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TPF-5(291) FINAL REPORT:

SERVICE LIFE EVALUATION

Prepared On Behalf Of	Date	Project Number
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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 an evaluation of the relative impact of SPS-2 design features on pavement service life.

2.0 INTRODUCTION

Prior analyses performed as part of this pooled-fund study determined the relative impact of SPS-2 design features on the deterioration rate of pavement performance. However, those analyses did not attempt to quantify the impact of design features in terms of the service life of the pavement. The rate of pavement deterioration did not directly correlate to service life, or to the timing of maintenance or rehabilitation. The serviceability of a test section was often based on the management approach of the agency, which may have included subjective factors such as roadway functionality, maintenance schedules, budgeting plans, preservation activities, and project limits for construction work. In addition, the decision-making process was not uniform throughout all SPS-2 projects. Even when performance measures, such as roughness, contributed to decision-making, the thresholds for treatment appeared to vary by agency.

Both MEPDG and the Federal Highway Administration (FHWA) commonly use condition metrics of roughness, faulting, and percent slab cracking to determining pavement serviceability. Depending on the severity and extent of underlying distress, a test section could be deteriorating in one type of performance measures more so than others. The relevant metrics for this evaluation, as shown in Table 1 include mean roughness index (MRI), average wheel-path faulting (AWF), and percent (transversely) cracked slabs (PCS).

Table 1. Recommended Performance Thresholds for Rating Pavements Using Condition Metrics.

Condition Metric	Performance Level	Threshold
MRI	Good	<95
	Fair	95-170
	Poor	>170
AWF	Good	<0.10
	Fair	0.10-0.15
	Poor	>0.15
PCS	Good	<5%
	Fair	5-15%
	Poor	>15%

Source: Visintine, B., G.R. Rada, A.L. Simpson. 2018. *Guidelines for Informing Decisionmaking to Affect Pavement Performance Measures: Final Report*. Federal Highway Administration Report No. FHWA-HRT-17-090. Washington, D.C.

Previous work to validate the AASHTOWare PavementME Design (PMED) software using measured performance data obtained from SPS-2 test sections was largely unsuccessful. PMED was unsuccessful in accurately predicting the performance of test sections with significant deterioration within an analysis period of 20 years. It was successful in the sense that many SPS-2 test sections exhibited very little distress and PMED was able to predict the good performance of several such test sections. However, these no-deterioration predictions could not provide meaningful correlation between measured and predicted data beyond the 20-year analysis period.

Previous work on the deterioration rates of condition metrics (MRI, AWF, and PCS) had determined the impact of design factors – very broadly – as either a positive or negative impact on deterioration rates. Because it was difficult to account for project-specific factors such as traffic loading, the analysis did not quantify the impact but focused on identifying trends. The study found that thicker pavements performed better than thinner pavements. Test sections with permeable asphalt treated base (PATB) performed better than those with dense-graded aggregate base (DGAB) or LCB. LCB test sections had more consistently poor performance while DGAB sections had mixed performance. Sections with high-strength PCC performed better than low-strength PCC sections in most metrics except transverse cracking. Sections with widened lanes performed better than standard lane-width test sections in most metrics except longitudinal cracking and joint seal performance.

Since it was determined that deterioration rates and modeled performance predictions would not be reliable in estimating the impact of SPS-2 design features on the test section's service life, this analysis exclusively focused on analyzing measured condition metrics of both in-study (active) and out-of-study (OOS) test sections. Table 2 shows a summary of the number of test sections currently in-study and OOS for each SPS-2 project per Standard Data Release 35. The table also describes the length of the monitoring period of test sections that were placed OOS.

Table 2. Number of SPS-2 Test Sections Currently Out-of-Study and the Length Their Monitoring Period.

State	In-Study		Out-of-Study				
					Length of Monitoring Period (years)		
	Cor.[1]	Sup.[2]	Cor.[1]	Sup.[2]	Average	Minimum	Maximum
Arizona (AZ)	12	7	–	–	–	–	–
Arkansas (AR)	–	–	12	–	19.6	15.2	20.0
California (CA)	10	–	2	–	18.2	18.2	18.2
Colorado (CO)	8*	1	4*	–	24.6	21.7	27.5
Delaware (DE)	–	–	12	2	24.2	24.2	24.2
Iowa (IA)	10	1	2	–	25.4	25.4	25.4
Kansas (KS)	10	1	2	–	27.4	27.4	27.4
Michigan (MI)	–	–	12	1	14.7	5.7	20.0
Nevada (NV)	–	–	11	1	10.0	4.7	11.0
North Carolina(NC)	6	2	6	–	11.5	11.5	11.5
North Dakota (ND)	12	6	–	–	–	–	–
Ohio (OH)	2	5	10	2	17.2	13.1	26.0
Washington (WA)	12	1	–	–	–	–	–
Wisconsin (WI)	12	8	–	–	–	–	–

– indicates zero PCC test sections
[1] Core test sections
[2] Supplemental test sections
* Colorado test section 080218 was placed OOS in July 2021, after Standard Data Release 35.

The monitoring period of a test section did not necessarily correlate to the effective service life of the test section. A variety of factors not solely related to performance could have determined when a test section was placed OOS, including serviceability assessment timing or the feasibility of construction activities. For example, remaining active test sections in the states of Arkansas, Delaware, Michigan, and Nevada were placed OOS all at the same time. However, this does not mean that all test sections had the same service life, but rather that a sufficient portion of the test sections and surrounding roadway had deteriorated to the extent that the entire project (or subdivision of the project) was placed OOS.

In a few cases, the reason for retiring a test section may have been largely unrelated to performance. Both in California and Colorado, some test sections were placed OOS because it was difficult to arrange traffic control needed for continued monitoring.

Conversely, there were also several cases of individual test section(s) going OOS independent of the rest on a particular project. The LTPP program could remove test sections from study for receiving treatments outside of full reconstruction, including significant panel replacements, joint transfer restoration, and functional widening.

Arizona, North Dakota, Washington, and Wisconsin projects have all test sections (including supplemental test sections) still in study. Among the remaining SPS-2 projects, California, Colorado, Iowa, and Kansas can also be said to have performed well based on active test sections and average span of their monitoring periods. Ohio has half of its test sections currently OOS, but Arkansas and Delaware projects – despite having all test sections OOS – had longer monitoring periods, on average. North Carolina, also with half of its test sections OOS, had average monitoring periods for OOS test sections comparable to Michigan and Nevada. Michigan, Nevada, and Ohio were outliers with sections that had material and construction issues.

3.0 EVALUATION

3.1 Comparison of Pavement Age and Last Measurement of Condition Metrics

Figures 1 through 3 show the last measured value of MRI, AWF, and PCS of OOS test sections relative to the age of the test section at the time of measurement, respectively. The figures also show the performance levels of "Good," "Fair," and "Poor" for each condition metric threshold listed in Table 1. These figures demonstrate how several test sections with Good performance in certain condition metrics could also be placed OOS and how test sections within the same project were placed OOS at the same time.

