Collaboration. Commitment. Confidence.℠

TPF-5(291) FINAL REPORT:

UPDATING PREVIOUS LTPP ANALYSES & THE SPS-2 EXPERIMENTAL MATRIX

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)

TABLE OF CONTENTS

LIST OF TABLES

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 reviews and, if practical, updates 12 previous analyses of SPS-2 projects.

2.0 OVERVIEW

For over 20 years, various analysts have investigated the performance of SPS-2 projects. Some of these analyses have been comprehensive, while others focused more narrowly on particular aspects of the experiment. Based on their relevance to this pooled fund study, 12 previous analyses of SPS-2 projects were selected, assessed, and updated. Some updates were purely a result of additional data collection since the time of original analysis, while others were sufficiently related to current work to confidently update and/or assess the original findings. Other studies, typically involving detailed analyses to a degree beyond that supported by this current project, did not have their results updated.

Analyses performed thus far by the research team for the TPF-5(291) SPS-2 Pavement Preservation Experiment have resulted in many findings related to the performance of SPS-2 test sections. These analyses include:

- Comparison of measured performance of SPS-2 test sections to performance predicted by MEPGD software. These performance measures included: roughness, faulting, and transverse cracking.
- Impact of SPS-2 core design features on measured performance and MEPGD predicted performance. Core design features include PCC thickness, PCC strength, base type, drainage, and lane width. The analyses did not focus of the impact of climate, traffic, materials (e.g., cement, aggregates, subgrade soil), or construction practices.
- Impact of SPS-2 core design features on deterioration rates of measured performance and MEPGD predicted performance. The analyses did not focus of the impact of climate, traffic, materials (e.g., cement, aggregates, subgrade soil), or construction methods, but did look at outside shoulder type. In addition to IRI, faulting, and transverse cracking, the analyses also evaluated the impact of design features on the deterioration rate of load transfer efficiency (LTE), mid-slab deflection, AREA value, lane shoulder drop-off and separation, corner breaks, longitudinal cracking, and transverse joint seal damage.

In addition, the initial SPS-2 experimental matrix was updated based on measured data (e.g., materials tests of subgrade, climatic information) and a matrix of all in-study test sections by project was created. The original SPS-2 matrix was based on assumptions with regards to existing conditions, and not every assumption (e.g., climate, subgrade type) was proven to be valid.

3.0 UPDATING PREVIOUS LTPP ANALYSES

The following reports were reviewed in chronological order, and key findings were identified. Based on the research conducted under the current study – TPF-5(291) – the findings from these reports were updated, confirmed, or not evaluated (i.e., no key findings were updated), as indicated in Table 1. Those not evaluated typically would involve substantial effort going beyond the scope of this investigation. In some cases, updated values have been provided using data collected since the time of the original analyses.

Table 1. Summary of Reviewed Reports and Updated Findings

Report No.		Summary of Updates
1	Ardani et al. 2000	Most key findings were not updated.
2	Perera and Kohn 2001	Most key findings were not updated.
3	Harrigan 2002	A key finding was updated.
4	Stubstad 2002	Most key findings were not updated.
5	Stubstad et al. 2002	No key findings were updated.
6	Hall and Correa 2003	Some key findings were updated.
7	Jiang and Darter 2005	Some key findings were updated.
8	Chatti et al. 2005	Some key findings were updated.
9	Hall and Crovetti 2007	Some key findings were updated.
10	Schmalzer et al. 2015	Some key findings were updated.
11	Xu and Cebon 2017	Most key findings were not updated.
12	Baladi et al. 2017	No key findings were updated.

1. **Author(s):** Ardani, Ahmad, Nadarajah Suthahar, and Dennis A. Morlan
   Title: Early Evaluation of Long-Term Pavement Performance Specific Pavement Studies-2
   Year: 2000
   Free Full Text Online: Yes

Key Findings:	Findings based on TPF-5(291):
(Colorado sections) Little difference in distress cracking between sections.	Confirmed finding that there was little difference in distress cracking between Colorado test sections.
Falling weight deflectometer (FWD) provided difference in load-carrying capacity of different sections.	Analyses did not evaluate load-carrying capacity of different sections.
Construction variability severe and could affect performance life of sections.	Analyses did not evaluate construction variability.
Widened slab design and tied-concrete shoulder design provided additional support compared to untied, standard-width lanes.	Analyses did not evaluate the additional support provided by tied concrete shoulders. However, change in mid-slab deflection over time was not affected by lane width or shoulder type.
Slab warping on higher-strength mixes on LCB.	Analyses did not evaluate the warping of slabs.
Thinner sections showed higher deflections after same traffic history – early fatigue failure likely to occur.	Analyses did not evaluate the impact of traffic loading on deflections. However, thinner sections had higher changes in mid-slab deflection over time.
State-designed standard section placed directly on subgrade with tied shoulder showed good structural response (low deflections).	Analyses did not evaluate this section specifically.
No difference in performance of drainable bases compared to other bases in this relatively dry climate.	Analyses did not evaluate the performance of different base types relative to climatic region. However, drained sections typically had better performance in most other SPS-2 projects.
Dense graded aggregate base (DGAB) sections showed the highest deflections, which agrees with relative stiffness of the base materials.	Analyses did not evaluate the total deflection of sections by base type.
Greater wear observed in 550 psi sections vs. 900 psi sections – future evaluation will determine if this results in shorter performance life or improved friction quality.	Confirmed finding that more wear was observed on 550 psi sections. PCC strength was typically found to have mixed results in terms of transverse and longitudinal cracking over time.

2. **Author(s):** Perera, R.W. and S.D. Kohn
   Title: LTPP Data Analysis - Factors Affecting Pavement Smoothness
   Year: 2001
   Free Full Text Online: Yes

Key Findings:	**Findings based on TPF-5(291):**
SPS-2 average early age IRI of the thin surfaces was 80 inch/mile with standard deviation of 18 inch/mile.	Initial IRI ranged from 50 to 140 inch/mile. Median initial IRI was close to 80 inch/mile.
Average early age IRI of the thick surfaces was 82 inch/mile with standard deviation of 19 inch/mile.	Analyses did not evaluate the average early age IRI of sections with different base types.
Changes in roughness in thin sections due to changes in curvature of slabs – in some case due to temperature changes – in many cases were not a result of temperature change (instead curling and warping just occurred over time).	Analyses did not evaluate the effect of slab curvature on roughness.
Average early-age IRI values for PCC pavements placed on DGAB, LCB, and permeable asphalt treated base (PATB) were 80 inch/mile, 89 inch/mile, and 79 inch/mile (highest on LCB).	Analyses did not evaluate the effect of slab curvature on roughness.
Section that showed an increase in roughness (greater than 10%) across all projects was the section with a thin PCC surface that had a slab width of 12 feet, a 14-day flexural strength of 550 psi, and was resting on a DGAB surface.	Analyses did not evaluate the commonality of sections with roughness increases greater than 10%. However, change is roughness was impacted by pavement thickness, base type, and drainage. The effect of PCC strength was not found to have a consistent effect on the change in roughness.

3. **Author(s):** Harrigan, E.T.
   Title: Performance of Pavement Subsurface Drainage
   Year: 2002
   Free Full Text Online: Yes

Key Findings:	**Findings based on TPF-5(291):**
Early performance data from SPS-2 supports that when PATB is used with jointed plain concrete pavement (JPCP), amount of cracking was very low in comparison with other base types	Sections with PATB bases typically had better performance in changes in roughness, faulting, transverse cracking, longitudinal cracking, and joint condition over time.

