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TPF-5(291) FINAL REPORT:

COMPARISON OF SPS-8 AND SPS-2 PERFORMANCE

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Nick Weitzel, P.E.
Project Engineer, NCE

Kevin Senn, P.E.
Principal Engineer, NCE

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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 compares 10 sets of SPS-2 and SPS-8 sections, two pairs in each of Arkansas, California, Colorado, Ohio, and Washington, including a total of 20 sections. The analysis reviews and updates a 2019 study that investigated SPS-2 projects compared to other LTPP low-traffic concrete sections after an additional 5 to 7 years of performance data were collected since the original research.

2.0 SUMMARY OF 2019 ARA REPORT

A key element of this task was to review a 2019 report by ARA[1] on the SPS-8 sections, recognizing that an additional 5 to 7 years of additional data were collected since the original research was conducted. The original study consisted of 16 SPS-8, 18 GPS-3 and 20 SPS-2 jointed plain concrete pavement (JPCP) sections, and the analyses were more focused on the asphalt concrete (AC) sections than on the JPCP sections. Nevertheless, there were several relevant findings in this report which are summarized below.

The 4 JPCP distresses evaluated were fatigue cracking (percent cracked slabs), transverse joint faulting, transverse joint spalling, and pavement roughness. For fatigue cracking, the results showed that thin JPCPs with high levels of traffic received the most cracked slabs, followed by thick JPCPs with high levels of traffic. The thin JCPC sections with low traffic had some cracked slabs, whereas the thick JCPCs with low traffic did not have any cracked slabs. The cracked slabs occurred mostly where the frost depth was not very deep, and the in-situ PCC temperature was high for both high- and low-traffic sections. The results showed that 8.6% and 0% of fatigue cracking was attributed to environmental factors for thin and thick JPCP sections, respectively.

For joint faulting, the results showed that overall faulting for the thin JPCP sections was relatively similar regardless of traffic level or most of the other factors evaluated (climate, frost depth, PCC temperature, subgrade temperature, and subgrade classification). The only factor that appeared to influence the faulting of the thin JPCP sections was the depth to the groundwater table, with faulting almost 3 times larger when the groundwater table was less than 40 feet below the pavement surface. For the thick JPCP sections, faulting was higher for the high-traffic sections. Analyses showed that environmental factors contributed to 85% and 39.4% of the faulting for the thin and thick JPCP sections, respectively.

Analysis of the transverse joint spalling showed that spalling mostly occurred on the thin JPCP sections. Most spalling on the thick JPCP sections occurred on the sections with high traffic, in freeze locations with high number of freeze-thaw cycles, high frost depth, low PCC temperature, and high amounts of rainfall. The results showed that the amount of spalling that occurred due to environmental factors was 87.6% and 0% for thin and thick JPCP sections, respectively.

Lastly, pavement roughness was analyzed; the results showed that traffic volumes had a huge impact on the roughness values for both thin and thick JPCP sections. For thin pavements, fewer freeze-thaw cycles and non-freeze climates resulted in higher amounts of roughness. For thicker pavements, higher roughness occurred on subgrades with lower amounts of clay, higher amounts of fine sand, and subgrade with lower plasticity index (PI) values. Overall, the results showed that the amount of roughness associated with environmental factors was 1.9% and 18.5% for thin and thick JPCP sections, respectively.

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[1] Titus-Grover, L., M.I. Darter, and H. Von Quintus. *Impact of Environmental Factors on Pavement Performance in the Absence of Heavy Loads.* Prepared for the Federal Highway Administration. Report No. FHWA-HRT-16-084. Washington, D.C. March 2019.

3.0 LTPP SECTIONS ANALYZED

As previously mentioned, 5 states have both an SPS-2 and a rigid SPS-8 project. Each rigid SPS-8 project contained 2 JPCP sections, one thin and one thick. The SPS-2 sections contained several more JPCP sections, but 2 companion sections were chosen with similar pavement structure and JPCP strengths as the corresponding SPS-8 sections. SPS-2 sections were constructed in areas with a traffic load level of at least 200,000 equivalent single axle loads (ESALs) per year. SPS-8 sections were constructed in areas with a maximum traffic load level of 10,000 ESALs per year. In essence, the companion pairs provide an estimate of the impact of traffic on distress development.

In total, 20 sections were used in this analysis. The pavement structure for these sections is summarized in Table 1. Climatic data are summarized in Table 2.

Table 1. Pavement Structure of 10 SPS-2 and 10 SPS-8 Sections Analyzed

State	SHRP ID	Construction Date	Pavement Structure				
			PCC Thickness (inch)	Layer 2		Layer 3	
				Type	Thickness (inch)	Type	Thickness (inch)
Arkansas	050214	10/1/1995	8.4	Soil-AB	10.0	--	--
	050216	10/1/1995	11.0	AB	6.0	--	--
	050809	12/1/1997	8.7	AB	8.0	--	--
	050810	12/1/1997	11.5	AB	8.0	--	--
California	060201	9/1/2000	8.3	AB	6.0	--	--
	060203	9/1/2000	11.4	AB	5.8	--	--
	060811	7/1/1999	8.3	AB	6.3	--	--
	060812	7/1/1999	10.6	AB	6.3	--	--
Colorado	080213	10/1/1993	8.6	AB	5.9	--	--
	080215	10/1/1993	11.5	AB	6.0	--	--
	080811	10/1/1993	8.9	AB	6.5	--	--
	080812	10/1/1993	12.9	AB	8.0	--	--
Ohio	390201	9/1/1996	7.9	AB	6.2	--	--
	390203	9/1/1996	11.2	AB	6.1	--	--
	390809	11/1/1994	7.7	AB	6.1	EMB	20.0
	390810	11/1/1994	11.2	AB	6.1	EMB	36.0
Washington	530202	11/1/1995	8.3	AB	6.5	EMB	36.3
	530204[1]	11/1/1995	11.2	AB	5.9	Rock	21.6
	53A809	6/1/2000	8.5	AB	4.5	EMB	90.8
	35A810	6/1/2000	10.9	AB	4.7	EMB	35.8

Notes: [1]Washington Section 530204 contains a Layer 4 Embankment with a 39.7-inch thickness
AB: Aggregate Base, EMB: Embankment
SPS-8 sections are shaded. Companion pairs consisted of the thin SPS-2 and SPS-8 section and thick SPS-2 and SPS-8 section within each state.

Table 2. Climate Data for 10 SPS-2 and 10 SPS-8 Sections Analyzed

State	SHRP ID	LTPP Climate Zone	Average Temperature (°F)	Average Annual Rainfall (in./yr)	Average Annual Freeze-Thaw Cycles
Arkansas	050214	Wet, No-Freeze	61.8	53.9	57.1
	050216				
	050809		63.0	55.6	49.6
	050810				
California	060201	Wet, No-Freeze	63.4	27.0	5.4
	060203				
	060811				
	060812				
Colorado	080213	Wet, Freeze	50.0	26.3	133.6
	080215				
	080811				
	080812				
Ohio	390201	Wet, Freeze	50.2	48.7	94.5
	390203				
	390809				
	390810				
Washington	530202	Wet, Freeze	50.4	20.0	99.0
	530204				
	53A809	Wet, No-Freeze	50.9	24.1	86.9
	35A810				

3.1 State of Arkansas

The SPS-2 project is located on I-30 near Haskell, Arkansas, about 25 miles southwest of Little Rock. The SPS-8 project is located on I-530 Frontage Road in Pine Bluff. The projects are approximately 47 miles apart (Figure 1). Note that a green dot indicates the section is still actively monitored and a blue dot indicates the sections are out of study and no longer monitored.

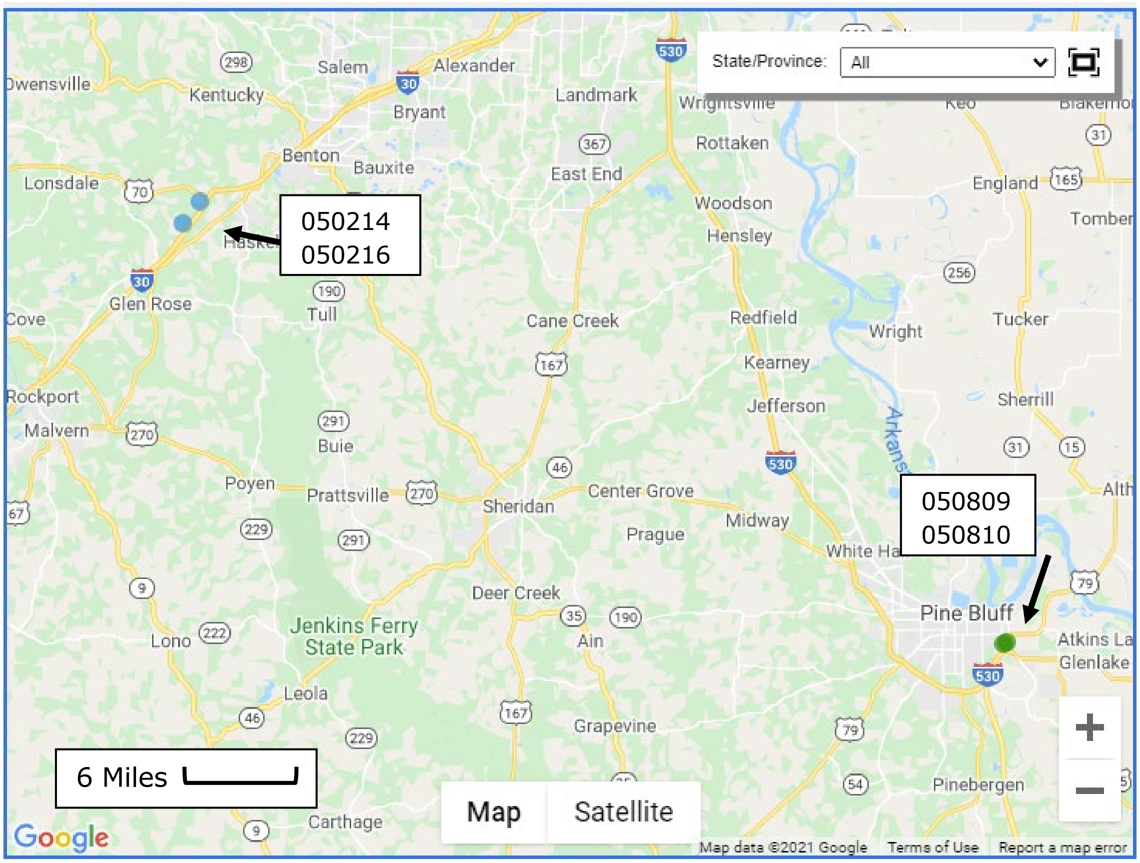


Figure 1. Location of Arkansas SPS-2 and SPS-8 Projects.

3.2 State of California

The SPS-2 is located on State Route 99 near Delhi, California, about 90 miles southeast of Sacramento. The SPS-8 is located on Stephens Street, which runs adjacent to SR-99, resulting in a near-zero-mile distance between the projects (Figure 2).

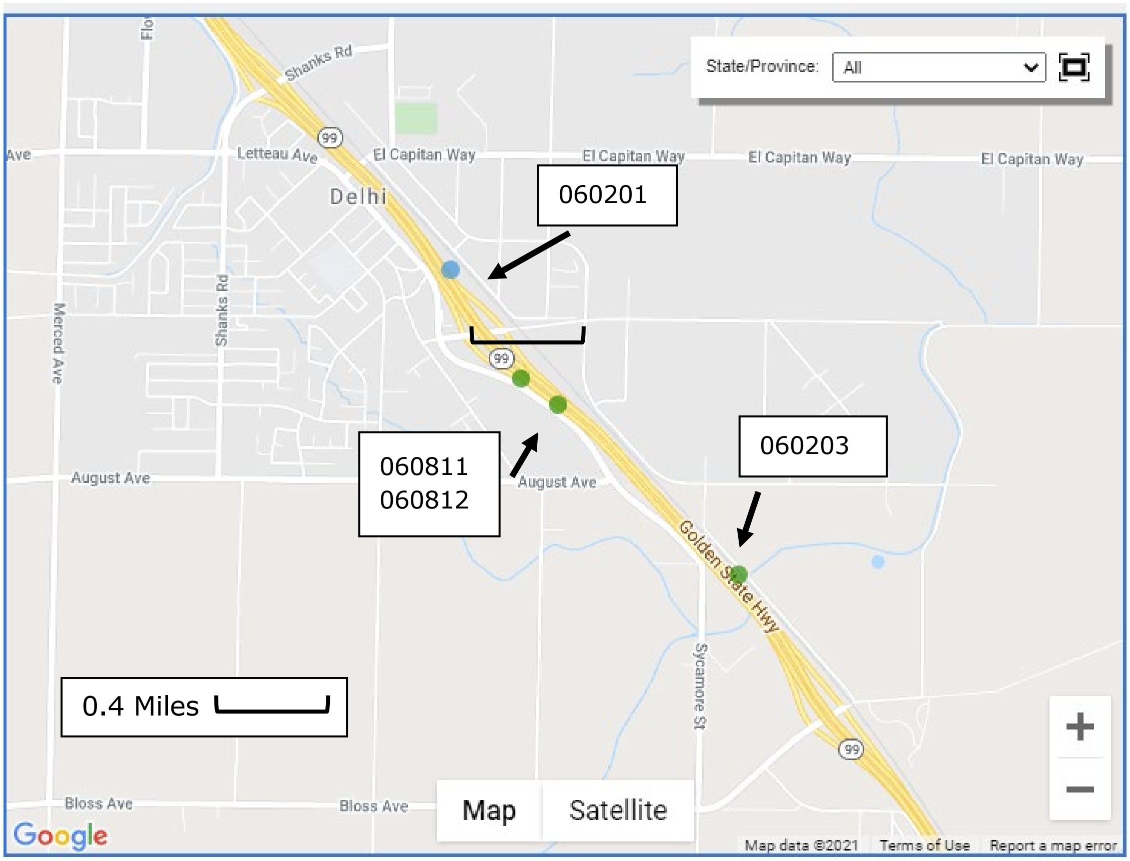


Figure 2. Location of California SPS-2 and SPS-8 Projects.

3.3 State of Colorado

The SPS-2 is located on I-70 near Brighton, Colorado, just northeast of Denver. The SPS-8 is located on Telluride Street that runs along I-70, resulting in about 1 mile between the projects (Figure 3).

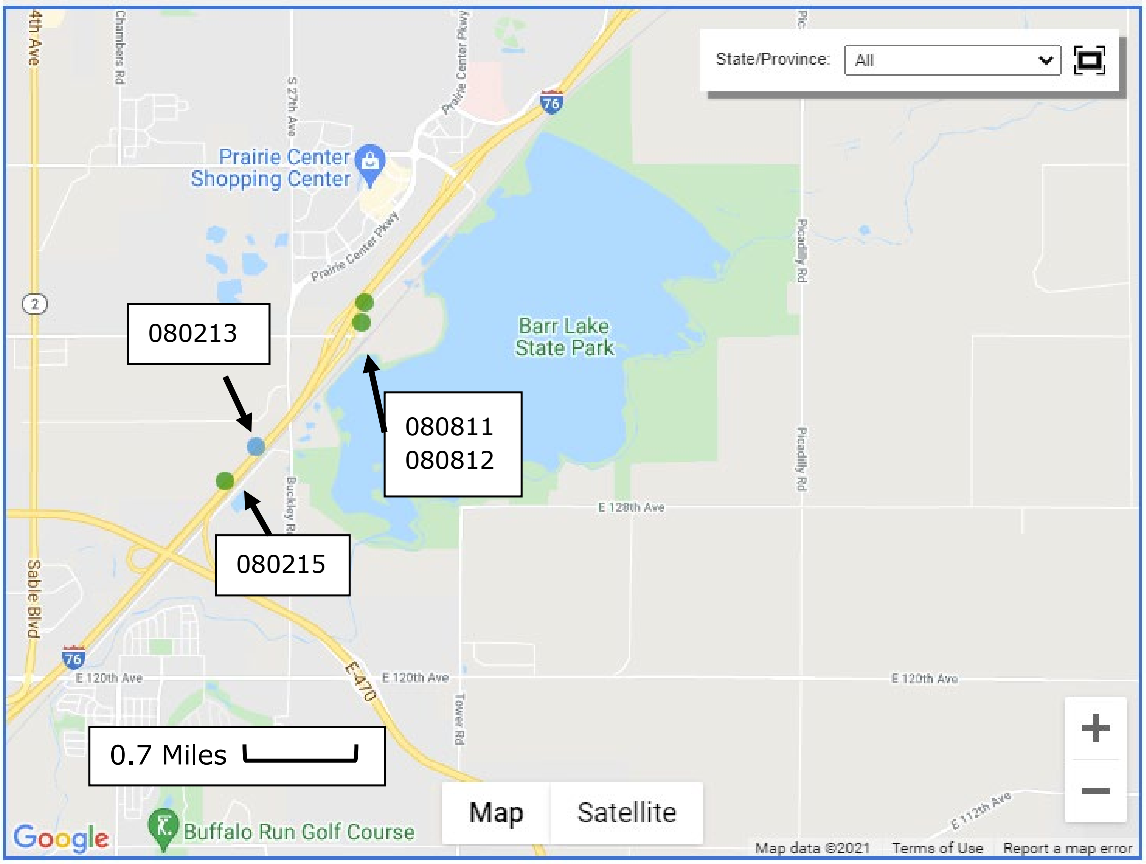


Figure 3. Location of Colorado SPS-2 and SPS-8 Projects.

3.4 State of Ohio

The SPS-2 is located on US-23 near Waldo, Ohio, about 30 miles north of Columbus. The SPS-8 is located on Waldo-Delaware Road located adjacent to US-23, resulting in a 2-mile difference between the projects (Figure 4).

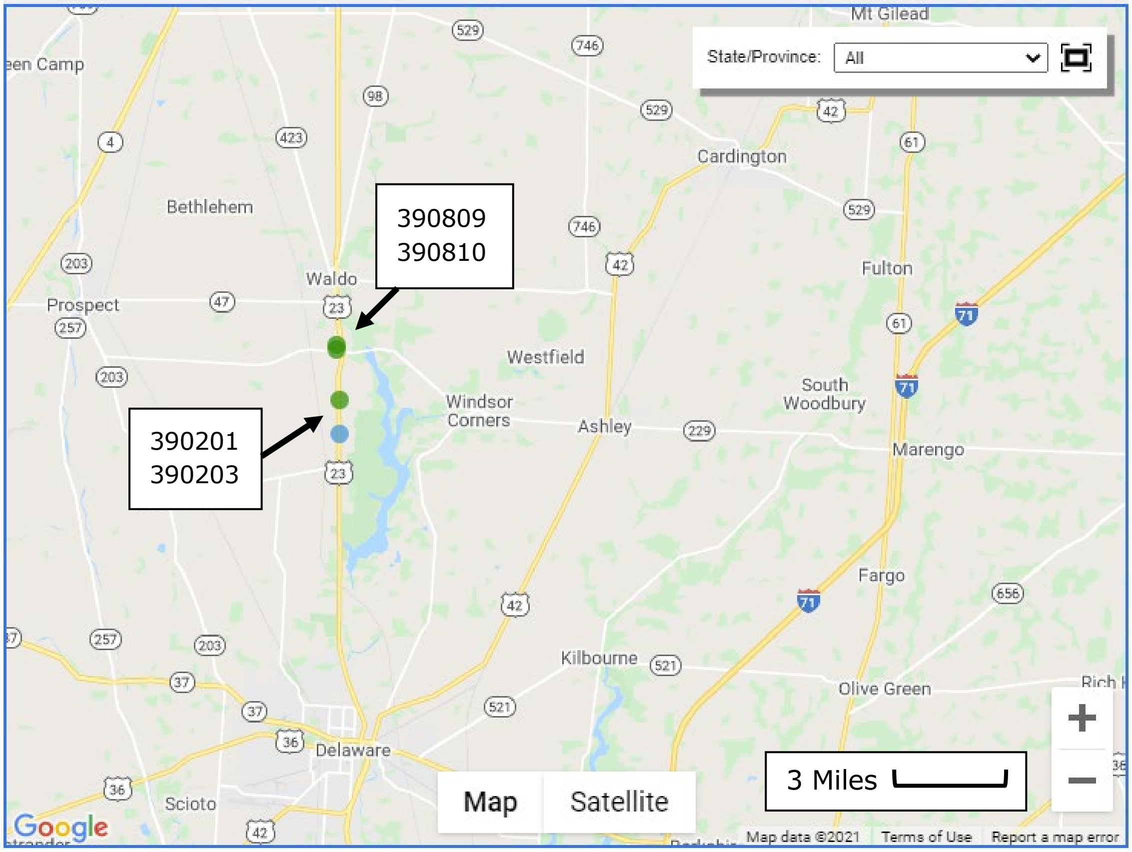


Figure 4. Location of Ohio SPS-2 and SPS-8 Projects.

3.5 State of Washington

The SPS-2 is located on US-395 near Ritzville, Washington, about 60 miles southwest of Spokane. The SPS-8 is located on North Touchet Road near Dayton, Washington, about 100 miles south of Spokane. The projects are located about 60 miles apart (Figure 5).

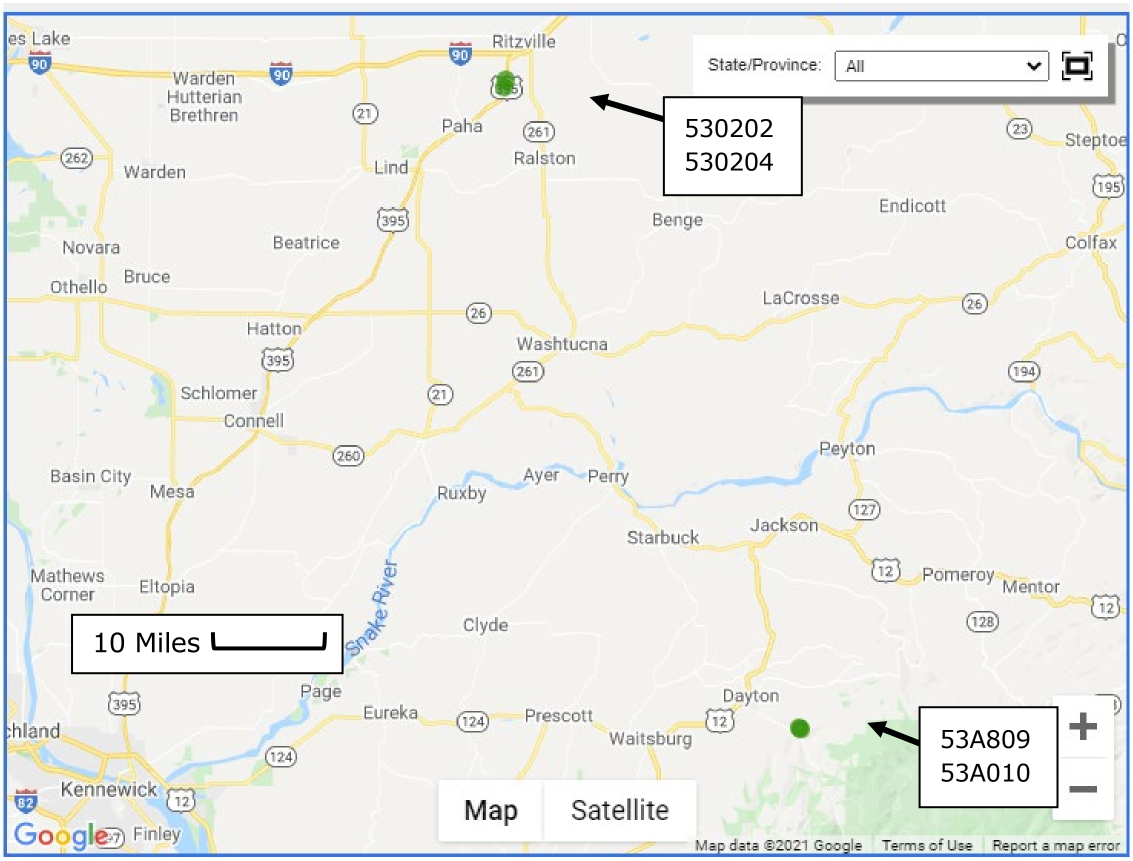


Figure 5. Location of Washington SPS-2 and SPS-8 Projects.

4.0 PERFORMANCE COMPARISONS

Performance comparisons were conducted between SPS-2 and SPS-8 companion sections for each state. Three different performance criteria were evaluated: surface distresses, pavement roughness, and faulting.

4.1 Surface Distresses

Ten different surface distresses were compared for each companion set of SPS-2 and SPS-8 sections. Plots of the surface distress comparisons are shown in Appendices A through E for each state. Comparisons were made by plotting time series of the distresses from all field visits performed for each section, which often differed between SPS-2 and SPS-8 sections and include up to an additional 7 years of performance data since the 2019 study. If a distress was not present on the sections within a state (e.g., longitudinal cracking in Arkansas) no comparison was made for that distress.

First, the distresses observed in the pairs of SPS-8/SPS-2 sections were compared. Then, as in the 2019 ARA report, the average distress per SPS-8 section was divided by the average distress per SPS-2 section to obtain the overall damage due to environmental factors. These values are provided within each distress subsection below. Finally, several comparisons were made between the SPS-2 and SPS-8 projects.

4.1.1 LONGITUDINAL CRACKING

California Section 060201 experienced cracking after 4 years that grew over time, whereas Section 060811 experienced a small amount of cracking after 9 years that remained nearly constant over time. Section 060203 experienced a small amount of cracking after 10 years that remained constant, while section 060812 did not have any longitudinal cracking.

Colorado sections 080213 and 080811 both experienced linear cracking after 7 years but the progression was slow on 080213 until after 20 years, while cracking grew considerably faster on 080811. No linear cracks were observed on either 080215 or 080812.

Table 3. Impact of Environmental Factors on Longitudinal Cracking

JPCP Thickness	SPS-2 Cracking Damage (ft)	SPS-8 Cracking Damage (ft)	Overall Damage due to Environmental Factors (%)
Thin	42.2	21.3	50
Thick	4.0	0	0

4.1.2 TRANSVERSE CRACKING

California Section 060201 experienced cracking immediately after construction that grew considerably over time; Section 060811 experienced the same behavior but with significantly less cracking.

Ohio Section 390201 experienced transverse cracking after 5 years that grew rapidly, whereas Section 390809 had some cracking occur within 5 years that grew very slowly over time. Section 390203 experienced some cracking after 15 years, while Section 390810 did not experience any cracking.

Washington Section 530202 had some transverse cracking first appear after 11 years that steadily grew over time. The other three Washington sections have not yet exhibited cracking.

Table 4. Impact of Environmental Factors on Transverse Cracking

JPCP Thickness	SPS-2 Cracking Damage (ft)	SPS-8 Cracking Damage (ft)	Overall Damage due to Environmental Factors (%)
Thin	124.9	30.9	25
Thick	10.5	13.8	100

4.1.3 LONGITUDINAL JOINT SEAL DAMAGE

Arkansas sections 050214 and 050809 both had equivalent amounts of joint seal damage, but this damage occurred 5 years earlier on 050214 than on 050809. For the thick PCC sections, Section 050216 had twice the amount of joint seal damage as Section 050810, and the damage occurred 2 years earlier.

California section 060201 experienced joint seal damage after 5 years that grew over time while section 060811 had a small amount of joint seal damage after 16 years. Section 060203 did not have any joint seal damage; section 060812 experienced a small amount after 14 years.
The Colorado SPS-2 sections experienced joint seal damage after 5 years that grew rapidly. The SPS-8 sections experienced joint seal damage after 14 years that also grew rapidly over time.

The Ohio SPS-2 sections experienced joint seal damage quickly that grew rapidly to year 6. The SPS-8 sections experienced joint seal damage after 5 years that also grew quickly and reached the same amount as the SPS-2 sections by year 10.

The Washington SPS-2 sections experienced joint seal damage after 4 years that was fixed but again showed up after 8 to 10 years. The SPS-8 sections had negligible amounts of joint seal damage.

Table 5. Impact of Environmental Factors on Longitudinal Joint Seal Damage

JPCP Thickness	SPS-2 Cracking Damage (ft)	SPS-8 Cracking Damage (ft)	Overall Damage due to Environmental Factors (%)
Thin	711.2	382.8	54
Thick	818.6	419.0	51

4.1.4 LONGITUDINAL SPALLING

For the thin Arkansas sections, 050809 had a significant amount of spalling occur within 4 years after construction, whereas section 050214 had minimal spalling throughout the monitoring period. The same holds true for the thick sections: 050810 had joint spalling occur within 4 years, while 050216 did not have any spalling until the last site visit.
California section 060201 saw a large amount of spalling occur between 6 and 9 years, while Section 060811 had minimal amounts of spalling. Section 060203 saw some spalling within a couple of years that slowly grew over time, whereas Section 060812 had minimal amounts of spalling after 9 years that increased slowly over time.

Spalling on Colorado sections 080213 and 080811 occurred after 15 years, but grew rapidly on 080811 while remaining low on 080213. For the thick sections, spalling occurred on 080215 after 15 years that remained constant while spalling occurred on 080812 after 17 years that grew slowly.

Ohio sections 390201 and 390809 both experienced minimal cracking until year, 10 where 390809 saw widespread spalling. Spalling occurred on sections 390203 and 390810 after 5 years, but spalling grew much quicker on 390810 than on 390203.

The Washington SPS-8 sections had spalling occur after 8 years that steadily grew over time. Section 530202 experienced negligible amounts of spalling after 15 years and Section 530204 had some spalling occur after 15 years that grew over time.

The manual distress maps for all 20 sections were reviewed and it showed that a majority of the longitudinal spalling occurred along the outside edge for both SPS-2 and SPS-8 sections. The SPS-8 sections were generally located on rural roads that had narrow AC shoulders that would not provide a lot of support should a vehicle's tire ride along the outside joint, allowing excessive stresses to form and spall the corners. All four Colorado Sections had a tied-PCC shoulder, the thick SPS-8 section had roughly 16% of the longitudinal spalling observed on the thick SPS-2 section, indicating that shoulder confinement could reduce longitudinal spalling. It should be noted the thin SPS-8 in Colorado had more longitudinal spalling than the thin SPS-2, meaning this may not explain all the longitudinal spalling on SPS-8s.

Table 6. Impact of Environmental Factors on Longitudinal Spalling

JPCP Thickness	SPS-2 Cracking Damage (ft)	SPS-8 Cracking Damage (ft)	Overall Damage due to Environmental Factors (%)
Thin	34.7	167.1	100
Thick	62.3	199.3	100

4.1.5 TRANSVERSE SPALLING

Joint spalling on Arkansas Section 050214 occurred after 7 years and slowly grew over time but Section 050809 had no spalling. Conversely, Section 050810 experienced some spalling after 13 years, while Section 050216 only had spalling occur on the last site visit.

California sections 060201 and 060811 both had minimal amounts of spalling that occurred after 8 and 17 years, respectively. Section 060203 experienced spalling after 6 years that grew over time. Section 060812 did not have any spalling.

Colorado Section 080213 did not experience any spalling until year 20, at which point it began to grow a constant rate. Section 080811 experienced spalling after 4 years that remained nearly constant until 15 years and then grew rapidly. Section 080215 experienced some spalling immediately but didn't start growing until after 7 years. Spalling on Section 080812 first occurred after 18 years and slowly grew.

No spalling occurred on the Ohio sections 390201 or 390809 until year 10. After that, Section 390809 saw rapid growth of spalling over time and the thick sections (390203 and 390810) had spalling growth at a similar rate.

Washington Section 530202 had transverse spalling occur after 10 years that grew over time, whereas Section 530204 did not have any spalling. Section 53A809 did not have any spalling; Section 53A810 had a negligible amount occur within a couple of years that remained steady over time.

Table 7. Impact of Environmental Factors on Transverse Spalling

JPCP Thickness	SPS-2 Cracking Damage (ft)	SPS-8 Cracking Damage (ft)	Overall Damage due to Environmental Factors (%)
Thin	7.5	8.9	100
Thick	23.0	15.0	65

4.1.6 SCALING

Scaling only occurred on 5 of the 20 sections analyzed. Scaling occurred on both Colorado SPS-8 sections after 20 years and on the thin SPS-2 section after 15 years while no scaling was present on the thick SPS-2 section.

There was no scaling on either of the Ohio thin sections. Scaling occurred on Section 390810 after 15 years but was not observed on Section 390203.

In California, scaling was only observed on the thick SPS-2 section after 15 years, scaling did not occur on any of the other 3 sections.

Scaling was not observed on any of the sections in Arkansas or Washington.

Table 8. Impact of Environmental Factors on Scaling

JPCP Thickness	SPS-2 Cracking Damage (ft)	SPS-8 Cracking Damage (ft)	Overall Damage due to Environmental Factors (%)
Thin	3.7	1,213.3	100
Thick	1.7	46.3	100

4.1.7 POLISHED AGGREGATES

Arkansas sections 050214 and 050216 both experienced polished aggregates after 15 and 10 years, respectively, while both SPS-8 sections experienced no polished aggregates.

The Colorado SPS-2 sections experienced polished aggregates after 3 years that grew quickly to cover half the sections by year 6. Polished aggregates for both SPS-8 sections occurred after 9 years but disappeared quickly on Section 080811 while remaining constant on Section 080812.

The Washington SPS-2 sections had polished aggregates occur after 6 years that grew rapidly, went away after year 10, and then grew steadily afterwards. Neither of the SPS-8 sections had polished aggregates.

Table 9. Impact of Environmental Factors on Polished Aggregates

JPCP Thickness	SPS-2 Cracking Damage (ft)	SPS-8 Cracking Damage (ft)	Overall Damage due to Environmental Factors (%)
Thin	1,811.9	0	0
Thick	1,607.1	595.6	37

4.1.8 PUMPING

Pumping was only observed in Arkansas on both SPS-2 sections experienced significant amounts of pumping starting at 5 years and growing over time. The Arkansas SPS-2 project was possibly located near an underground spring, resulting in a very shallow water table. Because of this, these two sections had a higher potential for pumping to occur compared to the other 18 sections analyzed in this study.

Table 10. Impact of Environmental Factors on Pumping

JPCP Thickness	SPS-2 Cracking Damage (ft)	SPS-8 Cracking Damage (ft)	Overall Damage due to Environmental Factors (%)
Thin	334.6	0	0
Thick	328.1	0	0

4.1.9 MAP CRACKING

The Arkansas SPS-8 sections had map cracking occur after 15 years and grow over time; the SPS-2 sections did not have any map cracking.

The California SPS-2 sections experienced immediate, widespread map cracking, whereas the SPS-8 sections did not see map cracking occur until after 9 years.