Figure 1 shows that for most test sections placed OOS, the last measured MRI rating was Fair. Higher MRI measurements typically occurred in test sections that were placed OOS early (less than 10 years). The suddenness of early failures in these test sections likely resulted in roughness reaching values above 200 inch/mile before they could be mitigated.

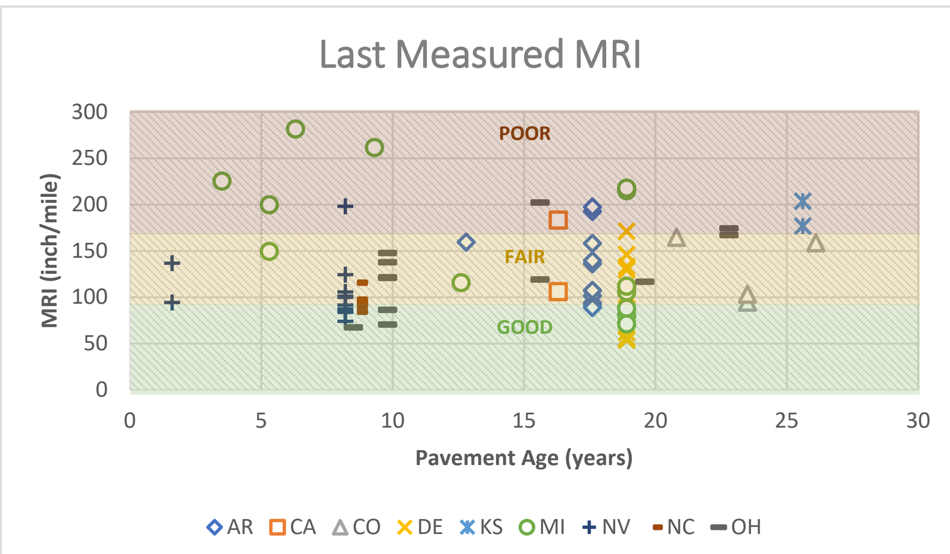

Figure 1. Last Measured MRI and Age of OOS Test Sections.

Figure 2 shows that most test sections that were placed OOS were performing well based on faulting (except for three test sections in Arkansas). Most had AWF within the range of ±0.04 inches. In comparison to MRI and PCS, AWF had the least impact in placing sections OOS.

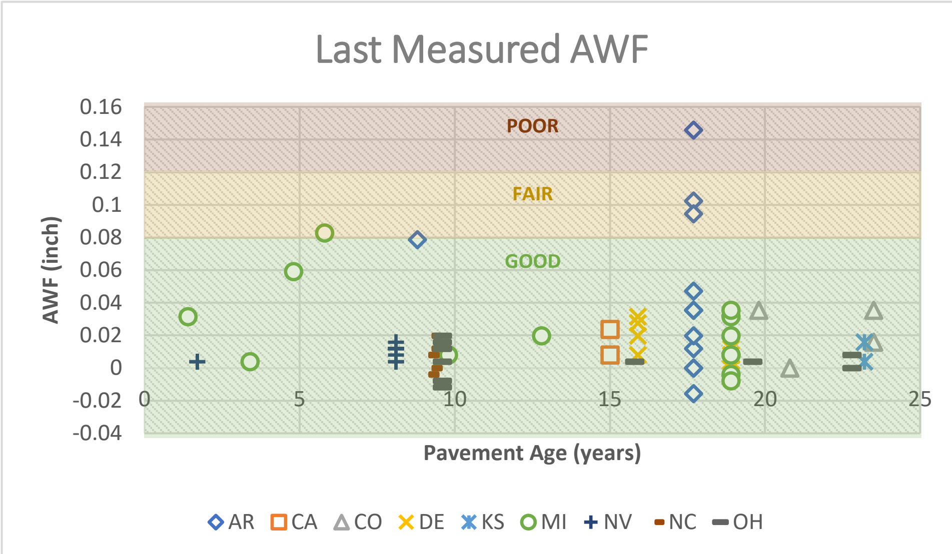

Figure 2. Last Measured AWF and Age of OOS Test Sections.

Figure 3 shows that poor slab cracking performance was common in OOS test sections. The PCS condition metric does not account for slab replacements that may have occurred prior to sections going OOS. Cracking in some of these sections may have been more severe than represented by their last PCS measurement.

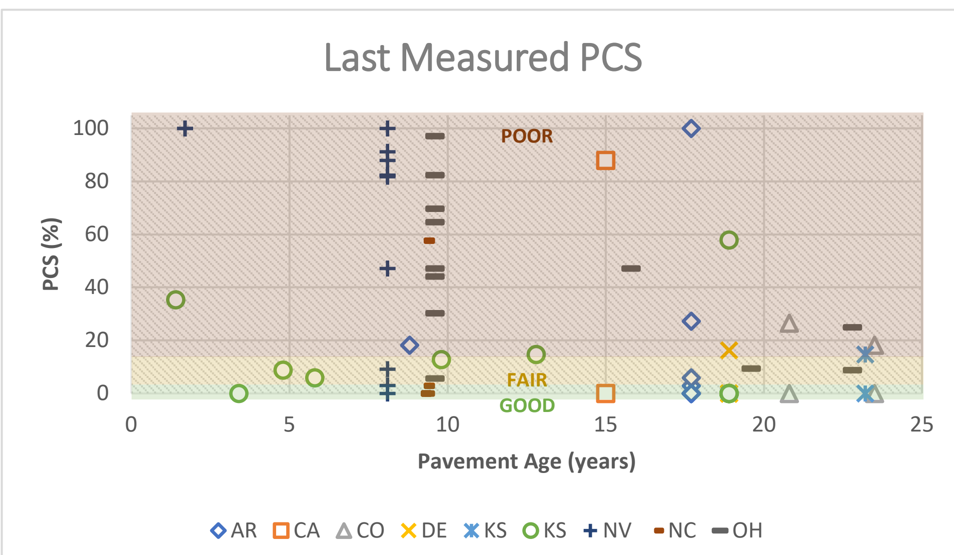

Figure 3. Last Measured PCS and Age of OOS Test Sections.

A more detailed analysis for the performance of individual OOS test sections can be found in the TPF-5(291) Tasks 11-1 to 4 report "*Evaluating the Impact of Non-Experimental Factors on Performance*". This report reviews agency-specific trends, construction and material-related issues, and lessons learned from early failures and supplemental sections. The same performance thresholds shown in Table 1 are evaluated in the context of all surveys and tests performed over the course of the monitoring period instead of only the final measurements, as in the current analysis.