4. **Author(s):** Stubstad, Richard N.
   Title: LTPP Data Analysis: Feasibility of Using FWD Deflection Data to Characterize Pavement Construction Quality
   Year: 2002
   Free Full Text Online: Yes

Key Findings:	**Findings based on TPF-5(291):**
Correlations of unbound material parameters derived from FWD vs. traditional methods were fair to good. Bound material parameter correlations were good (coefficient of variation between 0.1 and 5.2).	Analyses did not evaluate pavement material properties, traffic loading, and construction quality.
Simple methods are available for determining pavement layer stiffness and provide reasonable results. Methods were unique in that they used forward calculation.	Analyses did not evaluate pavement material properties, traffic loading, and construction quality.
Analyses showed that FWD can be used effectively to delineate certain important aspects of new pavement construction quality (e.g., well vs. poorly compacted base).	Analyses did not evaluate pavement material properties, traffic loading, and construction quality.
FWD results obtained on unbound materials during LTPP pavement construction were very reasonable – in terms of drop-to-drop variations and deflection magnitude. Potential of overloading these materials was compared to the effect of traffic loadings.	Analyses did not evaluate pavement material properties, traffic loading, and construction quality.
FWD results "tracked" (load-normalized deflections in parallel from one layer to the next) reasonably well from layer to layer with each succeeding layer showing less variation. Sensors 3 or 4 tracked best on unbound, sensors 6 or 7 tracked best on bound.	Analyses did not evaluate pavement material properties, traffic loading, and construction quality.
FWD results on bound materials showed very small drop-to-drop variations and several different loading levels to choose from.	Analyses did not evaluate pavement material properties, traffic loading, and construction quality.
PCC surface FWD results did not track well with results on unbound layers below; deflections in PCC surface were not in parallel to deflections in unbound layers.	Analyses did not evaluate pavement material properties, traffic loading, and construction quality.

5. **Author(s):** Stubstad, Richard, Shiraz D. Tayabji, and Erland O. Lukanen,
   Title: LTPP Data Analysis - Variations in Pavement Design Inputs. National Cooperative Highway Research Program.
   Year: 2002
   Free Full Text Online: Yes

Key Findings:	**Findings based on TPF-5(291):**
Higher-strength concrete (900 psi) found to be less variable than lower-strength concrete (550 psi).	Analyses did not evaluate the variability of concrete strength.
Good control was achieved with concrete production (low variability in cylinder strength data) and in placement process (low variability in core test data).	Analyses did not evaluate the variability of concrete strength.
While 550 psi concrete test sections typically achieved 550 psi at 14 days, many of the 900 psi concrete test sections did not achieve their target value of 900 psi at 14 days.	Analyses did not evaluate the variability of concrete strength.
At 1 year, both 550 and 900 psi concretes exhibited similar flexural strength values and some 900 psi concretes did not show significant increase in strength between 14 days and 1 year.	Analyses did not evaluate the variability of concrete strength.
Modulus of Elasticity: Average cement volume (CV) for modulus of elasticity found to range between 13% (at 28 days and 1 year) for 550 psi concrete, and 12% (at 28 days) and 11% (at 1 year) for 900 psi concrete. No significant increase in modulus value between 28 days and 1 year.	Analyses did not evaluate the variability of concrete strength.
As average LTE increased, CV decreased.	Analyses did not evaluate the average LTE and the coefficient of variation.
Parameters that affected variability in LTE: pavements with subsurface drainage showed more variability than those without, pavements with granular soil subgrade(SG) showed more variability than with silty-clay SG, variability of average LTE decreased as annual freezing index increased, variability of average LTE indirectly related to pavement age through changes of average LTE.	Analyses did not evaluate variability of LTE. However, drainage did not have a clear effect on change in LTE over time.

Key Findings:	Findings based on TPF-5(291):
Parameters that did NOT affect variability in LTE: average joint spacing, base type, and outside shoulder type, the amount of annual precipitation, number of annual freeze-thaw cycles, and average mean annual temperature; no direct relationships between pavement age and variability of LTE.	Analyses did not evaluate variability of LTE. However, base type and shoulder type did not have a clear effect on change in LTE over time.

6. **Author(s):** Hall, Kathleen Theresa, and Carlos E. Correa
   Title: Effects of Subsurface Drainage on Performance of Asphalt and Concrete Pavements
   Year: 2003
   Free Full Text Online: Yes

Key Findings:	Findings based on TPF-5(291):
IRI Change – larger mean differences for PATB sections with poor drainage vs. good drainage – true in comparison to both undrained base types (DGAB and LCB).	Differences in the change in IRI for PATB sections with poor drainage vs. good drainage were unconfirmed. However, the change in roughness over time was typically higher for undrained sections.
Undrained sections with either DGAB or LCB may develop roughness, transverse cracking, and longitudinal cracking more rapidly than drained sections (typically having PATB base).	Confirmed that drained sections typically had lower deterioration rates for IRI, transverse and longitudinal cracking, and transverse joint seal condition in comparison to drained sections.
There were larger mean differences of transverse and longitudinal cracking for PATB sections with good drainage than sections with poor drainage.	Analyses did not evaluate the mean differences in transverse and longitudinal cracking. However, the change in transverse and longitudinal cracking over time was typically higher for undrained sections.

7. **Author(s):** Jiang, Y. Jane, and Michael I. Darter
   Title: Structural Factors of Jointed Plain Concrete Pavements: SPS-2 – Initial Evaluation and Analysis
   Year: 2005
   Free Full Text Online: Yes

Key Findings:	Findings based on TPF-5(291):
Initial IRI of SPS-2 sections ranged from 0.76 to 2.19 m/km, mean of 1.30 m/km.	Initial IRI ranged from 50 to 140 inch/mile (0.7-2.2 m/km). Median initial IRI was close to 80 inch/mile (1.3 m/km).

Key Findings:	**Findings based on TPF-5(291):**
Lower initial IRI for JPCP constructed on coarse-grained soil vs. fine-grained soil.	Analyses did not compare initial IRI for different soil types.
Lower initial IRI for JPCP constructed on PATB vs. LCB or untreated DGAB base.	Analyses did not compare initial IRI for different base types.
IRI trend over time depended heavily on initial IRI, traffic loading, and extent of joint faulting.	Confirmed change in IRI was heavily dependent on initial IRI with added influence from other potential factors.
Lowest longitudinal cracking levels on sections on PATB, highest on sections on LCB.	Change in longitudinal cracking was highest in sections with LCB and lowest in sections with PATB or DGAB – except in Arizona, where sections with DGAB had higher average changes in longitudinal cracking.
Thinner (203 mm) slabs showed more longitudinal cracks, sections with thinner slabs and widened slabs showed the highest level of longitudinal cracking.	Confirmed that thinner slabs showed more longitudinal cracks and widened slabs showed significantly more longitudinal cracking.
Sections with PATB showed lowest percentage of transverse cracks, highest on sections with LCB.	Confirmed that sections with PATB showed lowest percentage of transverse cracks, while sections with LCB showed the highest.
Thinner (203 mm) slabs showed more transverse cracks than thicker ones, sections with thinner slabs and widened slabs showed highest level of transverse cracking.	Confirmed that change in transverse cracking was typically higher for sections with thinner slabs and/or 12’ lane width.
Sections with DGAB base showed highest joint faulting level, sections with LCB and PATB had lowest joint faulting.	Analyses did not evaluate total faulting of sections with different base types. However, change in faulting was higher in sections with LCB than sections with PATB. Sections with DGAB did not consistently show higher rates of faulting from project to project.
Widened slab sections showed less faulting than conventional-width slabs.	Analyses did not evaluate total faulting of sections with different slab widths. However, change in faulting was higher in sections with conventional-width slabs than sections with widened slabs.

