37	0212	8.84	99	0	70.4	0.0013	0
37	0212	12.07	99	1	74.9	-0.0019	0
37	0212	19.59	75	1.8	82.5	0.0039	0
37	0259	5.69	99	0	86	0.0079	0
37	0259	7.19	99	0	89.9	0.0106	0
37	0259	14.06	75	8	85.9	0.0049	0
37	0259	18.8	75	6.3	83.8	0.0045	0
37	0260	5.31	99	0	95.6	0.0004	0
37	0260	14.11	75	2.5	95	0.0066	0
37	0260	19.39	50	17.4	96.5	0.0019	0
38	0213	7.68	99	0	71.2	0.0079	0

NA – Data not available

State Code	SHRP ID	Age (years)	Target JCI	Failed Joint Seals (%)	Average IRI (inch/mile)	Average Faulting (inch)	Average Transversely Cracked Slabs (%)
38	0213	14.46	99	0	73	0.0416	0
38	0213	19.32	75	0	85.3	0.0292	0
38	0214	2.95	99	0	79.3	0.0027	0
38	0214	6.68	99	0.2	73.2	0.0155	0
38	0214	7.38	75	5.6	78.6	0.0085	0
38	0214	9.19	75	4.6	76.9	0.0138	0
38	0214	11.67	50	34.6	88.2	0.0008	0
38	0214	18.72	25	57.8	97.2	0.0053	0
38	0215	2.96	99	0	112.6	0.0013	0
38	0215	5.71	99	0	120.5	0.0197	0
38	0215	7.33	75	0	109.9	0.0197	0
38	0215	9.89	50	26.4	121.7	0.0219	0
38	0215	11.66	25	55	135.8	0.0126	0
38	0216	3.19	75	14.6	111	0.0056	0
38	0216	6.09	75	8.3	112.4	0.0021	0
38	0216	6.91	50	22.5	106.2	0.0013	0
38	0217	7.75	99	0.7	92.6	0.0175	14.1
38	0217	16.72	75	18.7	104.6	0.0343	4.8
38	0217	19.51	50	35.6	120.1	NA	7.3
38	0218	7.02	75	1.4	92.7	0.0079	0
38	0218	7.96	50	7.6	101.8	0.0034	0
38	0218	10.05	25	50.1	95.2	-0.0039	0
38	0218	11.82	0	100	105.2	-0.0039	0
38	0219	10.86	99	0	102	0.0057	3
38	0219	13.11	75	16.9	110.4	0.0422	2.1
38	0219	14.47	50	34.9	114.4	0.0704	1
38	0219	15.83	25	52.9	118.4	0.0984	0
38	0220	6.3	99	0	100.3	0.0026	0
38	0220	7.38	75	2.7	89.2	0.0039	0
38	0220	8.91	75	3.1	92.5	-0.0114	5.8
38	0220	10.02	50	36.4	96.2	-0.0071	4.7
38	0220	11.12	25	69.7	95.1	-0.0028	3.6
38	0221	3.9	99	0	86.8	0.0013	0
38	0221	7.55	99	0.2	81.5	0.0042	0
38	0221	12.91	75	6.3	82.6	0.0092	0
38	0221	16.78	50	27.3	84.7	0.0079	0
38	0222	2.96	99	0	99.4	0.0013	0
38	0222	6.93	99	0	89.8	0.0105	0