3.1.1 ARKANSAS OOS TEST SECTIONS

One test section (050213) was placed OOS earlier than the rest. At the time of measurement, section 050213 had Poor performance in PCS, Fair performance in MRI, and borderline Good performance in AWF. The other test sections went OOS 5 years later, in 2013. Four of these sections had Poor performance in one or more condition metrics (as seen in Table 3). Most of these sections were in the Fair condition range for MRI, but in the Good condition range for AWF and PCS.

3.1.2 CALIFORNIA OOS TEST SECTIONS

The two test sections went OOS at the same time. Section 060201 had Poor performance in MRI and PCS, while section 060204 (having higher-strength PCC) had Fair performance in MRI and zero PCS. Section 060204 went OOS not for poor performance, but because of the difficulty in arranging traffic control.

3.1.3 COLORADO OOS TEST SECTIONS

Four test sections went OOS between 2014 and 2020. Only two went OOS at the same time; sections 080215 and 080221 went OOS in 2017, both with MRI near 100 inch/mile and zero PCS. These two sections were in relatively good condition and were placed OOS for difficulties in obtaining traffic control. On the other hand, sections 080217 and 080218 went OOS with MRI on the borderline of Poor and with PCS well in Poor condition.

3.1.4 DELAWARE OOS TEST SECTIONS

Despite all test sections being OOS, there was no transverse cracking on most test sections (except for section 100205). Test sections were in the Good to Fair performance range for MRI and entirely in the Good performance range for AWF.

3.1.5 KANSAS OOS TEST SECTIONS

Two test sections, 200201 and 200205, went OOS with MRI in Poor condition. Both sections had AWF in Good condition, but PCS was in the Good to Fair range.

3.1.6 NEVADA OOS TEST SECTIONS

All test sections went OOS by 2004 – two of which, sections 320202 and 320206 – went OOS in 1997. Only section 320201 had MRI in the Poor performance range. Other sections had MRI near the borderline between Good and Fair condition. The AWF for all test sections were tightly grouped in the Fair performance range. Almost all test section had PCS in the Poor range (except for 320209, 320211, and 320259.

3.1.7 NORTH CAROLINA OOS TEST SECTIONS

Six test sections went OOS in 2003. Five of the sections had Good performance in MRI, AWF, and PCS. One section, 370205, had Fair performance in MRI, Good performance in AWF, and Poor performance in PCS.

3.1.8 OHIO OOS TEST SECTIONS

All test sections have gone OOS: seven in 2007, two in 2012 and three between 2019 and 2020. Most OOS sections had MRI performance in the Good to Fair range. The only section with MRI well within the Poor performance range was 390264. MRI for sections 390208 and 390212 were on the borderline between Fair and Poor. AWF performance for all test sections was tightly grouped within the Good performance range. All but three sections had PCS in the Poor performance range. Sections 390207, 390212, and 390264 had PCS performance in the Fair range.

3.2 Comparison of Performance Ratings to OOS Status

Table 3 summarizes the final performance level ratings for OOS sections by state and Table 4 provides the last measured performance ratings for active test sections by state. The distribution of test sections between Tables 3 and 4 shows the significance of Poor and Fair performance ratings on sections that were placed OOS. Among the OOS test sections, there were 36 that had exactly one condition metric rated as Poor. There were 40 OOS sections where exactly one condition metric was rated as Fair. This appears to be a gray area, as there were also 52 active test sections where exactly one condition metric was rated as Fair. Among active test sections, there were 42 sections where all condition metrics were rated as Good. However, there were very few active test sections that showed a Poor rating for any condition metric.

Table 3. Count of Final Measured Performance Ratings for OOS Test Sections.

Count of Performance Ratings by Level [1]			Out-of-Study Test Sections										
			States										Total
Poor	Fair	Good	AR	CA	CO	DE	IA	KS	MI	NV	NC	OH	
3	0	0	–	–	–	–	–	–	–	–	–	–	–
2	1	0	–	–	–	–	–	–	–	–	–	–	–
2	0	1	1	1	–	–	–	–	1	1	–	–	4
1	2	0	–	–	–	–	–	–	–	–	–	–	–
1	1	1	2	–	2	–	1	1	2	4	1	8	21
1	0	2	1	–	–	2	–	1	4	4	–	3	15
0	2	1	1	–	–	–	–	–	2	–	–	1	4
0	1	2	6	1	1	5	1	–	2	2	1	–	19
0	0	3	1	–	1	7	–	–	2	1	4	–	16
Total			12	2	4	14	2	2	13	12	6	12	79

[1] Total of performance levels based the final measurement of condition metrics in Table 1.

Table 4 is based on the last measured performance of in-study test sections. Unlike OOS sections, active test sections will continue to deteriorate. The distribution of test section counts in Table 4 is expected to change over time into the distribution seen in Table 3, where:

- There are fewer sections with Good ratings in all condition metrics.
- There are fewer sections with a Fair rating in at least one condition metric.
- There are significantly more test sections with at least one Poor rating.

Table 4. Count of last measured performance ratings for active Test Sections.

Count of Performance Ratings by Level [1]			In-Study Test Sections										
			States										Total
Poor	Fair	Good	AZ	CA	CO	IA	KS	NC	ND	OH	WA	WI	
3	0	0	–	–	–	–	–	–	–	–	–	–	0
2	1	0	–	–	–	–	–	–	–	–	–	–	0
2	0	1	2	–	–	–	–	–	1	–	–	–	3
1	2	0	–	–	–	–	–	–	–	–	–	–	0
1	1	1	2	2	2	1	–	–	–	–	2	–	9
1	0	2	3	4	–	–	–	–	–	–	1	–	8
0	2	1	3	1	1	1	1	–	1	2	1	1	12
0	1	2	6	1	3	6	6	6	11	3	3	7	52
0	0	3	3	2	3	3	4	2	5	2	6	12	42
Total			19	10	9	11	11	8	18	7	13	20	126

[1] Total of performance levels based the last measurement of condition metrics in Table 1.

Tables 3 and 4 did not differentiate between test sections that went OOS recently or should be placed OOS but are currently still active. Nor does it account for seasonal and diurnal variability in the last measurement of MRI. Also, there is no consideration for how much time has passed between the final close-out measurement and the removal from study. However, the distributions in these tables may imply different tiers in the overall serviceability of the pavement. For example, test sections where all condition metrics remain in the Good performance range could present a different tier of serviceability than sections where at least one metric is in the Fair performance range, or at least one metric is the Poor performance range.

Table 5 shows (averaged by project) the mean age (MA) of test sections at the time when they met the given criteria for each condition metric. All SPS-2 test sections started off with Good performance in all three condition metrics (i.e., MRI, AWF, and PCS). Of these, some test sections progressed to having at least one or more metrics in the Fair condition or the Poor condition. In Table 5, as test sections in each project deteriorated further, the time needed to achieve that degree of deterioration also increased; thus, the mean age of the pavement was shown to increase.