8. **Author(s):** Chatti, K, N. Buch, S.W. Haider, A.S. Pulipaka, R.W. Lyles, D. Gilliland, and P. Desaraju
Title: LTPP Data Analysis: Influence of Design and Construction Features on the Response and Performance of New Flexible and Rigid Pavements
Year: 2005
Free Full Text Online: Yes

Key Findings:	**Findings based on TPF-5(291):**
Transverse cracking: PCC slab thickness and base type were the most important factors, drainage had marginal effect.	PCC strength also had a marginal effect.
Transverse cracking and longitudinal cracking were at higher level in thin (203 mm) slabs vs. 279 mm slabs.	Confirmed that thin slabs had a negative performance impact in terms of transverse and longitudinal cracking.
Transverse cracking and longitudinal cracking were at higher level in sections with LCB vs. those with PATB or with DGAB. PATB and DGAB showed least occurrence of cracking.	Confirmed that LCB base type had a negative performance impact in terms of transverse and longitudinal cracking.
Sections without drainage had slightly higher likelihood of cracking than sections with drainage.	Confirmed that sections without drainage had a negative performance impact in terms of transverse and longitudinal cracking.
Among sections built on LCB, thin slabs had higher occurrence of transverse cracking and longitudinal cracking than thick slabs.	Confirmed that thin PCC sections with LCB bases had higher rates of transverse cracking.
Sections built on fine-grained soils had slightly higher chances of transverse cracking vs. sections built on coarse-grained soils.	Analyses did not focus on the impact of subgrade soil type on pavement performance.
Faulting: majority of SPS-2 sections exhibited “good” performance. One-third of sections had 0 to 20% of joints that faulted more than 1 mm, and 5% of sections had more than 20% of joints that faulted more than 1 mm.	Most SPS-2 sections have exhibited “good” performance, but the percent of joints faulted over 1 mm varied from project to project. Six projects had 0% sections with faulting over 1 mm of 0-20% of joints. Five projects had 5-10% sections with faulting over 1 mm of 0-20% of joints. Three projects had 15-58% sections with faulting over 1 mm of 0-20% of joints (Arkansas, Michigan, and North Dakota). Most undoweled sections also had faulting over 1 mm of 0-20% of joints.

Key Findings:	Findings based on TPF-5(291):
Lane width seemed to be most important factor for faulting of PCC joints. Standard lane width (3.7 m) showed higher faulting than a wider lane (4.3 m). Effect of lane width was more prominent among sections built on fine-grained soils vs. coarse-grained soils. Effect greater in WF zone.	Pavement thickness also had an important effect on faulting. Also, PCC strength and base type had a marginal effect.
Roughness: Drainage and base type seemed to be most important factors, whereas slab thickness had marginal effect.	Confirmed that base type and drainage had a significant impact of roughness, while slab thickness had a marginal effect in comparison.
Sections with PATB showed lower change in IRI vs. sections DGAB or LCB. DGAB had highest change in roughness.	Sections with LCB had the highest change in roughness. The change in roughness for sections with DGAB (relative to sections with other base types) was not consistent from project to project.
Among sections with standard lane width, sections with DGAB had higher change in IRI than those with LCB or PATB.	Analyses did not evaluate if test sections with standard lane width had higher IRI deterioration rates for sections with DGAB bases than sections with LCB or PATB bases.
Among sections built on fine-grained soils, those with thinner slabs had higher change in IRI than those with thicker slabs. Effect greater in wet-freeze (WF) zone. Among sections in WF zone and built on fine-grained soils, those with drainage had lower change in IRI vs. those without drainage.	Analyses did not evaluate if test sections with fine-grained soils had higher IRI deterioration rates for sections with thinner bases than sections with thicker bases.
Sections on DGAB had higher peak deflection under FWD load (d_0) than ones on PATB. Sections on LCB had least d_0 values. Thin slabs had higher d_0 than thick slabs. In WF zone, sections on fine SG soils had higher d_0 than those on coarse SG soils.	Analyses did not evaluate d_0 relative to different base types. However, the change in d_0 over time is not impacted by base type but rather pavement thickness.
Far sensor deflection (d_6): Sections on DGAB had higher d_6 than those on PTAB. Pavements on LCB had least d_6 values. Thinner slabs had higher d_6 values than thick slabs. In WF zones, sections built on fine SG soils had higher d_6 values than those on coarse SG soils.	Analyses did not evaluate the performance of d_6 sensor deflections.

Key Findings:	Findings based on TPF-5(291):
Thicker slabs had higher AREA value (AV) than thinner slabs. Among sections on LCB, those on coarse-grained SG had higher AV than those on fine-grained SG. These effects were not significant for final survey AV values. Sections with 900 psi concrete had higher AF than 550 psi concrete. Sections in wet climate had higher AV than those in dry climate.	Analyses did not evaluate the impact of design factors on AV relative to subgrade soil type. However, the change in AV over time was not consistently impacted by any particular design factor.
Effect of slab thickness on effective stiffness (ES) was more prominent among sections on DGAB than those on LCB. The effect of PCC flexural strength on ES was more apparent for pavements on DGAB or PATB than for those on LCB. Sections on coarse-grained SG soil stiffer than those on fine-grained SG soil. Effects of slab thickness and base type on ES from final survey similar as in case of initial ES. Pavements built with drainage have higher ES than those without drainage. Also, pavements with high strength concrete have higher ES than those with low strength concrete.	Analyses did not evaluate the impact of design factors on ES.

9. **Author(s):** Hall, Kathleen Theresa, and James A. Crovetti
   Title: Effects of Subsurface Drainage on Pavement Performance: Analysis of the SPS-1 and SPS-2 Field Sections
   Year: 2007
   Free Full Text Online: Yes

Key Findings:	Findings based on TPF-5(291):
Sections expected to be weakest (with DGAB) did not have back-calculated effective pavement thickness much different from sections with PATB.	Analyses did not evaluate back-calculated thickness.
Effective thickness of sections with LCB was notably greater than effective thickness of otherwise similar sections with the other two base types.	Analyses did not evaluate back-calculated thickness.
Leave-side load transfer values greater than approach-side, but insensitive to slab temperature.	Analyses did not confirm the sensitivity of slab temperature. However, the change in LTE over time was similar for the leave-side and approach-side of the transverse joint.