Map cracking was similar for both Colorado SPS-2 sections, where map cracking occurred after about 10 years and slowly grew over time. Section 080811 had map cracking occur after 11 years that fluctuated over time as the scaling began to form, while Section 080812 had map cracking occur after 16 years that covered the entire section by year 18.

The Washington SPS-8 sections experienced map cracking after 5 to 9 years that quickly covered the entire test section. Section 530202 had map cracking within 2 years of construction but disappeared before the next site visit and did not return. Section 530204 had a small amount of map cracking occur after 20 years.

Table 11. Impact of Environmental Factors on Map Cracking

JPCP Thickness	SPS-2 Cracking Damage (ft)	SPS-8 Cracking Damage (ft)	Overall Damage due to Environmental Factors (%)
Thin	1431.3	3014.3	100
Thick	1964.9	3599.5	100

4.1.10 CRACKED SLABS

Arkansas Section 050214 experienced one cracked slab after 15 years but the other three sections did not have any cracked slabs.

California Section 060201 saw a significant number of cracked slabs that occurred immediately and grew over time; Section 060811 also had cracked slabs occur immediately but grew at a much lower rate. Section 060203 experienced a couple of cracked slabs early and remained constant, while Section 060812 had cracked slabs after 6 years that continued to form over time.

Colorado Section 080213 and 080811 both experienced cracked slabs after 6 years; these formed slowly on 080213 while forming much faster on 080811. Neither of the thick Colorado sections experienced any cracked slabs.

Ohio Section 390201 experienced cracked slabs after 5 years that grew extremely quick, leading to the section being put out-of-study by year 10. Section 390809 saw cracked slabs by year 5 but remained nearly constant over the life of the section. For the thick sections, 390203 had one cracked slab after 15 years while Section 390810 did not have any.

Washington Section 530202 experienced a few cracked slabs after 10 years, but the remaining three sections did not have any cracked slabs.

Table 12. Impact of Environmental Factors on Cracked Slabs

JPCP Thickness	SPS-2 Cracking Damage (ft)	SPS-8 Cracking Damage (ft)	Overall Damage due to Environmental Factors (%)
Thin	9.8	3.2	33
Thick	0	0	--

4.1.11 SUMMARY OF SPS-8 AND SPS-2 DISTRESSES

Table 13 provides a summary of the overall damage due to environmental factors for each of the 10 companion sets.

Comparisons between the final amount of distress between companion SPS-2 and SPS-8 sections were also performed by subtracting the total quantity of SPS-8 distress from the total amount of SPS-2 distress. A positive difference indicated that the SPS-2 section had more distress than the companion SPS-8 section. A negative value indicated that the SPS-8 section had more distress than the companion SPS-2 section. A summary of the differences in total distress is shown in Table 14.

These comparisons indicated in most cases, the impact of environmental factors on distress is higher for the thicker sections than the thinner sections. This is most likely due to the reduced stresses that occur in thicker pavement sections. The results show that 38% of the time, the SPS-8 had no distress while the SPS-2 companion section did. Additionally, 31% of the time, the SPS-8 section had more distress than SPS-2 companion section.

Finally, to account for the different ways these distresses can manifest, the year of first occurrence and rate of distress growth on each section were calculated. Table 15 summarizes the first year the distress occurred on each SPS-2 section and Table 16 summarizes how fast the distress developed on each SPS-2 section. Table 17 summarizes the first year the distress occurred on each SPS-8 section and Table 18 summarizes how fast the distress developed on each SPS-8 section.

The results show that longitudinal cracking and joint seal damage occur earlier on SPS-2 sections compared to SPS-8 sections. Conversely, transverse cracking, longitudinal spalling, and cracked slabs occur earlier on SPS-8 sections compared to SPS-2 sections. Longitudinal spalling is the only distresses that consistently developed faster on SPS-8 sections compared to SPS-2 sections. Conversely, transverse cracking and map cracking developed faster on SPS-2 sections compared to SPS-8 sections.

Table 13. Impact of Environmental Factors on Distress Development (%)

Distress	**Arkansas**		**California**		**Colorado**		**Ohio**		**Washington**		***Average***	
	Thin	**Thick**	**Thin**	**Thick**	**Thin**	**Thick**	**Thin**	**Thick**	**Thin**	**Thick**	***Thin***	***Thick***
Longitudinal Cracking	--	--	6%	0%	100%	--	--	--	--	--	*53%*	*0%*
Transverse Cracking	0%	--	18%	100%	--	--	6%	--	0%	--	*6%*	*100%*
Longitudinal Joint Seal Damage	91%	50%	0%	19%	91%	93%	100%	100%	0%	0%	*56%*	*52%*
Longitudinal Spalling	100%	100%	1%	13%	100%	16%	75%	100%	100%	100%	*75%*	*66%*
Transverse Spalling	0%	100%	0%	0%	100%	14%	--	100%	0%	--	*25%*	*54%*
Scaling	--	--	--	0%	100%	100%	--	100%	--	--	*100%*	*67%*
Polished Aggregates	0%	0%	--	--	0%	100%	--	--	0%	0%	*0%*	*33%*
Pumping	0%	0%	0%	--	--	--	--	--	--	--	*0%*	*0%*
Map Cracking	100%	100%	40%	70%	100%	100%	--	--	100%	100%	*85%*	*93%*
Cracked Slabs	0%	--	52%	--	--	--	6%	--	0%	--	*15%*	*--*

Note: A value of 100% indicates a greater than or equal amount of distress was observed on the SPS-8 section than on the companion SPS-2 section.
"--" indicates distress was not observed on neither SPS-2 nor companion SPS-8 section.

Table 14. Differences Between Recorded SPS-2 and SPS-8 Distresses

Distress	Arkansas		California		Colorado		Ohio		Washington	
	Thin	Thick	Thin	Thick	Thin	Thick	Thin	Thick	Thin	Thick
Longitudinal Cracking (ft)	--	--	132	20	-27	--	--	--	--	--
Transverse Cracking (ft)	12	--	330	-16	-70	--	183	--	15	--
Longitudinal Joint Seal Damage (ft)	50	500	1000	711	86	74	0 [c]	0 [c]	506	712
Longitudinal Spalling (ft)	-482	-149	127	60	-196	25	4	-466	-115	-154
Transverse Spalling (ft)	11	-1	3	54	-37	12	--	-23	16	-1
Scaling (sq ft)	--	--	--	9	-6048	-3	--	-228	--	--
Polished Aggregates (sq ft)	1649	2297	--	--	3935	-190	--	--	3475	2951
Pumping (sq ft)	1641	1641	32	--	--	--	--	--	--	--
Map Cracking (sq ft)	-5087	-949	3534	2124	-296	-3281	--	--	-6067	-6067
Cracked Slabs (#)	1	--	14	--	--	--	15	--	3	--

Notes: Positive value: SPS-2 section had more distress than companion SPS-8 section.
Negative value: SPS-8 section had more distress than companion SPS-2 section.
"--" denotes distress did not manifest on either SPS-2 or SPS-8 section.
Both Ohio companion sets had equal amounts of longitudinal joint seal damage, resulting in no difference between SPS-2 and SPS-8 sections.

Table 15. Time of Distress First Occurrence on SPS-2 Sections (years)

Distress	Arkansas		California		Colorado		Ohio		Washington	
	Thin	Thick	Thin	Thick	Thin	Thick	Thin	Thick	Thin	Thick
Longitudinal Cracking	--	--	4.2	11.2	9.7	--	--	--	--	--
Transverse Cracking	16.6	--	1.1	1.1	--	--	6.1	17.8	12.6	--
Longitudinal Joint Seal Damage	4.7	5.8	6.8	18.9	4.9	4.9	3.0	4.6	5.8	5.8
Longitudinal Spalling	5.8	16.6	8.2	1.1	16.0	16.0	9.4	6.8	16.5	16.5
Transverse Spalling	5.8	16.6	9.3	8.2	2.6	20.9	--	15.9	10.9	--
Scaling	--	--	--	15.2	14.9	--	--	13.1	--	--
Polished Aggregates	16.6	11.6	--	--	4.9	4.9	--	--	7.8	7.8
Pumping	1.1	1.1	14.1	--	--	--	--	--	--	--
Map Cracking	--	--	1.1	1.1	9.7	11.9	--	--	1.6	21.4
Cracked Slabs	16.6	--	1.1	1.1	9.7	--	6.1	17.8	12.6	--

Table 16. Distress Growth Rate for SPS-2 Sections (distress unit per year)

Distress	Arkansas		California		Colorado		Ohio		Washington	
	Thin	Thick	Thin	Thick	Thin	Thick	Thin	Thick	Thin	Thick
Longitudinal Cracking	--	--	11.7	2.3	3.7	--	--	--	--	--
Transverse Cracking	9.0	--	31.3	14.6	--	--	37.4	10.1	4.2	--
Longitudinal Joint Seal Damage	45.6	95.2	90.6	239.3	120.3	140.3	64.4	132.7	73.0	63.6
Longitudinal Spalling	1.4	3.0	27.2	5.2	2.4	2.0	9.9	12.7	0.8	6.9
Transverse Spalling	1.2	3.7	1.2	4.4	1.3	1.0	--	3.2	2.3	--
Scaling	--	--	--	7.9	1.9	--	--	1.0	--	--
Polished Aggregates	351.3	257.7	--	--	402.3	988.1	--	--	389.9	305.0
Pumping	211.6	99.1	17.4	--	--	--	--	--	--	--
Map Cracking	--	--	5,397.1	6,540.5	105.8	272.1	--	--	3,334.5	1,054.0
Cracked Slabs	0.7	--	3.5	0.6	0.6	--	3.1	0.5	0.4	--

Table 17. Time of Distress First Occurrence on SPS-8 Sections (years)

Distress	Arkansas		California		Colorado		Ohio		Washington	
	Thin	Thick	Thin	Thick	Thin	Thick	Thin	Thick	Thin	Thick
Longitudinal Cracking	--	--	9.3	--	8.8	--	--	--	--	--
Transverse Cracking	16.6	--	0.4	7.9	6.6	--	4.9	--	--	--
Longitudinal Joint Seal Damage	13.0	8.3	17.4	15.3	4.9	14.0	7.8	9.4	3.2	3.2
Longitudinal Spalling	2.6	2.6	10.5	9.3	14.9	18.0	14.8	7.8	6.3	8.9
Transverse Spalling	--	13.0	19.7	--	4.9	20.0	14.8	14.8	1.2	1.2
Scaling	--	--	--	--	22.0	--	--	16.1	--	--
Polished Aggregates	--	14.4	--	--	9.7	9.7	--	--	--	--
Pumping	--	--	--	--	--	--	--	--	--	--
Map Cracking	14.4	15.4	9.3	7.9	11.9	17.0	19.6	--	10.2	6.3
Cracked Slabs	--	--	0.4	7.9	6.6	--	4.9	--	--	--

Table 18. Distress Growth Rate for SPS-8 Sections (distress unit per year)

Distress	Arkansas		California		Colorado		Ohio		Washington	
	Thin	Thick	Thin	Thick	Thin	Thick	Thin	Thick	Thin	Thick
Longitudinal Cracking	--	--	5.9	--	4.9	--	--	--	--	--
Transverse Cracking	--	--	6.4	4.2	6.4	--	2.1	--	--	--
Longitudinal Joint Seal Damage	140.2	80.1	101.8	26.8	61.5	99.1	129.9	314.5	29.8	10.2
Longitudinal Spalling	38.4	11.1	0.5	0.9	12.4	1.6	76.2	48.9	10.7	23.0
Transverse Spalling	--	1.3	1.7	--	2.5	0.5	16.1	4.3	0.4	0.5
Scaling	--	--	--	--	519.3	--	--	178.0	--	--
Polished Aggregates	--	6.4	--	--	3,584.0	948.8	--	--	--	--
Pumping	--	--	--	--	--	--	--	--	--	--
Map Cracking	1,278.6	204.5	500.4	482.6	537.1	3,015.3	5.5	0.0	4,684.7	4,819.6
Cracked Slabs	--	--	1.3	0.9	1.0	--	0.1	--	--	--

Table 19. Average Time of Distress First Occurrence (years)

Distress	Average of SPS-2 Sections		Average of SPS-8 Sections		Difference	
	Thin	Thick	Thin	Thick	Thin	Thick
Longitudinal Cracking	7.0	11.2	9.1	--	-2.1	--
Transverse Cracking	9.1	9.5	7.1	7.9	2.0	1.6
Longitudinal Joint Seal Damage	5.0	8.0	9.3	10.0	-4.2	-2.0
Longitudinal Spalling	11.2	11.4	9.8	9.3	1.4	2.1
Transverse Spalling	7.2	15.4	10.2	12.3	-3.0	3.2
Scaling	14.9	14.2	22.0	16.1	-7.1	-2.0
Polished Aggregates	9.8	8.1	9.7	12.1	0.1	-4.0
Pumping	7.6	1.1	--	--	--	-
Map Cracking	4.1	11.5	13.1	11.7	-8.9	-0.2
Cracked Slabs	9.2	9.5	4.0	7.9	5.3	1.6

Notes: Negative value: Distress occurred on SPS-2 sections earlier than SPS-8 sections.
Positive value: Distress occurred on SPS-8 sections earlier than SPS-2 sections.
"--" denotes distress did not manifest.

Table 20. Average Distress Growth Rate (distress unit per year)

Distress	Average of SPS-2 Sections		Average of SPS-8 Sections		Difference	
	Thin	Thick	Thin	Thick	Thin	Thick
Longitudinal Cracking	7.7	2.3	5.4	--	2.3	--
Transverse Cracking	20.5	12.4	5.0	4.2	15.5	8.2
Longitudinal Joint Seal Damage	78.8	134.2	92.6	106.1	-13.9	28.1
Longitudinal Spalling	8.3	6.0	27.6	17.1	-19.3	-11.1
Transverse Spalling	1.5	3.1	5.2	1.7	-3.7	1.4
Scaling	1.9	4.5	519.3	178.0	-517.4	-173.6
Polished Aggregates	381.2	516.9	3584.0	477.6	-3202.8	39.3
Pumping	114.5	99.1	--	--	--	--
Map Cracking	2945.8	2622.2	1401.3	1704.4	1544.5	917.8
Cracked Slabs	1.7	0.6	0.8	0.9	0.9	-0.4

Notes: Negative value: Distress developed slower on SPS-2 sections faster than SPS-8 sections.
Positive value: Distress developed faster on SPS-2 sections faster than SPS-8 sections.
"--" denotes distress did not manifest.

4.2 Roughness

Plots of the roughness for each state are shown in Figure 6 through Figure 10. Linear regressions were fitted to the data for each section to obtain an average yearly change in International Roughness Index (IRI); the results are shown in Table 21. IRI values can be influenced by several factors, such as warp and curl of the slabs during data collection or surface distress development. Two sections received diamond grinding: California Section 060203 and Ohio Section 060203.

As expected, the results show that almost all SPS-2 sections had a larger yearly increase in IRI than the companion SPS-8 section. The exception was Colorado Section 080213, which had a much lower yearly change in IRI than the companion 080811 section. The results also show that the thicker PCC sections had a lower yearly increase in IRI than the thinner PCC sections.

Table 21. Average Yearly Changes in Roughness

State	Category	SPS-2 Section	Average Yearly Change (in/mile)	SPS-8 Section	Average Yearly Change (in./mile)
Arkansas	Thin	050214	5.27	050809	0.43
	Thick	050216	2.88	050810	0.40
California	Thin	060201	6.46	060811	1.53
	Thick	060203	1.21 [1]	060812	1.19
Colorado	Thin	080213	0.27	080811	2.16
	Thick	080215	1.67	080812	0.75
Ohio	Thin	390201	3.01	390809	0.46
	Thick	390203	0.61	390810	0.14
Washington	Thin	530202	0.10	53A809	0.04
	Thick	530204	0.09	53A810	0.04

[1]Yearly change reflects first 5 years after construction before section received grinding. Yearly IRI change was
-0.63 after second grinding in year 7.

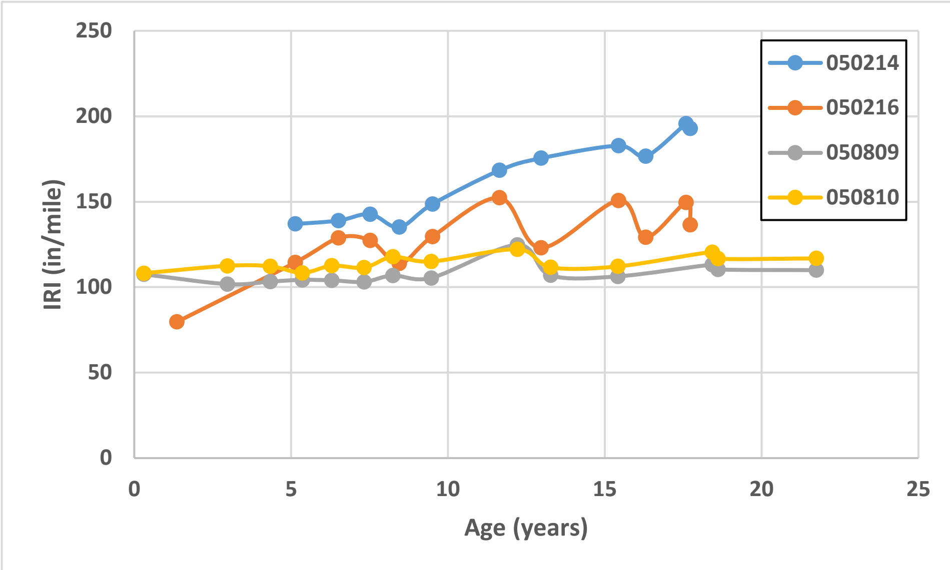


Figure 6. Roughness of the four Arkansas LTPP sections.

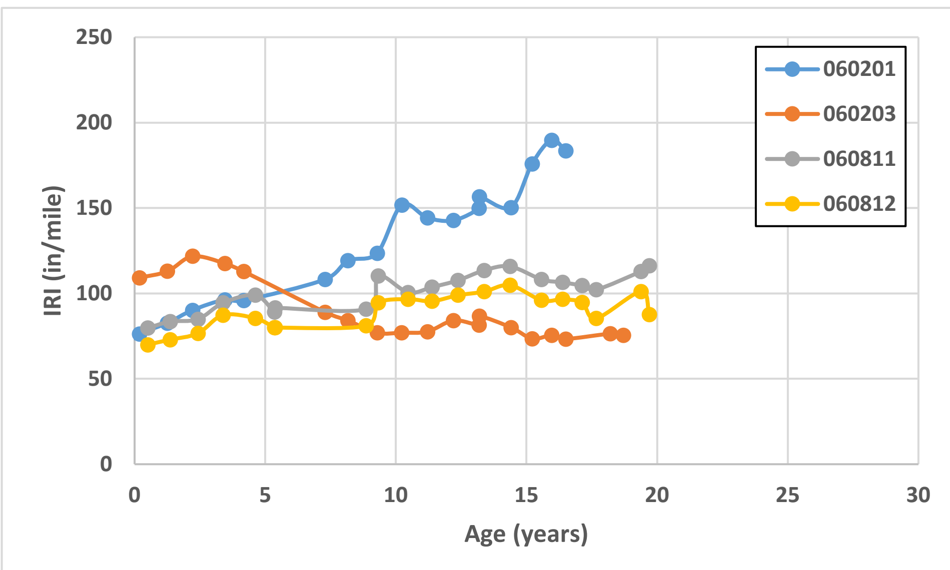


Figure 7. Roughness of the four California LTPP sections.

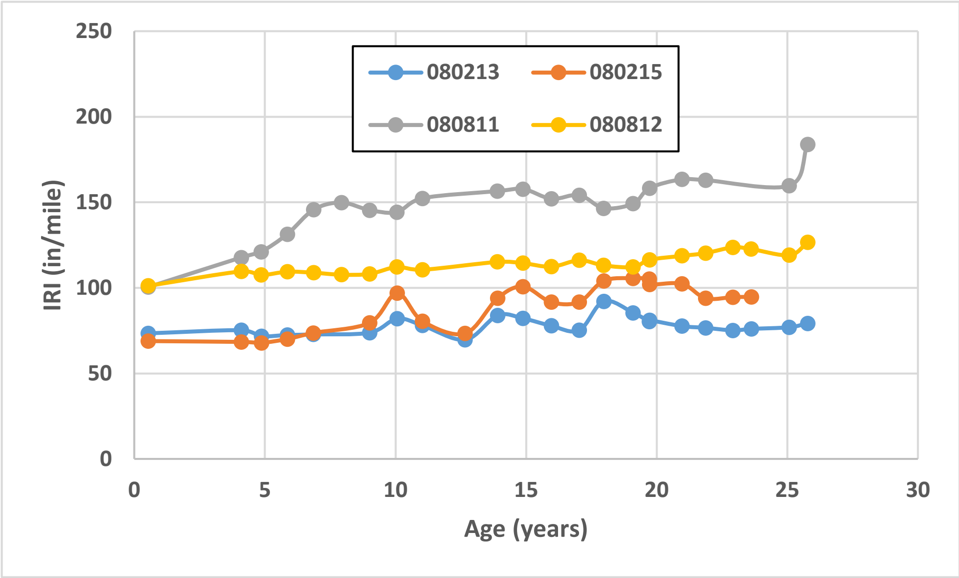


Figure 8. Roughness of the four Colorado LTPP sections.

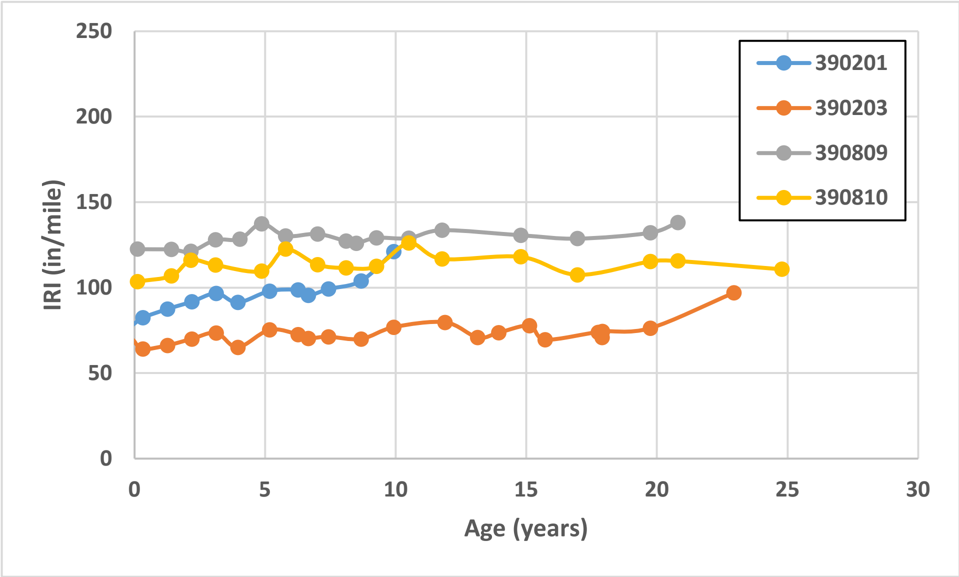


Figure 9. Roughness of the four Ohio LTPP sections.

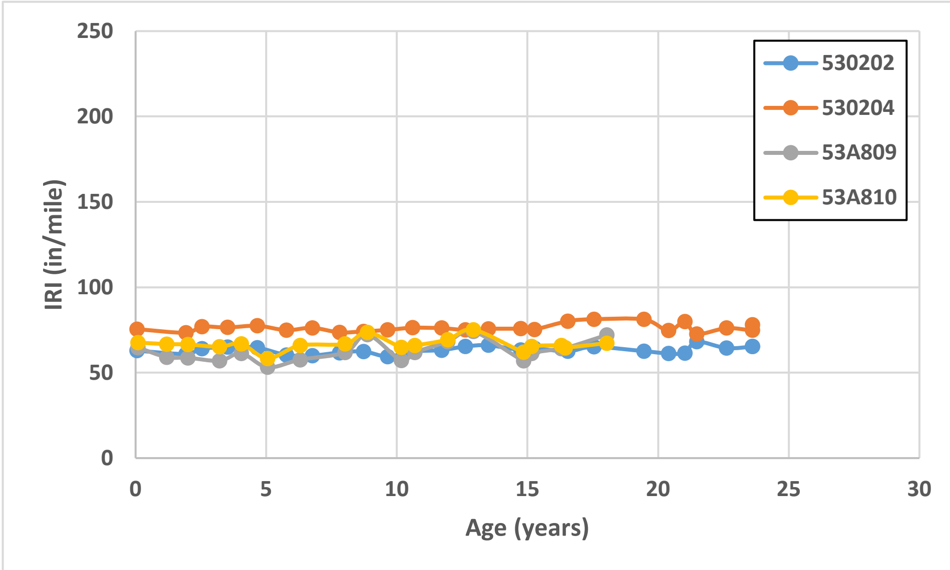


Figure 10. Roughness of the four Washington LTPP sections.

4.3 Faulting

Plots of the faulting for each state are shown in Figure 11 through Figure 15. Faulting was collected with a Georgia faultmeter and measured to the nearest millimeter (0.039 inch). The faulting measurements do not show any clear trends for a bulk of the sections analyzed. The Arkansas sections show a general increase in faulting over time with both SPS-2 sections having higher faulting measurements than either of the SPS-8 sections. All four Ohio sections show virtually no change in faulting over time. The California, Colorado, and Washington sections all show an oscillating pattern where faulting measurements generally hover around zero faulting. It must be noted that the faulting measurements were very small for all sections; and thus, calculation of faulting rates may not be measurable using LTPP data.

Table 22. Average Yearly Changes in Faulting

State	Category	SPS-2 Section	Average Yearly Change (inch)	SPS-8 Section	Average Yearly Change (inch)
Arkansas	Thin	050214	0.0055	050809	0.0008
	Thick	050216	0.0014	050810	0.0003
California	Thin	060201	0.0005	060811	-0.0001
	Thick	060203	0.0	060812	0.0005
Colorado	Thin	080213	0.0008	080811	0.0005
	Thick	080215	0.0005	080812	0.0001
Ohio	Thin	390201	0.0004	390809	-0.0006
	Thick	390203	-0.0001	390810	-0.0002
Washington	Thin	530202	0.0005	53A809	0.0003
	Thick	530204	0.0003	53A810	0.0008

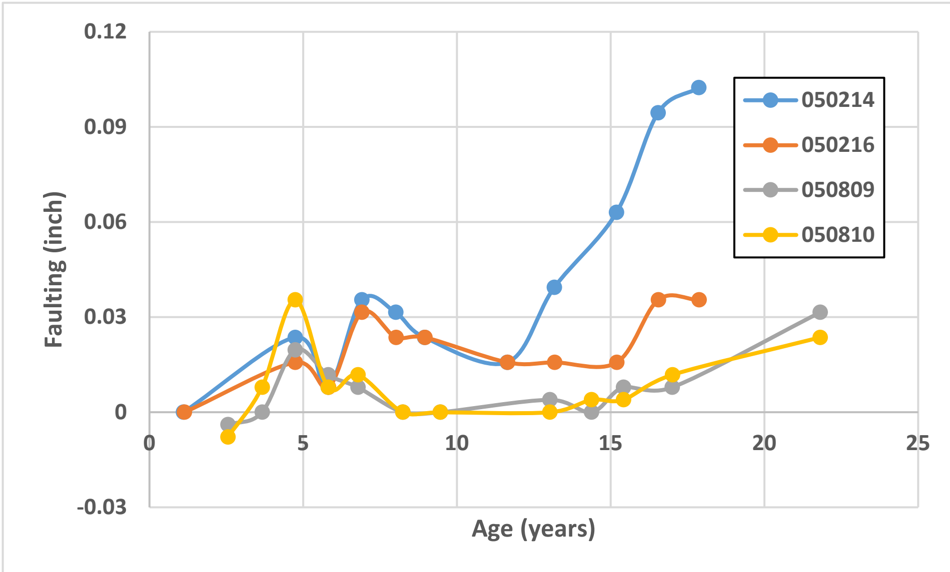


Figure 11. Faulting of the four Arkansas LTPP sections.

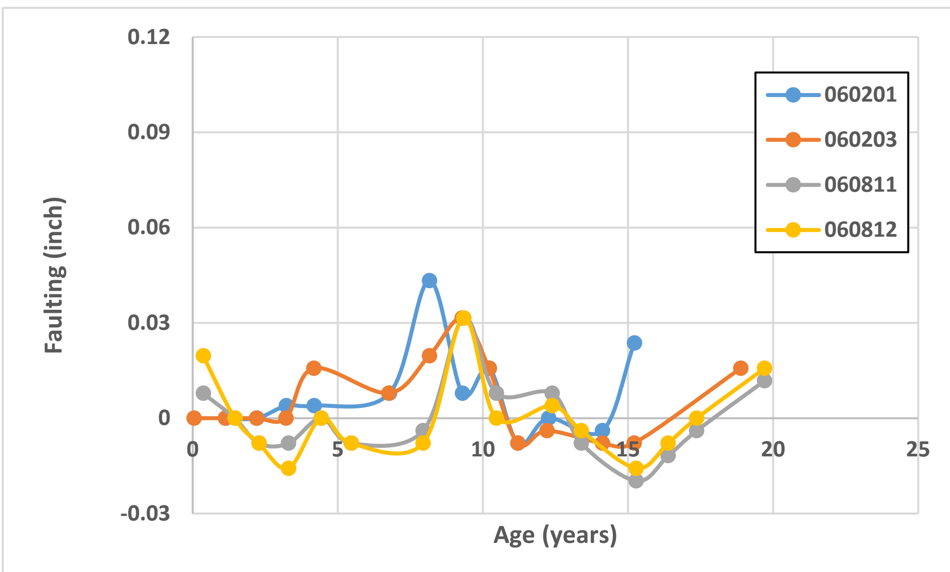


Figure 12. Faulting of the four California LTPP sections.

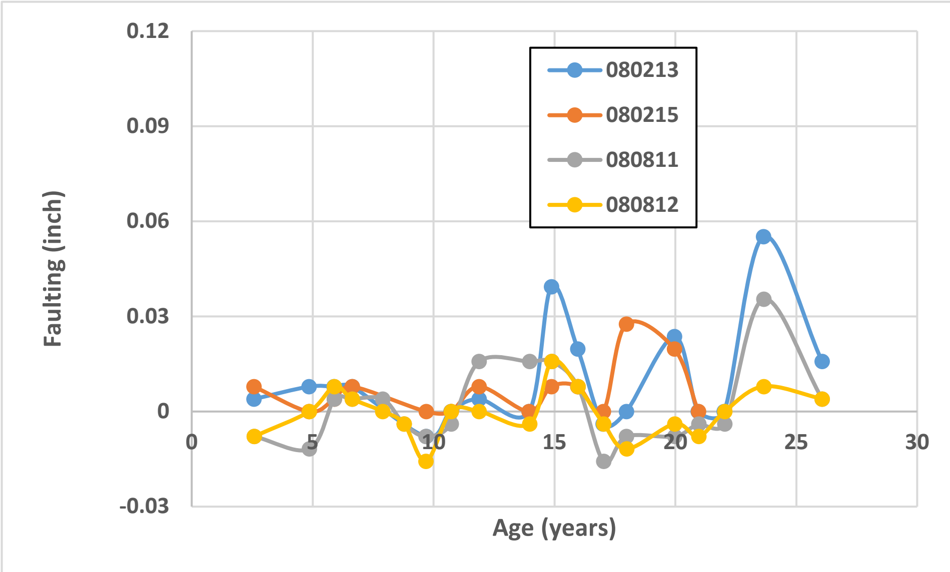


Figure 13. Faulting of the four Colorado LTPP sections.

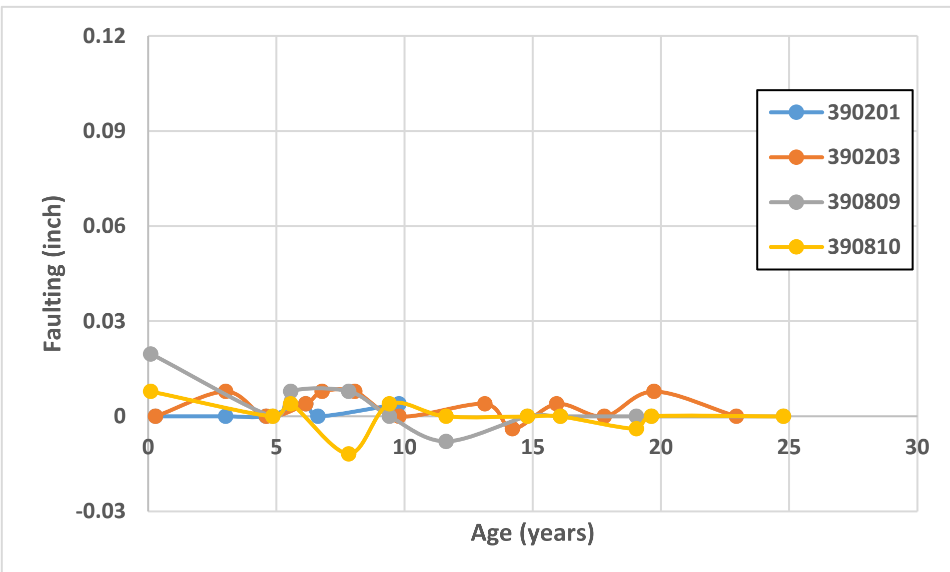


Figure 14. Faulting of the four Ohio LTPP sections.

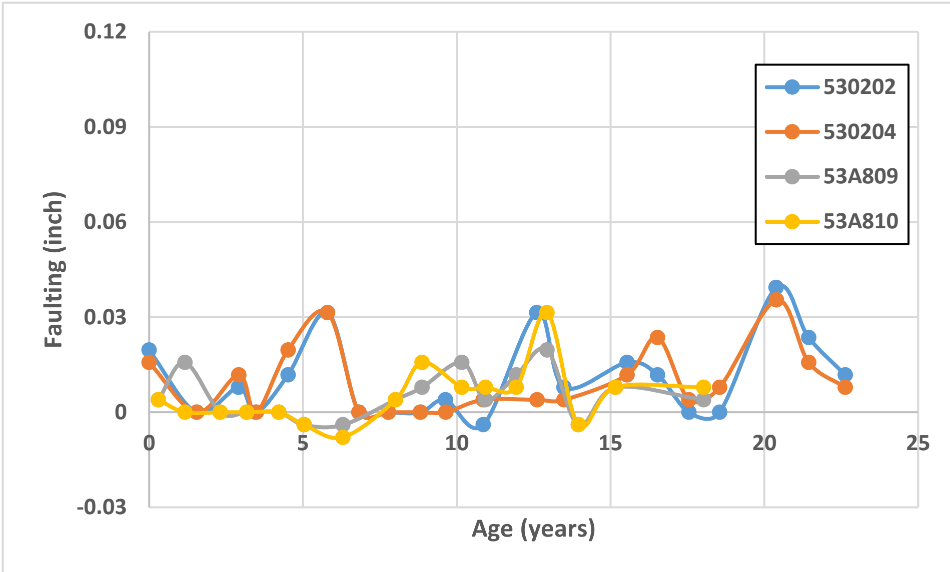


Figure 15. Faulting of the four Washington LTPP sections.