The performance level criteria in Table 5 were ordered first by AWF, then MRI, and lastly PCS. While it is not possible to show a consistent increasing trend in the average age, the ordering of condition criteria in Table 5 highlights some of the relationships between AWF, MRI, and PCS at various performance levels, such as:

- There were very few cases where AWF reached the Poor performance level. It was much more common for MRI or PCS to reach the poor level.
- The average pavement age when MRI was Fair and PCS was Good, was very similar to the average pavement age when MRI was Good and PCS was Fair. However, for certain projects, a PCS rating of Fair tended to happen sooner than an MRI rating of Fair. In

other words, PCS was deteriorating faster that MRI and/or possible driving the deterioration of MRI.

- Performance ratings of Poor tended to occur when test sections were relatively older, except in projects that had test sections with early failures.
- Comparing the average age of pavements rated Poor in PCS to those rated Poor in MRI, it was more common that a Poor rating in PCS would occur sooner than a Poor rating in MRI – also conforming with relative progression from Good to Fair as stated previously.

Table 5. Mean Age (averaged by state) of Test Sections per the Defined Performance Level Criteria.

Performance Level			Average Pavement Age of Test Sections at Performance Level Criteria Threshold (years)														
AWF	**MRI**	**PCS**	**AZ**	**AR**	**CA**	**CO**	**DE**	**IA**	**KS**	**MI**	**NV**	**NC**	**ND**	**OH**	**WA**	**WI**	**ALL**
Good	Good	Good	11.4	8.2	6.9	12.0	7.8	10.0	11.1	5.1	3.9	7.9	10.2	5.6	10.0	9.6	8.5
		Fair	17.4	10.7	10.9	17.4	6.0	18.3	15.2	8.5	4.9	7.4	8.8	11.1	14.3	–	11.6
		Poor	18.1	11.7	12.3	21.2	11.0	24.8	19.0	8.2	3.9	8.2	7.7	10.4	19.4	–	13.5
	Fair	Good	16.4	11.5	10.0	17.0	13.7	13.9	15.8	8.5	4.3	10.3	15.9	12.9	20.1	12.7	13.1
		Fair	–	–	12.0	–	–	–	18.1	–	–	–	–	–	13.3	–	14.5
		Poor	–	–	10.1	–	–	–	–	–	–	–	–	–	24.6	–	17.3
	Poor	Good	24.2	14.6	15.7	15.8	18.9	22.5	25.6	9.5	8.2	–	21.9	19.2	–	–	17.8
		Fair	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
		Poor	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Fair	Good	Good	12.2	16.6	–	–	–	–	–	–	–	–	19.4	–	–	21.7	17.5
		Fair	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
		Poor	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Fair	Good	16.2	–	–	–	–	–	–	–	–	–	–	–	–	–	16.2
		Fair	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
		Poor	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Poor	Good	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
		Fair	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
		Poor	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Poor	Good	Good	21.9	–	–	–	–	–	–	–	–	–	18.1	–	–	–	20.0
		Fair	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
		Poor	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Fair	Good	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
		Fair	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
		Poor	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Poor	Good	–	–	–	–	–	–	–	–	–	–	23.5	–	–	–	23.5
		Fair	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
		Poor	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

– indicates no test sections met the performance criteria as defined in Table 1 to compute an average.

3.3 Relative Extension in Service Life by Project

Table 6 shows averages by state of the mean age (MA) of test sections in the Good, Fair, and Poor categories. MA does not equate to the lifespan of the test section in each category, but rather the mean age of the pavement when the condition metric measurements satisfied the requirements of the category:

- *Good category* refers to the pavement while all condition metrics satisfy the threshold for Good performance per Table 1.
- *Fair category* refers to the pavement while at least one condition metric satisfies the threshold for Fair performance per Table 1.
- *Poor category* refers to the pavement while at least one condition metric satisfies the threshold for Poor performance per Table 1.

Table 6. Average Pavement Age by Performance Categories.

State	Percent of Test Sections in GC[1]	Average MA of GC[1]	Percent of Test Sections in FC[2]	Average MA of FC[2]	Percent of Test Sections in PC[3]	Average MA of PC[3]
AZ	100%	12.0	75%	20.2	25%	23.8
AR	100%	8.2	100%	13.5	33%	16.2
CA	100%	6.9	83%	12.7	42%	17.4
CO	100%	11.8	92%	19.5	33%	24.8
DE	92%	7.9	50%	13.3	17%	16.5
IA	100%	9.8	83%	18.2	17%	26.8
KS	100%	11.1	67%	19.2	17%	29.3
MI	100%	4.9	75%	9.6	42%	11.2
NV	82%	3.8	45%	5.9	36%	7.5
NC	100%	7.5	83%	13.3	8%	11.9
ND	100%	10.9	83%	19.6	17%	22.6
OH	92%	3.9	92%	10.5	75%	12.4
WA	100%	9.8	67%	19.0	25%	23.4
WI	100%	9.3	58%	16.2	0%	–
Average	**98%**	**8.4**	**75%**	**15.1**	**28%**	**17.4**

– indicates no test sections achieved given performance criteria to compute the average.
MA refers to the mean of the age of the pavement at the time of measurement while in each category.
[1] GC: Good category indicates the test section had "Good" performance in all condition metrics per Table 1.
[2] FC: Fair category indicates the test section had "Fair" performance in at least one of the condition metrics listed in Table 1.
[3] PC: Poor category indicates the test section had "Poor" performance in at least one of the condition metrics listed in Table 1.

The difference between MA values indicates the time needed to transition from one level of serviceability to the next. For comparison purposes, relative changes between MA values equate to the relative change in the service life of test sections as defined by the performance category. For example, the MA for Arizona test sections in the Good category was 12 years and the MA for 75% of those test sections which deteriorated in the Fair category was 12.2 years. If transition from Good to Fair category happened, halfway, at an age of 16.1 years, this approximates the service life of Arizona pavements in the Good category as 16.1 years.

The transition point between the Good and Fair categories would be at a point in time between the MA for the Good category and the MA for the Fair category. Likewise, typically the transition point between the Fair and Poor categories would be at a point in time between the MA for the Fair category and the MA for the Poor category. The exception to this would be for test sections that deteriorated quickly and transitioned from the Good category directly to the Poor category. It was possible that no measurements were taken while these test sections were in the Fair category, giving the appearance of a direct transition from Good to Poor. For this reason, MA in the Fair category may not be as reliable as MA in the Poor category. However, there are not as many test sections per project that met the criteria for the Poor category.

As shown in Table 6, the percentage of test sections in the Poor category was between 0 and 29 percent (19% on average). In comparison, an average of 75% percent of test sections were in the Fair category. However, there was a significant difference in the sample size when calculating average MA in the Fair and Poor category. On average, there were 2 to 3 sections per project in the Poor category. If even one of these sections were an early failure (failing for reasons outside the intended design parameters), the average MA could be significantly biased to show a shorter average MA for pavement in the Poor category than expected. In contrast, the number of test sections in the Fair category was, on average, 9 per project, so the same early-failure test sections would have less influence on biasing the average. In some cases of early failure, no measurements were taken during the Fair category phase – seeming to show a test section transitioning directly from Good to Poor and adding further bias to average MA for Poor category.