Key Findings:	Findings based on TPF-5(291):
Load transfer in sections with DGAB and LCB no worse than PATB sections.	Analyses did not evaluate the impact of base type on average LTE. However, the change in LTE over time was not found to be impacted by base type.
Long-term IRI for sections with DGAB and LCB similar and higher than for PATB sections.	Analyses did not evaluate the impact of base type on long-term IRI. However, the change in roughness was higher for sections with LCB base and lower for that with PATB base. The impact of DGAB base on change in IRI varied from project to project.
Changes in IRI over time greater in DGAB and LCB, followed by PATB.	Sections with LCB had the highest change in roughness and sections with PATB base had the lowest change in roughness. The change in roughness for sections with DGAB (relative to sections with other base types) was not consistent from project to project.
Undrained hot-mix asphalt concrete base had highest median initial IRI, but showed smaller changes in IRI than PATB, so had similar long-term IRI to PATB.	Analyses did not evaluate the impact of base type on initial IRI. However, undrained sections had a higher change in roughness than drained sections. It was not clear how well the drains were functioning.
Undrained LCB base had smallest changes in IRI and lowest long-term IRI than any of the drainage/base combinations.	Analyses did not evaluate the impact of base type on long-term IRI. However, undrained sections had a higher change in roughness than drained sections. It was not clear how well the drains were functioning.
Latest observed IRI and rates of change in IRI concluded to be due mainly to base stiffness. Effect of drainage not ruled out but shown to have little effect.	Pavement thickness was also an important factor in the change in IRI.
Sections with LCB and PATB had similar levels of faulting; sections with DGAB developed more faulting.	Base type and PCC strength had a marginal effect on the change in faulting. Pavement thickness and lane width had a more significant effect.
60% of sections with LCB developed cracking compared to 30% of sections with DGAB or PATB. Sections with DGAB had more cracking than sections with PATB.	Sections with LCB typically had a higher rate of transverse cracking and sections with PATB had a lower rate of transverse cracking. Sections with DGAB had transverse cracking rates similar to sections with PATB except in the case of sites in California and Ohio.

Key Findings:	Findings based on TPF-5(291):
Cracking issues attributed more to base stiffness than to drainage.	Analyses did not evaluate the effect base stiffness on cracking issues. However, the change in transverse cracking over time was typically higher for undrained sections.

10. **Author(s):** Schmalzer, Peter Steven Karamihas, Hans Meyer, Kevin Senn, and Jason Puccinelli
    Title: Performance Evaluation of Arizona's LTPP SPS-2 Project
    Year: 2015
    Free Full Text Online: Yes

Key Findings:	Findings based on TPF-5(291):
State 406 bituminous-treated base (BTB) performed better than PATB section in all measured deflection parameters. Roughness and distress performance were similar from a comparison of only one pair of sections.	Analyses did not specifically evaluate State 406 BTB.
Role of drained sections (PATB) to get better pavement performance unclear in this study.	Drained pavements typically had better performance in roughness, transverse cracking, longitudinal cracking, and joint condition. However, this trend was unclear in the Arizona SPS-2.
Slabs on LCB had greatest decline in stiffness, developed more transverse and longitudinal cracking. Change in IRI was less than for other sections, and in some cases IRI improved.	Change in IRI was typically higher for sections with LCB, but in Arizona, sections with DGAB had higher changes in IRI.
LCB sections did not show changes in IRI proportional to amount of cracking – roughness and roughness progression alone cannot be used to assess health of section.	Analyses did not evaluate the changes in IRI in proportion to the amount of cracking. However, sections with LCB had higher change in transverse cracking over time (both in Arizona and in general). DGAB sections in Arizona showed more change in roughness than other base types – this trend was not seen in most other SPS-2 projects.
Curl and warp contributed to, and in some cases dominated, roughness.	Analyses did not evaluate the effect of curl and warp on roughness.

Key Findings:	**Findings based on TPF-5(291):**
Map cracking found in multiple sections; dynamic loading before section 040214 may be cause of map cracking but it was unclear. High-strength sections with greatest declines in stiffness affected by map cracking. ASR was not contributor.	Analyses did not evaluate map cracking, dynamic loading, and ASR.
Thicker sections showed greater slab stiffness, subgrade support, cracking resistance, and performed as expected under deflection and distress analysis.	Analyses did not evaluate slab stiffness, subgrade support, and cracking resistance. However, thicker sections performed better in a number of performance measures related to cracking and deflection (both in Arizona and in general).
Wider (14-foot) sections had better LTE between joints and the least lane-to-shoulder drop compared to thinner (12-foot) sections.	Less lane-to-shoulder drop-off was not confirmed for wider slabs. However, wider slabs did have less change in LTE over time (both in Arizona and in general).
Undoweled DGAB sections (040262 and 040265) had most faulting. DGAB sections had better LTE than PATB sections – as measured at slab leave. LTE measured at slab approach tested similar for DGAB and PATB – perhaps formation of voids under leave edge due to erosion of DGAB material.	Analyses did not evaluate faulting for doweled vs. undoweled sections. However, change in LTE was higher for DGAB and PATB at the slab leave. Typically, base type did not significantly affect change in LTE over time in most other SPS-2 projects.

11. **Author(s):** Changwei Xu and David Cebon
    Title: Analysis of Cracking in Jointed Plain Concrete Pavements
    Year: 2017
    Free Full Text Online: Yes

Key Findings:	**Findings based on TPF-5(291):**
Severity of longitudinal and transverse cracking sensitive to slab thickness. Slab width and strength had a less clear effect.	Slab thickness (along with base type and drainage) did have an impact on cracking. High-strength PCC and wider lanes showed mixed results – better performance in transverse cracking and poorer performance in longitudinal cracking.
Cracks occurred earlier and were more severe in dry zones.	Analyses did not compare the severity of cracks in different climate zones.
Two longitudinal cracking patterns: single, long crack 1 meter from edge of slab adjacent to shoulder and short crack near center line of slab (neither of any specific length).	Analyses did not evaluate the location of longitudinal cracks.

Key Findings:	Findings based on TPF-5(291):
Most longitudinal cracks initiated from slab transverse edges. Most transverse cracks initiated from the slab longitudinal edge close to shoulder.	Analyses did not evaluate the initiation point of longitudinal cracks.
In Arkansas (wet zone), edge pumping occurred as result of crack as opposed to vice versa.	Analyses did not evaluate edge pumping.
Plausible explanation for premature cracking was occurrence of voiding in foundation soil due to localized plastic deformation.	Analyses did not evaluate premature cracking.

12. **Author(s):** Gilbert Y. Baladi, Tyler Dawson, Gopikrishna Musunuru, Michael Prohaska, and Kyle Thomas
    Title: Pavement Performance Measures and Forecasting and the Effects of Maintenance and Rehabilitation Strategy on Treatment Effectiveness
    Year: 2017
    Free Full Text Online: Yes

Key Findings:	Findings based on TPF-5(291):
Majority of SPS-2 section in wet-no-freeze (WNF) region performed worse in terms of longitudinal cracking than those in the dry-no-freeze (DNF) region – impact of excessive moisture on pavement performance.	Analyses did not evaluate cracking as impact of climatic region.
On average, IRI was not affected by the climatic region, but the data indicated that SPS-2 sections in the WF region performed slightly worse than compatible sections in the other three climatic regions.	Analyses did not evaluate cracking as impact of climatic region.
The WF region had a more damaging impact in terms of transverse cracking than those in WNF, dry-freeze (DF), or DNF regions.	Analyses did not evaluate cracking as impact of climatic region.

4.0 UPDATING SPS-2 EXPERIMENTAL MATRIX

Table 2 shows the as-nominated experimental matrix for half-factorial experiment design of the SPS-2 experiment. Table 3 shows the as-constructed experimental matrix for SPS-2 test sections using measured data to update the climatic regions and provide ranges for pavement thickness and modulus of rupture (indicative of the flexural strength of PCC).

Cells with light-gray shading indicate test sections that are currently out-of-study. Bold font indicates test sections that were constructed with different design features than as-nominated. Most of the projects were constructed as nominated; however, there were some exceptions:

- In Iowa, test sections 0216 and 0219 were interchanged so that the sections have different lane widths than as-nominated.
- In Kansas, test section 0212 has no drainage according to the LTPP database.
- In Arkansas, test sections 0222 and 0223 have a fine subgrade soil type.
- In Colorado, test sections 0214, 0216, 0219, 0223, and 0224 have a coarse subgrade soil type.
- In Nevada, all test sections have a fine subgrade soil type, except for 0201. Test section 0210 could be considered on the borderline of a thick, low-strength PCC section, with a PCC layer thickness of 10.1 inches and modulus of rupture of 740 psi. Lastly, the Nevada SPS-2 site does not have a section 0212.
- Ohio test section 0212 and Arkansas test section 0224 had low 14-day moduli of rupture but gained high moduli of rupture at 28 days and 1 year.