NA – Data not available

State Code	SHRP ID	Age (years)	Target JCI	Failed Joint Seals (%)	Average IRI (inch/mile)	Average Faulting (inch)	Average Transversely Cracked Slabs (%)
38	0222	13.03	75	13	91.2	0.0055	0
38	0222	15.69	50	35.1	97.4	0.0263	0
38	0223	7.18	99	0	86.8	0.0105	0
38	0223	12.29	75	5.3	90.2	0.0081	0
38	0223	14.49	50	30.3	92.3	0.0276	0
38	0223	18.19	25	59	95.1	0.0079	0
38	0224	2.96	99	0	127.5	0.0053	0
38	0224	7.19	99	0	121.7	0.0013	0
38	0224	12.09	99	0.4	122.6	0.0045	0
38	0224	19.54	75	13.9	119.9	0.0023	0
38	0259	11.87	99	0.9	102.3	-0.0074	0
38	0259	13.01	75	21.4	98.9	0.0026	0
38	0259	14.2	50	42.9	99.6	0.013	0
38	0259	15.38	25	64.3	100.2	0.0235	0
38	0260	8.01	75	8.8	96.3	0.0118	0
38	0260	10.38	50	24.1	101.8	0.0118	0
38	0261	6.58	75	7.9	93.7	0.0918	0
38	0261	11.08	50	22	114.4	0.0979	0
38	0261	19.27	50	50	161.9	0.1713	0
38	0262	7	99	0	109.5	0.0522	0
38	0262	12.35	75	12.1	120.1	0.0763	0
38	0262	13.65	50	42	123.8	0.0993	0
38	0262	14.95	25	71.8	127.6	0.1223	0
38	0263	11.12	75	7	99.1	0.0191	0
38	0263	13.34	50	35.7	102.8	0.0316	0
38	0263	15	25	65.7	104.5	0.0446	0
38	0263	17.72	0	100	108.2	0.0276	0
38	0264	7.8	75	18	88.9	0.0157	0
38	0264	16.13	50	37.3	94.7	0.0494	0
38	0264	17.72	25	64.7	94.7	0.0394	0
39	0202	6.48	99	0.7	98.4	0.0039	42.6
39	0202	7.18	75	17.2	103.2	0.0019	47.1
39	0203	9.77	99	0	76.8	0.0002	0
39	0203	13.31	75	0	71.9	0.0015	0
39	0205	4.49	99	0	92.7	-0.0067	22.9
39	0205	6.49	75	3.1	96.8	0.0078	74.1
39	0205	6.95	50	35.5	100.4	0.0065	79.8
39	0205	7.4	25	67.8	105.2	0.0052	85.5

NA – Data not available

State Code	SHRP ID	Age (years)	Target JCI	Failed Joint Seals (%)	Average IRI (inch/mile)	Average Faulting (inch)	Average Transversely Cracked Slabs (%)
39	0205	7.85	0	100	112.6	0.0039	91.2
39	0206	0.57	99	0.5	79.2	-0.0007	0
39	0206	3.8	75	16	89.7	-0.0003	12.6
39	0206	5.06	50	33.1	94.9	0.0044	29.2
39	0206	6.57	25	61.2	110.3	0.0003	47.1
39	0206	7.85	0	100	109.6	0.0039	47.1
39	0207	6.9	99	0	94	0.017	0
39	0207	10.77	75	13.6	108.5	0.0014	1
39	0207	12.09	50	29.1	98.4	0.0029	2.2
39	0207	14.99	25	54.4	86.1	0	10.4
39	0208	4.5	99	0.4	88.8	0.0003	0
39	0208	5.65	75	10	83.7	0.0065	0
39	0208	6.9	50	25.4	88.9	0.0152	0
39	0208	8.32	25	63.7	91.7	0.0206	0.7
39	0208	9.61	0	100	103.4	0	2.9
39	0209	8.46	99	1	79.7	-0.004	6.9
39	0209	11.4	75	18.9	96.1	0.0039	19.9
39	0209	13.43	50	36.9	110.1	0.0039	32.5
39	0209	15.46	25	54.9	120.4	0.0039	45.2
39	0210	6.13	99	0	72.5	0.0131	14.7
39	0210	7.01	75	7.4	79.7	0	21.8
39	0210	7.66	50	15.7	80.5	0	23.1
39	0211	9.69	99	0.1	92.2	0.0001	0
39	0211	11.59	75	1.8	91.8	0.0023	0
39	0211	13.33	50	17.2	95.6	0.0039	0
39	0211	16.22	25	61.4	98.3	0	0
39	0211	17.59	0	100	103.3	0	0
39	0212	5.44	99	0	65	0.0052	1.9
39	0212	10.32	75	25	73.4	-0.007	39.9
39	0212	12.14	50	50	75.4	-0.0046	58.9
39	0212	13.95	25	75	77.4	-0.0023	78
39	0212	15.76	0	100	85.1	0	97.1
39	0259	0.72	99	0.7	49.7	0	6.7
39	0260	6.65	99	0	77.4	0.0142	0
39	0260	10.37	75	25	77.5	0.0143	0
39	0260	11.24	50	50	77.9	0.0082	0
39	0260	12.1	25	75	77.9	0.0021	0
39	0260	12.97	0	100	77.3	-0.0039	0