In North Carolina, for example, data from 83% of project test sections that were in the Fair category showed the MA for these test sections was 13.3 years. However, only 8% of test sections – specifically section 370205 – deteriorated enough to fall into the Poor category, but since the only section in the sample was an early failure, the average MA equated to only 11.9 years (less than the average MA for the Fair category). In the context of sample size, this should not imply that test sections directly deteriorated into the Poor and then improved into the Fair category. Rather the interpretation should be that most North Carolina test sections did not deteriorate past the Fair category; the one section that did drop deteriorated very quickly and was placed OOS.

Table 6 shows that the Wisconsin and Delaware projects experienced the lowest amount of deterioration; these projects also had the lowest traffic loading. Wisconsin and Delaware had respectively only 58% and 54% of test sections that met the Fair category; implying that many test sections remained in the Good category throughout the study period (42% and 56% respectively). Following Wisconsin and Delaware, projects in Kansas, Iowa, North Carolina, and North Dakota had overall lower deterioration and a lower amount of test sections that entered the Poor category. Arizona and Washington can be considered the median among SPS-2 projects in terms of overall pavement deterioration.

The highest pavement deterioration was found in the Nevada, Michigan, and Ohio projects, which had many early-failure test sections due to material and construction issues. A significant percentage of test sections entered the Poor category and the corresponding MA values were also very low. In terms of higher project-wide deterioration, Arkansas and California also had more test sections in the Poor category and lower MA values. Arkansas and California had the highest traffic loading among the SPS-2 projects. Because the poor performance in Nevada, Michigan, and Ohio were due to material and construction issues instead of traffic loading, they are considered outliers in most analyses performed as part of this TPF-5(291) pooled-fund study.

3.4 Impact of Design Features on Relative Extension in Service Life

SPS-2 design features included:

- PCC thickness: nominally 11-inch (thick) and 8-inch (thin)
- Base type: DGAB, LCB, and PATB
- PCC strength: 900 psi (high-strength) and 550 psi (low-strength)
- Lane width: 12-foot standard and 14-foot widened (13-foot in California)

The SPS-2 used a half-factorial experimental design, where half of the 24 possible combinations of design features were used on some projects and the other half of possible combinations were used on different projects. Typically, there would be 12 core test sections per project with various numbers of supplemental test sections. Nevada was the only project with 11 core test sections. Supplemental sections have been excluded from this design feature comparisons for impartiality.

The methodology used to compare the impact of design features was somewhat subjective. Overall, the difference in average MA values was used to determine the relative extension in service but adjusted with consideration given to projects with early-failure test sections, varying amounts of traffic loading, sample size, and other project-specific trends. These findings are based on performance measurements collected to-date. As many SPS-2 test sections are still in-study, with few reaching the Poor category, it is expected that when new performance data becomes available, these analyses could be revisited and more-informed trends can be realized.

Additionally, a combination of design features could compound the respective impact each design feature has on pavement service life. Interaction between design features and non-experimental, project-specific factors such as climate, traffic, maintenance, materials, and construction practices add another layer of complexity and room for interpretation. Traffic loading was not stipulated by the experimental design (with only a minimum requirement of 200 KESALs[1] per year), yet potentially had a significant impact on service life. Accordingly, to evaluate the impact of design features in general, this analysis counter-balances project-wide averages with expert knowledge of biases that exist from project to project.

[1] KESALs are a thousand equivalent single axle loads

3.4.1 IMPACT OF PAVEMENT THICKNESS ON MA

As shown in Table 7, thicker pavements in the SPS-2 experiment have provided about an extra 4 years (about 15-20% increase) in service life. For projects with less traffic, the benefit was slightly reduced – about an additional 2 years (10-15% increase) in service life. However, the amount of benefit from thicker pavement was not strictly correlated to traffic. California, for example, has only benefited an extra year of service life from thicker pavements to-date.

Table 7. Comparison of MA Categories Based on Pavement Thickness.

State	Design Factor	Sections in GC[1]	Average MA of GC[1]	Sections in FC[2]	Average MA of FC[2]	Sections in PC[3]	Average MA of PC[3]
AZ	Thick	100%	11.2	100%	20.6	17%	25.6
	Thin	100%	12.8	50%	19.4	33%	22.9
AR	Thick	100%	9.0	100%	14.5	0%	–
	Thin	100%	7.4	100%	12.6	67%	15.4
CA	Thick	100%	7.3	83%	12.1	33%	17.8
	Thin	100%	6.5	83%	13.2	50%	16.9
CO	Thick	100%	12.0	100%	19.9	33%	25.3
	Thin	100%	11.6	83%	19.0	33%	24.2
DE	Thick	83%	7.3	67%	14.5	17%	17.7
	Thin	100%	8.4	33%	10.8	17%	15.5
IA	Thick	100%	10.5	83%	19.1	0%	–
	Thin	100%	9.1	83%	17.4	33%	26.1
KS	Thick	100%	12.2	67%	20.4	0%	–
	Thin	100%	10.0	67%	18.1	33%	27.7
MI	Thick	100%	6.4	83%	12.4	50%	14.6
	Thin	100%	3.4	67%	6.1	33%	6.6
NV	Thick	83%	4.7	50%	5.9	33%	7.0
	Thin	80%	2.8	40%	5.8	40%	7.5
NC	Thick	100%	10.3	83%	19.1	0%	–
	Thin	100%	4.8	83%	7.3	17%	9.1
ND	Thick	100%	10.9	100%	19.8	17%	24.5
	Thin	100%	10.8	67%	19.2	17%	20.3
OH	Thick	83%	5.4	83%	13.8	50%	16.5
	Thin	100%	2.6	100%	7.7	100%	9.8
WA	Thick	100%	10.6	50%	19.5	17%	24.6
	Thin	100%	9.0	83%	18.6	33%	22.7
WI	Thick	100%	8.9	50%	16.1	0%	–
	Thin	100%	9.6	67%	16.2	0%	–

– indicates no test sections achieved given performance criteria to compute the average.
MA refers to the mean of the age of the pavement at the time of measurement while in each category.
[1] GC: Good category indicates the test section had "Good" performance in all condition metrics per Table 1.
[2] FC: Fair category indicates the test section had "Fair" performance in at least one of the condition metrics listed in Table 1.
[3] PC: Poor category indicates the test section had "Poor" performance in at least one of the condition metrics listed in Table 1.