Tables 4 and 5 provide measurement data more specific to the project or individual test section. Table 4 includes average annual precipitation, average freezing index, climatic region, and KESALs per year. Table 5 provides drainage type, outside shoulder type, base type, lane width, layer thickness, modulus of rupture (14-day, 28-day, and 1-year), subgrade soil type, and status.

Table 2. As-Nominated Experimental Matrix for Half-Factorial Experiment Design for SPS-2 Experiment.

Pavement Structure					Core Test Sections by Climatic Conditions, Subgrade Soil Type, and State															
Drainage	Base Type	PCC Thickness, in.	Flexural Strength, psi (14-d)	Lane Width, ft	Wet								Dry							
					Freeze						No-Freeze		Freeze					No-Freeze		
					Fine			Coarse			Fine	Coarse	Fine				Coarse	Fine	Coarse	
					OH	IA	MI	DE	AR	WI	NC		KS	WA	ND	CO	NV		CA	AZ
No	DGAB	8	550	12	1			1			1		1	1			1		1	
				14		13	13		13	13					13	13				13
			900	12		14	14		14	14					14	14				14
				14	2			2			2		2	2			2		2	
		11	550	12		15	15		15	15					15	15				15
				14	3			3			3		3	3			3		3	
			900	12	4			4			4		4	4			4		4	
				14		16	16		16	16					16	16				16
	LCB	8	550	12	5			5			5		5	5			5		5	
				14		17	17		17	17					17	17				17
			900	12		18	18		18	18					18	18				18
				14	6			6			6		6	6			6		6	
		11	550	12		19	19		19	19					19	19				19
				14	7			7			7		7	7			7		7	
			900	12	8			8			8		8	8			8		8	
				14		20	20		20	20					20	20				20
Yes	PATB	8	550	12	9			9			9		9	9			9		9	
				14		21	21		21	21					21	21				21
			900	12		22	22		22	22					22	22				22
				14	10			10			10		10	10			10		10	
		11	550	12		23	23		23	23					23	23				23
				14	11			11			11		11	11			11		11	
			900	12	12			12			12		12	12			12		12	
				14		24	24		24	24					24	24				24

Table 3. As-Constructed Experimental Matrix for Half-Factorial Experiment Design for SPS-2 Experiment.

Pavement Structure					Core Test Sections by Climatic Conditions, State, and Shoulder Type													
Drainage	Base Type	PCC Thickness, in.	Modulus of Rupture, psi (14-d)	Lane Width, ft	Wet							Dry						
					Freeze				No-Freeze			Freeze			No-freeze			
					ND	WI	IA	MI	OH	KS	DE	NC	AR	CO	WA	NV	AZ	CA
					AC	AC	AC	AC	AC	PCC	AC	PCC	AC	PCC	AC	PCC	PCC	PCC
No	DGAB	7.7-9.2	520-736	12					1^{F}	1^{F}	1^{C}	1^{F}			1^{F}	1^{C}		1^{C}
		7.4-8.7	500-645	14	13^{F}	13^{C}	13^{F}	13^{F}					13^{C}	13^{F}			13^{C}	
		8-8.8	700-975	12	14^{F}	14^{C}	14^{F}	14^{F}					14^{C}	$14^{\mathbf{C}}$			14^{C}	
		7.5-8.9	713-920	13/14					2^{F}	2^{F}	2^{C}	2^{F}			2^{F}	$2^{\mathbf{F}}$		2^{C}
		11-11.7	510-625	12	15^{F}	15^{C}	15^{F}	15^{F}					15^{C}	15^{F}			15^{C}	
		11.1-11.9	413-645	13/14					3^{F}	3^{F}	3^{C}	3^{F}			3^{F}	$3^{\mathbf{F}}$		3^{C}
		11-11.8	784-885	12			$\mathbf{16}^{F}$		4^{F}	4^{F}	4^{C}	4^{F}			4^{F}	$4^{\mathbf{F}}$		4^{C}
		11-11.9	790-900	14	16^{F}	16^{C}		16^{F}					16^{C}	$16^{\mathbf{C}}$			16^{C}	
	LCB	7.3-9.2	487-750	12					5^{F}	5^{F}	5^{C}	5^{F}			5^{F}	5^{C}		5^{C}
		7.8-8.6	508-564	14	17^{F}	17^{C}	17^{F}	17^{F}					17^{C}	17^{F}			17^{C}	
		7.3-8.5	810-960	12	18^{F}	18^{C}	18^{F}	18^{F}					18^{C}	18^{F}			18^{C}	
		7.7-8.9	730-829	13/14					6^{F}	6^{F}	6^{C}	6^{F}			6^{F}	$6^{\mathbf{F}}$		6^{C}
		9.9-11.6	506-620	12	19^{F}	19^{C}		19^{F}					19^{C}	$19^{\mathbf{C}}$			19^{C}	
		10.9-11.7	440-650	13/14			$\mathbf{19}^{F}$		7^{F}	7^{F}	7^{C}	7^{F}			7^{F}	$7^{\mathbf{F}}$		7^{C}
		10.7-12.1	620-855	12					8^{F}	8^{F}	8^{C}	8^{F}			8^{F}	$8^{\mathbf{F}}$		8^{C}
		10.7-11.4	770-970	14	20^{F}	20^{C}	20^{F}	20^{F}					20^{C}	20^{F}			20^{C}	
DB/LD	PATB	8.2-9	624-624	12					9^{F}	$9^{LD,F}$	9^{C}	9^{F}			9^{F}	$9^{\mathbf{F}}$		9^{C}
		8-9	475-521	14	21^{F}	21^{C}	21^{F}	21^{F}					21^{C}	21^{F}			21^{C}	
		8.1-8.8	945-950	12	22^{F}	22^{C}	22^{F}	22^{F}					$22^{\mathbf{F}}$	22^{F}			22^{C}	
		8-9.1	924-924	13/14					10^{F}	$10^{LD,F}$	10^{C}	10^{F}			10^{F}			10^{C}
		10.9-12	460-665	12	23^{F}	23^{C}	23^{F}	23^{F}					$23^{\mathbf{F}}$	$23^{\mathbf{C}}$			23^{C}	
		11.2-12.1	494-749	13/14					11^{F}	$11^{LD,F}$	11^{C}	11^{F}			11^{F}	$11^{\mathbf{F}}$		11^{C}
		10.8-12.4	438-865	12					12^{F}	$12^{\mathbf{ND},F}$	12^{C}	12^{F}			12^{F}			12^{C}
		10.1-11.7	506-870	14	24^{F}	24^{C}	24^{F}	24^{F}					24^{C}	$24^{\mathbf{C}}$		$\mathbf{10}^{\mathbf{F}}$	24^{C}	

States are listed in order of Average Freezing Index.
Values in light gray shading indicate test sections that are out-of-study as of July 2020.
Values in **bold** indicate test sections that have a different design than as-nominated.
AC/PCC – the outside shoulder type for core test section at the SPS-2 site.
13/14 – CA sections have 13-foot-wide lanes while others have 14-foot-wide lanes.
DB/LD – Drainage blanket with longitudinal drains.
LD – Longitudinal drains only.
ND – No drainage.
F – Subgrade material is classified as a fine soil type.
C – Subgrade material is classified as a coarse soil type.