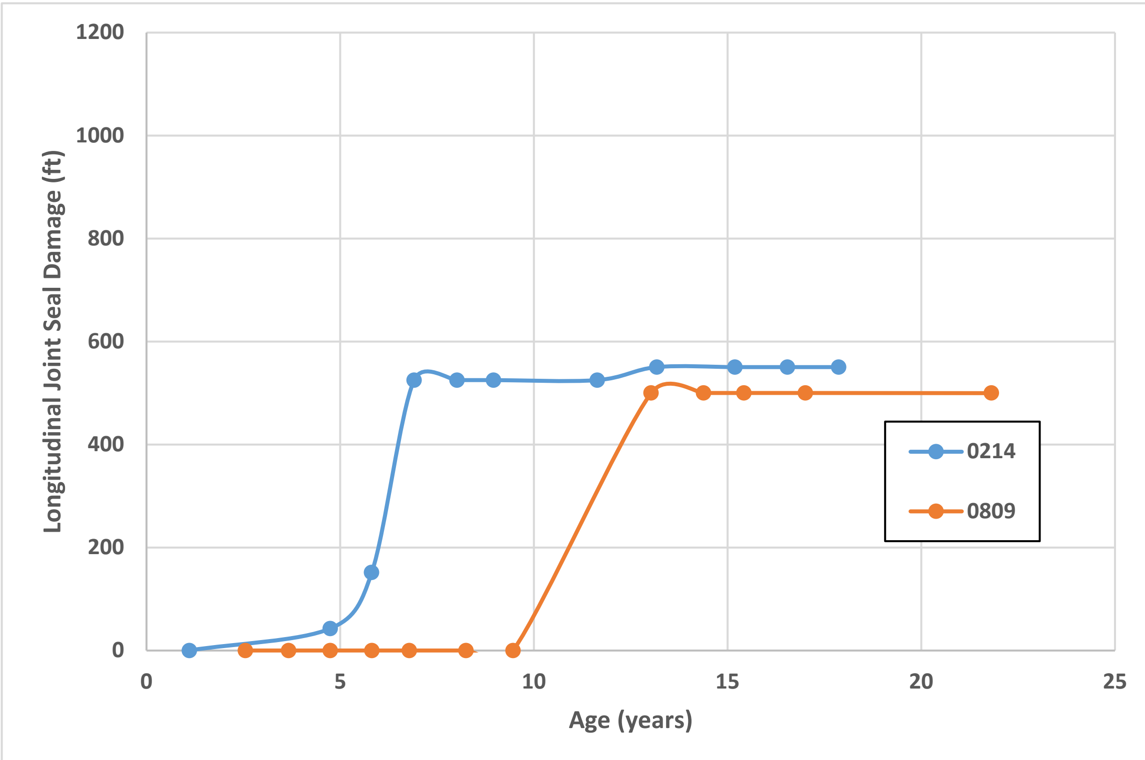
5.0 CONCLUSIONS AND RECOMMENDATIONS

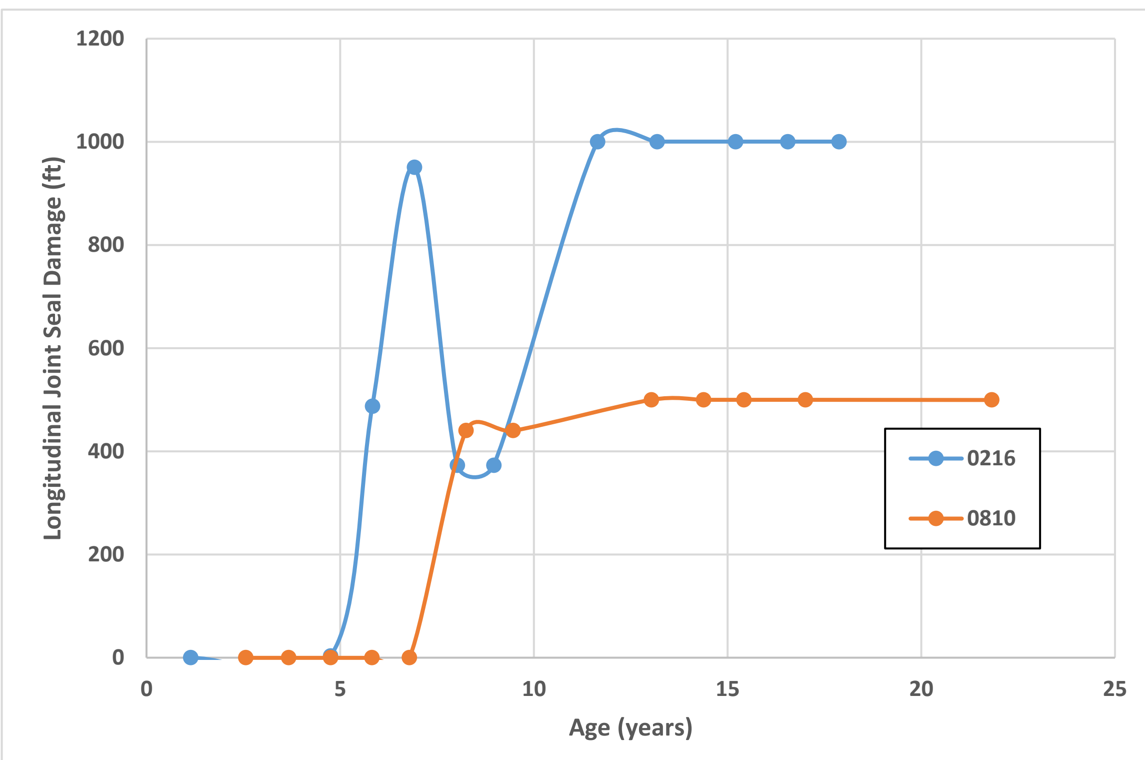
The goal of this study was to compare the performance of LTPP PCC sections of equivalent structure to understand the impact of traffic on distress development. Surface distresses, roughness, and faulting were compared between 10 companion sets of SPS-2 and SPS-8 sections from 5 states. The following observations resulted from this study:

- Surface Distresses
    - Longitudinal and transverse cracking were more common, formed sooner, and developed faster on thinner PCC sections and sections with higher traffic volumes (SPS-2 sections).
    - Longitudinal joint seal damage was common and both SPS-2 and SPS-8 sections experienced large amounts of damage. Higher traffic appeared to influence the total amount of joint seal damage and accelerated the starting age and rate of damage. However, some SPS-8 sections ultimately achieved the same amount of joint seal damage as their companion SPS-2 sections.
    - Longitudinal and transverse spalling results varied. These distresses sometimes occurred on SPS-8 sections but not on SPS-2 sections; at other times, spalling occurred on SPS-2 sections but not on SPS-8 sections. This could be due to differences in climate between the different states.
    - Polished aggregates primarily occurred on SPS-2 sections, indicating this distress was primarily caused by higher traffic volumes.
    - Scaling primarily occurred on SPS-8 sections. Investigations into the PCC mix designs may provide further insight into the formation of scaling. It is possible that the higher traffic levels on the SPS-2 sections wore away the surface before scaling reached a measurable level.
    - Pumping was only observed on the two Arkansas SPS-2 sections and was likely caused by the underground spring located close to, if not directly underneath, these sections.
    - Map cracking was observed on both SPS-2 and SPS-8 sections but was generally more prevalent on SPS-8 sections. Map cracking began at various times following construction. Investigations into the PCC mix designs may provide further insight into the formation of map cracking on these sections.
    - Cracked slabs were more common on thinner SPS-2 sections, indicating both PCC thickness and higher traffic volumes caused a higher number of cracked slabs.
- Roughness
    - Pavement roughness appeared to be influenced by higher traffic volumes; SPS-2 sections had higher average yearly changes in IRI than companion SPS-8 sections.
- Faulting
    - No clear trends were observed when comparing faulting measurements between companion SPS-2 and SPS-8 sections.

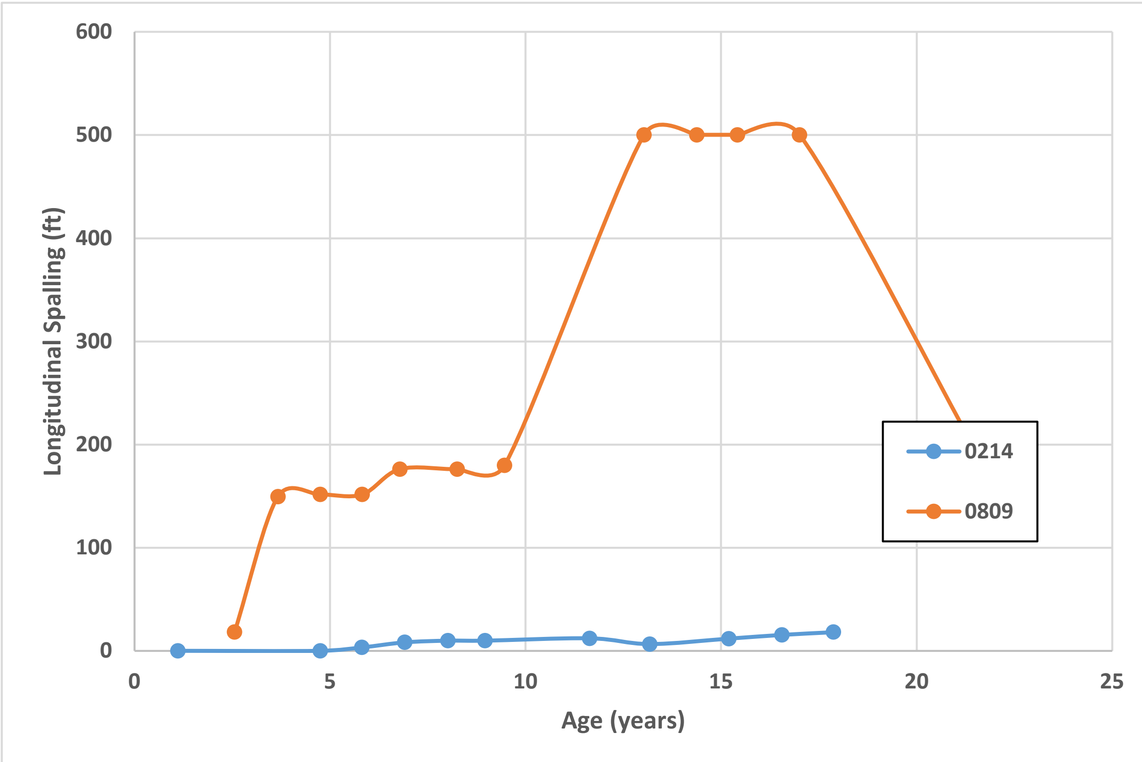
Appendix A

ARKANSAS DISTRESS GRAPHS

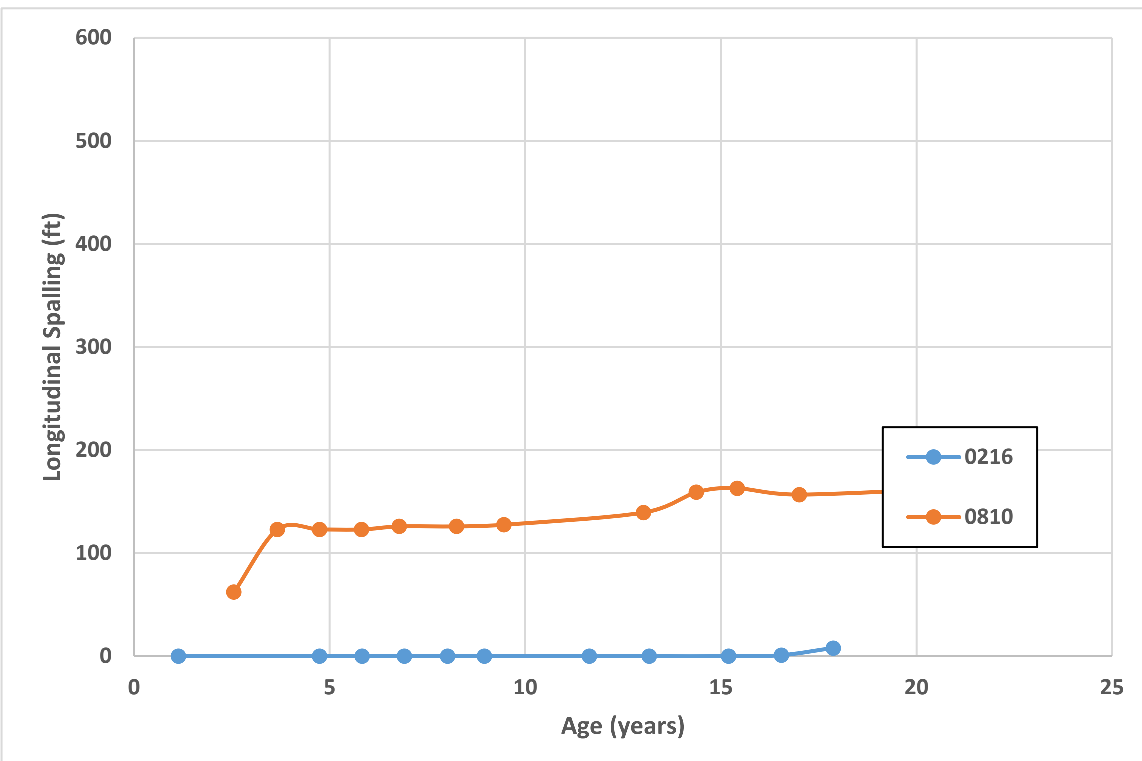




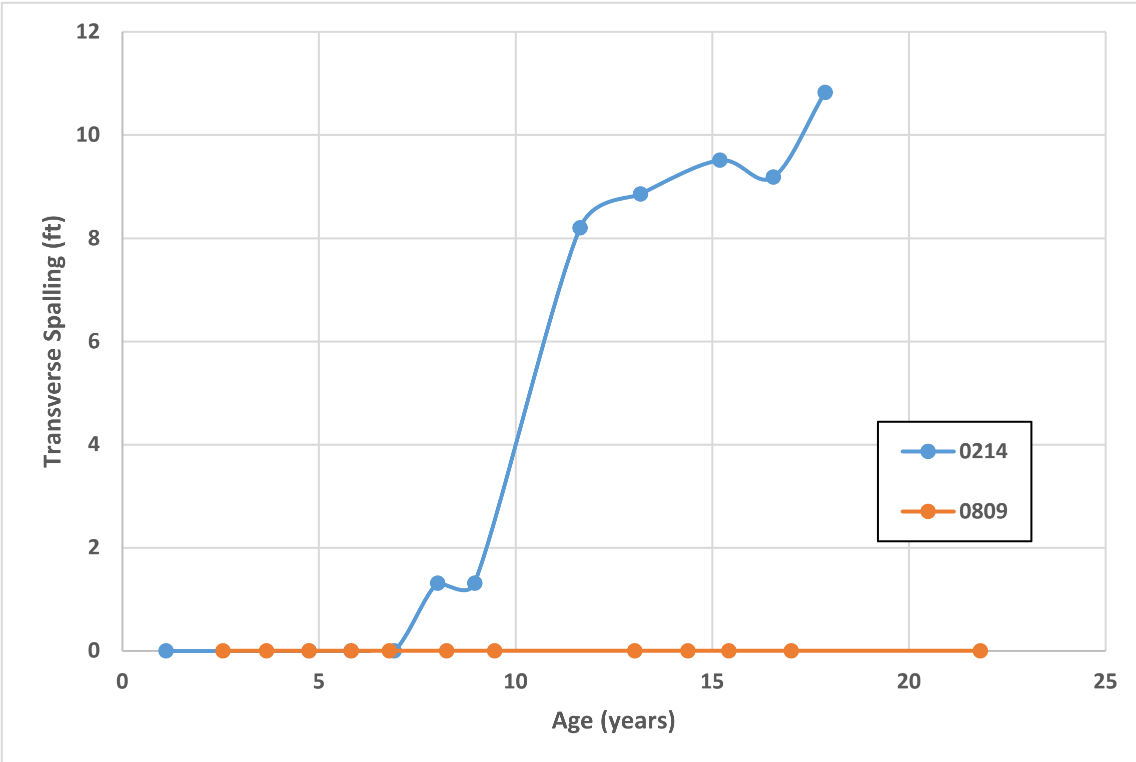
Section 050216 received inside edge joint seal reapplication at year 8.3

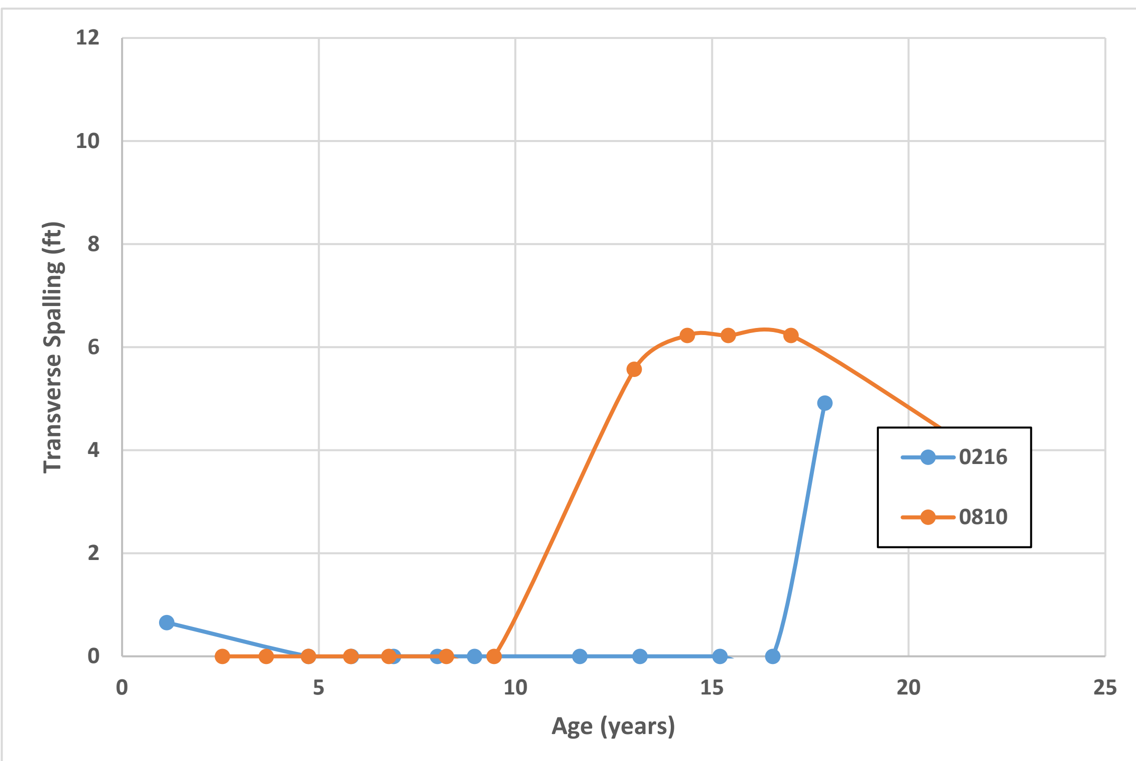


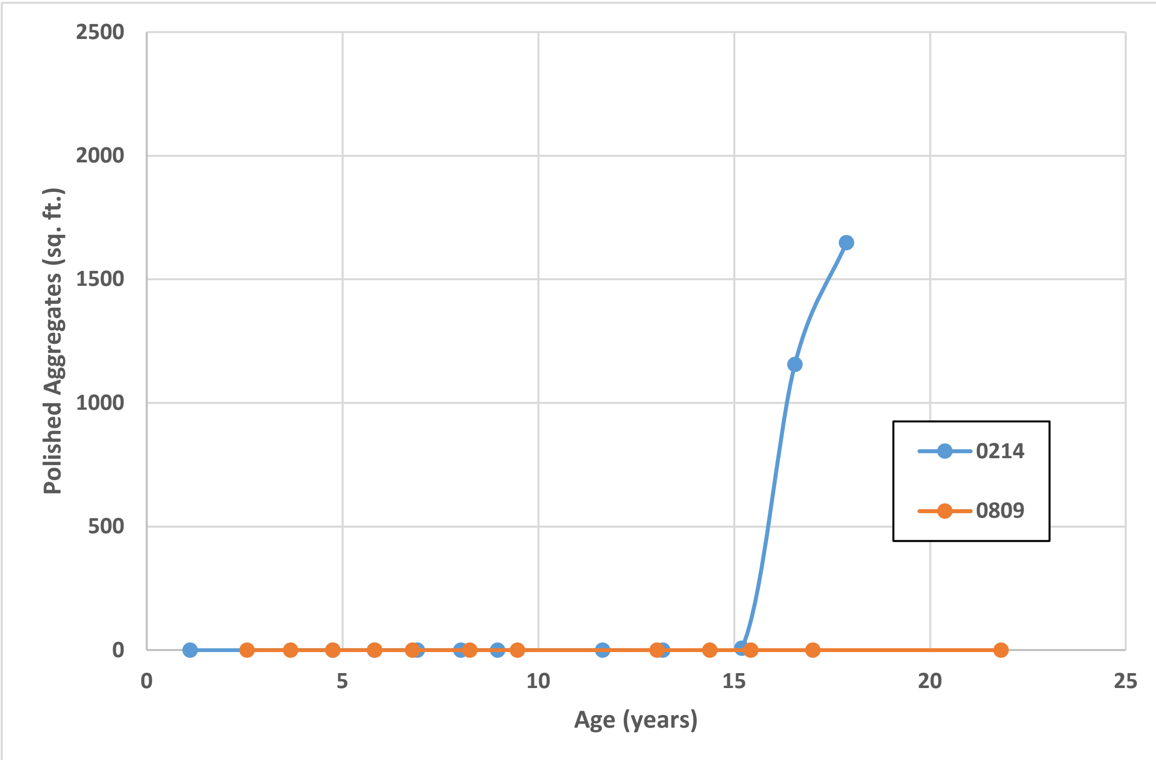
600
500
400
300
200
100
0
0
5
10
15
20
25
Longitudinal Spalling (ft)
Age (years)
0214
0809



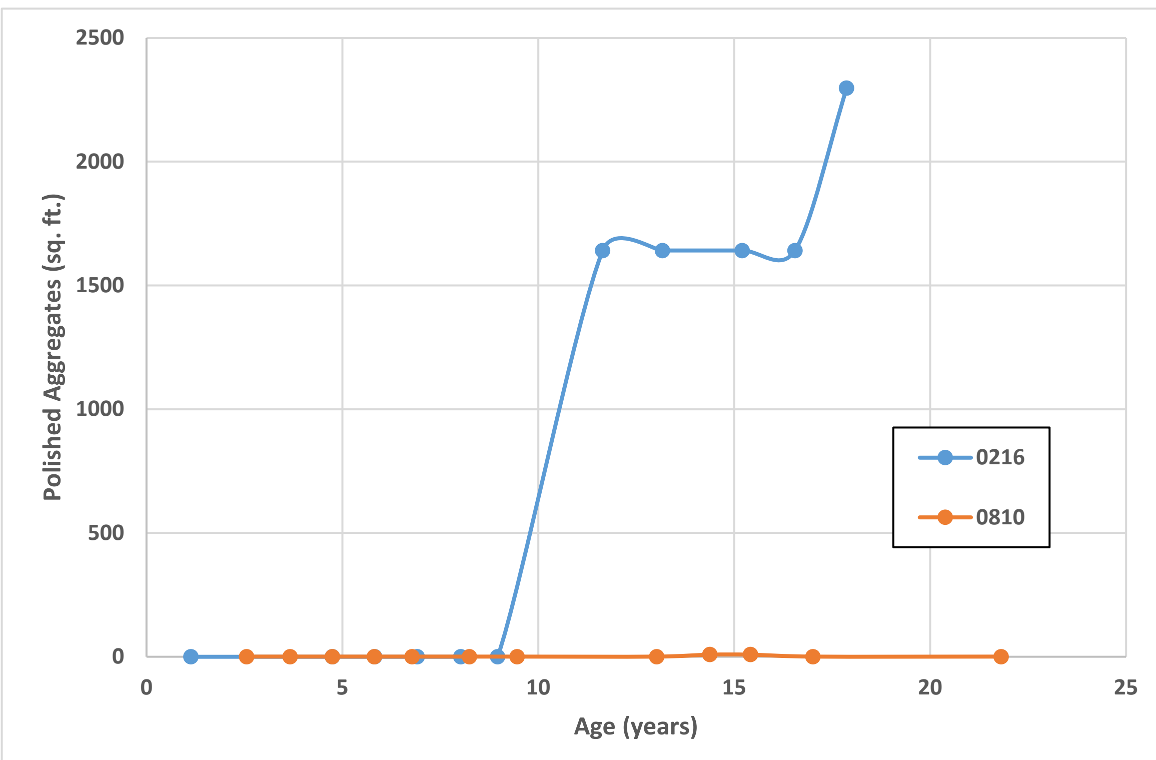
600
500
400
300
200
100
0
0
5
10
15
20
25
Longitudinal Spalling (ft)
Age (years)
0216
0810


12
10
8
6
4
2
0
Transverse Spalling (ft)
0
5
10
15
20
25
Age (years)
0214
0809

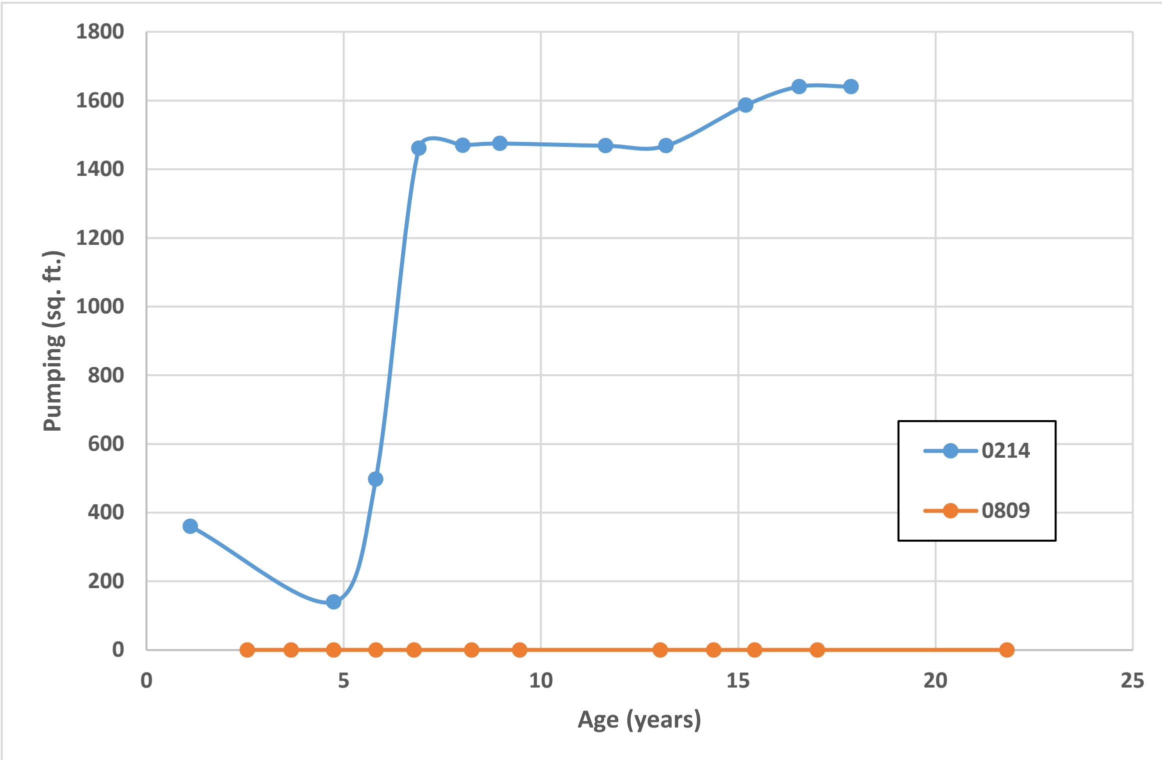

12
10
8
6
4
2
0
Transverse Spalling (ft)
0
5
10
15
20
25
Age (years)
0216
0810



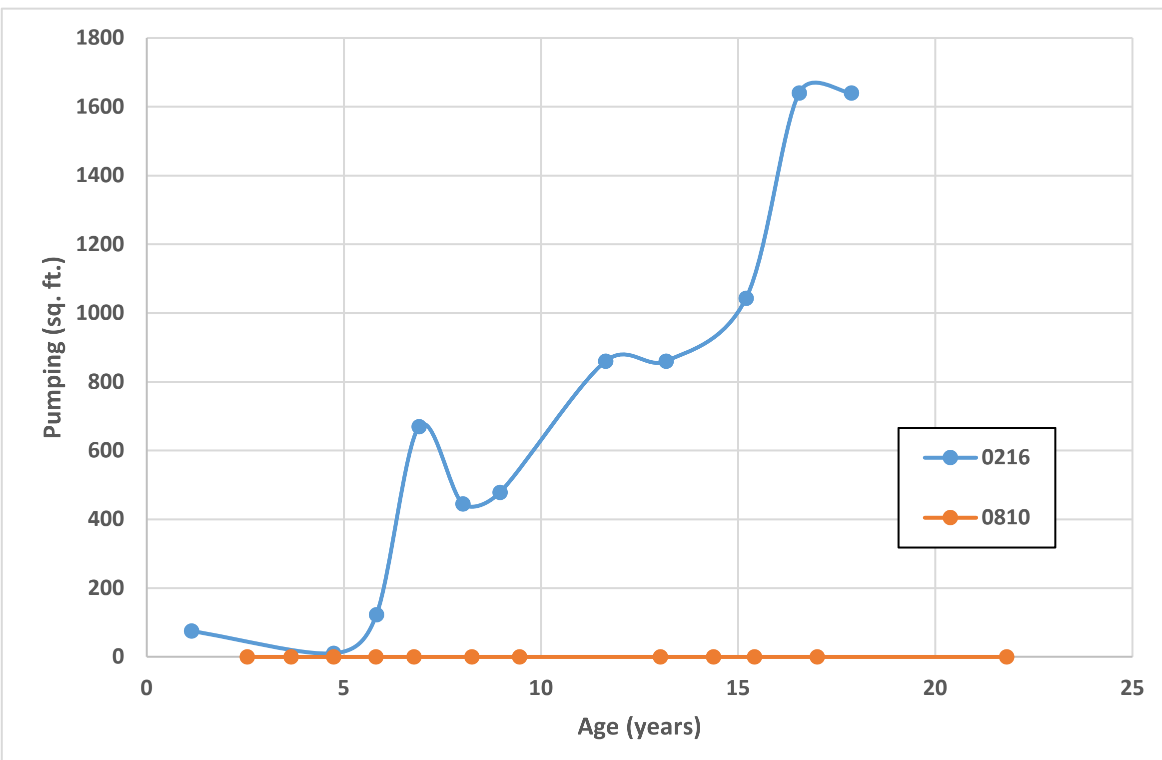
2500
2000
1500
1000
500
0
Polished Aggregates (sq. ft.)
0
5
10
15
20
25
Age (years)
0214
0809



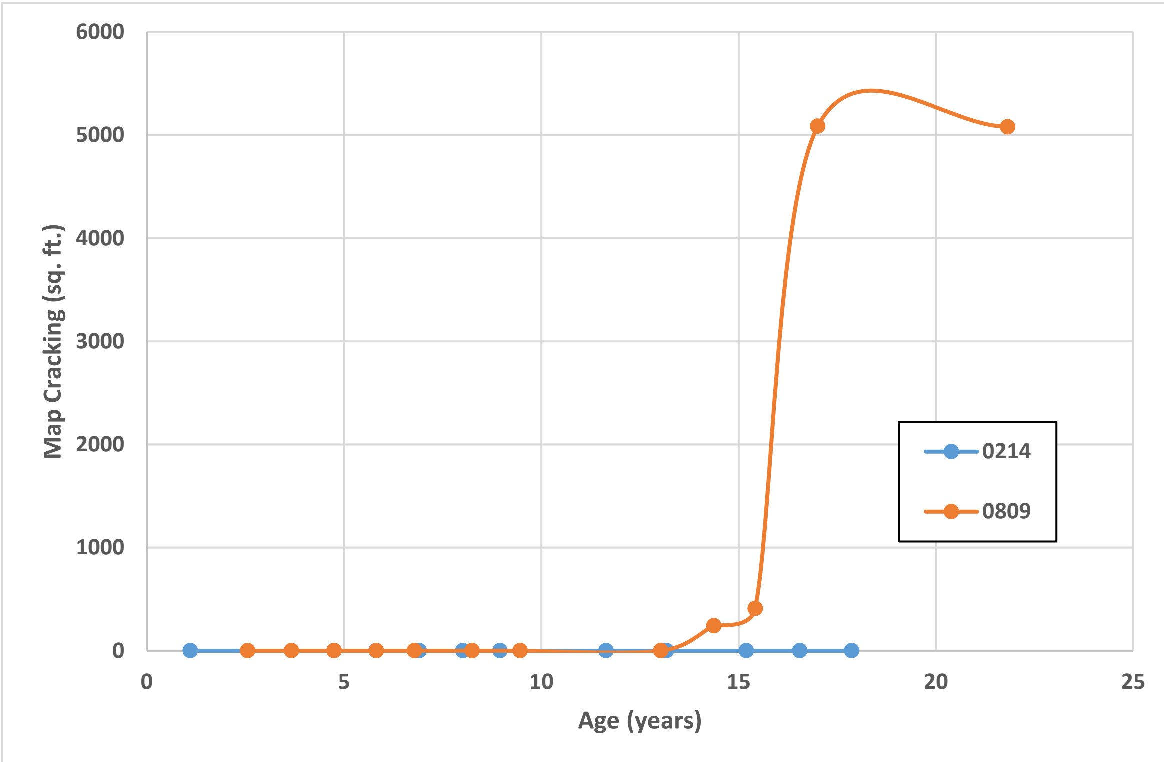
2500
2000
1500
1000
500
0
Polished Aggregates (sq. ft.)
0
5
10
15
20
25
Age (years)
0216
0810