3.4.2 IMPACT OF BASE TYPE ON MA

The data in Table 8 indicate that test sections with PATB bases were lasting longer than other base types. Test sections with a PATB base typically gained a benefit of 2 years (about 10-15%) of additional service life over test sections with DGAB or LCB. The service life benefit between pavements with DGAB and LCB bases was inconsistent by project. The long-term benefit is difficult to assess, as most test sections with PATB did not frequently deteriorate into the Poor category. The advantage of PATB was still present in lower-traffic projects but the benefit was minor – less than half a year of additional service life.

Table 8. Comparison of Average MA Categories Based on Pavement Base Type.

State	Design Factor	Sections in GC[1]	Average MA of GC[1]	Sections in FC[2]	Average MA of FC[2]	Sections in PC[3]	Average MA of PC[3]
AZ	DGAB	100%	10.0	100%	19.9	25%	24.7
	LCB	100%	12.5	50%	21.6	25%	25.0
	PATB	100%	13.5	75%	19.5	25%	21.8
AR	DGAB	100%	7.2	100%	12.4	50%	13.6
	LCB	100%	8.0	100%	13.7	50%	17.7
	PATB	100%	9.4	100%	14.6	0%	–
CA	DGAB	100%	5.1	75%	11.5	50%	16.5
	LCB	100%	7.4	75%	11.9	75%	16.4
	PATB	100%	8.3	100%	14.1	0%	–
CO	DGAB	100%	12.5	75%	20.5	25%	24.9
	LCB	100%	10.5	100%	18.8	50%	23.8
	PATB	100%	12.3	100%	19.4	25%	25.8
DE	DGAB	75%	7.5	50%	13.5	0%	–
	LCB	100%	7.7	75%	12.7	50%	16.5
	PATB	100%	8.4	25%	14.5	0%	–
IA	DGAB	100%	9.5	75%	17.9	25%	26.9
	LCB	100%	8.4	100%	18.2	25%	25.2
	PATB	100%	11.5	75%	18.6	0%	–
KS	DGAB	100%	9.0	75%	18.0	25%	29.2
	LCB	100%	11.0	100%	19.7	25%	28.1
	PATB	100%	13.2	25%	21.0	0%	–
MI	DGAB	100%	3.3	100%	7.1	75%	10.0
	LCB	100%	4.0	75%	9.8	50%	11.5
	PATB	100%	7.4	50%	14.3	0%	–
NV	DGAB	50%	3.0	25%	5.6	25%	7.7
	LCB	100%	3.9	75%	5.9	75%	7.4
	PATB	100%	4.2	33%	5.8	0%	–
NC	DGAB	100%	7.1	100%	12.6	0%	–
	LCB	100%	7.8	100%	12.8	25%	12.2
	PATB	100%	7.8	50%	15.4	0%	–
ND	DGAB	100%	10.8	75%	19.7	25%	23.9
	LCB	100%	9.8	100%	19.4	25%	20.1
	PATB	100%	12.0	75%	19.7	0%	–
OH	DGAB	75%	2.3	75%	6.5	75%	8.6
	LCB	100%	3.7	100%	11.0	75%	13.0
	PATB	100%	5.3	100%	13.0	75%	15.2
WA	DGAB	100%	10.7	75%	21.7	0%	–
	LCB	100%	7.0	100%	16.5	75%	21.9
	PATB	100%	11.7	25%	20.7	0%	–
WI	DGAB	100%	9.1	100%	15.9	0%	–
	LCB	100%	9.2	25%	16.4	0%	–
	PATB	100%	9.4	50%	16.6	0%	–

– indicates no test sections achieved given performance criteria to compute the average.
MA refers to the mean of the age of the pavement at the time of measurement while in each category.
[1] GC: Good category indicates the test section had "Good" performance in all condition metrics per Table 1.
[2] FC: Fair category indicates the test section had "Fair" performance in at least one of the condition metrics listed in Table 1.
[3] PC: Poor category indicates the test section had "Poor" performance in at least one of the condition metrics listed in Table 1.

3.4.3 IMPACT OF PCC STRENGTH ON MA

On average, as seen in Table 9, high-strength sections provided a benefit to the service life of pavement of about 1 to 2 years (about 10% increase). For lower-traffic projects, the benefit of high-strength PCC was negligible. For example, in Wisconsin, low-strength test sections appeared to perform better than high-strength sections. In Arizona and North Dakota, in the latter half of the monitoring period, high-strength PCC test sections entered the Poor category sooner than the low-strength sections. Across most projects, there was a slightly larger percent of high-strength than low strength PCC sections in the Fair category. These inconsistencies are expected: the previous deterioration rate analyses found that high-strength sections were more susceptible to transverse cracking, but this could have been an effect compounded by the presence of thinner pavement and/or LCB bases.

Table 9. Comparison of MA Categories Based on PCC Strength.

State	Design Factor	Sections in GC[1]	Average MA of GC[1]	Sections in FC[2]	Average MA of FC[2]	Sections in PC[3]	Average MA of PC[3]
AZ	High	100%	12.8	83%	21.9	17%	21.0
	Low	100%	11.3	67%	18.1	33%	24.4
AR	High	100%	9.1	100%	14.5	33%	17.0
	Low	100%	7.3	100%	12.5	33%	15.5
CA	High	100%	6.6	100%	12.5	50%	17.0
	Low	100%	7.2	67%	13.0	33%	18.0
CO	High	100%	12.0	100%	20.4	33%	26.6
	Low	100%	11.6	83%	18.5	33%	23.0
DE	High	100%	7.9	60%	14.2	20%	18.1
	Low	86%	7.9	43%	12.3	14%	14.8
IA	High	100%	9.0	83%	18.1	33%	25.8
	Low	100%	10.6	83%	18.3	0%	–
KS	High	100%	12.2	67%	20.6	0%	–
	Low	100%	9.9	67%	17.8	33%	27.6
MI	High	100%	4.8	100%	10.1	67%	12.2
	Low	100%	5.0	50%	8.5	17%	7.9
NV	High	60%	4.1	20%	7.5	20%	8.1
	Low	100%	3.7	67%	5.4	50%	7.5
NC	High	100%	7.2	100%	13.5	0%	–
	Low	100%	7.9	67%	12.9	17%	12.3
ND	High	100%	11.1	100%	19.9	17%	21.4
	Low	100%	10.6	67%	19.0	17%	23.3
OH	High	100%	3.4	100%	9.5	100%	11.9
	Low	83%	4.5	83%	11.7	50%	12.9
WA	High	100%	9.8	50%	17.0	17%	25.0
	Low	100%	9.8	83%	20.0	33%	22.6
WI	High	100%	9.2	67%	16.3	0%	–
	Low	100%	9.4	50%	15.9	0%	–

– indicates no test sections achieved given performance criteria to compute the average.
MA refers to the mean of the age of the pavement at the time of measurement while in each category.
[1] GC: Good category indicates the test section had "Good" performance in all condition metrics per Table 1.
[2] FC: Fair category indicates the test section had "Fair" performance in at least one of the condition metrics listed in Table 1.
[3] PC: Poor category indicates the test section had "Poor" performance in at least one of the condition metrics listed in Table 1.