Table 4. Measured Climate and Traffic for SPS-2 Experiment.

State Code	Average Annual Precipitation (in.)	Average Freezing Index (°C days)	Climatic Region	KESALs per Year
4	7.5	0	Dry, No-freeze	1,610
5	53.3	28	Wet, No-freeze	3,560
6	10.9	0	Dry, No-freeze	1,870
8	14.3	302	Dry, Freeze	390
10	45.8	87	Wet, Freeze	250
19	35.6	548	Wet, Freeze	570
20	33.4	252	Wet, Freeze	720
26	34.5	370	Wet, Freeze	1,870
32	9.7	190	Dry, Freeze	730
37	43.8	32	Wet, No-freeze	760
38	25.2	1283	Wet, Freeze	480
39	41.2	327	Wet, Freeze	630
53	12.2	207	Dry, Freeze	420
55	33.5	913	Wet, Freeze	280

Table 5. Measured Design Factors for SPS-2 Experiment.

State Code	SHRP D	Drainage Type	Shoulder Type	Base Type	Lane Width	PCC Thickness	Modulus of Rupture (psi)			Subgrade Soil Type	Active as of July 2020
							14-day	28-day	1-year		
4	0213	ND	PCC	DGAB	14'	7.9"	560	630	850	Coarse	Yes
4	0214	ND	PCC	DGAB	12'	8.3"	810	840	960	Coarse	Yes
4	0215	ND	PCC	DGAB	12'	11"	580	685	945	Coarse	Yes
4	0216	ND	PCC	DGAB	14'	11.2"	790	825	890	Coarse	Yes
4	0217	ND	PCC	LCB	14'	8.1"	—	—	—	Coarse	Yes
4	0218	ND	PCC	LCB	12'	8.3"	860	925	970	Coarse	Yes
4	0219	ND	PCC	LCB	12'	10.8"	575	680	805	Coarse	Yes
4	0220	ND	PCC	LCB	14'	11.2"	810	840	975	Coarse	Yes
4	0221	DB/LD	PCC	PATB	14'	8.1"	—	—	—	Coarse	Yes
4	0222	DB/LD	PCC	PATB	12'	8.6"	945	950	1085	Coarse	Yes
4	0223	DB/LD	PCC	PATB	12'	11.1"	—	—	—	Coarse	Yes
4	0224	DB/LD	PCC	PATB	14'	10.6"	805	825	915	Coarse	Yes
4	0262	ND	PCC	DGAB	14'	8.1"	580	670	845	Coarse	Yes
4	0263	LD	PCC	PATB	14'	8.2"	—	—	—	Coarse	Yes
4	0264	LD	PCC	PATB	12'	11.5"	—	—	890	Coarse	Yes
4	0265	ND	PCC	DGAB	12'	10.8"	515	545	690	Coarse	Yes
4	0266	ND	PCC	HMAC	14'	12.3"	—	—	—	Coarse	Yes
4	0267	ND	PCC	HMAC	14'	11.3"	570	580	815	Coarse	Yes
4	0268	ND	PCC	HMAC	14'	8.5"	520	625	770	Coarse	Yes
5	0213	ND	AC	DGAB	14'	7.4"	568	414	585	Coarse	No
5	0214	ND	AC	DGAB	12'	8.4"	—	—	—	Coarse	No
5	0215	ND	AC	DGAB	12'	11.5"	—	—	—	Coarse	No
5	0216	ND	AC	DGAB	14'	11"	—	—	—	Coarse	No
5	0217	ND	AC	LCB	14'	8.3"	564	491	630	Coarse	No
5	0218	ND	AC	LCB	12'	8.2"	825	557	1000	Coarse	No

State Code	SHRP D	Drainage Type	Shoulder Type	Base Type	Lane Width	PCC Thickness	Modulus of Rupture (psi)			Subgrade Soil Type	Active as of July 2020
							14-day	28-day	1-year		
5	0219	ND	AC	LCB	12'	11.1"	506	439	730	Coarse	No
5	0220	ND	AC	LCB	14'	10.7"	—	—	—	Coarse	No
5	0221	DB/LD	AC	PATB	14'	8.3"	521	555	625	Coarse	No
5	0222	DB/LD	AC	PATB	12'	8.3"	—	—	—	Fine	No
5	0223	DB/LD	AC	PATB	12'	10.9"	568	493	630	Fine	No
5	0224	DB/LD	AC	PATB	14'	10.9"	506	752	814	Coarse	No
6	0201	ND	PCC	DGAB	12'	8.3"	—	—	—	Coarse	No
6	0202	ND	PCC	DGAB	13'	8"	—	—	—	Coarse	Yes
6	0203	ND	PCC	DGAB	13'	11.4"	—	—	—	Coarse	Yes
6	0204	ND	PCC	DGAB	12'	11.1"	—	—	—	Coarse	No
6	0205	ND	PCC	LCB	12'	8.2"	—	—	—	Coarse	Yes
6	0206	ND	PCC	LCB	13'	8"	—	—	—	Coarse	Yes
6	0207	ND	PCC	LCB	13'	11"	—	—	—	Coarse	Yes
6	0208	ND	PCC	LCB	12'	10.7"	—	—	—	Coarse	Yes
6	0209	DB/LD	PCC	PATB	12'	8.4"	—	—	—	Coarse	Yes
6	0210	DB/LD	PCC	PATB	13'	8.6"	—	—	—	Coarse	Yes
6	0211	DB/LD	PCC	PATB	13'	12.1"	—	—	—	Coarse	Yes
6	0212	DB/LD	PCC	PATB	12'	11.1"	—	—	—	Coarse	Yes
8	0213	ND	PCC	DGAB	14'	8.6"	520	630	710	Fine	Yes
8	0214	ND	PCC	DGAB	12'	8.4"	930	950	950	Coarse	Yes
8	0215	ND	PCC	DGAB	12'	11.5"	510	580	650	Fine	No
8	0216	ND	PCC	DGAB	14'	11.9"	900	925	870	Coarse	Yes
8	0217	ND	PCC	LCB	14'	8.6"	508	588	680	Fine	No
8	0218	ND	PCC	LCB	12'	7.6"	810	950	840	Fine	Yes
8	0219	ND	PCC	LCB	12'	9.9"	515	640	655	Coarse	Yes
8	0220	ND	PCC	LCB	14'	11.2"	925	987.5	950	Fine	Yes