NA – Data not available

State Code	SHRP ID	Age (years)	Target JCI	Failed Joint Seals (%)	Average IRI (inch/mile)	Average Faulting (inch)	Average Transversely Cracked Slabs (%)
39	0261	6.5	99	0.6	73.9	0.0011	0
39	0261	7.53	75	15.9	76.8	0.0266	0
39	0261	10.51	50	48.8	75.2	0.0011	0
39	0261	11.87	25	72	75.9	0.0026	0
39	0261	14.04	0	100	78.1	0	0
39	0262	4.5	99	0.4	75.9	0.0002	0
39	0262	5.73	75	10.7	76	0.0046	0
39	0262	8.25	50	32	80.4	-0.0031	0
39	0262	9.23	25	69.9	78	-0.0009	0
39	0262	12.97	0	100	81.9	0	0
39	0263	3.12	99	0.5	83	0	0
39	0263	6.4	75	5.8	84.4	0.0106	0
39	0263	8.13	50	37.5	84.2	0	0
39	0263	9.11	25	70.8	83	0	0
39	0263	17.59	0	100	87.6	0	0
39	0264	0.29	99	0.2	66.8	0.0005	0
39	0264	8.43	75	20.1	102.5	0.0118	3.6
39	0265	5.16	99	0	99	0.0065	0
39	0265	9.65	99	0.9	96.6	0.004	0
39	0265	10.6	75	20.6	96.7	0.0051	0
39	0265	11.59	50	41.1	97.1	0.0063	0
39	0265	12.58	25	61.6	98.6	0.0074	0
53	0201	9.49	99	1.1	84.6	-0.0038	0
53	0201	9.78	75	25.2	84.6	0	0
53	0201	10.09	50	50.1	84.6	0.004	0
53	0201	10.39	25	75.1	84.6	0.0079	0
53	0201	10.69	0	100	84.9	0.0118	0
53	0201	16.62	75	3.8	91.3	0.0088	2.9
53	0201	17.39	50	15.2	95	-0.0118	2.9
53	0201	20.22	50	15.2	97.8	0.0197	2.9
53	0202	10.28	99	0	61.9	-0.0012	0
53	0203	9.67	99	0	83.3	0.0013	0
53	0204	9.56	99	0	75.1	0.0003	0
53	0204	12.15	75	0	75.4	0.0039	0
53	0204	13.74	50	25.4	75.7	0.0055	0
53	0204	19.76	25	59.9	77.8	0.0286	0
53	0205	12.74	99	0	82.9	0.021	9.8
53	0205	17.35	75	0	85.4	-0.0032	14.6

NA – Data not available

State Code	SHRP ID	Age (years)	Target JCI	Failed Joint Seals (%)	Average IRI (inch/mile)	Average Faulting (inch)	Average Transversely Cracked Slabs (%)
53	0206	16.59	99	0	113.6	-0.0013	18.3
53	0207	11.08	99	0	89.5	0.0039	2.9
53	0208	9.76	99	0	107.7	0.0087	0
53	0208	19.19	75	0	94.4	0.0155	2.9
53	0209	2.28	99	0	83.5	0.0012	0
53	0209	11.85	99	0	90.8	0.0182	0
53	0209	19.43	75	0	99.9	0.0365	0
53	0210	12.5	99	0	70.3	0.0341	0
53	0210	18.54	75	0	54.9	0.0111	0
53	0211	16.03	99	0	77.9	0.021	0
53	0212	9.53	99	0.1	65.7	-0.0036	0
53	0212	12.01	75	3	72.4	0.0216	0
53	0212	13.23	50	32.8	75.4	0.01	0
53	0212	17.32	25	62.7	62.2	0.0039	0
53	0259	9.59	99	0.5	73	0	0
53	0259	13.47	75	4.7	74.6	0.0084	0
53	0259	17.95	50	23.9	85.7	0.0034	0
53	0259	19.8	25	56.6	84.9	0.0243	0
55	0213	7.76	99	0.8	81.1	0.0078	0
55	0213	9.1	75	20.6	87.5	0.0067	0
55	0213	10.49	50	41.1	94	0.0056	0
55	0213	11.88	25	61.6	72.7	0.0044	0
55	0213	14.66	0	100	97.7	0.0157	0
55	0214	7.41	99	0	88.1	-0.0179	0
55	0214	9.27	75	16	88.3	-0.0184	0
55	0214	10.93	50	33	92.6	-0.017	0
55	0214	15.52	50	24.7	94.5	0	0
55	0214	16.8	25	61.5	91.1	0	0
55	0215	2.93	99	0.7	88.3	0.0031	0
55	0215	5.82	75	11.9	82.8	0.0017	0
55	0215	8.35	75	15.4	89.9	0.0034	0
55	0215	9.77	50	42.7	93.8	0.0022	0
55	0215	11.2	25	70	91.7	0.001	0
55	0215	17.93	0	100	91.2	-0.0039	0
55	0216	1.88	99	0	100.2	0.0012	0
55	0216	6.87	99	0.1	104.1	-0.002	0
55	0216	7.83	75	5.6	101.6	-0.0038	0
55	0216	9.39	50	36.7	100.5	-0.0025	0