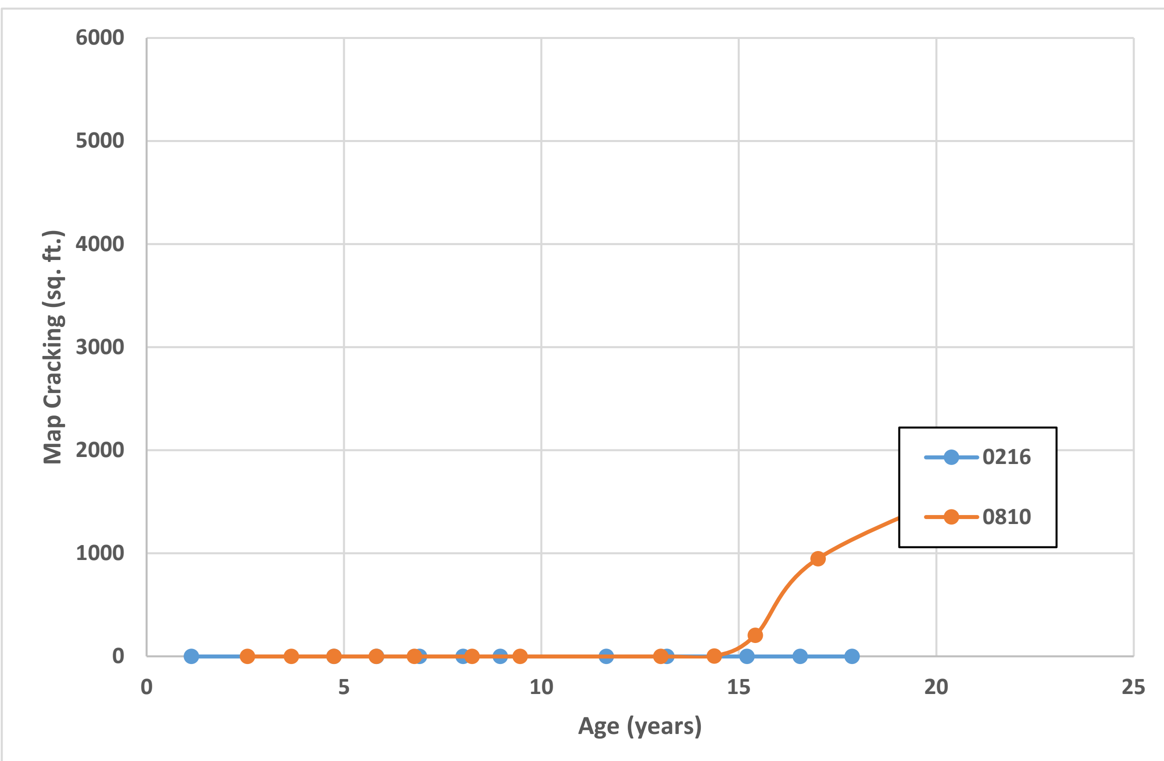


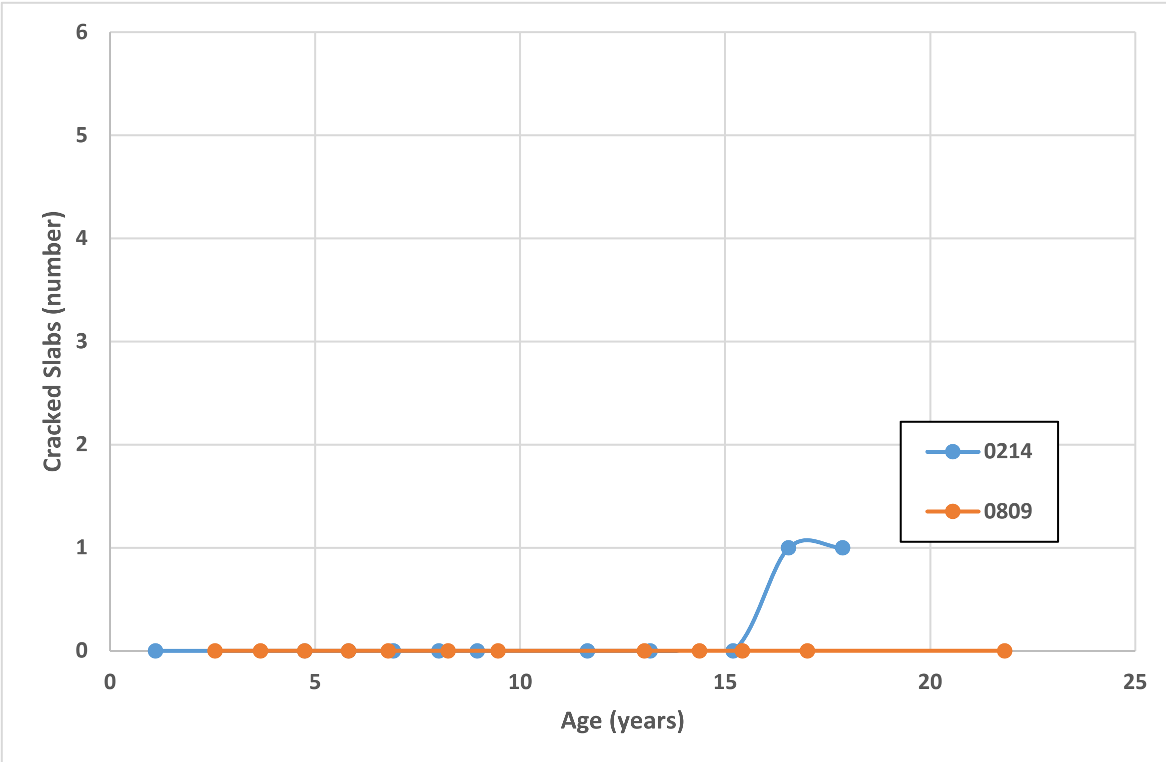
1800
1600
1400
1200
1000
800
600
400
200
0
Pumping (sq. ft.)
0
5
10
15
20
25
Age (years)
0214
0809

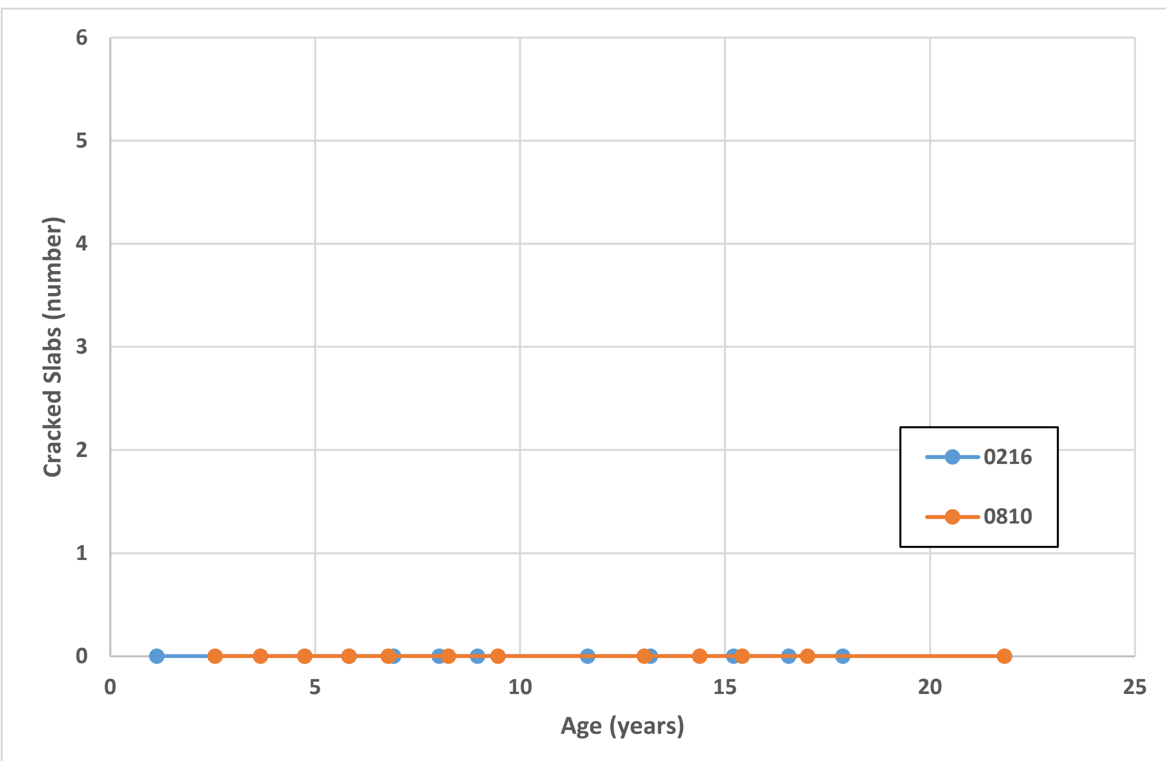


1800
1600
1400
1200
1000
800
600
400
200
0
Pumping (sq. ft.)
0
5
10
15
20
25
Age (years)
0216
0810


6000
5000
4000
3000
2000
1000
0
Map Cracking (sq. ft.)
0
5
10
15
20
25
Age (years)
0214
0809

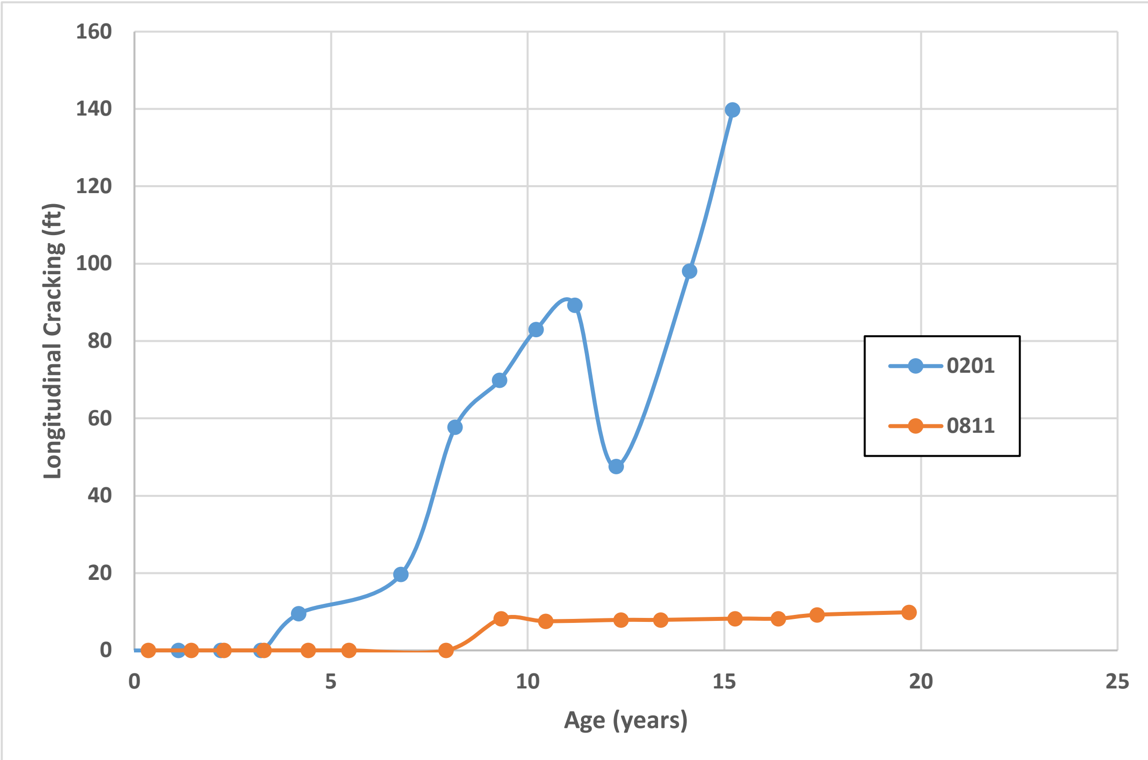

6000
5000
4000
3000
2000
1000
0
Map Cracking (sq. ft.)
0
5
10
15
20
25
Age (years)
0216
0810


Cracked Slabs (number)
6
5
4
3
2
1
0
0
5
10
15
20
25
Age (years)
0214
0809

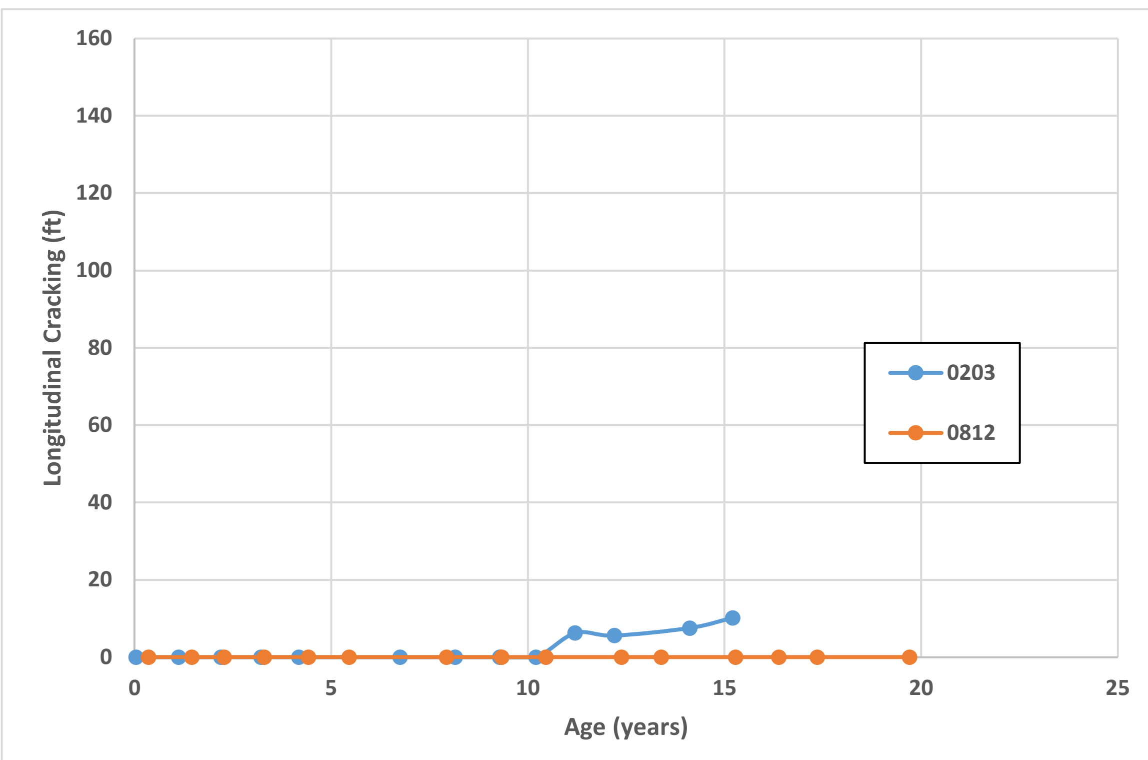

Cracked Slabs (number)
6
5
4
3
2
1
0
0
5
10
15
20
25
Age (years)
0216
0810

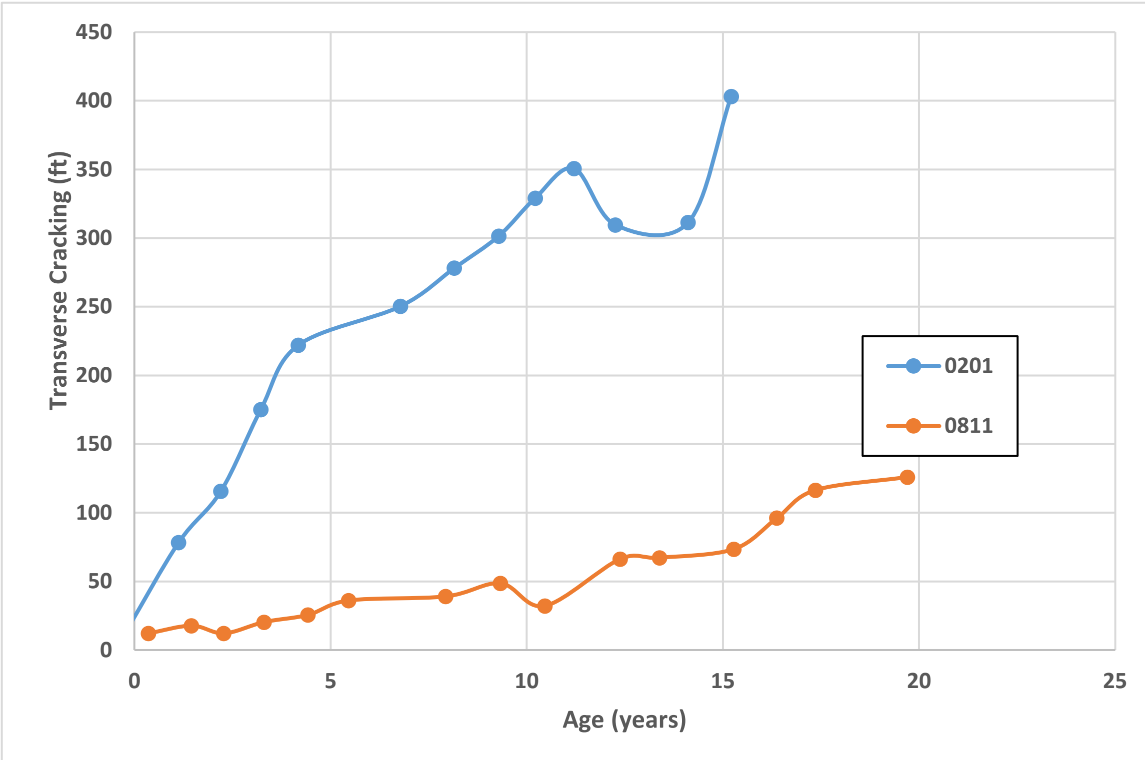
Appendix B

California Distress Graphs



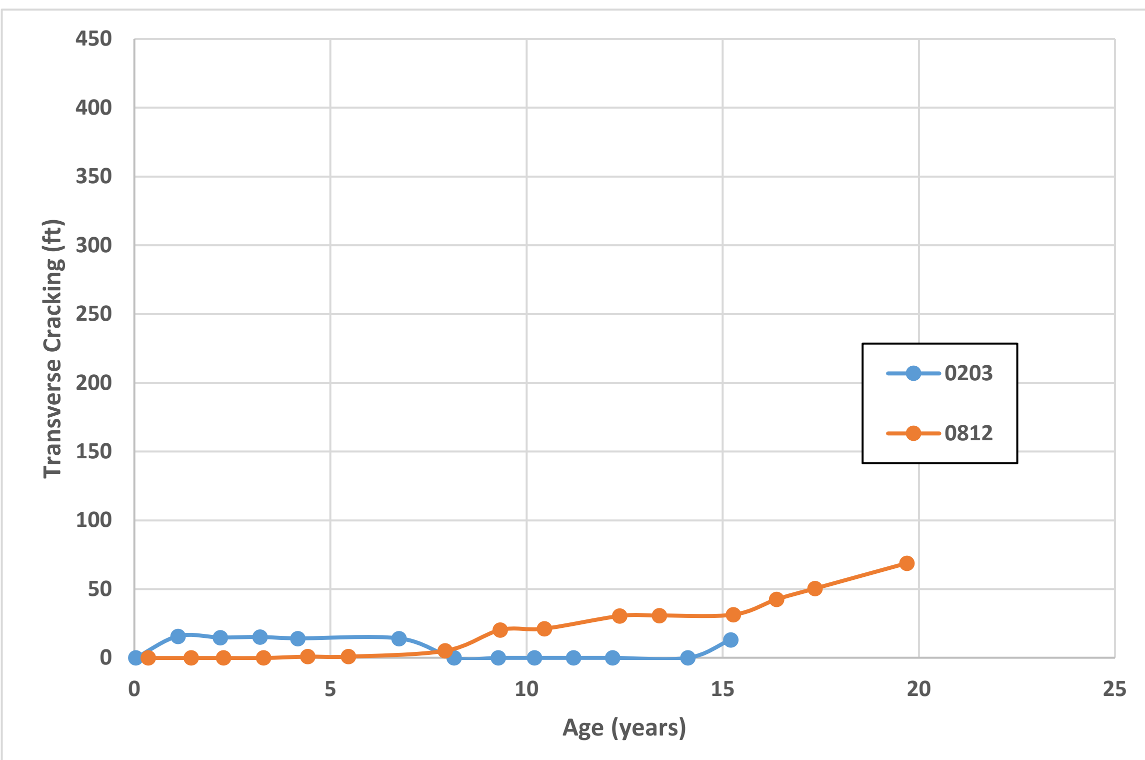
Section 060201 received partial-depth patching at 12.5 years

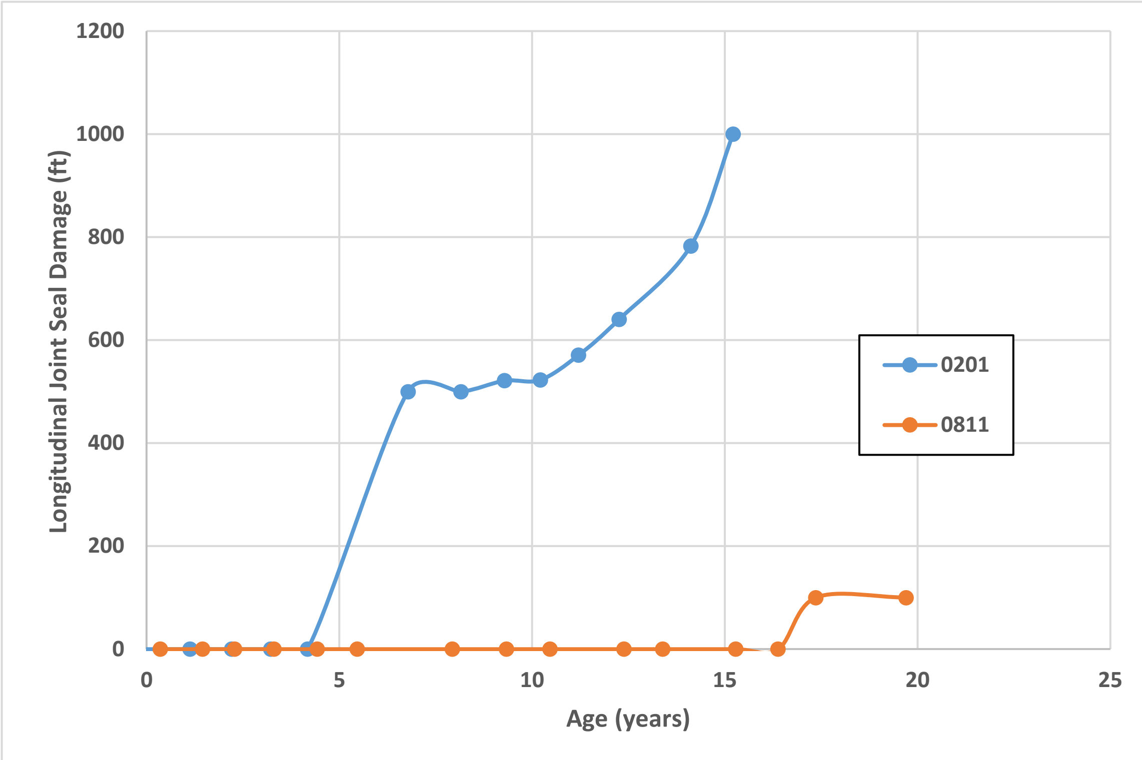




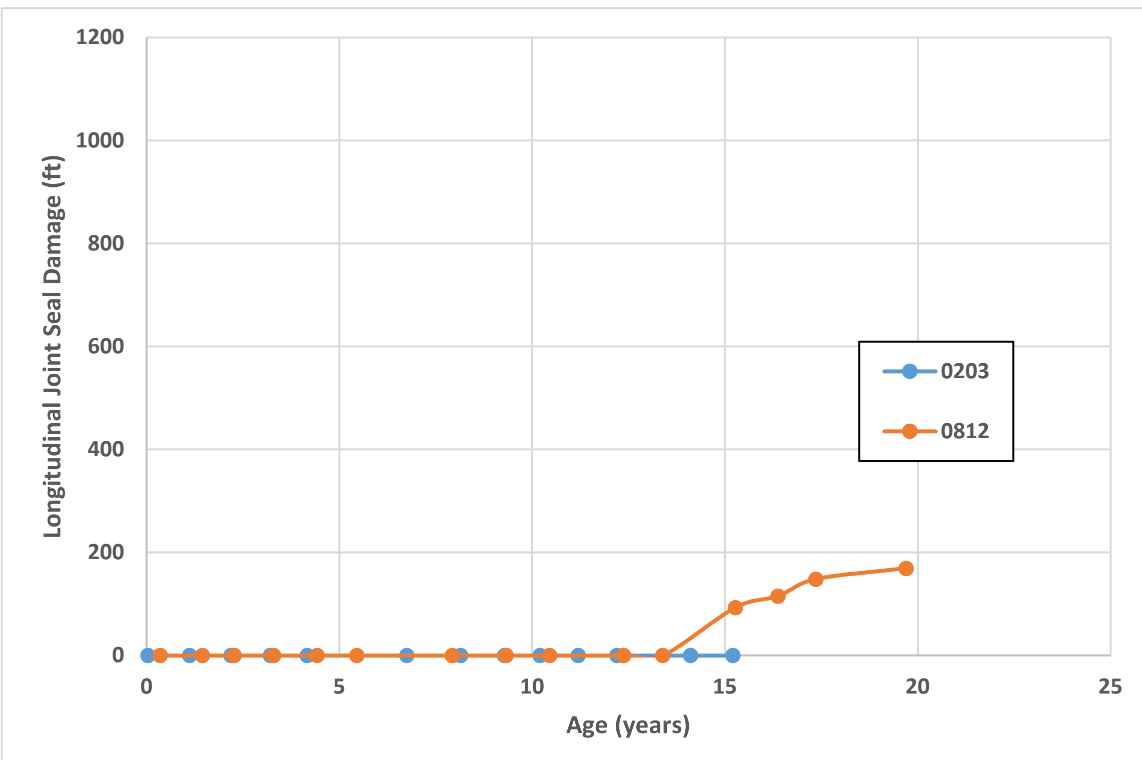
Section 060201 received partial-depth patching at 12.5 years

Section 060811 received partial-depth patching at 3.5 and 8.5 years

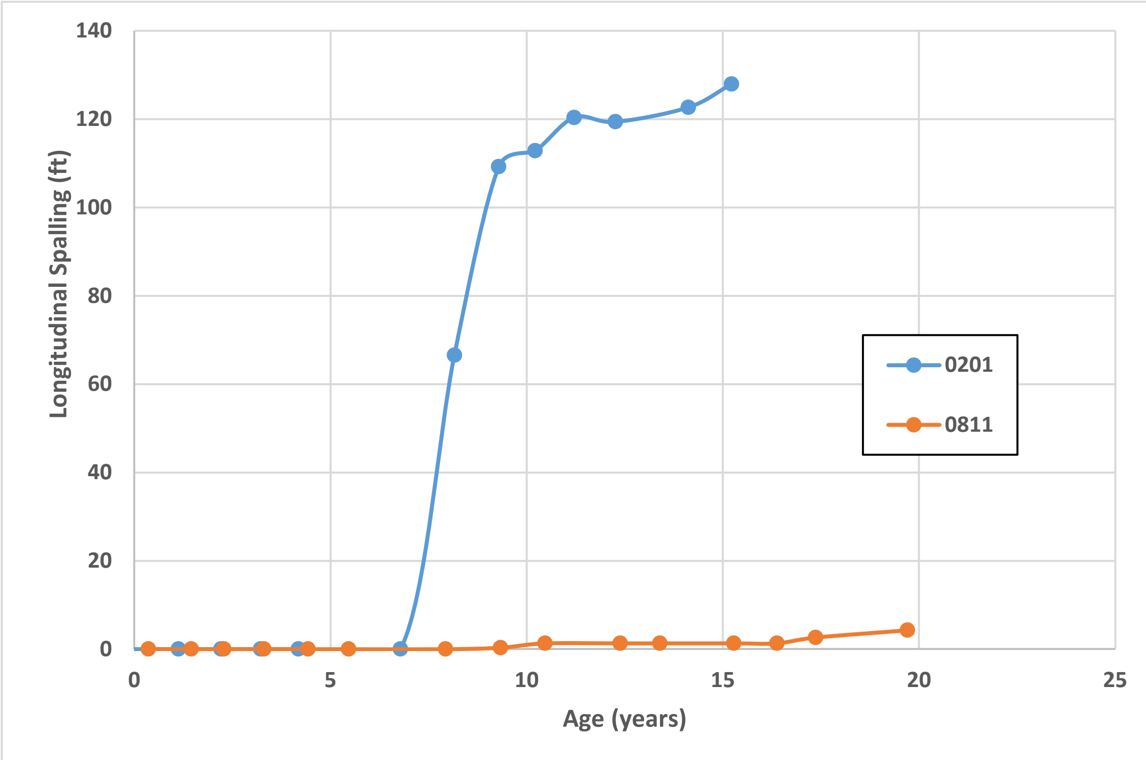


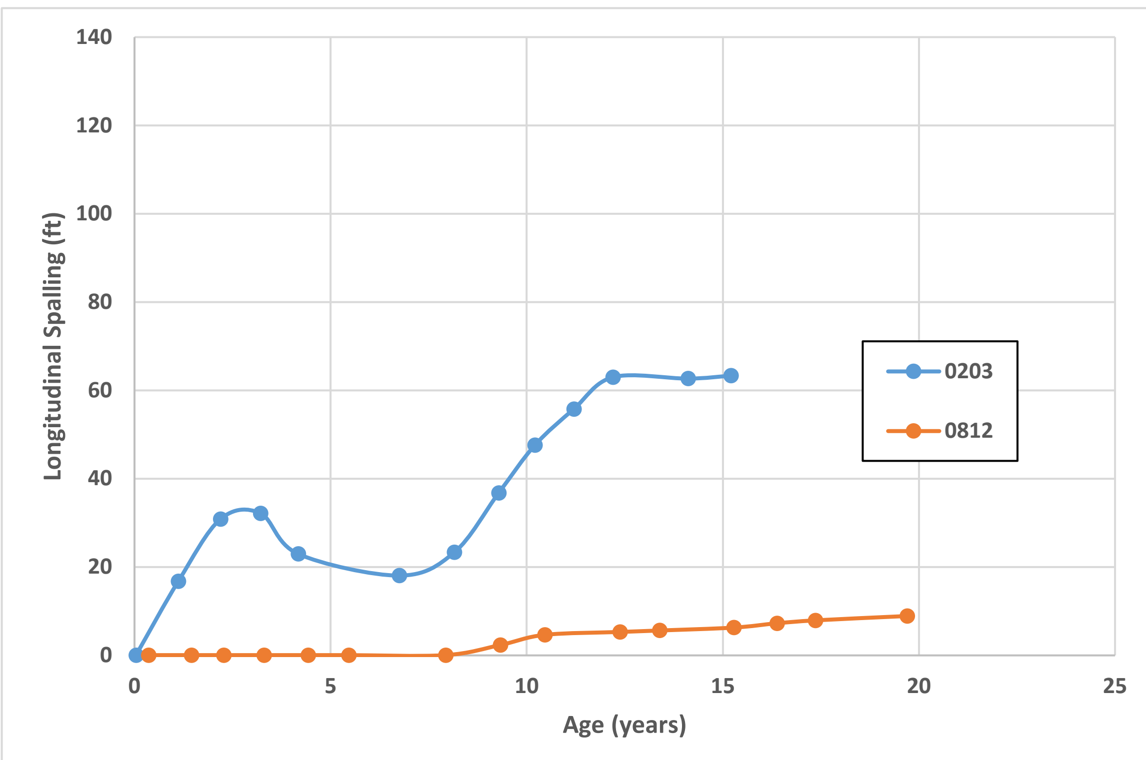


Longitudinal Joint Seal Damage (ft)
1200
1000
800
600
400
200
0
0
5
10
15
20
25
Age (years)
0201
0811

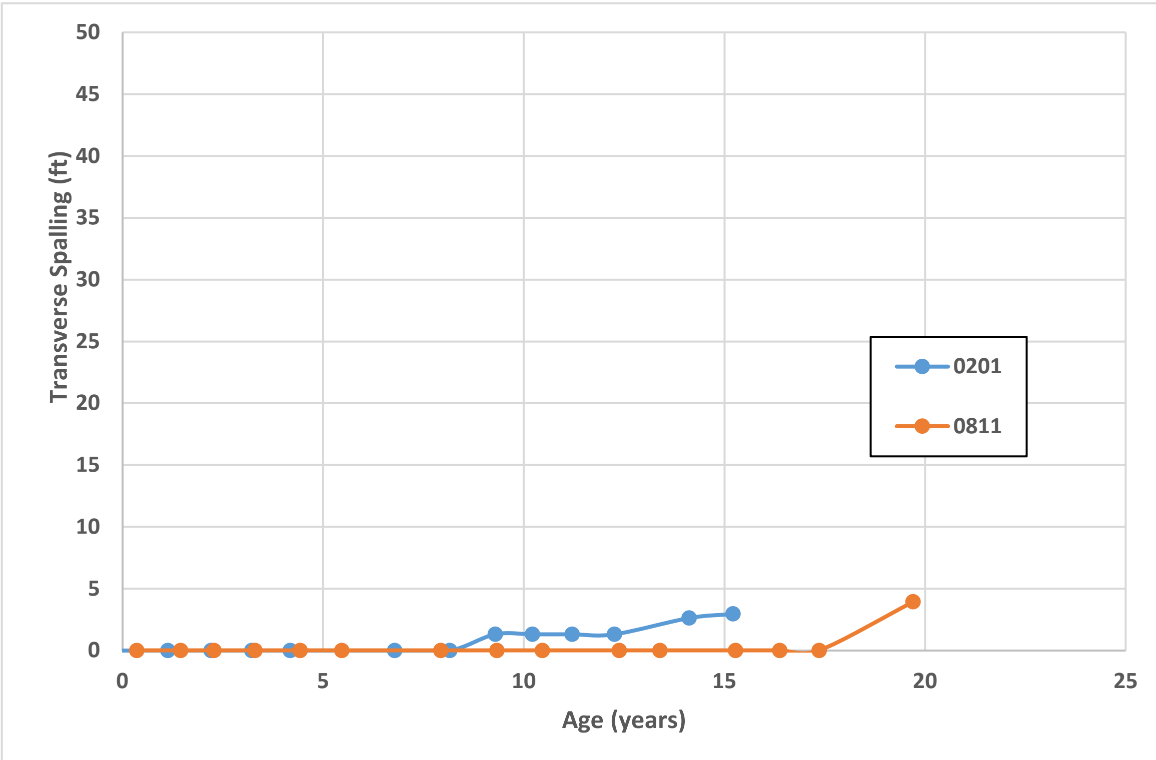


Longitudinal Joint Seal Damage (ft)
1200
1000
800
600
400
200
0
0
5
10
15
20
25
Age (years)
0203
0812