State Code	SHRP D	Drainage Type	Shoulder Type	Base Type	Lane Width	PCC Thickness	Modulus of Rupture (psi)			Subgrade Soil Type	Active as of July 2020
							14-day	28-day	1-year		
8	0221	DB/LD	PCC	PATB	14'	8.3"	475	470	620	Fine	No
8	0222	DB/LD	PCC	PATB	12'	8.5"	950	952	1008	Fine	Yes
8	0223	DB/LD	PCC	PATB	12'	11.7"	595	560	—	Coarse	Yes
8	0224	DB/LD	PCC	PATB	14'	11.6"	815	700	1050	Coarse	Yes
8	0259	ND	PCC		12'	11.9"	680	793	768	Coarse	Yes
10	0201	ND	AC	DGAB	12'	8.3"	—	—	—	Coarse	No
10	0202	ND	AC	DGAB	14'	8.8"	920	1190	1120	Coarse	No
10	0203	ND	AC	DGAB	14'	11.7"	—	—	—	Coarse	No
10	0204	ND	AC	DGAB	12'	11"	—	—	—	Coarse	No
10	0205	ND	AC	LCB	12'	9.2"	750	930	970	Coarse	No
10	0206	ND	AC	LCB	14'	8.9"	—	—	—	Coarse	No
10	0207	ND	AC	LCB	14'	11.3"	550	650	680	Coarse	No
10	0208	ND	AC	LCB	12'	12.1"	620	730	680	Coarse	No
10	0209	DB/LD	AC	PATB	12'	8.2"	—	—	—	Coarse	No
10	0210	DB/LD	AC	PATB	14'	8.3"	—	—	—	Coarse	No
10	0211	DB/LD	AC	PATB	14'	11.8"	670	720	740	Coarse	No
10	0212	DB/LD	AC	PATB	12'	12.4"	730	730	710	Coarse	No
10	0259	LD	AC	DGAB	12'	10.2"	750	840	770	Coarse	No
10	0260	LD	AC	DGAB	12'	10.2"	710	730	—	Coarse	No
19	0213	ND	AC	DGAB	14'	8.7"	500	590	610	Fine	Yes
19	0214	ND	AC	DGAB	12'	8.4"	700	770	890	Fine	Yes
19	0215	ND	AC	DGAB	12'	11.7"	—	—	—	Fine	Yes
19	0216	ND	AC	DGAB	12'	11.6"	—	—	—	Fine	Yes
19	0217	ND	AC	LCB	14'	7.8"	—	—	—	Fine	Yes
19	0218	ND	AC	LCB	12'	8.3"	—	—	—	Fine	Yes
19	0219	ND	AC	LCB	14'	11.3"	440	530	590	Fine	Yes

State Code	SHRP D	Drainage Type	Shoulder Type	Base Type	Lane Width	PCC Thickness	Modulus of Rupture (psi)			Subgrade Soil Type	Active as of July 2020
							14-day	28-day	1-year		
19	0220	ND	AC	LCB	14'	11.4"	770	720	770	Fine	Yes
19	0221	DB/LD	AC	PATB	14'	9"	—	—	—	Fine	Yes
19	0222	DB/LD	AC	PATB	12'	8.3"	—	—	—	Fine	Yes
19	0223	DB/LD	AC	PATB	12'	12"	460	520	680	Fine	Yes
19	0224	DB/LD	AC	PATB	14'	11"	790	750	930	Fine	Yes
19	0259	DB/LD	AC	DGAB	14'	8.5"	—	—	—	Fine	Yes
20	0201	ND	PCC	DGAB	12'	7.7"	605.5	638	692	Fine	Yes
20	0202	ND	PCC	DGAB	14'	7.5"	803	911	915	Fine	Yes
20	0203	ND	PCC	DGAB	14'	11.2"	595	656	744	Fine	Yes
20	0204	ND	PCC	DGAB	12'	11.3"	784	849	816	Fine	Yes
20	0205	ND	PCC	LCB	12'	7.3"	702	706	722	Fine	Yes
20	0206	ND	PCC	LCB	14'	7.7"	829	928	904	Fine	Yes
20	0207	ND	PCC	LCB	14'	10.9"	559.5	645	715	Fine	Yes
20	0208	ND	PCC	LCB	12'	10.9"	855	1035	883	Fine	Yes
20	0209	LD	PCC	PATB	12'	8.4"	624	576	746	Fine	Yes
20	0210	LD	PCC	PATB	14'	8.5"	924	839	1002	Fine	Yes
20	0211	LD	PCC	PATB	14'	11.2"	576	674	693	Fine	Yes
20	0212	ND	PCC	PATB	12'	11.1"	865	990	992	Fine	Yes
20	0259	ND	PCC	CTB	12'	11.9"	617.5	677	738	Fine	Yes
26	0213	ND	AC	DGAB	14'	8.3"	645	760	915	Fine	No
26	0214	ND	AC	DGAB	12'	8.8"	975	980	1000	Fine	No
26	0215	ND	AC	DGAB	12'	11.1"	585	900	915	Fine	No
26	0216	ND	AC	DGAB	14'	11.3"	—	—	—	Fine	No
26	0217	ND	AC	LCB	14'	8.4"	—	—	—	Fine	No
26	0218	ND	AC	LCB	12'	7.3"	—	—	—	Fine	No
26	0219	ND	AC	LCB	12'	11.3"	620	1040	835	Fine	No

State Code	SHRP D	Drainage Type	Shoulder Type	Base Type	Lane Width	PCC Thickness	Modulus of Rupture (psi)			Subgrade Soil Type	Active as of July 2020
							14-day	28-day	1-year		
26	0220	ND	AC	LCB	14'	11.2"	970	1015	965	Fine	No
26	0221	DB/LD	PCC	PATB	14'	8.1"	—	—	—	Fine	No
26	0222	DB/LD	AC	PATB	12'	8.3"	—	—	—	Fine	No
26	0223	DB/LD	AC	PATB	12'	11"	—	—	—	Fine	No
26	0224	DB/LD	AC	PATB	14'	11.1"	840	940	875	Fine	No
26	0259	ND	PCC	PATB	12'	11.3"	690	790	970	Fine	No
32	0201	ND	PCC	DGAB	12'	9.2"	520	575	605	Coarse	No
32	0202	ND	PCC	DGAB	14'	8.2"	—	—	—	Fine	No
32	0203	ND	PCC	DGAB	14'	11.9"	—	—	—	Fine	No
32	0204	ND	PCC	DGAB	12'	11.8"	885	890	920	Fine	No
32	0205	ND	PCC	LCB	12'	8.5"	—	—	—	Coarse	No
32	0206	ND	PCC	LCB	14'	7.8"	730	840	845	Fine	No
32	0207	ND	PCC	LCB	14'	10.9"	490	525	575	Fine	No
32	0208	ND	PCC	LCB	12'	11"	—	—	—	Fine	No
32	0209	DB/LD	PCC	PATB	12'	8.9"	—	—	—	Fine	No
32	0210	DB/LD	PCC	PATB	14'	10.1"	740	785	850	Fine	No
32	0211	DB/LD	PCC	PATB	14'	11.3"	555	585	715	Fine	No
32	0259	ND	PCC	HMAC	12'	10.8"	—	—	—	Coarse	No
37	0201	ND	PCC	DGAB	12'	9.2"	736	564	824	Fine	No
37	0202	ND	PCC	DGAB	14'	8.9"	—	1020	1065	Fine	No
37	0203	ND	PCC	DGAB	14'	11.9"	—	—	—	Fine	Yes
37	0204	ND	PCC	DGAB	12'	11.6"	—	—	—	Fine	Yes
37	0205	ND	PCC	LCB	12'	8"	—	—	—	Fine	No
37	0206	ND	PCC	LCB	14'	8.4"	—	993.5	1034	Fine	No
37	0207	ND	PCC	LCB	14'	11.7"	650	736	972	Fine	Yes
37	0208	ND	PCC	LCB	12'	11.2"	—	—	—	Fine	Yes