NA – Data not available

State Code	SHRP ID	Age (years)	Target JCI	Failed Joint Seals (%)	Average IRI (inch/mile)	Average Faulting (inch)	Average Transversely Cracked Slabs (%)
55	0216	10.95	25	67.8	102.4	-0.0012	0
55	0216	14.66	0	100	108.3	0.0118	0
55	0217	4.91	99	0	51.1	0.0039	0
55	0217	15.06	75	8.6	56.6	0.0039	0
55	0217	16.51	50	28.8	57.1	0.0039	0
55	0218	7.89	99	0	76.1	-0.0117	0
55	0218	12.3	75	0	78.5	-0.008	0
55	0218	15.96	75	4.8	76.4	-0.0055	0
55	0218	17.55	50	10.7	78.8	-0.0074	0
55	0219	7.92	99	0	69.7	0.0075	0
55	0219	17.48	75	0	76.1	0.0016	0
55	0220	5.19	99	0	87.4	-0.001	0
55	0220	9.02	75	17.8	90.8	-0.0028	0
55	0220	10.52	50	37.9	91.9	-0.0016	0
55	0220	12.02	25	58.1	99.4	-0.0003	0
55	0220	17.92	0	100	106.8	0.0039	0
55	0221	2.92	99	0	86.4	-0.0017	0
55	0221	5.7	75	11.5	79.5	-0.0047	0
55	0221	7.7	50	6.1	84.3	0	0
55	0221	10.39	25	52.7	95.4	0	0
55	0222	7.77	99	0.7	103.3	-0.0194	0
55	0222	9.36	75	16	109	-0.0128	0
55	0222	11.02	50	32	108.6	-0.0059	0
55	0222	13.83	25	51.1	110.4	0.0025	0
55	0223	7.81	99	0.2	80.4	-0.0042	0
55	0223	10.3	75	5	88.9	-0.0104	0
55	0223	13.27	50	13.6	90.7	-0.0069	0
55	0224	3.74	99	0	77	0	0
55	0224	5.05	75	21	68.8	0	0
55	0224	5.77	50	43.4	69.2	0	0
55	0224	6.5	25	65.7	68	0	0
55	0224	7.85	50	11.8	71.4	0	0
55	0224	10.28	25	55.5	74.5	0	0
55	0224	14.66	0	100	78.3	0.0039	0
55	0261	7.41	99	0	70.8	-0.0035	0
55	0261	9.26	75	15	63.9	-0.0039	0
55	0261	10.92	50	31	65.5	-0.0039	0
55	0261	12.73	25	50.1	65.3	-0.0023	0

NA – Data not available

State Code	SHRP ID	Age (years)	Target JCI	Failed Joint Seals (%)	Average IRI (inch/mile)	Average Faulting (inch)	Average Transversely Cracked Slabs (%)
55	0262	7.79	99	0.3	76.5	-0.004	0
55	0262	9.88	75	8.3	74.7	-0.0057	0
55	0262	12.05	50	16.7	75	-0.0075	0
55	0262	16.15	50	31.4	70.9	0.0021	0
55	0262	17.78	25	52.6	75.6	0.0002	0
55	0264	0.47	99	1	77.5	0.0001	0
55	0264	2.02	75	25	85.1	0.0026	0
55	0264	3.62	50	50	91.8	0.0052	0
55	0264	5.23	25	75	92.4	0.0078	0
55	0264	6.84	0	100	80.7	0.0104	0
55	0265	0.47	99	1	82	0.0117	0
55	0265	2.02	75	25	90.4	0.0092	0
55	0265	3.62	50	50	97.5	0.0066	0
55	0265	5.23	25	75	98.8	0.004	0
55	0265	6.84	0	100	83.6	0.0014	0

NA – Data not available