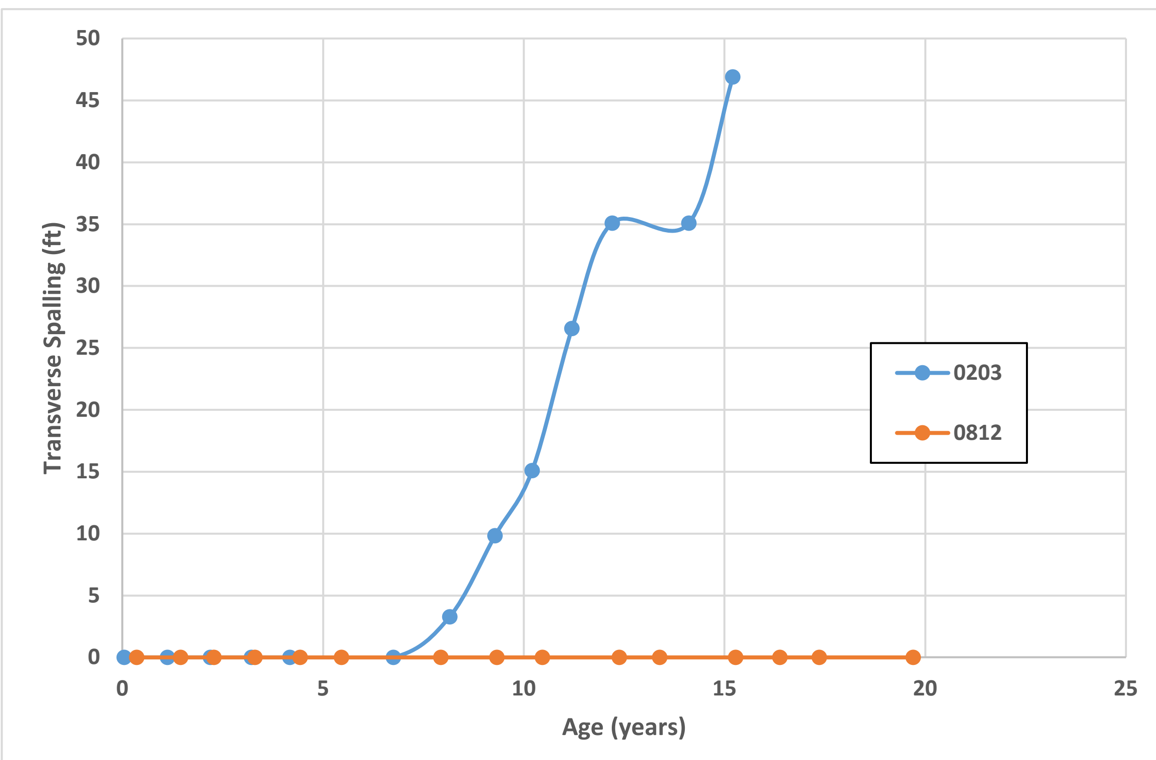




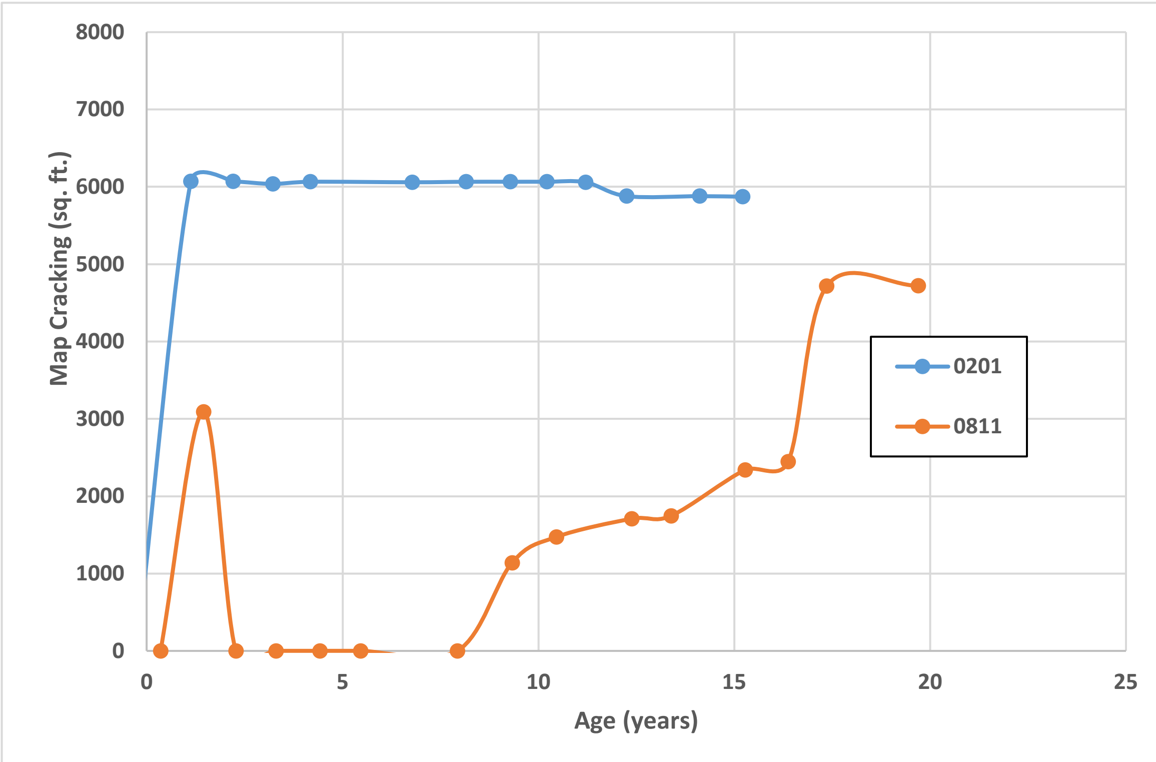
Section 060203 received diamond grinding at 5.5 and 8.5 years.



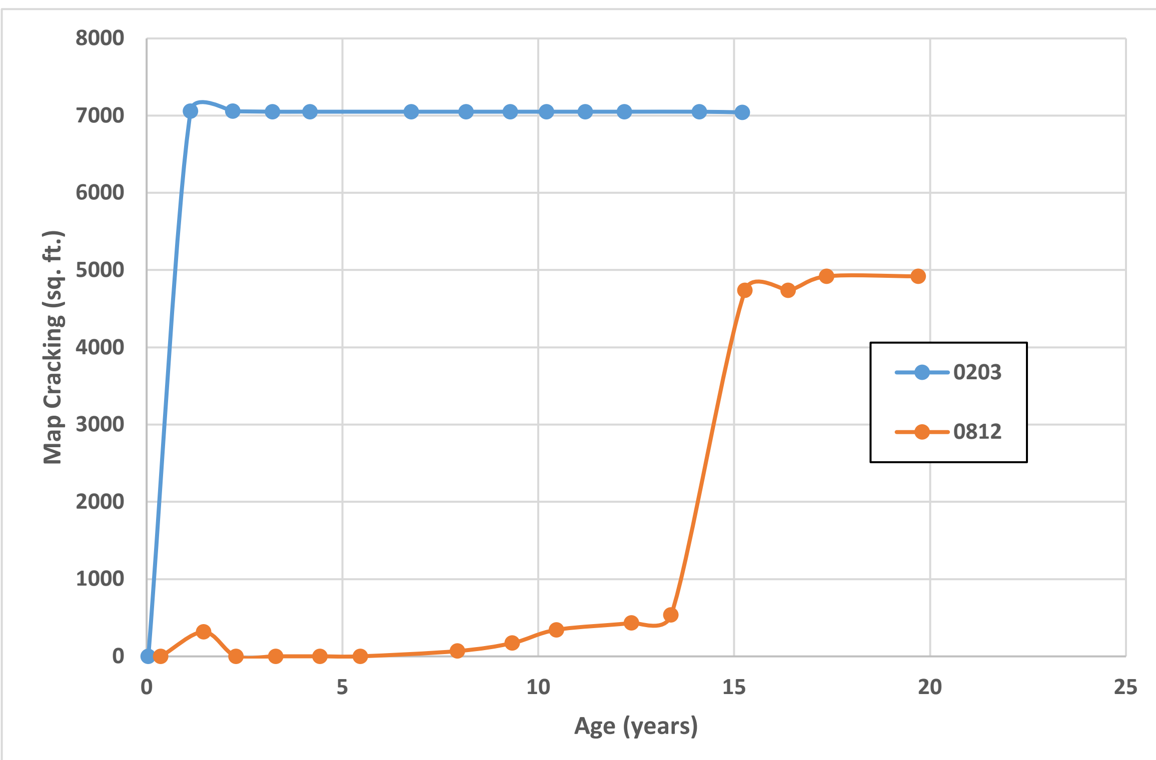
Transverse Spalling (ft)
Age (years)
0201
0811

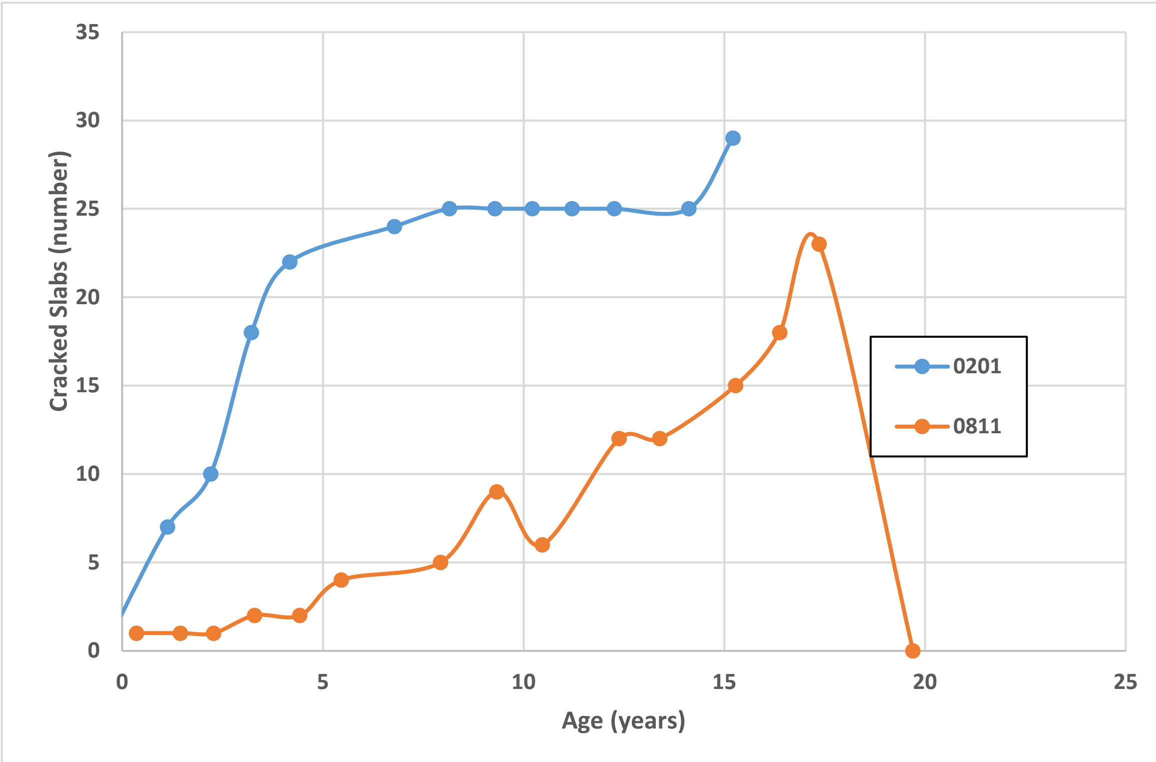


Transverse Spalling (ft)
Age (years)
0203
0812

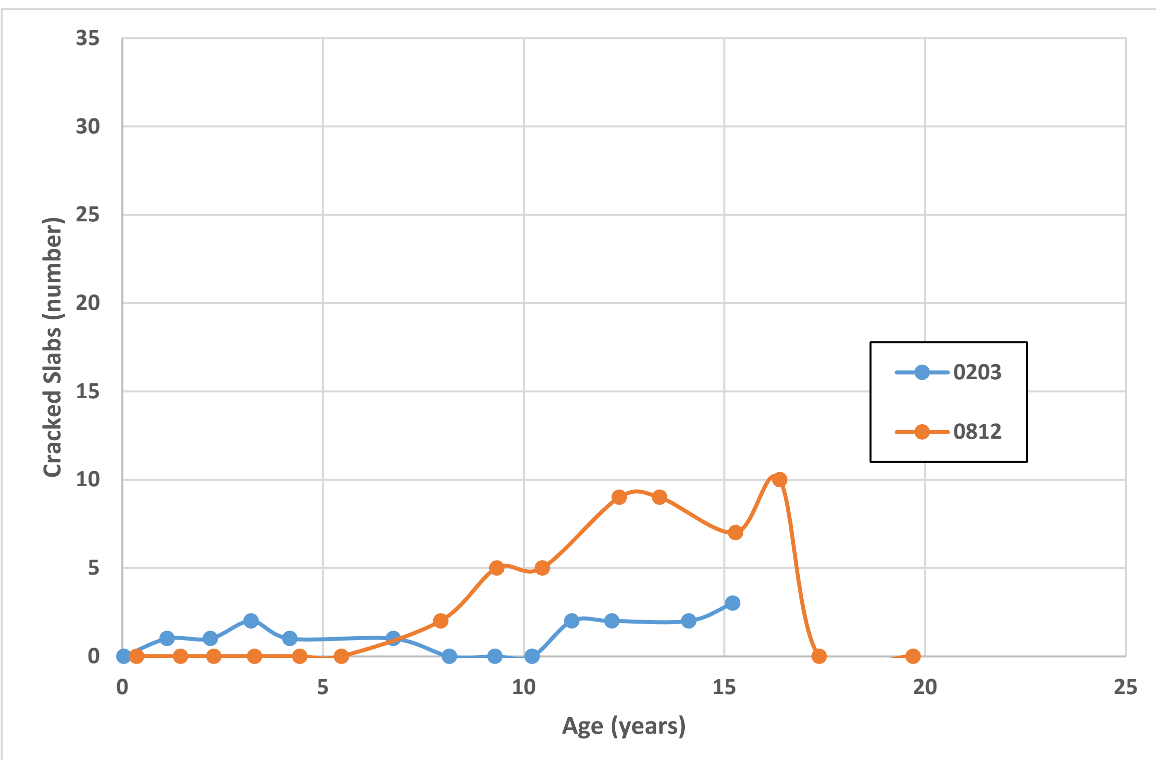


Section 060811 received partial-depth patching at 3.5 and 8.5 years



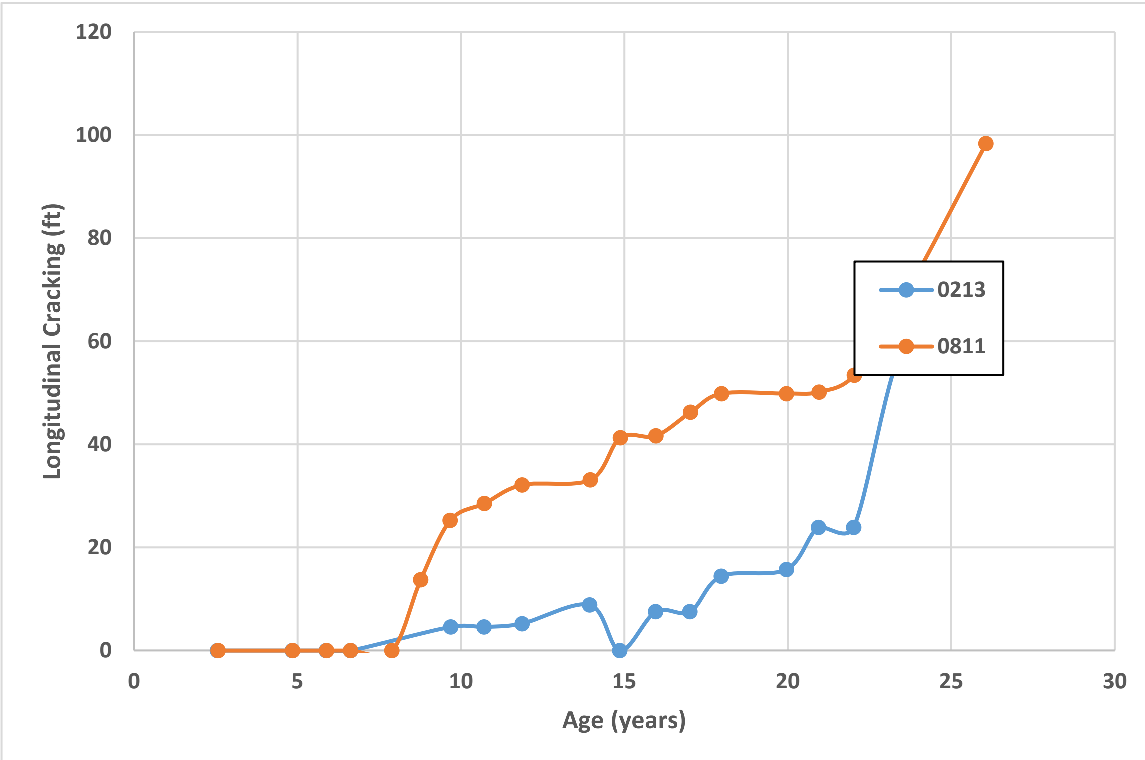


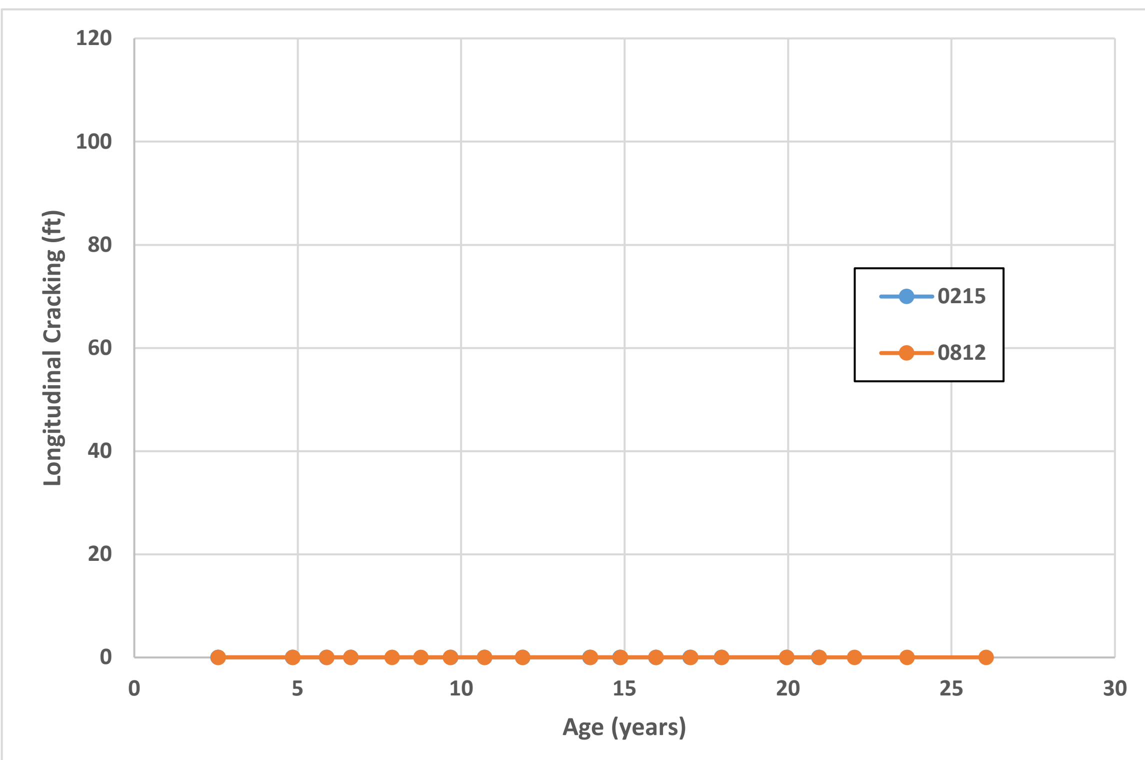
Section 060811 received partial-depth patching at 3.5 and 8.5 years

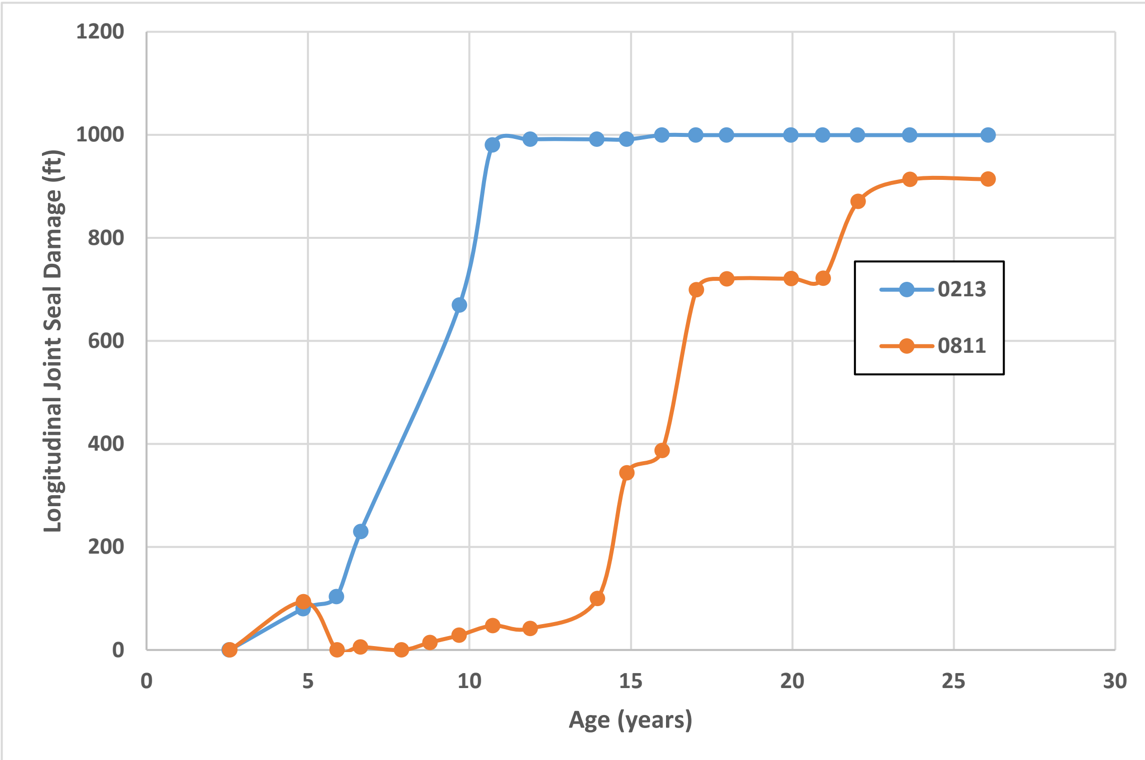


Appendix C

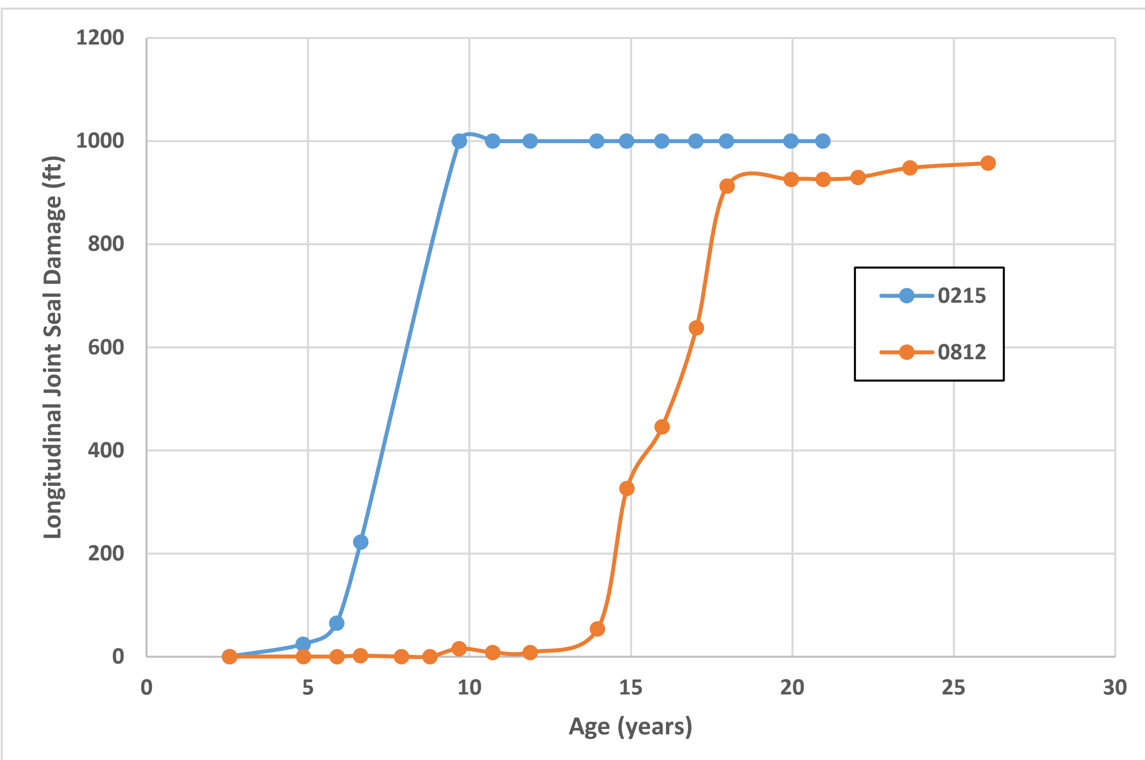
COLORADO DISTRESS GRAPHS


120
100
80
60
40
20
0
Longitudinal Cracking (ft)
0
5
10
15
20
25
30
Age (years)
0213
0811

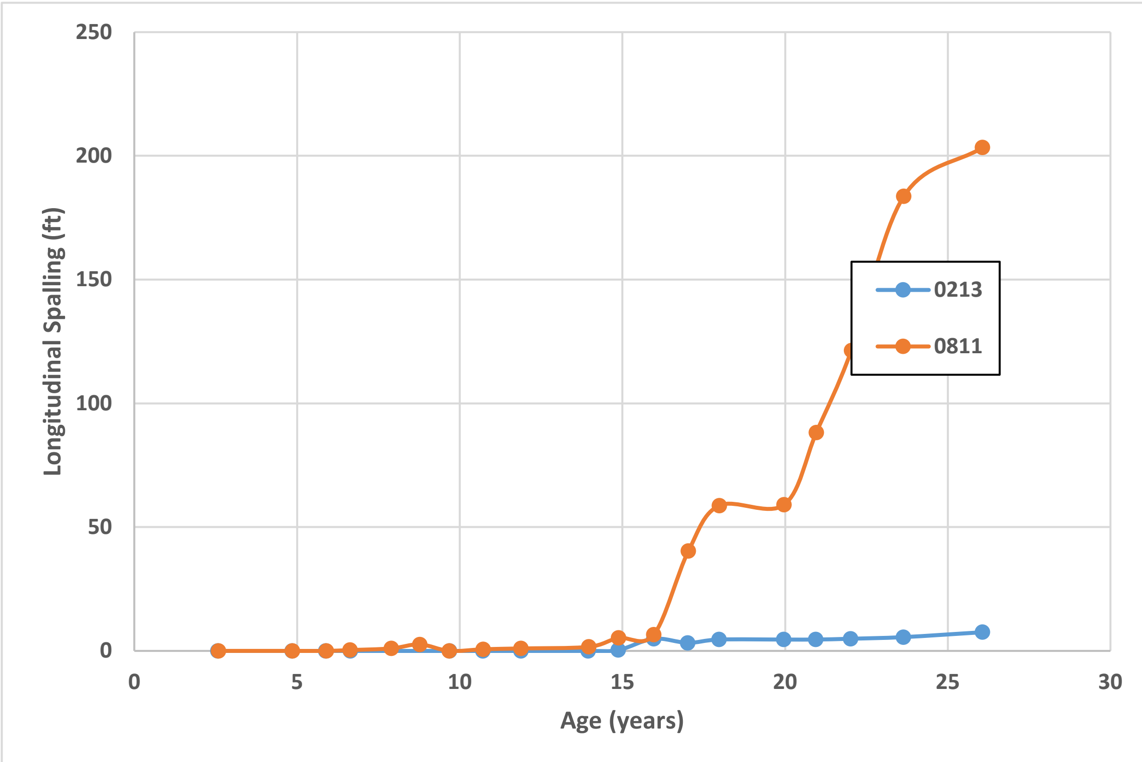

120
100
80
60
40
20
0
Longitudinal Cracking (ft)
0
5
10
15
20
25
30
Age (years)
0215
0812



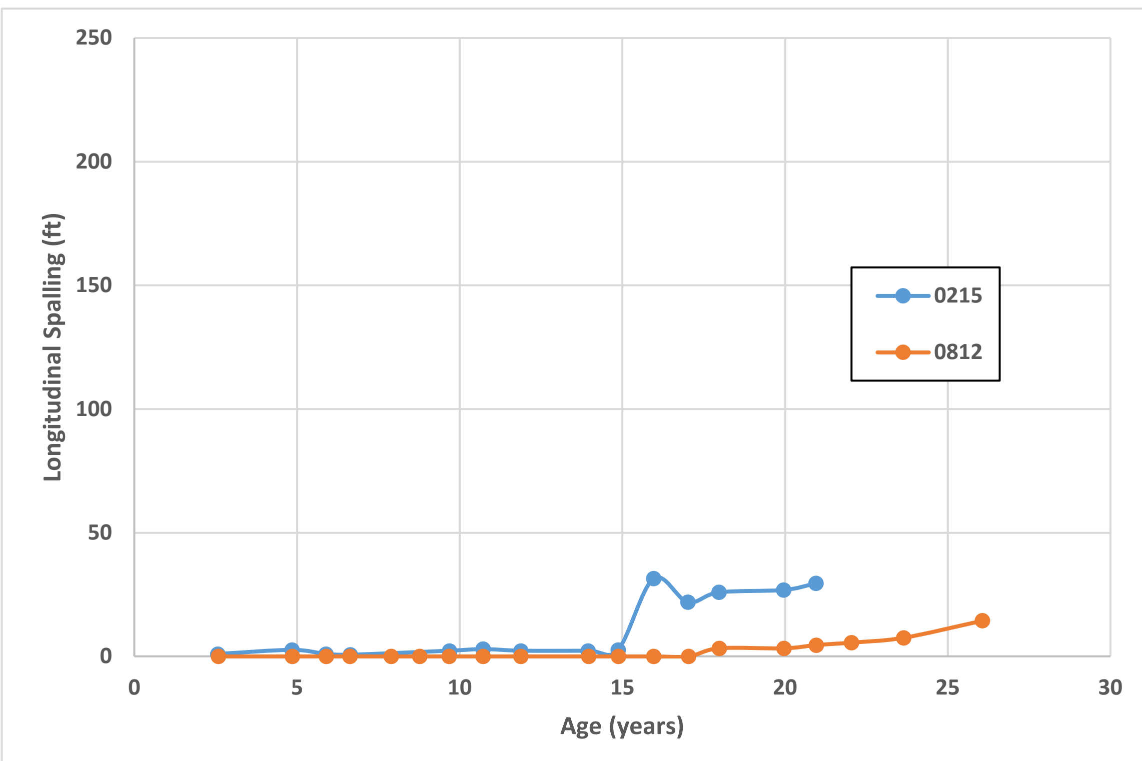
1200
1000
800
600
400
200
0
0
5
10
15
20
25
30
Longitudinal Joint Seal Damage (ft)
Age (years)
0213
0811



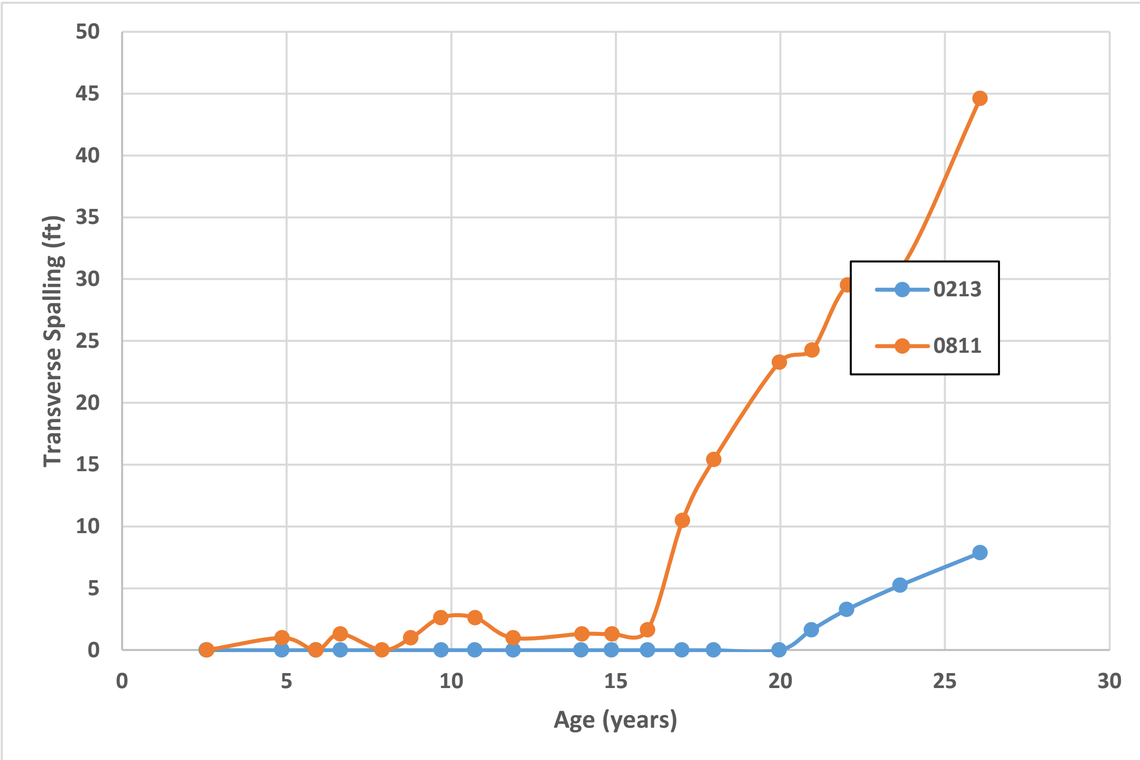
1200
1000
800
600
400
200
0
0
5
10
15
20
25
30
Longitudinal Joint Seal Damage (ft)
Age (years)
0215
0812