State Code	SHRP D	Drainage Type	Shoulder Type	Base Type	Lane Width	PCC Thickness	Modulus of Rupture (psi)			Subgrade Soil Type	Active as of July 2020
							14-day	28-day	1-year		
37	0209	DB/LD	PCC	PATB	12'	8.6"	—	—	—	Fine	No
37	0210	DB/LD	PCC	PATB	14'	9.1"	—	—	—	Fine	No
37	0211	DB/LD	PCC	PATB	14'	11.5"	—	—	—	Fine	Yes
37	0212	DB/LD	PCC	PATB	12'	11.2"	850	—	1010	Fine	Yes
37	0259	DB/LD	PCC	ATB	12'	10.8"	578	616	789	Fine	Yes
37	0260	LD	PCC	ATB	14'	11.6"	663	642	955	Fine	Yes
38	0213	ND	AC	DGAB	14'	8.1"	—	710	785	Fine	Yes
38	0214	ND	AC	DGAB	12'	8"	—	—	895	Fine	Yes
38	0215	ND	AC	DGAB	12'	11"	—	—	710	Fine	Yes
38	0216	ND	AC	DGAB	14'	11.1"	—	980	920	Fine	Yes
38	0217	ND	AC	LCB	14'	7.9"	—	665	705	Fine	Yes
38	0218	ND	AC	LCB	12'	7.9"	—	—	930	Fine	Yes
38	0219	ND	AC	LCB	12'	10.9"	—	—	750	Fine	Yes
38	0220	ND	AC	LCB	14'	11"	—	910	890	Fine	Yes
38	0221	DB/LD	AC	PATB	14'	8"	—	630	—	Fine	Yes
38	0222	DB/LD	AC	PATB	12'	8.1"	—	—	690	Fine	Yes
38	0223	DB/LD	AC	PATB	12'	11.1"	—	—	700	Fine	Yes
38	0224	DB/LD	AC	PATB	14'	10.9"	—	—	950	Fine	Yes
38	0259	DB/LD	PCC	PATB	12'	9.7"	—	—	830	Fine	Yes
38	0260	ND	PCC	DGAB	12'	11"	—	—	893	Fine	Yes
38	0261	ND	AC	DGAB	12'	11"	—	—	695	Fine	Yes
38	0262	ND	AC	LCB	14'	11.1"	—	640	680	Fine	Yes
38	0263	DB/LD	AC	PATB	12'	11"	—	—	835	Fine	Yes
38	0264	DB/LD	PCC	PATB	12'	11"	—	820	860	Fine	Yes
39	0201	ND	AC	DGAB	12'	7.9"	659	831	850	Fine	No
39	0202	ND	AC	DGAB	14'	8.3"	713	890	946	Fine	No

State Code	SHRP D	Drainage Type	Shoulder Type	Base Type	Lane Width	PCC Thickness	Modulus of Rupture (psi)			Subgrade Soil Type	Active as of July 2020
							14-day	28-day	1-year		
39	0203	ND	AC	DGAB	14'	11.2"	645	702	918	Fine	Yes
39	0204	ND	AC	DGAB	12'	11.1"	—	—	—	Fine	No
39	0205	ND	AC	LCB	12'	8"	—	—	—	Fine	No
39	0206	ND	AC	LCB	14'	7.9"	—	—	—	Fine	No
39	0207	ND	AC	LCB	14'	11.2"	—	—	—	Fine	Yes
39	0208	ND	AC	LCB	12'	11.1"	690	784	955	Fine	No
39	0209	DB/LD	AC	PATB	12'	8.3"	—	—	—	Fine	No
39	0210	DB/LD	AC	PATB	14'	8"	—	—	—	Fine	No
39	0211	DB/LD	AC	PATB	14'	11.3"	749	880	945	Fine	Yes
39	0212	DB/LD	AC	PATB	12'	10.8"	438	828	930	Fine	No
39	0259	LD	AC	DGAB	12'	10.9"	568	489	1075	Fine	No
39	0260	DB/LD	AC	PATB	12'	11.6"	730	790	1040	Fine	Yes
39	0261	DB/LD	AC	CTB	14'	11.1"	—	—	—	Fine	Yes
39	0262	DB/LD	AC	CTB	12'	11.5"	565	705	850	Fine	Yes
39	0263	LD	AC	DGAB	14'	11.1"	—	—	—	Fine	Yes
39	0264	LD	AC	CTB	12'	11.5"	—	—	—	Fine	No
39	0265	DB/LD	AC	PATB	12'	11.2"	—	—	—	Fine	Yes
53	0201	ND	AC	DGAB	12'	8.7"	—	—	—	Fine	Yes
53	0202	ND	AC	DGAB	14'	8.3"	823	1041	807	Fine	Yes
53	0203	ND	AC	DGAB	14'	11.1"	413	622	667	Fine	Yes
53	0204	ND	AC	DGAB	12'	11.2"	870	915	880	Fine	Yes
53	0205	ND	AC	LCB	12'	8.5"	487	524	597	Fine	Yes
53	0206	ND	AC	LCB	14'	8.6"	801	880	738	Fine	Yes
53	0207	ND	AC	LCB	14'	11.1"	546	611	772	Fine	Yes
53	0208	ND	AC	LCB	12'	11.2"	—	—	—	Fine	Yes
53	0209	DB/LD	AC	PATB	12'	9"	—	—	—	Fine	Yes

State Code	SHRP D	Drainage Type	Shoulder Type	Base Type	Lane Width	PCC Thickness	Modulus of Rupture (psi)			Subgrade Soil Type	Active as of July 2020
							14-day	28-day	1-year		
53	0210	DB/LD	AC	PATB	14'	8.3"	—	—	—	Fine	Yes
53	0211	DB/LD	AC	PATB	14'	11.8"	494	709	667	Fine	Yes
53	0212	DB/LD	AC	PATB	12'	11.3"	—	—	—	Fine	Yes
53	0259	ND	AC	HMAC	14'	10.3"	612	663	796	Fine	Yes
55	0213	ND	AC	DGAB	14'	8.5"	610	665	—	Coarse	Yes
55	0214	ND	AC	DGAB	12'	8.8"	865	945	—	Coarse	Yes
55	0215	ND	AC	DGAB	12'	11.5"	625	645	—	Coarse	Yes
55	0216	ND	AC	DGAB	14'	11.1"	—	—	—	Coarse	Yes
55	0217	ND	AC	LCB	14'	8.5"	—	—	—	Coarse	Yes
55	0218	ND	AC	LCB	12'	8.5"	960	1115	—	Coarse	Yes
55	0219	ND	AC	LCB	12'	11.6"	—	—	—	Coarse	Yes
55	0220	ND	AC	LCB	14'	11.4"	840	970	—	Coarse	Yes
55	0221	DB/LD	AC	PATB	14'	8.4"	—	—	—	Coarse	Yes
55	0222	DB/LD	AC	PATB	12'	8.8"	—	—	—	Coarse	Yes
55	0223	DB/LD	AC	PATB	12'	11.6"	665	700	—	Coarse	Yes
55	0224	DB/LD	AC	PATB	14'	11.7"	870	920	—	Coarse	Yes
55	0259	DB/LD	AC	DGAB	12'	11.5"	—	—	—	Coarse	Yes
55	0260	ND	AC	DGAB	12'	11.3"	595	640	—	Coarse	Yes
55	0261	ND	AC	CTB	12'	9.4"	—	—	—	Coarse	Yes
55	0262	ND	PCC	DGAB	12'	8.7"	—	—	—	Coarse	Yes
55	0263	DB/LD	AC	DGAB	12'	10.4"	665	695	—	Coarse	Yes
55	0264	ND	AC	DGAB	12'	11"	605	635	—	Coarse	Yes
55	0265	ND	AC	DGAB	12'	11.1"	—	—	—	Coarse	Yes
55	0266	ND	AC	DGAB	12'	11"	—	—	—	Coarse	Yes

— indicates that data are not available.
ND: no subsurface drainage
DB/LD: drainage blanket with longitudinal drains
LD: longitudinal drains