3.4.4 IMPACT OF LANE WIDTH ON MA

As shown in Table 10, test sections with widened lanes typically showed a very negligible amount of additional service life (less than half a year) compared to sections with standard lane widths. Because the service life benefit was so negligible, the amount of traffic loading did not have a compounding effect as seen with other design factors. Two projects did stand out as exceptions: Arizona and Colorado. In Arizona, there were fewer test sections with widened lanes that fell into the Poor category and these test sections deteriorated into the Poor category 3 years (on average) after test sections with standard lane widths. In contrast, Colorado test sections with widened lanes fell into the Poor category 8 years sooner than test sections with standard lane width. This was evident in Colorado site visits, as widened lane tests sections frequently suffered longitudinal cracking.

Table 10. Comparison of MA Categories Based on Lane Width.

State	Design Factor	Sections in GC[1]	Average MA of GC[1]	Sections in FC[2]	Average MA of FC[2]	Sections in PC[3]	Average MA of PC[3]
AZ	12	100%	11.2	83%	18.8	33%	22.0
	14	100%	12.9	67%	22.0	17%	26.9
AR	12	100%	8.5	100%	14.2	33%	16.4
	14	100%	7.9	100%	12.9	33%	16.1
CA	12	100%	6.0	83%	12.2	33%	17.6
	13[4]	100%	7.8	83%	13.1	50%	17.5
CO	12	100%	11.6	100%	19.8	33%	26.4
	14	100%	12.0	83%	19.1	33%	23.2
DE	12	100%	7.8	83%	12.9	33%	16.8
	14	83%	8.0	17%	15.5	0%	–
IA	12	100%	9.2	100%	17.8	33%	26.7
	14	100%	10.4	67%	18.8	0%	–
KS	12	100%	10.9	67%	18.3	33%	29.0
	14	100%	11.3	67%	20.2	0%	–
MI	12	100%	4.4	83%	8.0	50%	7.5
	14	100%	5.4	67%	11.6	33%	16.5
NV	12	80%	4.2	60%	6.4	60%	7.7
	14	83%	3.6	33%	5.1	17%	6.9
NC	12	100%	7.0	83%	14.4	17%	11.8
	14	100%	8.1	83%	12.1	0%	–
ND	12	100%	10.5	100%	19.5	33%	22.5
	14	100%	11.2	67%	19.7	0%	–
OH	12	100%	3.5	100%	10.4	100%	13.3
	14	83%	4.4	83%	10.6	50%	10.4
WA	12	100%	10.5	67%	19.4	17%	20.7
	14	100%	9.1	67%	18.6	33%	24.2
WI	12	100%	9.5	50%	16.3	0%	–
	14	100%	9.1	67%	16.0	0%	–

– indicates no test sections achieved given performance criteria to compute the average.
MA refers to the mean of the age of the pavement at the time of measurement while in each category.
[1] GC: Good category indicates the test section had "Good" performance in all condition metrics per Table 1.
[2] FC: Fair category indicates the test section had "Fair" performance in at least one of the condition metrics listed in Table 1.
[3] PC: Poor category indicates the test section had "Poor" performance in at least one of the condition metrics listed in Table 1.
[4] Widened lanes in California were 13 feet instead of 14 feet.

In Washington, widened lanes test sections entered the Poor category later than standard lane test sections, but with nearly double the frequency. In California, widened lane test sections were only 13-feet instead of 14-feet wide. While it was more frequent for California widened lane test sections to enter the Poor category, there was no change in the average MA.

3.5 Impact of Lane Width on Longitudinal Cracking Progression

Longitudinal cracking does not currently have a decision-making threshold established by FHWA on PMED. Following the previous methodology, test sections were evaluated purely in terms of percent longitudinal cracking (PLC). PLC is a manufactured condition metric for this analysis, to determine the progression of longitudinal cracking across different performance thresholds and the corresponding impact of lane width on MA. PLC is not an indicator of the actual service life of test sections. Following the performance thresholds for PCS in Table 1, PLC was also defined as shown in Table 11 with ratings of Good, Fair, and Poor. PLC is not calculated in terms of percent of slabs cracked longitudinally; rather, PLC uses the total length of longitudinal cracking per 500 feet (i.e., the standard length of SPS-2 test sections).

Table 11. Performance Thresholds for Rating Percent Longitudinal Cracking.

Condition Metric	Performance Level	Threshold	Threshold for 500-foot Section
PLC	Good	<5%	<25 feet
	Fair	5-15%	25-75 feet
	Poor	>15%	>75 feet

Figure 4 shows that PLC can decrease over time due to maintenance activities. For example, Delaware 100207 had a reduction in PLC from 12.2% in 2012 to 3.4% in 2015 with a skin patching maintenance event in 2014. To get the most value from the MA comparison analyses, certain surveys with significant decreases in PLC (a lower PLC means less longitudinal cracking) were excluded from the calculation of average MA. These surveys are listed in Table 12.

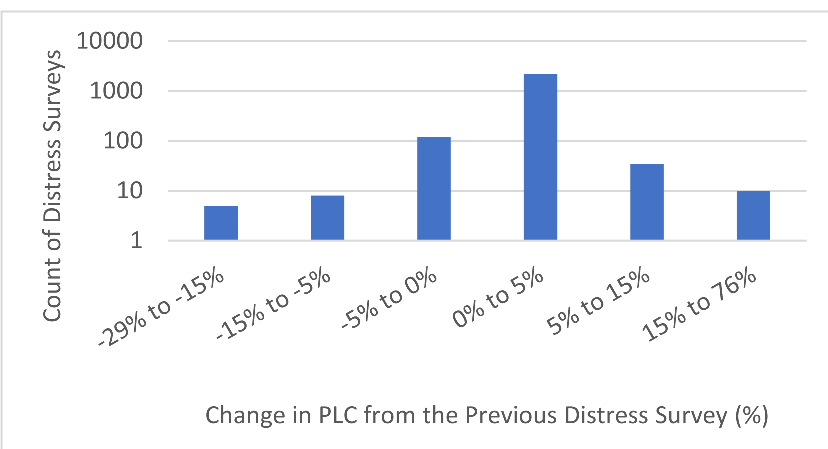

Figure 4. Histogram of change in PLC with respect to the previous distress survey (logarithmic scale).

Table 12. Distress Surveys Excluded from MA Average Comparisons.

State	SHRP ID	Distress Survey[1]	Decrease in PLC
DE	100207	5/27/2015	9%
KS	200205	10/20/2010	23%
NV	320201	10/27/2003	22%
ND	380217	6/5/2018	29%
OH	390212	8/13/2019	11%

[1] No distress surveys on or after this date were used in the computation of average MA in Table 13.