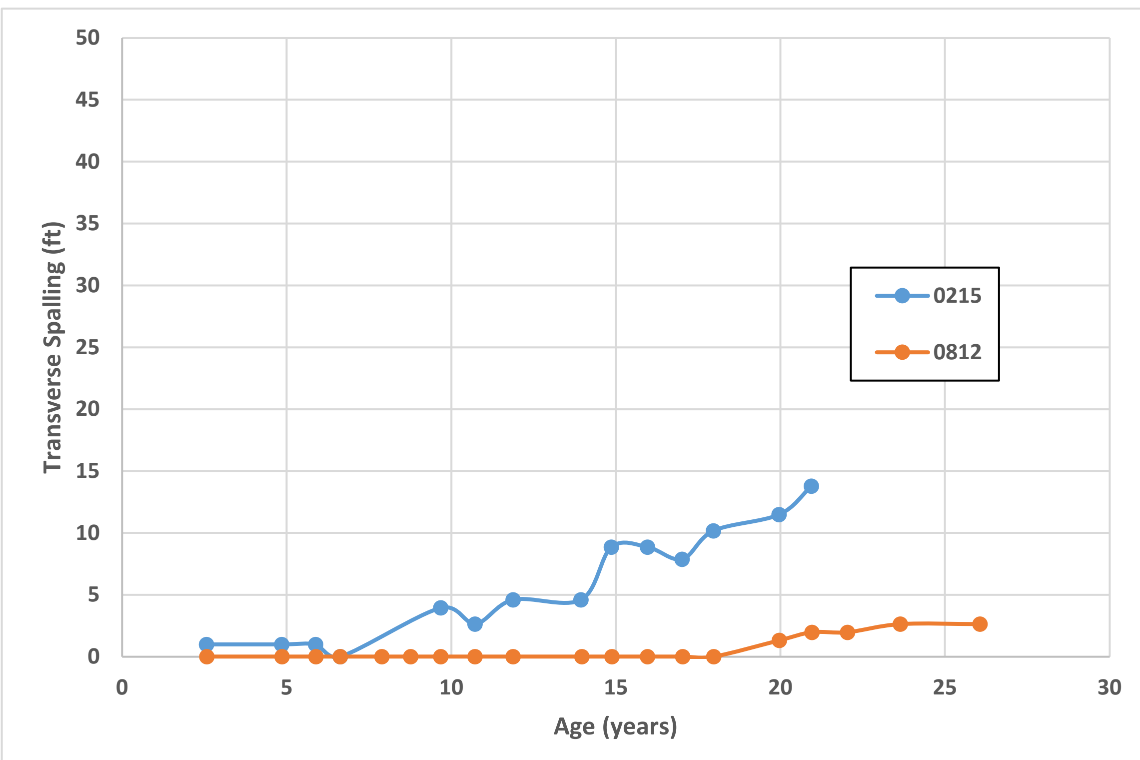
250
200
150
100
50
0
0
5
10
15
20
25
30
Longitudinal Spalling (ft)
Age (years)
0213
0811



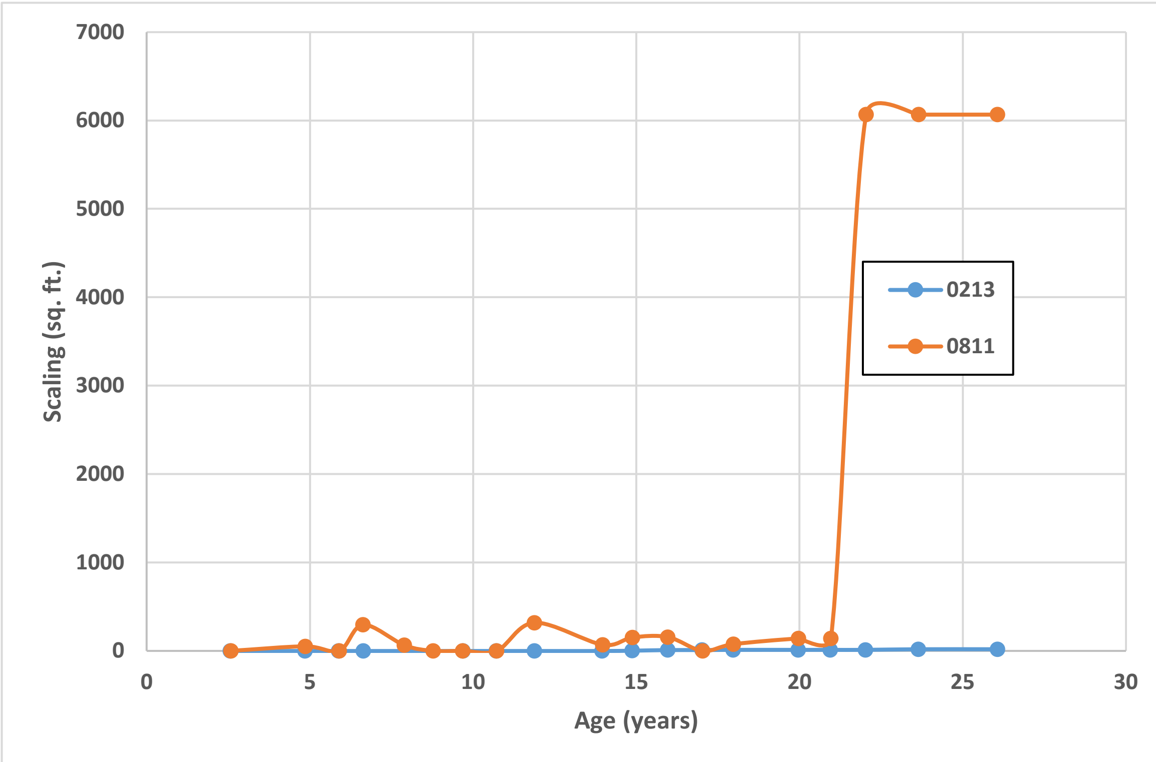
250
200
150
100
50
0
0
5
10
15
20
25
30
Longitudinal Spalling (ft)
Age (years)
0215
0812



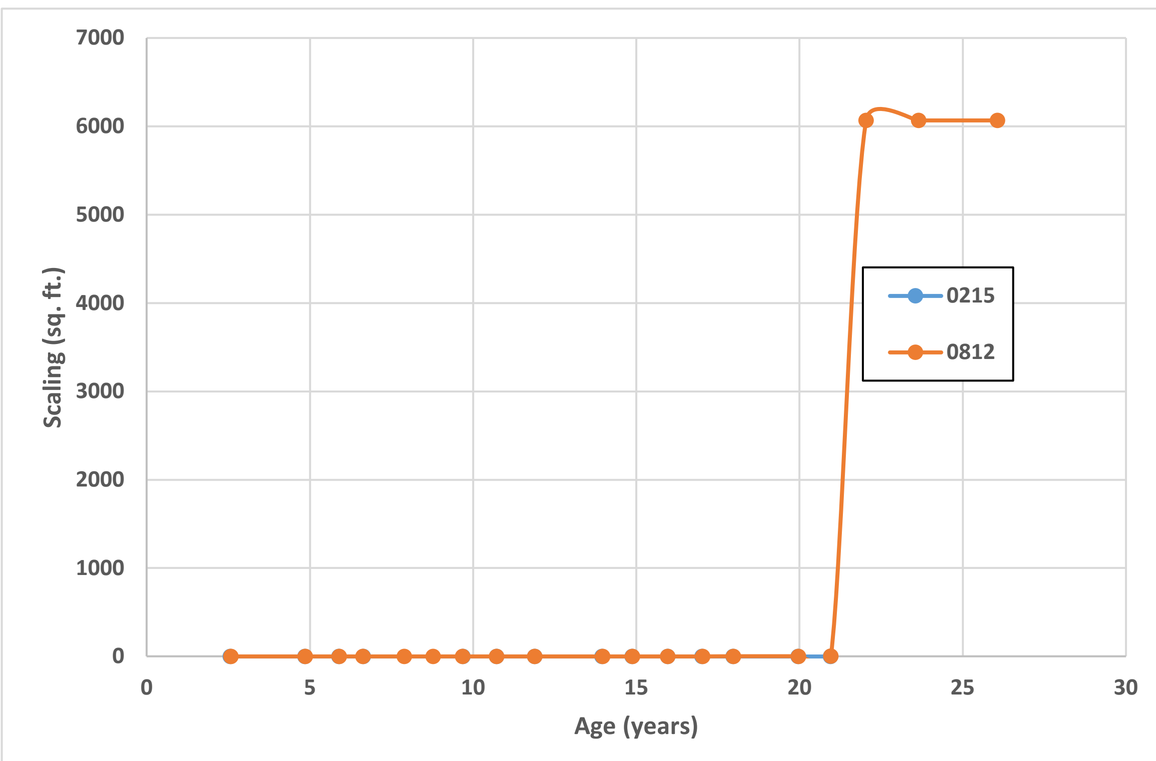
Transverse Spalling (ft)
Age (years)
0213
0811



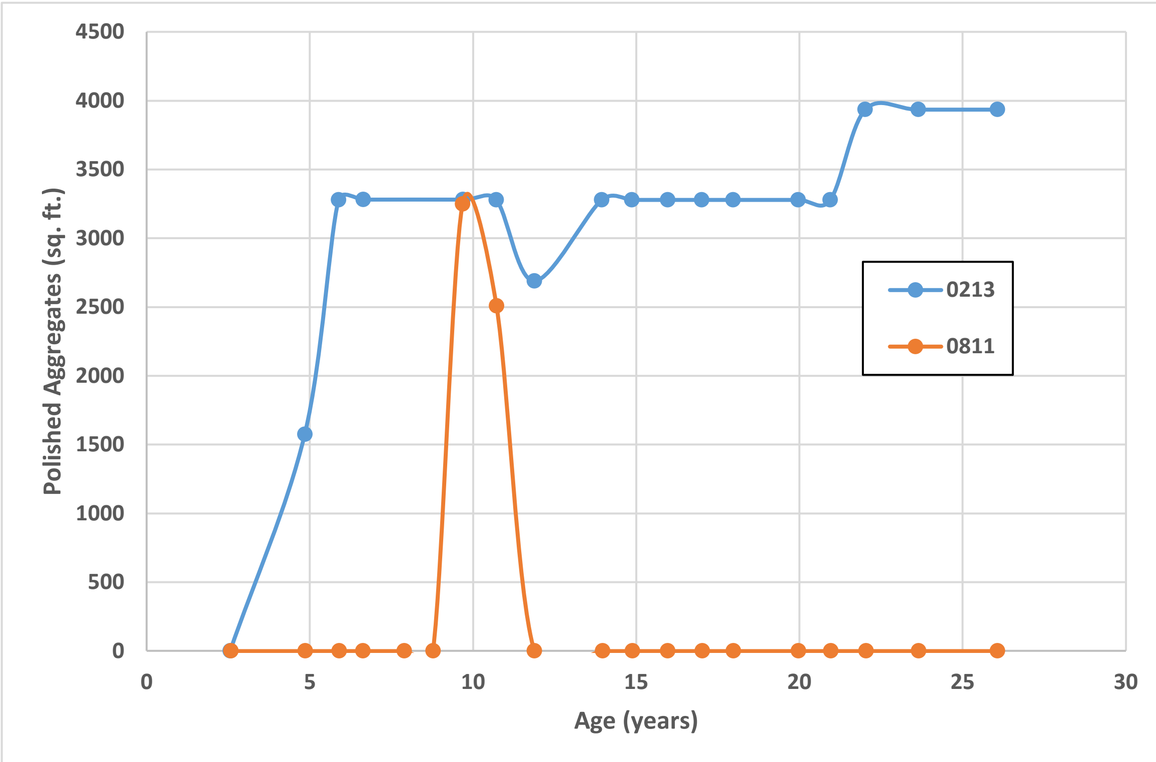
Transverse Spalling (ft)
Age (years)
0215
0812



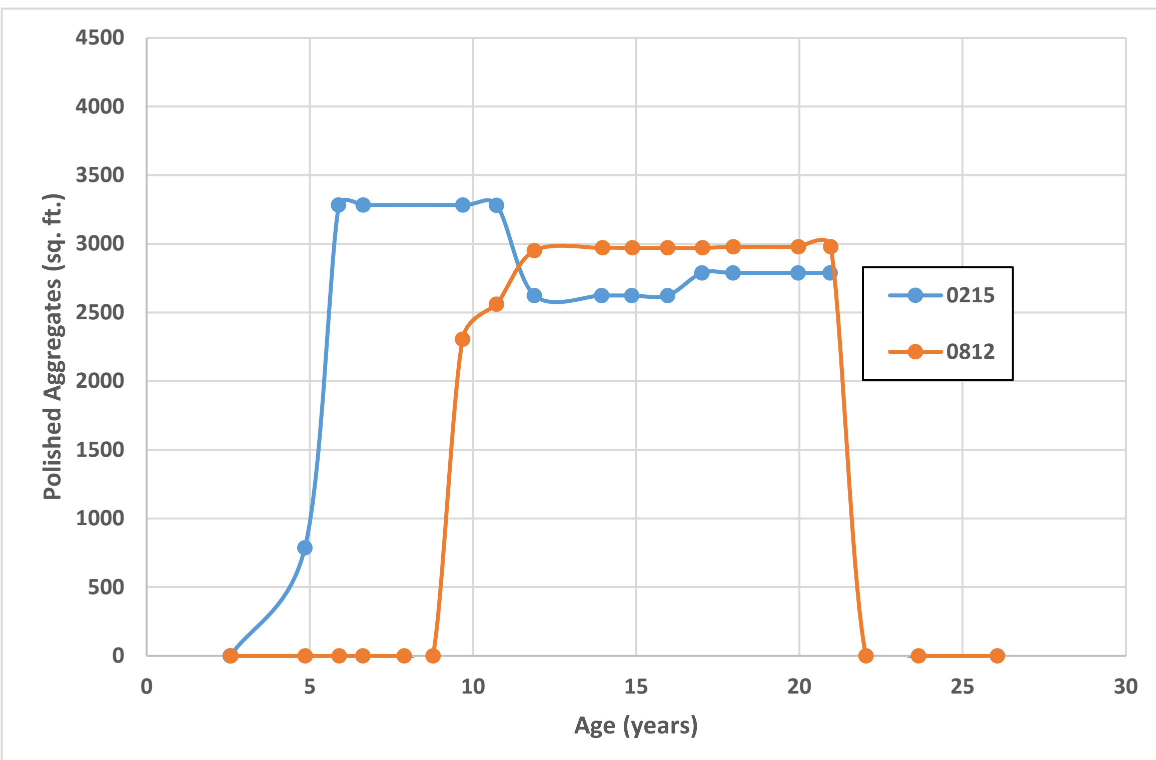
Scaling (sq. ft.)
7000
6000
5000
4000
3000
2000
1000
0
0
5
10
15
20
25
30
Age (years)
0213
0811



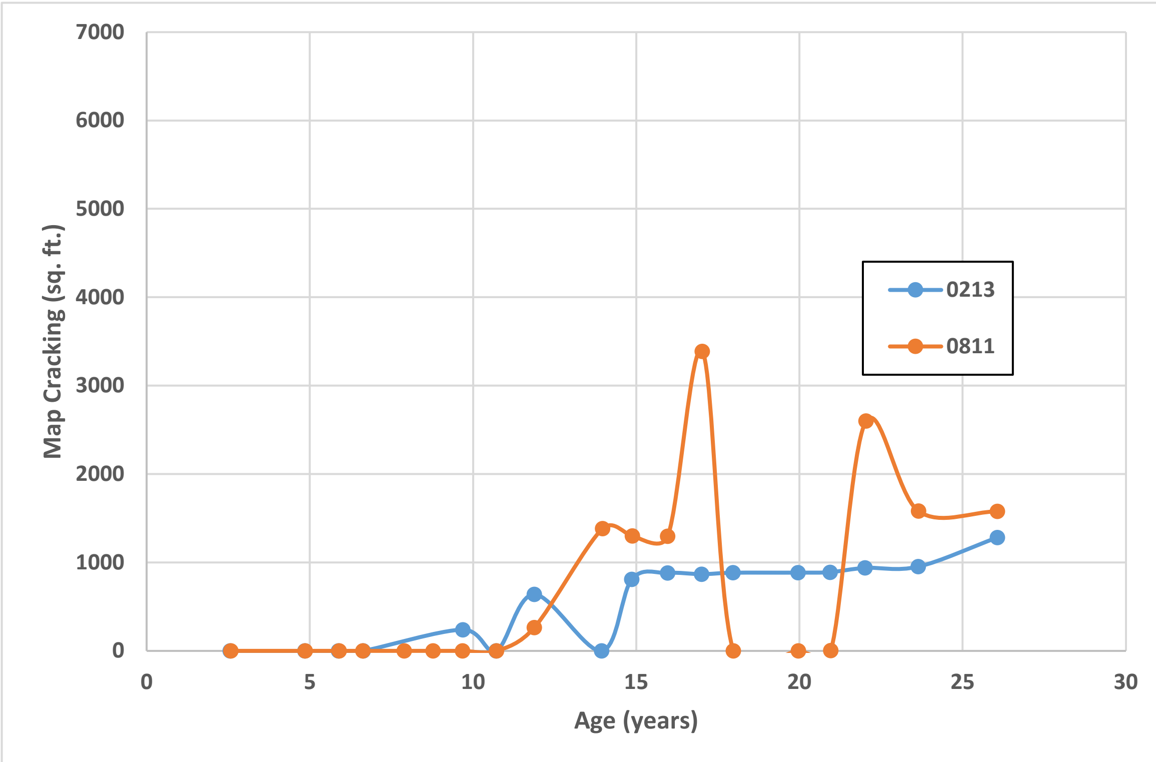
Scaling (sq. ft.)
7000
6000
5000
4000
3000
2000
1000
0
0
5
10
15
20
25
30
Age (years)
0215
0812



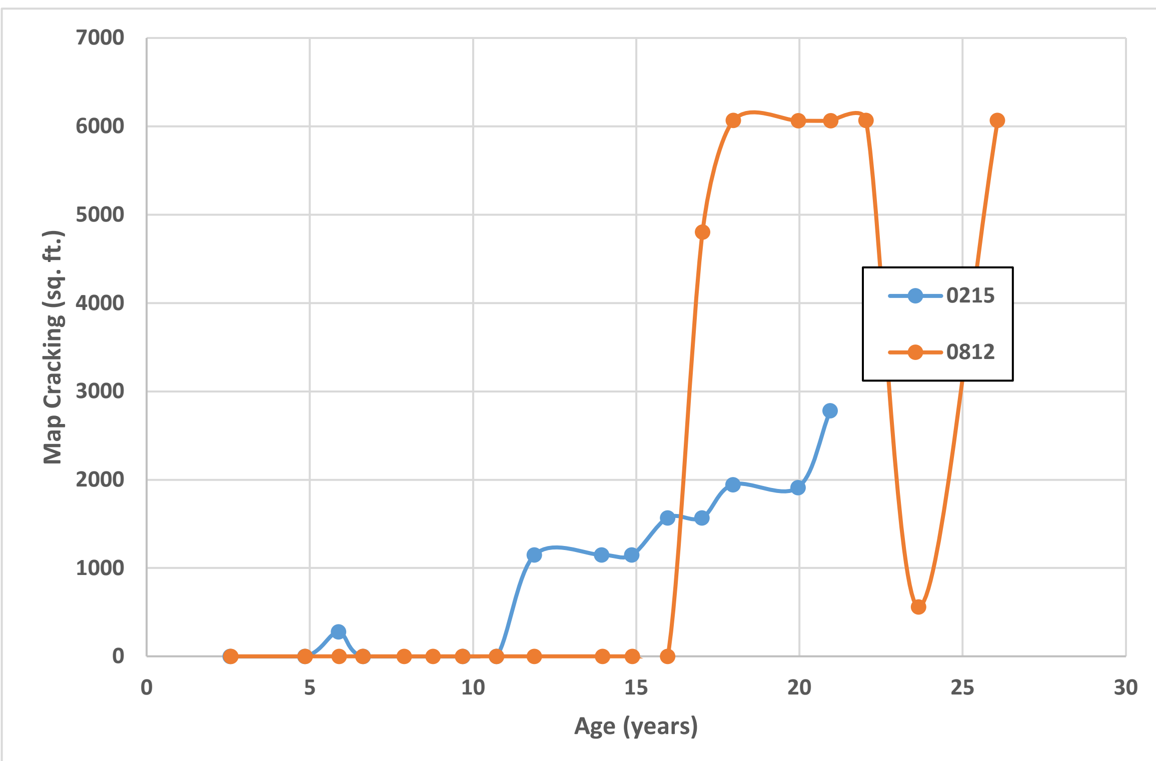
4500
4000
3500
3000
2500
2000
1500
1000
500
0
0
5
10
15
20
25
30
Polished Aggregates (sq. ft.)
Age (years)
0213
0811



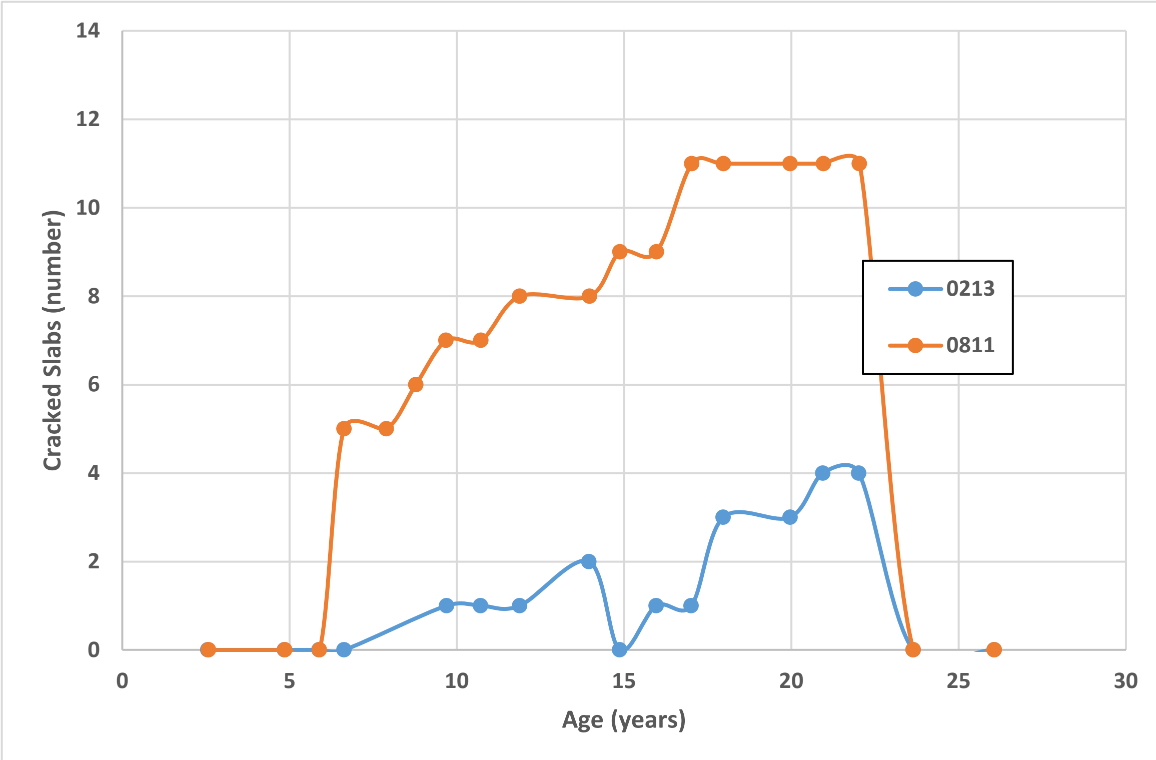
4500
4000
3500
3000
2500
2000
1500
1000
500
0
0
5
10
15
20
25
30
Polished Aggregates (sq. ft.)
Age (years)
0215
0812



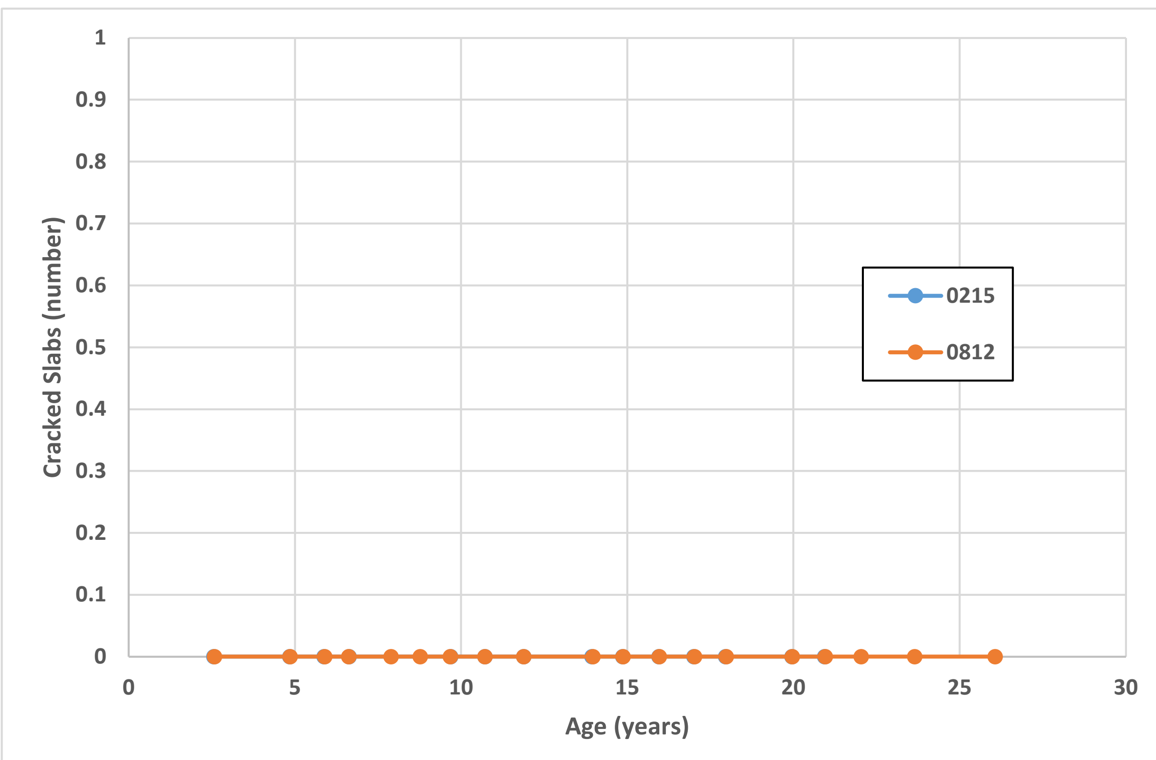
Map Cracking (sq. ft.)
7000
6000
5000
4000
3000
2000
1000
0
0
5
10
15
20
25
30
Age (years)
0213
0811



Map Cracking (sq. ft.)
7000
6000
5000
4000
3000
2000
1000
0
0
5
10
15
20
25
30
Age (years)
0215
0812



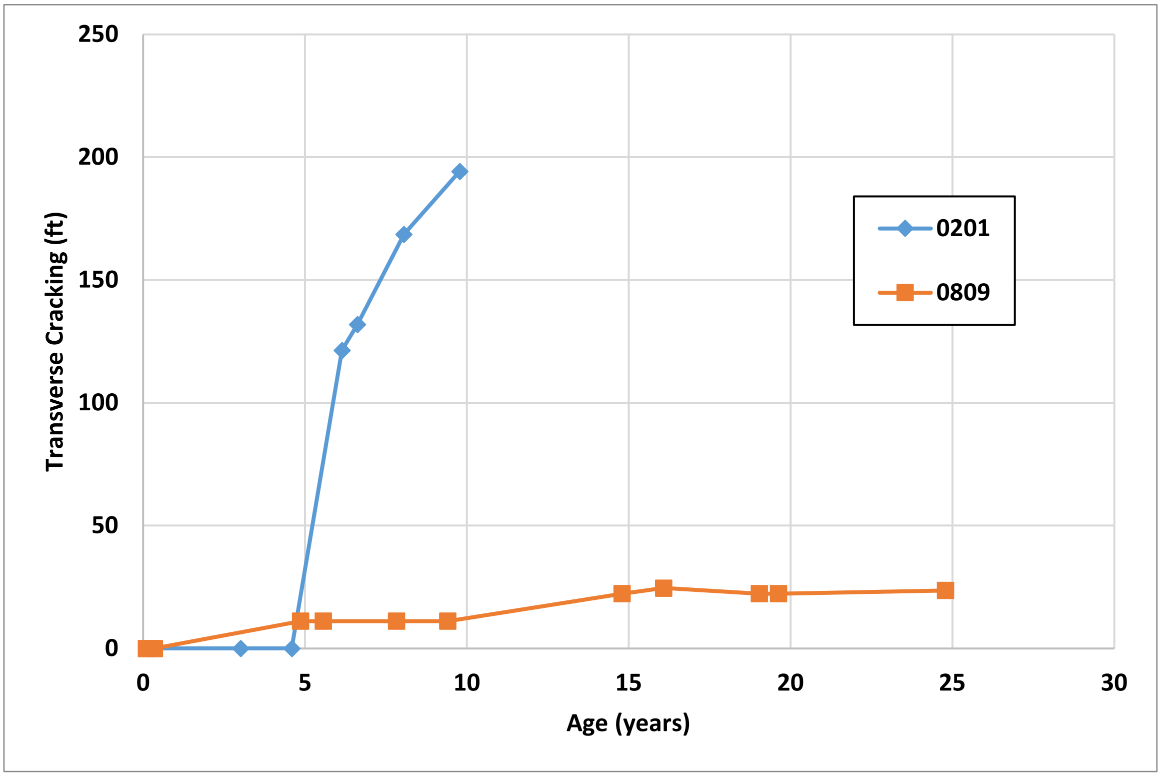
Cracked Slabs (number)
Age (years)
0213
0811

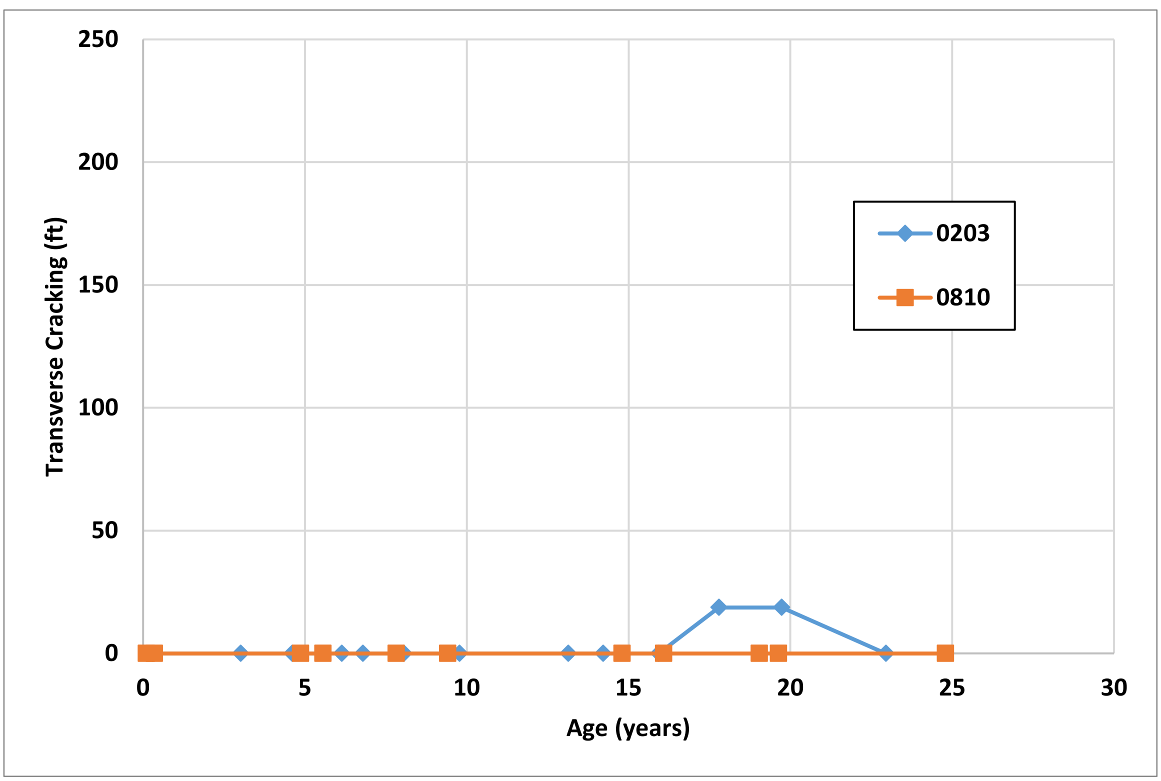


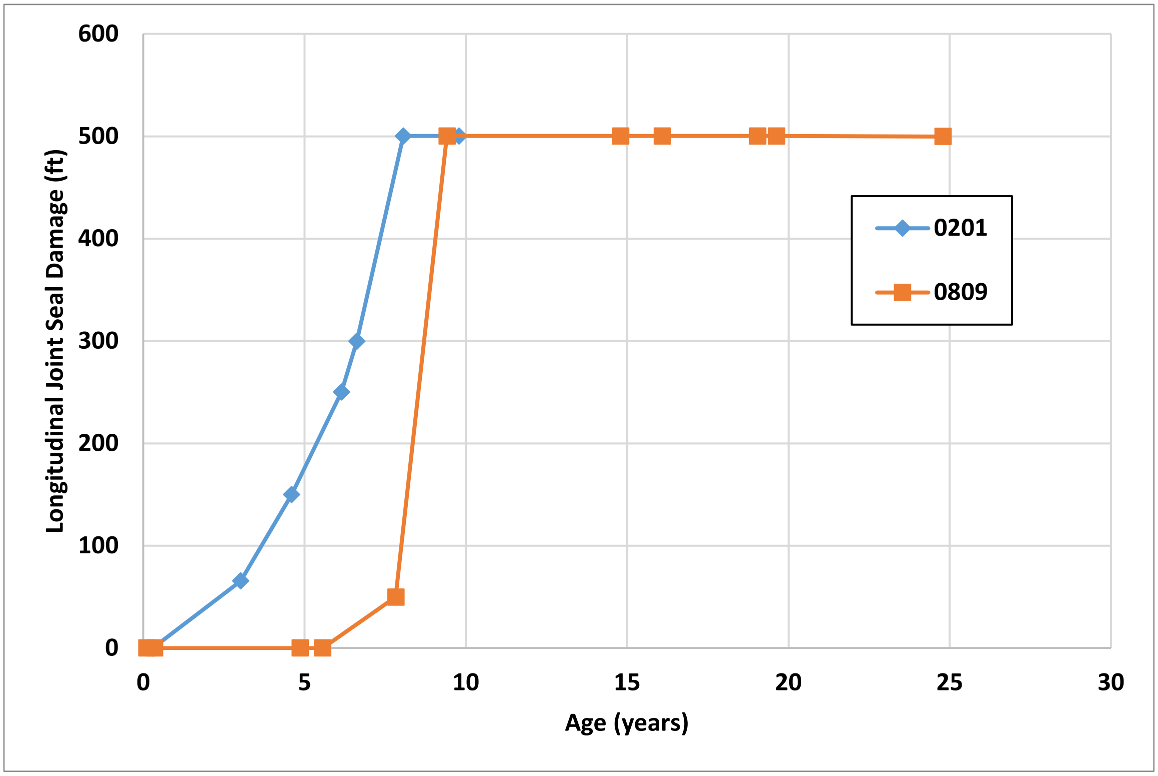
Cracked Slabs (number)
Age (years)
0215
0812

Appendix D

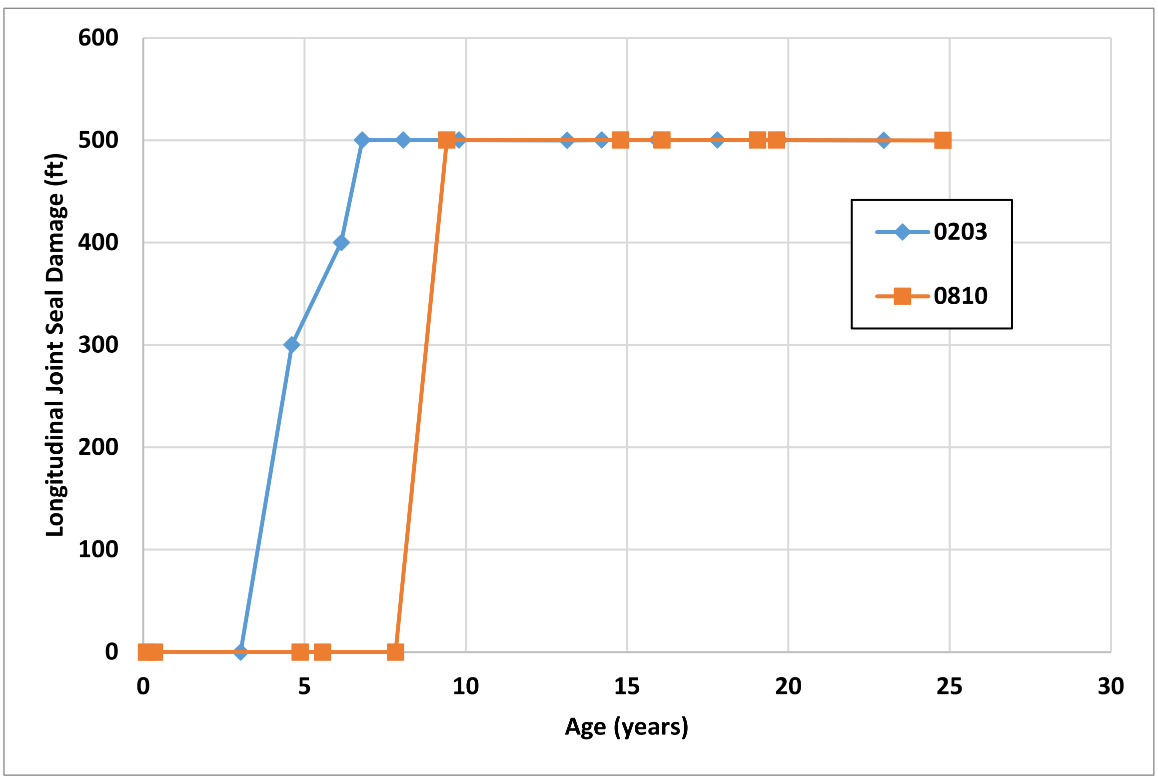
OHIO DISTRESS GRAPHS


Transverse Cracking (ft)
Age (years)
0201
0809

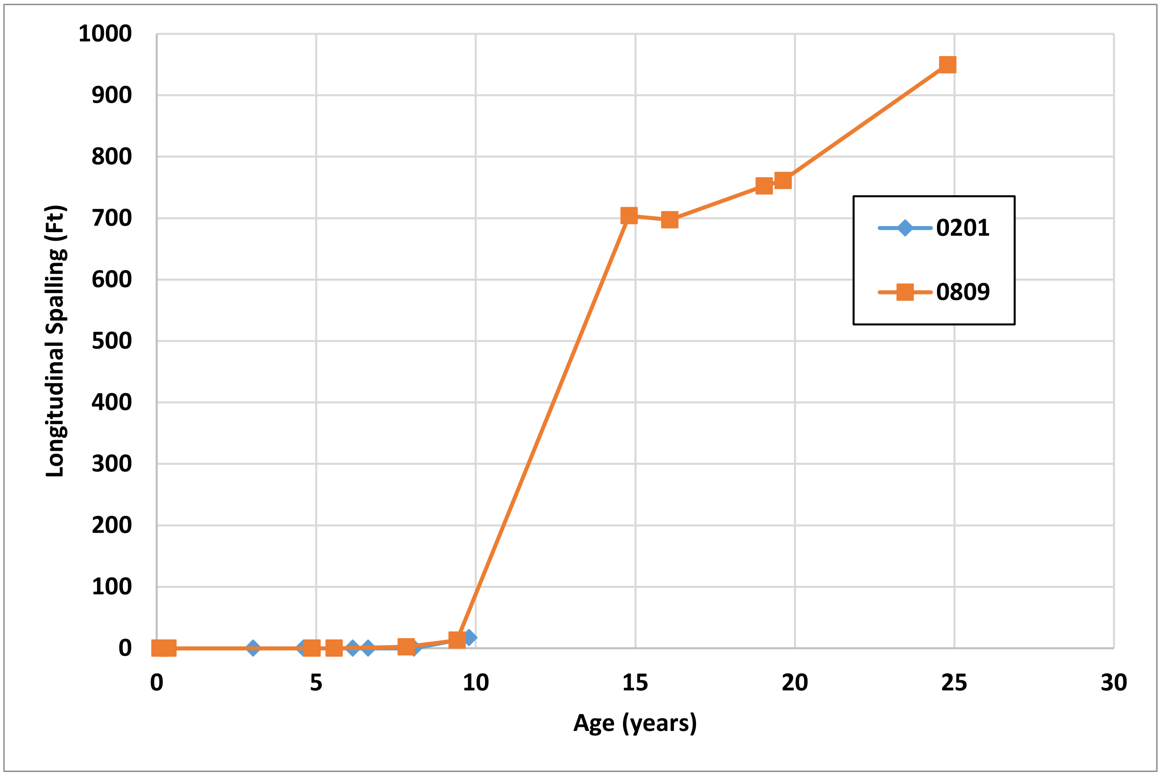

Transverse Cracking (ft)
Age (years)
0203
0810

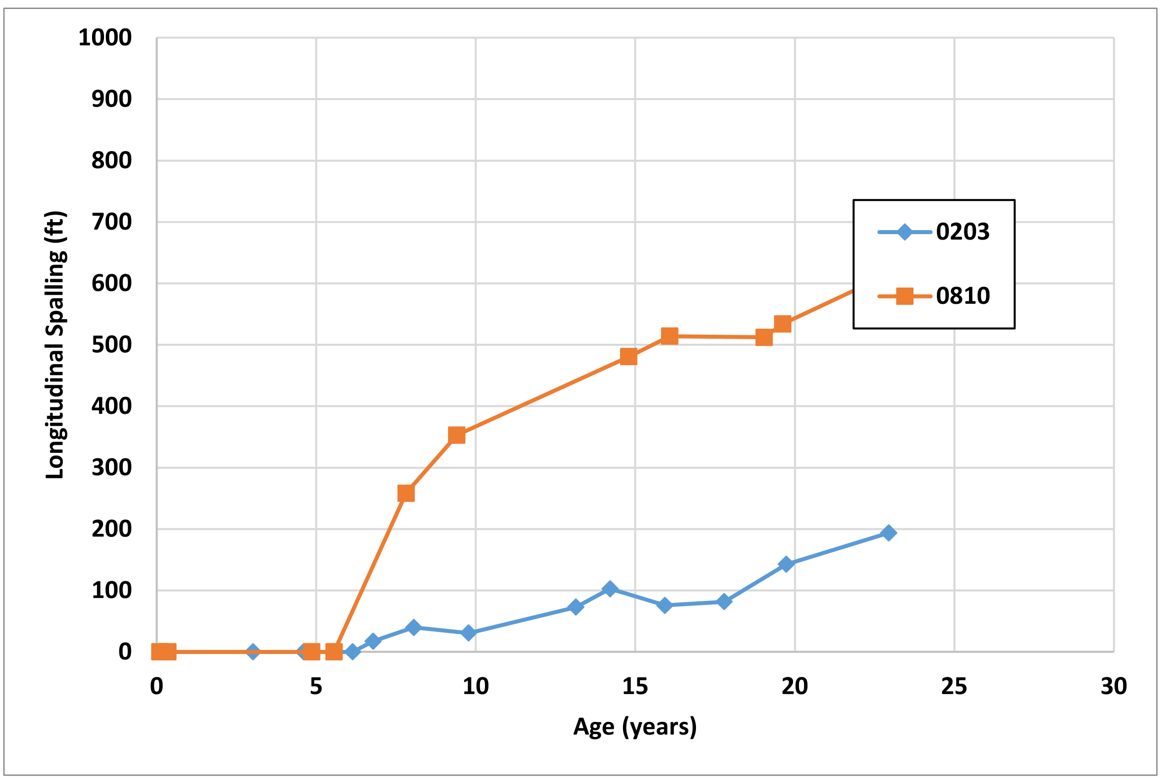


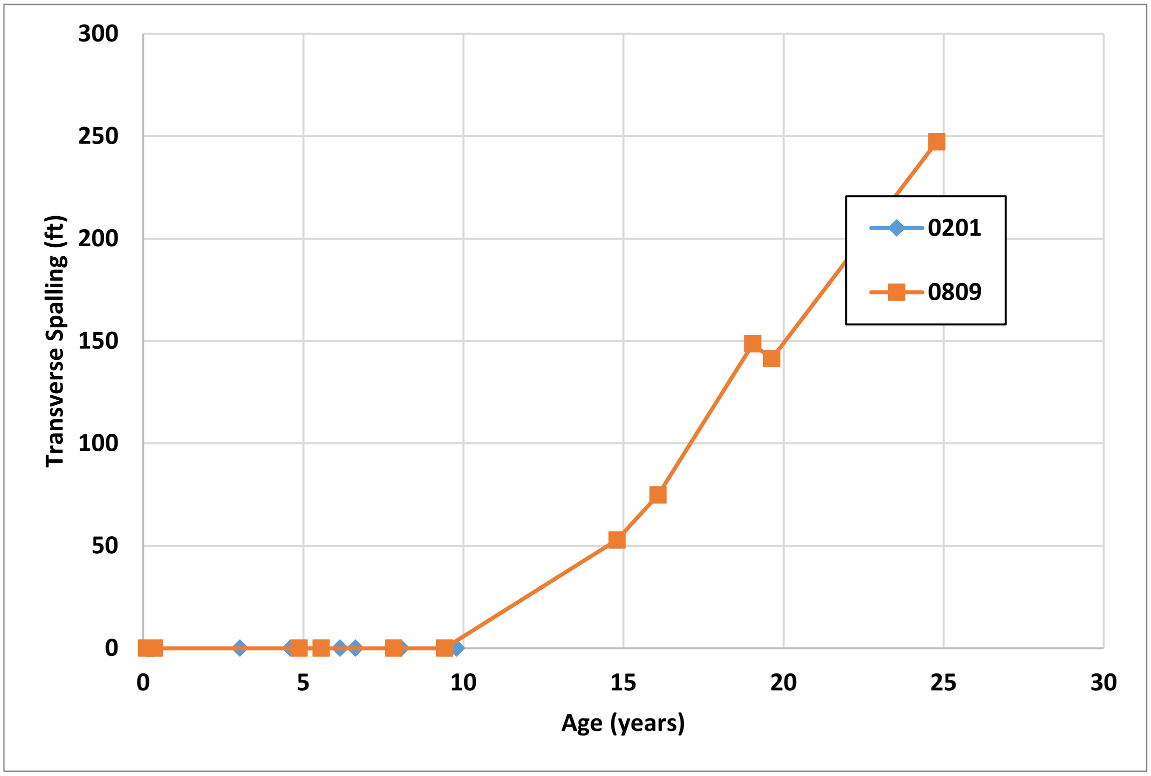
600
500
400
300
200
100
0
0
5
10
15
20
25
30
Longitudinal Joint Seal Damage (ft)
Age (years)
0201
0809



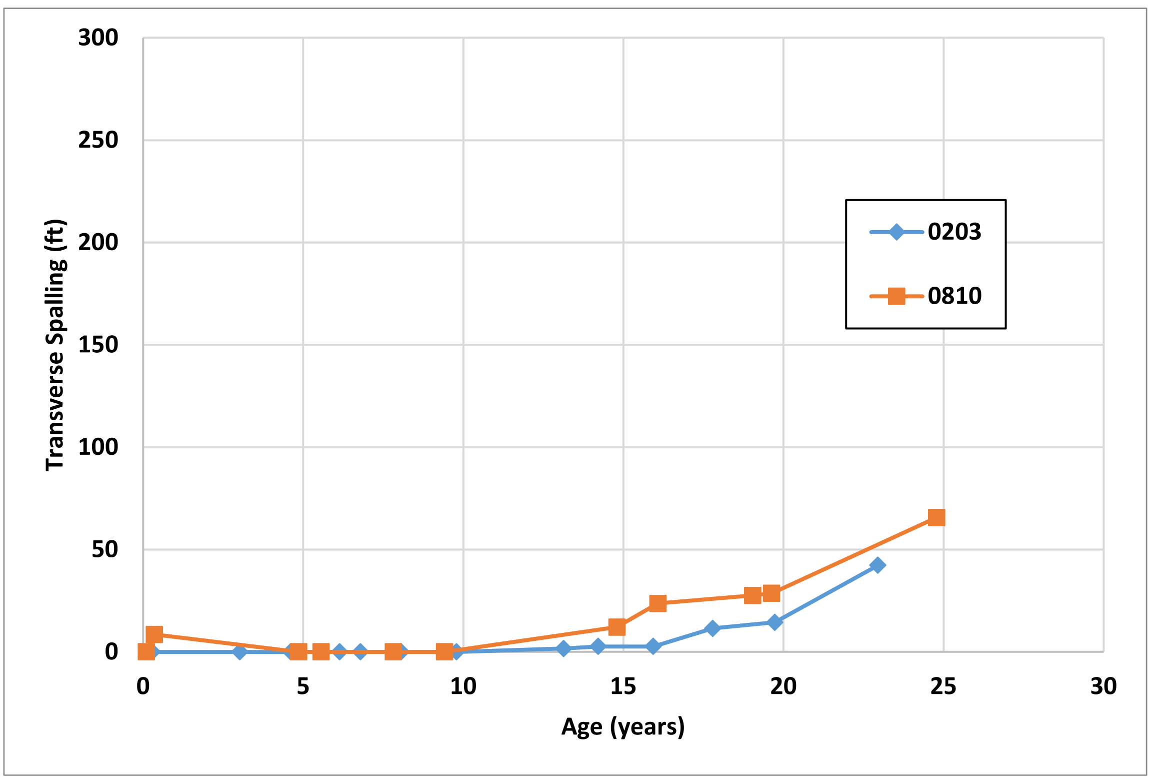
600
500
400
300
200
100
0
0
5
10
15
20
25
30
Longitudinal Joint Seal Damage (ft)
Age (years)
0203
0810


1000
900
800
700
600
500
400
300
200
100
0
Longitudinal Spalling (Ft)
0
5
10
15
20
25
30
Age (years)
0201
0809

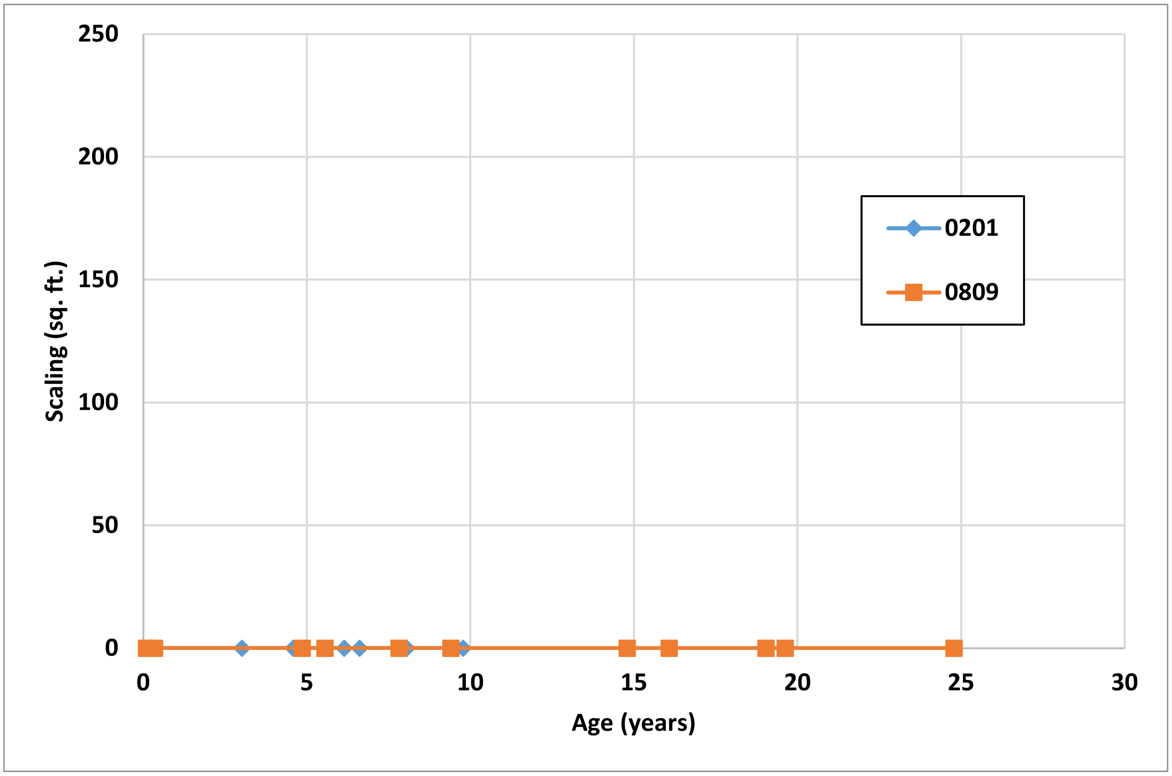

1000
900
800
700
600
500
400
300
200
100
0
Longitudinal Spalling (ft)
0
5
10
15
20
25
30
Age (years)
0203
0810



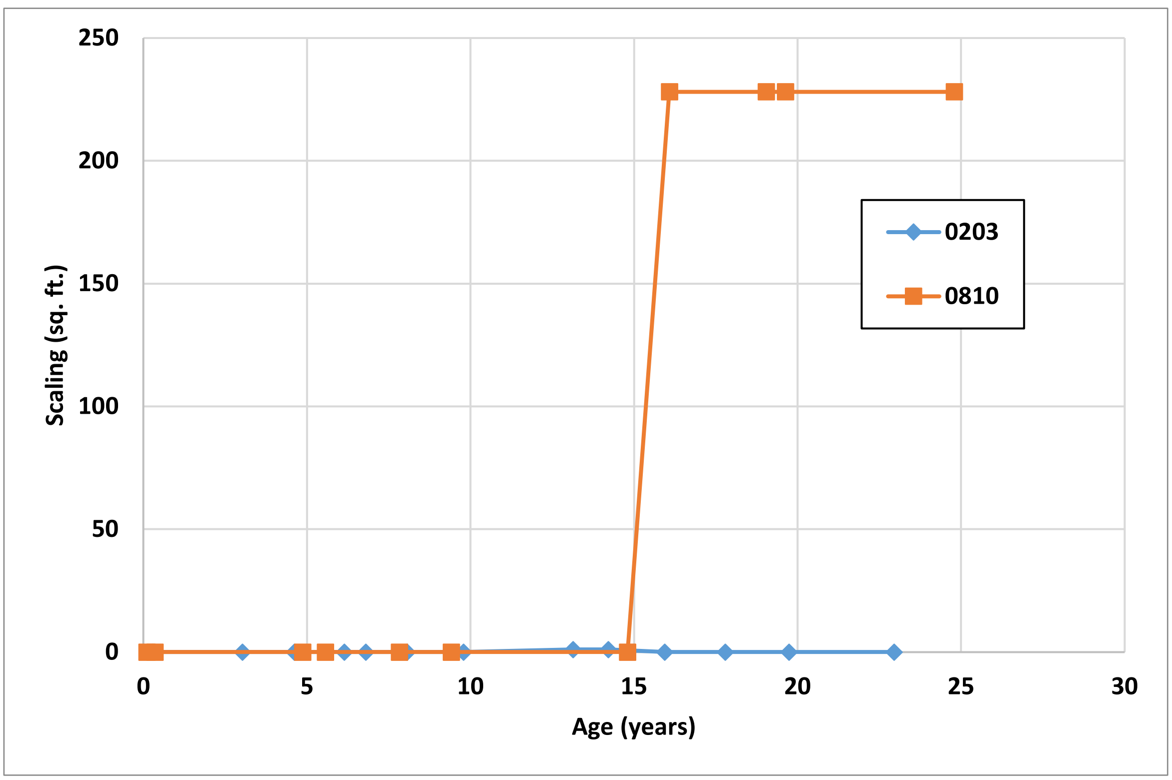
Transverse Spalling (ft)
Age (years)
0201
0809
0
50
100
150
200
250
300
0
5
10
15
20
25
30



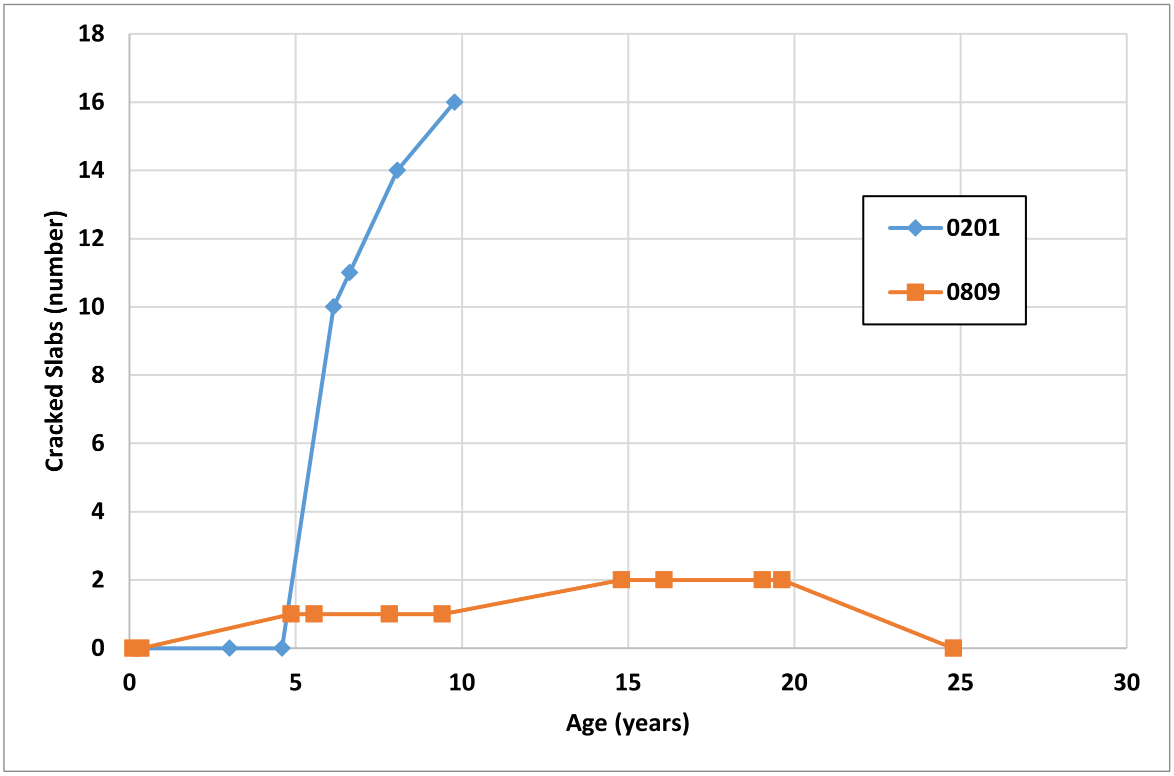
Transverse Spalling (ft)
Age (years)
0203
0810
0
50
100
150
200
250
300
0
5
10
15
20
25
30

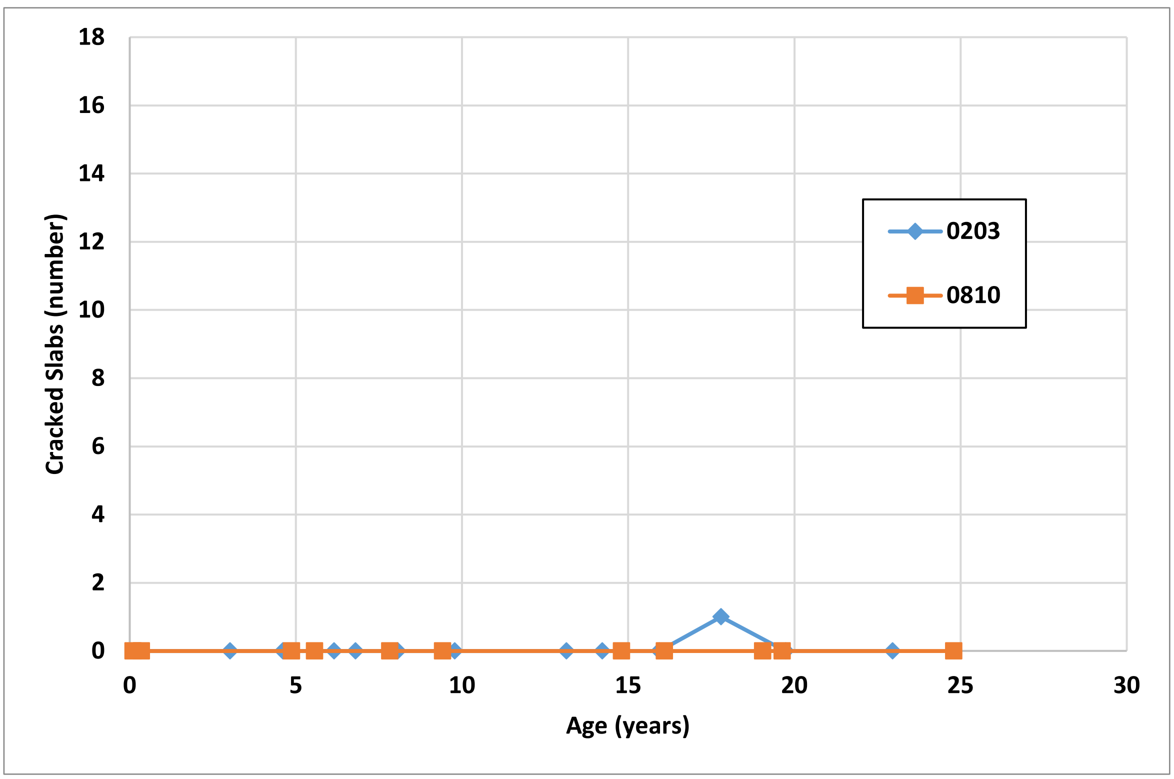


250
200
150
100
50
0
Scaling (sq. ft.)
0
5
10
15
20
25
30
Age (years)
0201
0809



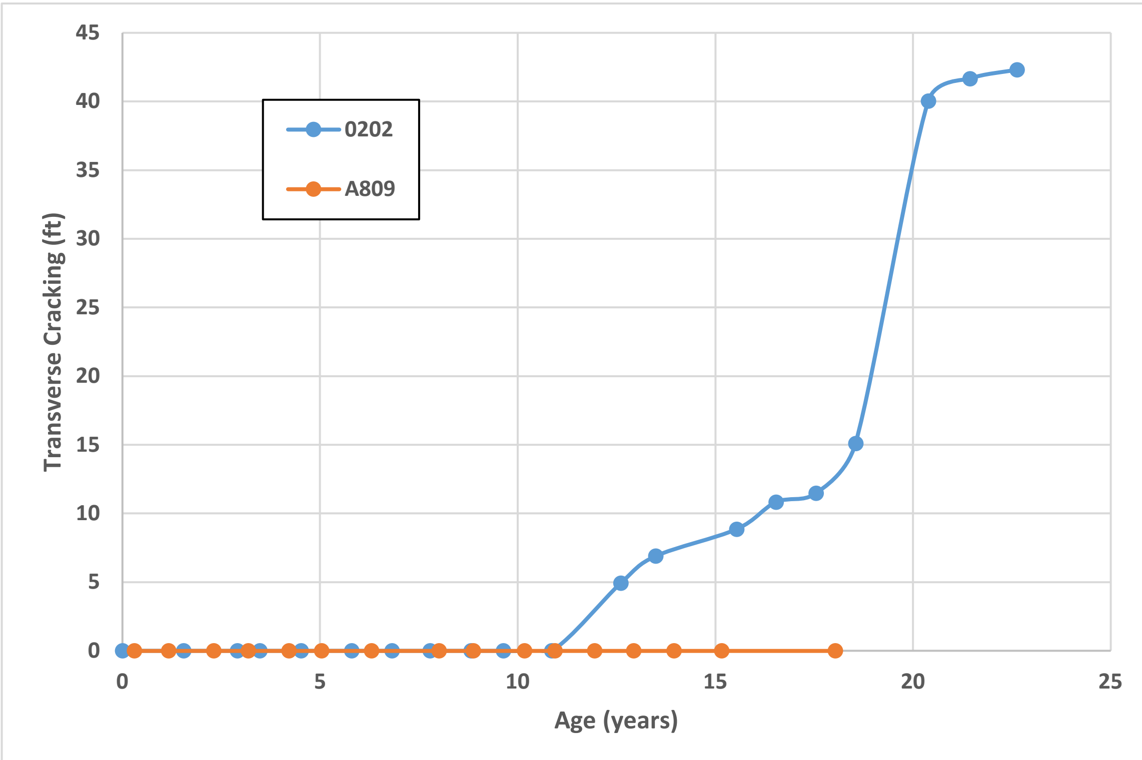
250
200
150
100
50
0
Scaling (sq. ft.)
0
5
10
15
20
25
30
Age (years)
0203
0810