Table 13 shows the average MA for the PLC performance threshold by project and lane width of test sections (except as mentioned above). As this table is only based on one condition metric, the number of test sections in that achieved the Fair and Poor threshold were much lower than in Table 10. Typically, projects only had 1 to 3 test sections that had PLC in Fair or Poor. Fair-to-Poor PLC was more common in Arizona and Nevada (6 to 8 test sections per project). However, in 4 projects (Iowa, Michigan, North Carolina, and Washington), none of the test sections achieved Fair-to-Poor PLC. The limited dataset made it difficult to compare MA of test sections with Fair or Poor ratings.

It was also difficult to account for other design factors and generalize findings that indicated the impact of lane width on PLC. In Arizona, Colorado, North Dakota, Ohio, and Washington, test sections with standard lanes had 7 years of additional service life in terms of Fair PLC (on average) when compared to test sections with widened lanes. However, in California and Kansas, widener-laned sections appeared to have better service life. Kansas and North Dakota had the most dramatic – but opposite – results regarding PLC service life lost or gained. Because of the lack of sample size, the average MA of Good PLC may show more representative findings than the average MA of Fair or Poor PLC.

In Table 13, the average MA of test sections with Good PLC was mixed with respect to the impact of lane width. In California, Michigan, Nevada, Ohio, and Wisconsin, the widened test sections appeared to show more life in terms PLC. However, these projects were considered as exceptions in many ways:

- California's widened lanes were only 13-feet.
- Michigan, Nevada, and Ohio were all outliers in terms of material and construction issues.
- Wisconsin had one of the lowest traffic loadings among all SPS-2 projects.

Arizona, Arkansas, Colorado, and Washington instead showed that the standard 12-foot-wide test sections had better performance in PLC, with 1 to 2 years of additional service life in terms of Good PLC. These projects were more representative of normal traffic and having fewer exceptions outside the experimental design.

Table 13. Comparison of MA for PLC Performance Thresholds Based on Lane Width.

State	Design Factor	Sections in G[1]	Average MA of G[1]	Sections in F[2]	Average MA of F[2]	Sections in P[3]	Average MA of P[3]
AZ	12	100%	11.3	67%	23.5	33%	26.6
	14	100%	9.5	67%	19.1	67%	24.1
AR	12	100%	8.3	17%	11.9	17%	18.7
	14	100%	6.9	33%	11.1	33%	16.3
CA	12	100%	5.4	50%	13.5	17%	19.5
	13[4]	100%	7.7	17%	17.2	0%	–
CO	12	100%	13.1	33%	24.8	0%	–
	14	100%	11.4	17%	18.4	33%	23.8
DE	12	100%	8.1	0%	–	0%	–
	14	83%	8.2	17%	14.9	17%	18.8
IA	12	100%	11.5	0%	–	0%	–
	14	100%	11.4	0%	–	0%	–
KS	12	100%	12.2	17%	17.3	17%	21.3
	14	100%	12.7	33%	27.2	0%	–
MI	12	100%	5.6	0%	–	0%	–
	14	100%	6.5	0%	–	0%	–
NV	12	80%	2.4	60%	5.2	40%	7.4
	14	50%	3.5	50%	6.0	50%	6.1
NC	12	100%	9.2	0%	–	0%	–
	14	100%	9.6	0%	–	0%	–
ND	12	100%	11.6	17%	26.2	0%	–
	14	100%	10.4	17%	14.7	33%	13.9
OH	12	100%	5.9	33%	18.7	0%	–
	14	100%	7.7	17%	12.6	0%	–
WA	12	100%	11.1	17%	24.3	0%	–
	14	100%	10.3	17%	17.3	17%	25.3
WI	12	100%	9.8	0%	–	0%	–
	14	100%	11.0	0%	–	0%	–

– indicates no test sections achieved given performance criteria to compute the average.
MA refers to the mean of the age of the pavement at the time of measurement while in each category.
[1] G: Good PLC indicates the test section had "Good" performance in PLC per Table 11.
[2] F: Fair PLC indicates the test section had "Fair" performance in PLC per Table 11.
[3] P: Poor PLC indicates the test section had "Poor" performance in PLC per Table 11.
[4] Widened lanes in California were 13 feet instead of 14 feet.

4.0 SUMMARY OF FINDINGS

For reasons stated previously, it is difficult to accurately estimate the service life for every SPS-2 test section. Instead, this analysis compared the mean age of test sections as they transitioned through stages of serviceability as defined by condition metrics. Table 14 shows a summary of the results from the mean age comparisons. The design factor with the most impact on service life was pavement thickness, followed by base type, PCC strength, and lane width. It was found that the relative service life benefit from design factors was significantly reduced in projects with lower traffic loading. Since traffic loading is a primary cause of pavement deterioration, a lack of traffic loading typically means longer service life. Therefore, the benefit from design factors in further extending that service life would take longer to manifest.

Table 14. Summary of Design Factor Impact on Service Life.

Design Factor	Relative Service Life Improvement	
	Regular Traffic	Lower Traffic
Thick pavements	4 years (15-20%)	2 years (10-15%)
PATB base type	2 years (10-15%)	<0.5 years
High-strength PCC	1-2 years (10%)	<0.5 years
Widened lanes	<0.5 years	N/A

N/A = service life improvement could not be assessed
Serviceability based on performance rating of MRI, AWF, and PCS only (excludes considerations for longitudinal cracking).

While the service life benefit from thicker pavements and PATB base type was consistently apparent, the benefit from high-strength PCC and widened lanes came with exceptions. The exceptions aligned with the findings from previous analyses using deterioration rates. High-strength PCC and widened lanes may provide for better performance in the early stage of a pavement's life. But in the later stages, these factors may lead to increased deterioration, potentially nullifying the initial benefit. The deterioration rate analyses had concluded low-strength PCC and standard lane widths typically lead to better performance in transverse and longitudinal cracking, respectively. The initial service life benefit from widened lanes was sufficiently minor that it should be considered negligible and may subject the pavement to the risk of longitudinal cracking in the future.

To further determine the impact widened lanes had on longitudinal cracking, a supplementary analysis was performed using the manufactured condition metric of PLC. This analysis determined that while widened lanes showed better performance in overall serviceability (i.e., MRI, AWF, and PCS) in the early stage, they had 1 to 2 years less service life purely in terms of PLC. This may be a contributing factor to the mixed and lackluster performance in the latter stages of the service life of widened-lane test sections in some projects.

The findings from this analysis were based on an aggregated approach, comparing averages by project. This was necessary to account for the compounding effects of multiple design factors, the variety of condition metrics, project-specific variables, and the subjectiveness of maintenance practices. Therefore, the quantities in Table 14 reflect a best-estimate based on data, expectations, and experience from the cumulative analyses performed through the course of this pooled-fund study.