Cracked Slabs (number)
Age (years)
0201
0809

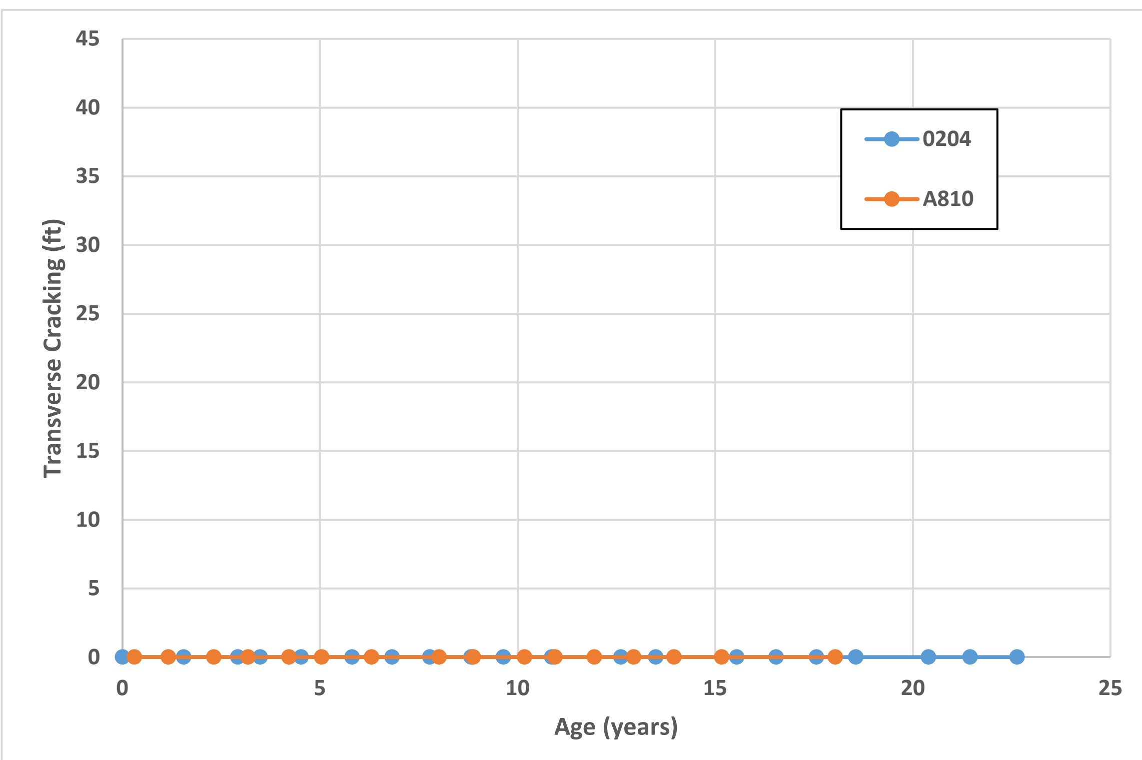

Cracked Slabs (number)
Age (years)
0203
0810

Appendix E

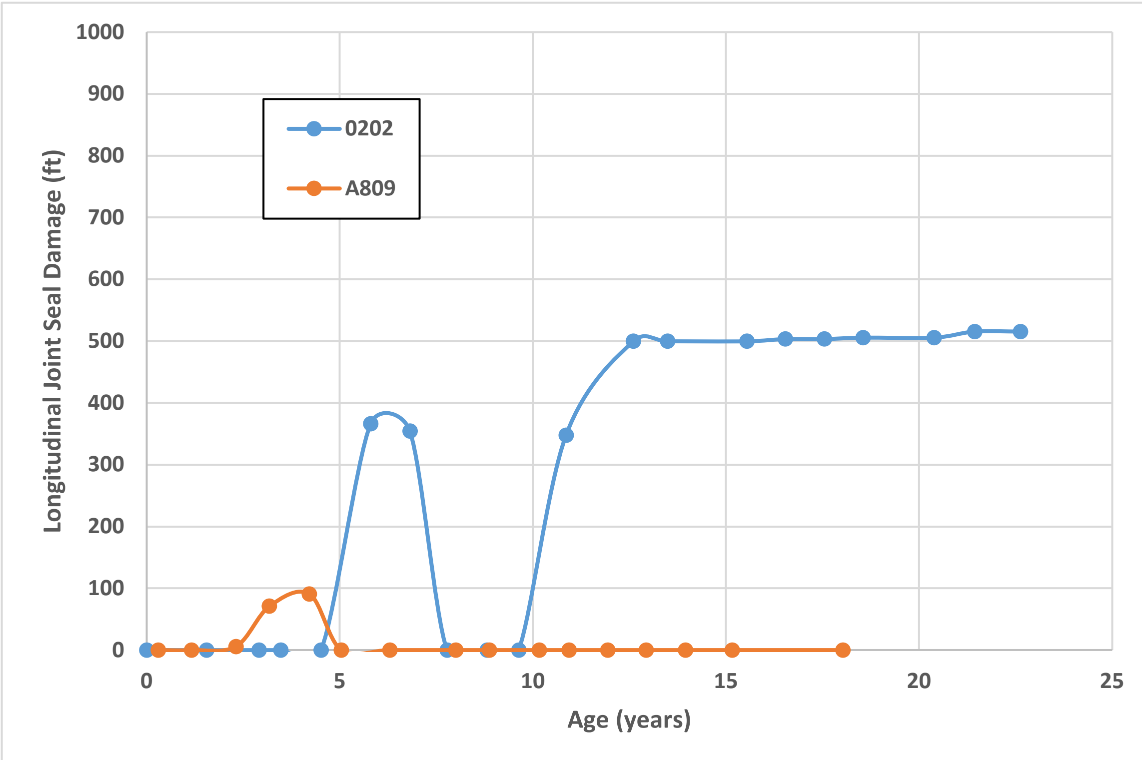
WASHINGTON DISTRESS GRAPHS



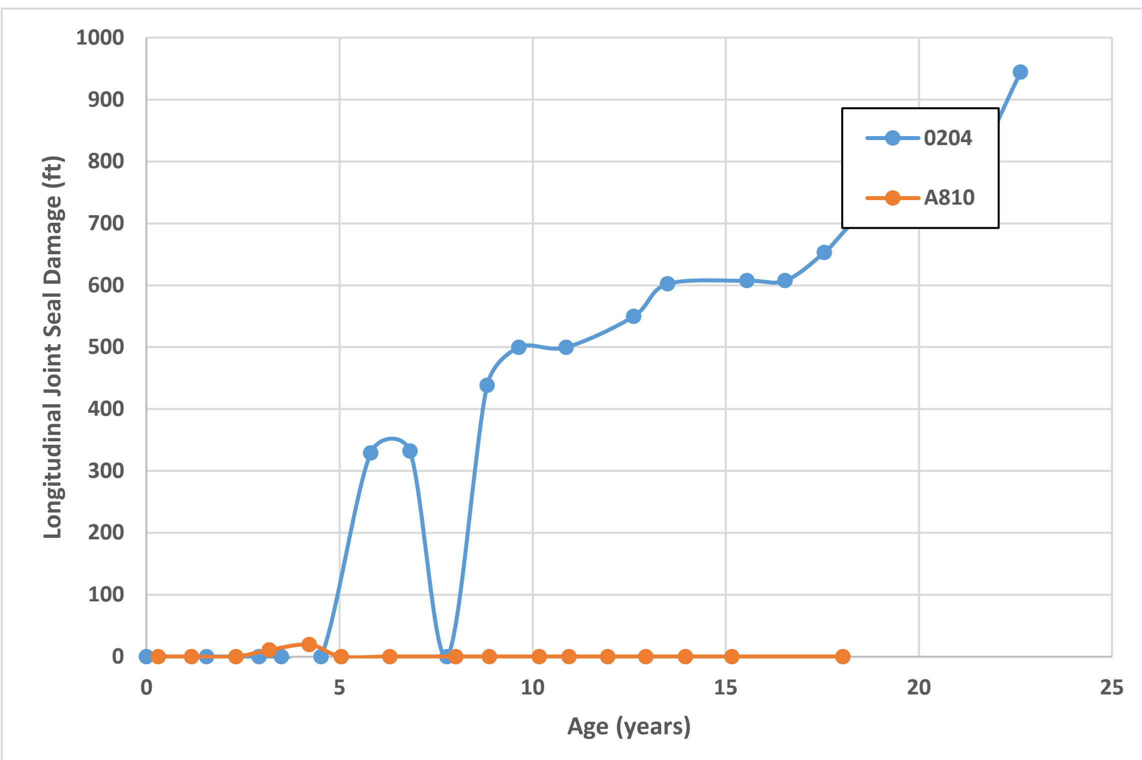
45
40
35
30
25
20
15
10
5
0
0
5
10
15
20
25
Transverse Cracking (ft)
Age (years)
0202
A809



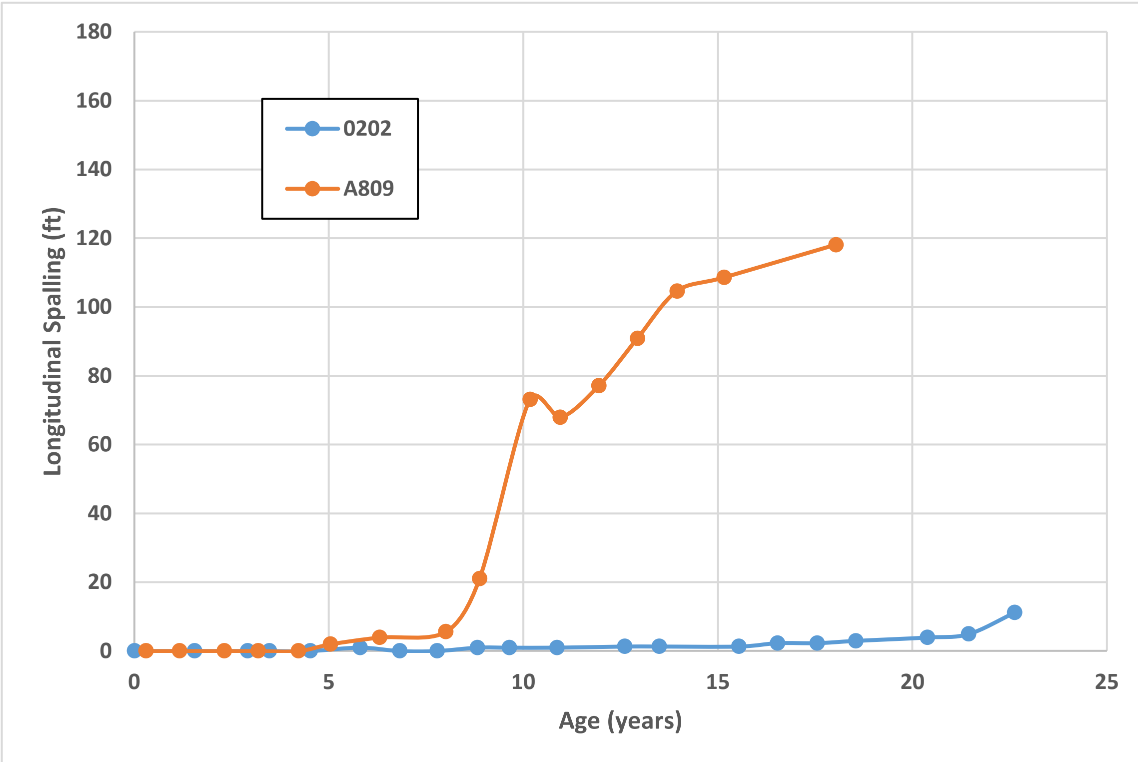
45
40
35
30
25
20
15
10
5
0
0
5
10
15
20
25
Transverse Cracking (ft)
Age (years)
0204
A810



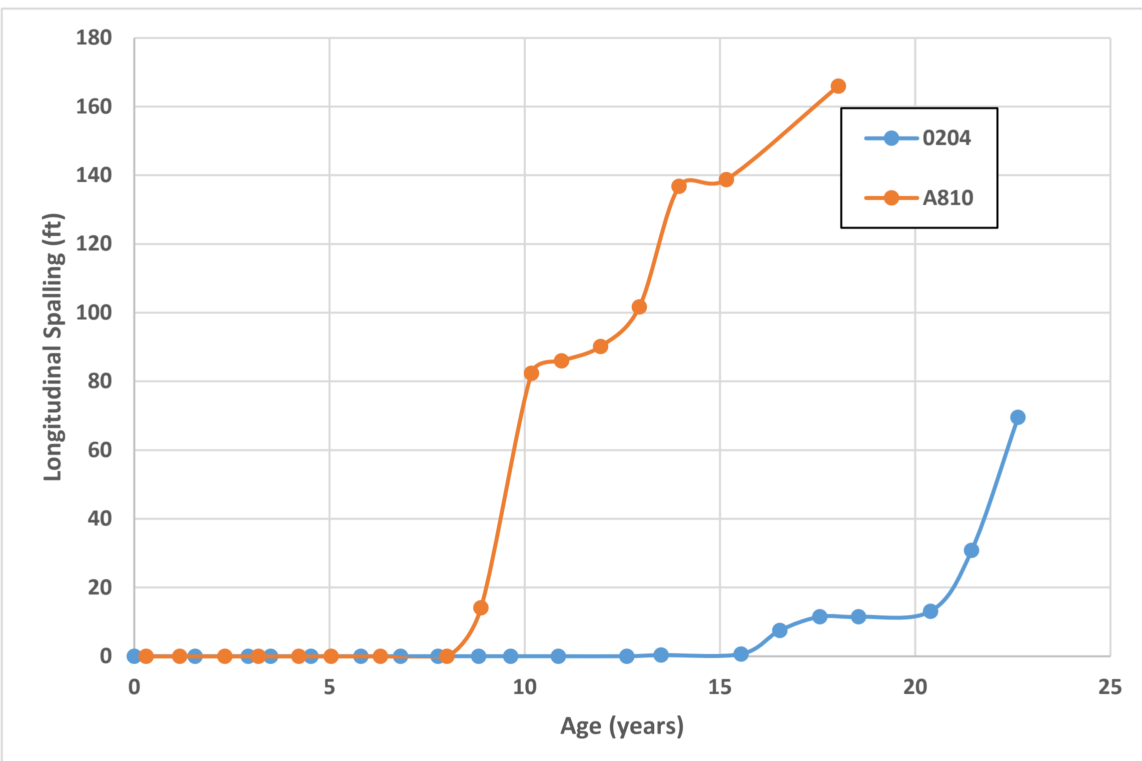
1000
900
800
700
600
500
400
300
200
100
0
0
5
10
15
20
25
Longitudinal Joint Seal Damage (ft)
Age (years)
0202
A809



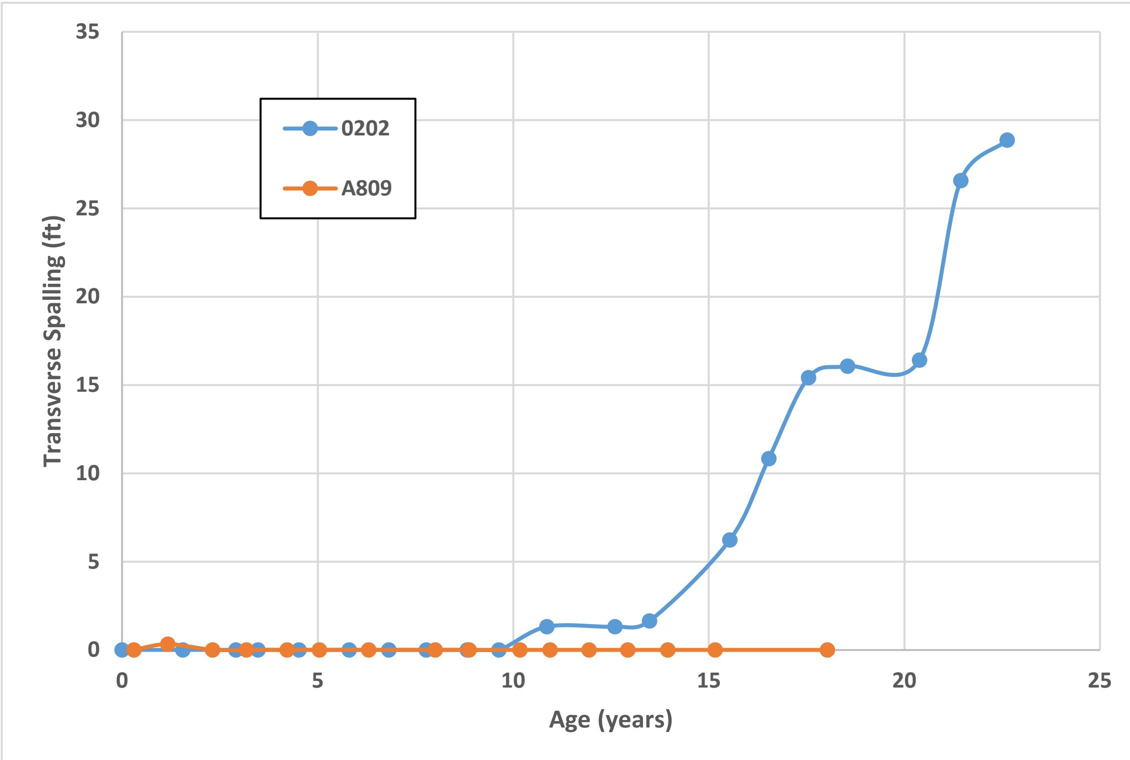
1000
900
800
700
600
500
400
300
200
100
0
0
5
10
15
20
25
Longitudinal Joint Seal Damage (ft)
Age (years)
0204
A810

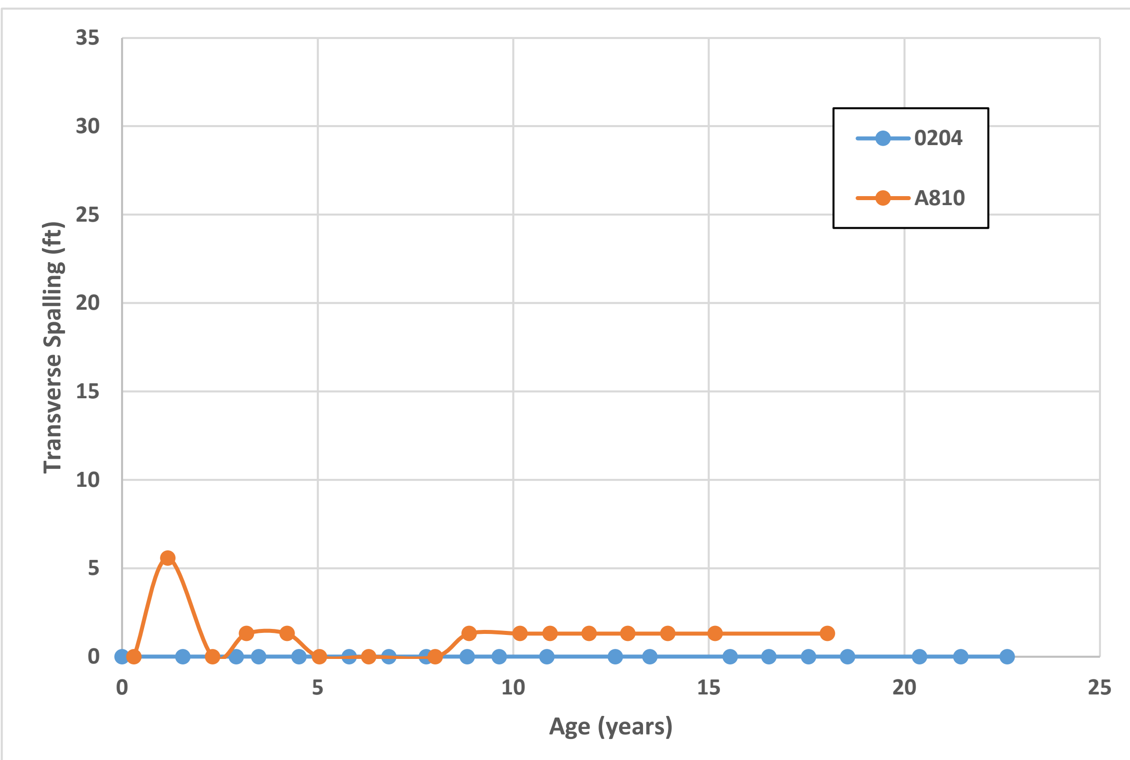


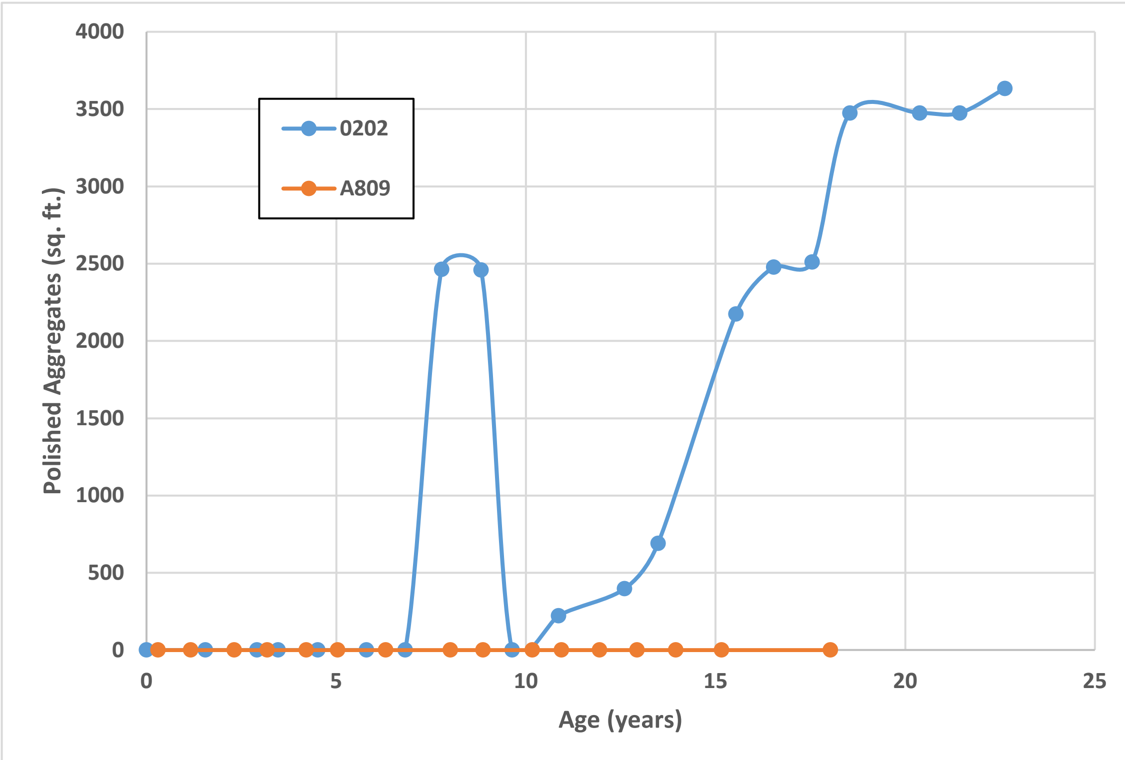
180
160
140
120
100
80
60
40
20
0
0
5
10
15
20
25
Longitudinal Spalling (ft)
Age (years)
0202
A809

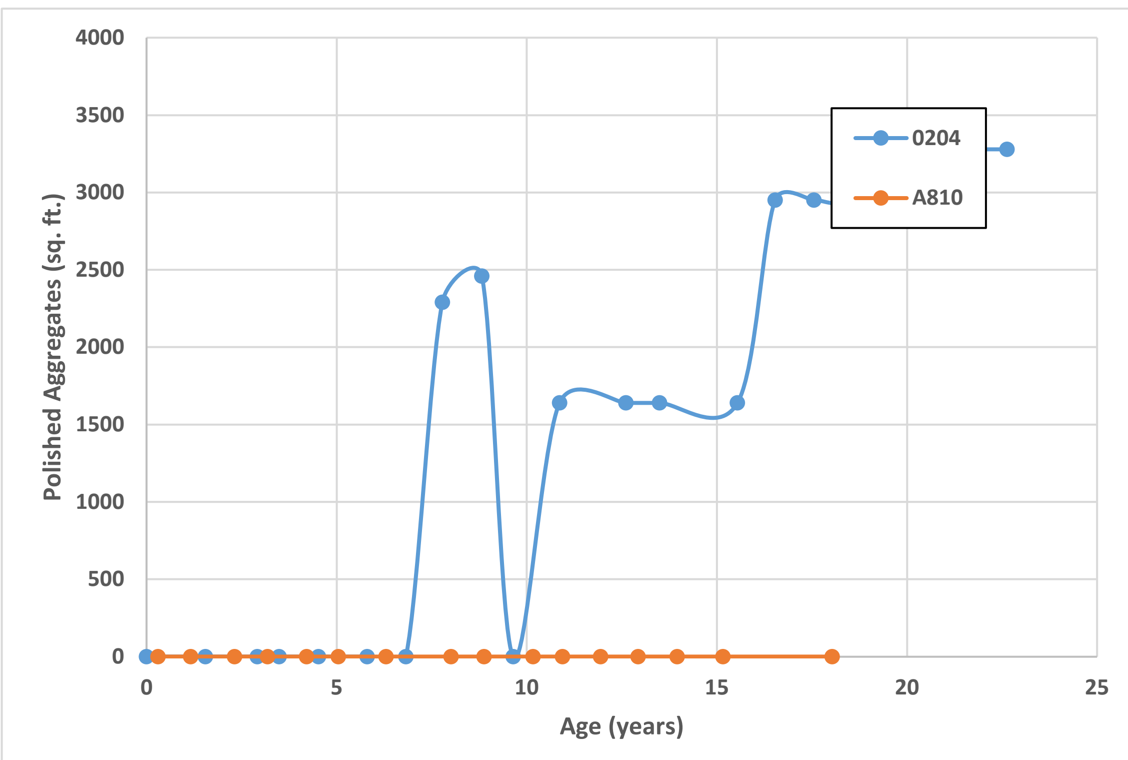


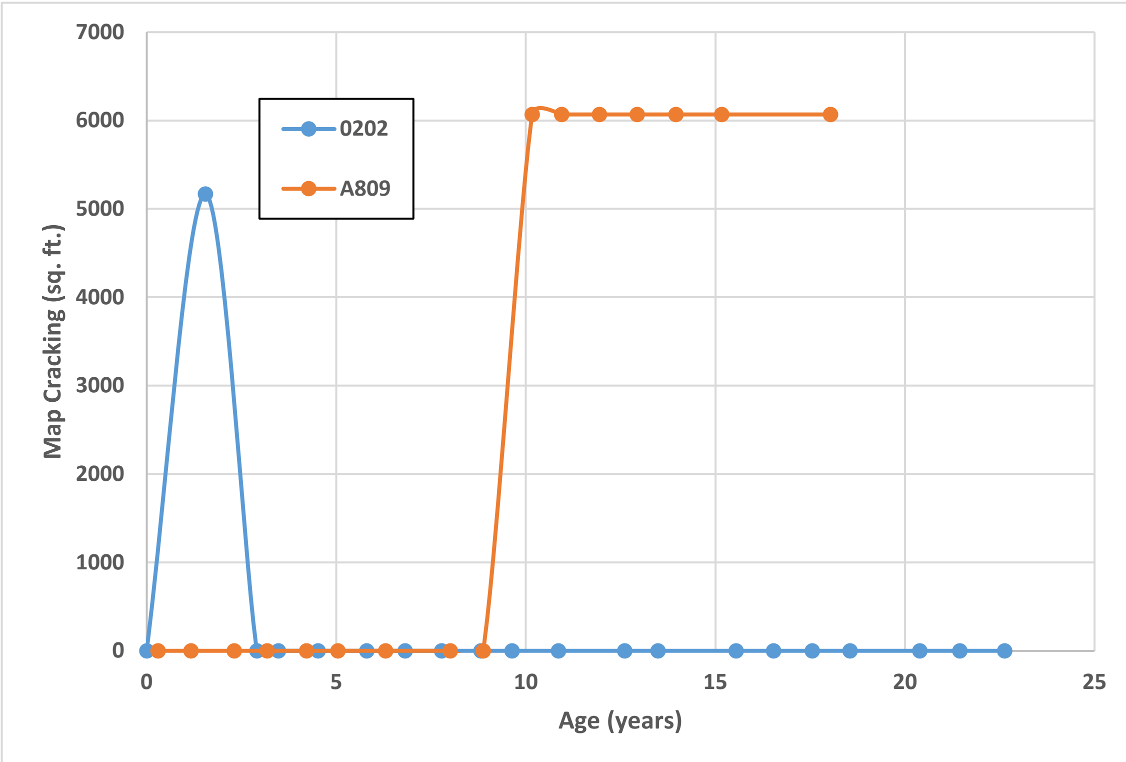
180
160
140
120
100
80
60
40
20
0
0
5
10
15
20
25
Longitudinal Spalling (ft)
Age (years)
0204
A810


35
30
25
20
15
10
5
0
Transverse Spalling (ft)
0202
A809
0
5
10
15
20
25
Age (years)

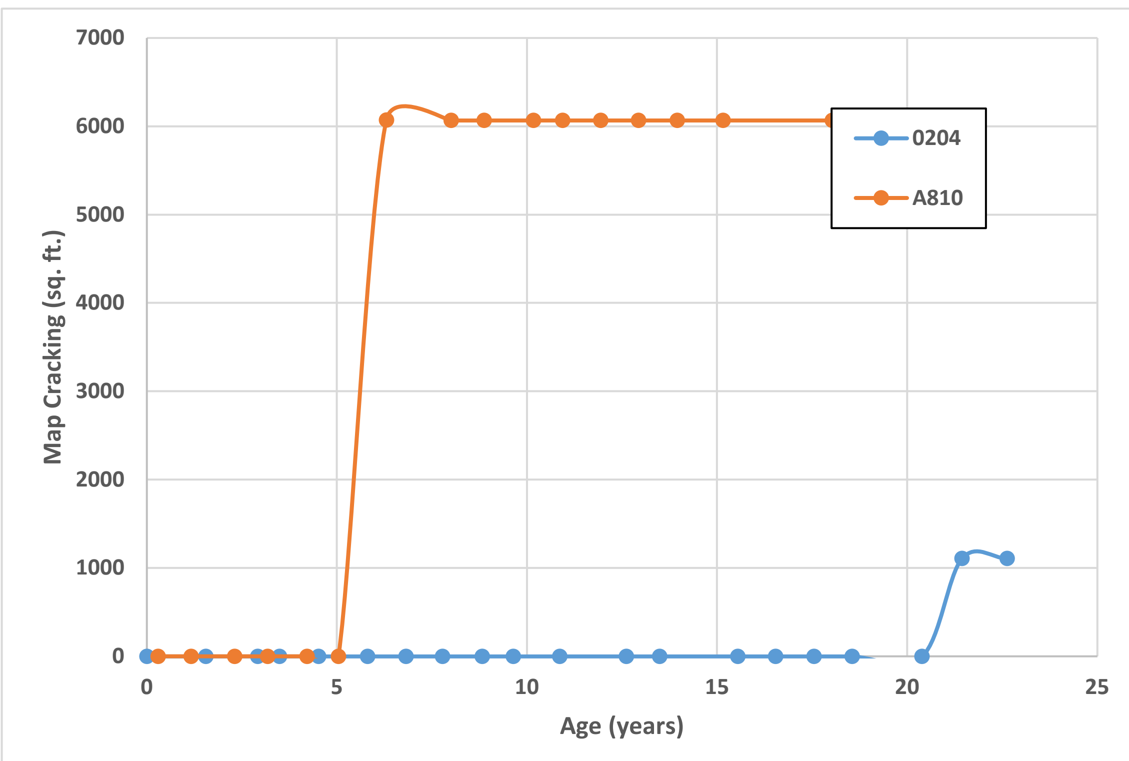

35
30
25
20
15
10
5
0
Transverse Spalling (ft)
0204
A810
0
5
10
15
20
25
Age (years)


4000
3500
3000
2500
2000
1500
1000
500
0
0
5
10
15
20
25
Polished Aggregates (sq. ft.)
Age (years)
0202
A809

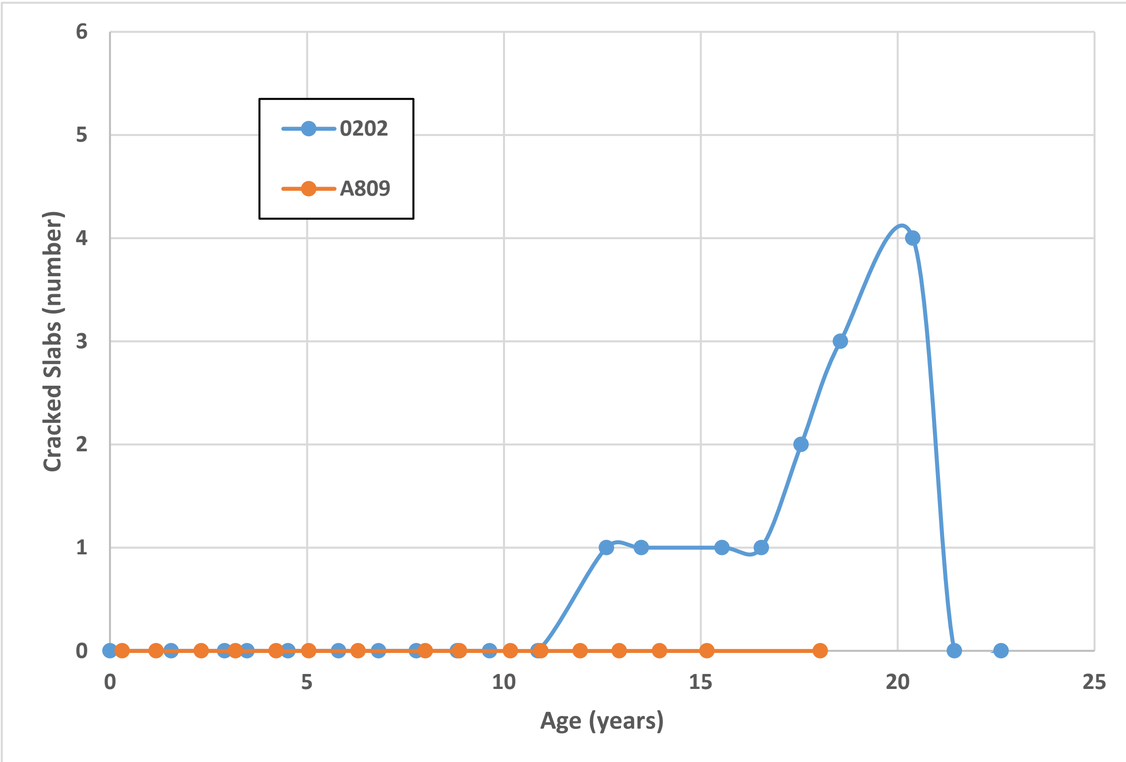

4000
3500
3000
2500
2000
1500
1000
500
0
0
5
10
15
20
25
Polished Aggregates (sq. ft.)
Age (years)
0204
A810

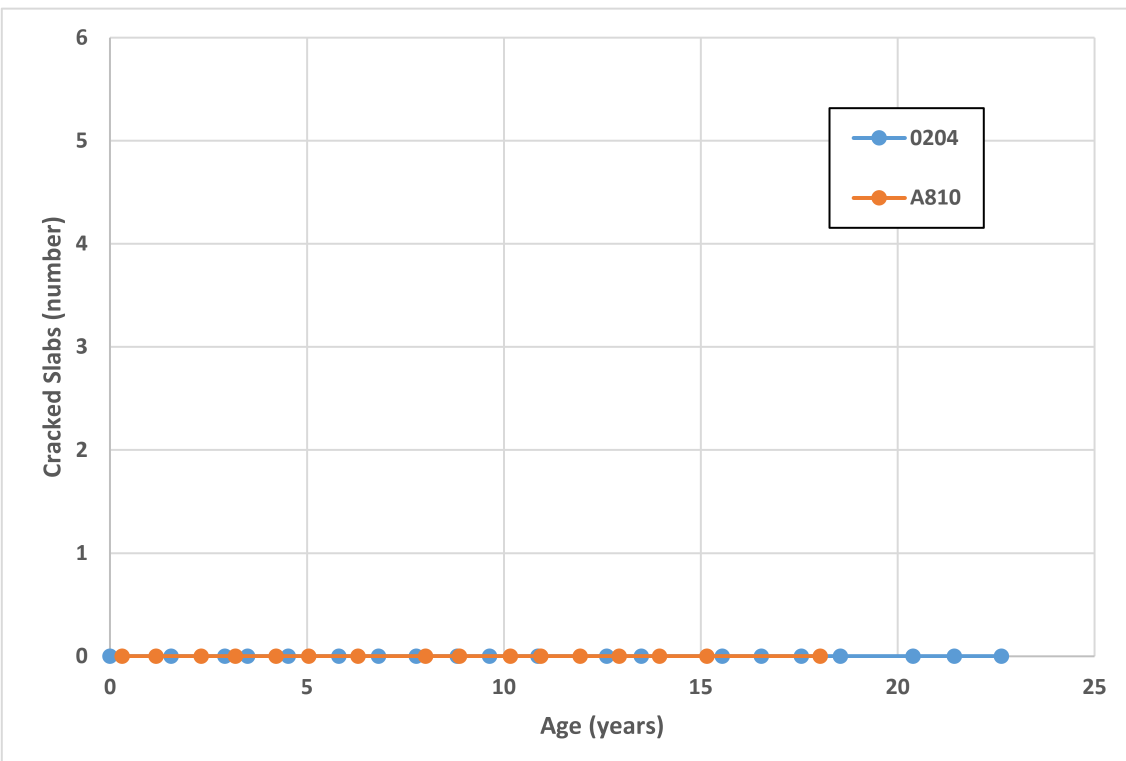


7000
6000
5000
4000
3000
2000
1000
0
Map Cracking (sq. ft.)
0
5
10
15
20
25
Age (years)
0202
A809



7000
6000
5000
4000
3000
2000
1000
0
Map Cracking (sq. ft.)
0
5
10
15
20
25
Age (years)
0204
A810


Cracked Slabs (number)
Age (years)
0202
A809
0
1
2
3
4
5
6
0
5
10
15
20
25


Cracked Slabs (number)
Age (years)
0204
A810
0
1
2
3
4
5
6
0
5
10
15
20
25