Landside Pavement Assessment

Duluth Airport Authority

Duluth, Minnesota

DULAI 150733 | September 13, 2020

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Executive Summary

This report is an insert to the Airport Master Plan for the Duluth International Airport dated 2021 and is intended to provide insight into the landside pavement conditions and projected maintenance and rehabilitation needs at the Duluth International Airport (DLH).

The landside pavement conditions were assessed using the Pavement Condition Index (PCI) procedure as outlined in the Federal Aviation Administration (FAA) Advisory Circular (AC) 150/5380-7B and ASTM D6433 for road and parking lot pavements.

How the data and results contained in this report should be used

It is assumed the needs and priorities of the DAA will change over time. It is essential for staff to review this report, along with developments in priority and pavement condition on an annual basis to select the appropriate project for repair or maintenance each year. The report should be updated periodically to update priorities, reallocate projects for future years, and update estimates as materials and labor costs increase over time.

Prioritization Methodology

The prioritization of projects is linked to the overall Capital Improvement Plan (CIP). During 2022 and 2023 various landside pavement maintenance and rehabilitation projects are named specifically on the CIP due to their poor condition and high usage of the pavement section.

Starting in 2024, the CIP plans for a set amount of $100,000 of funds annually to go towards landside pavement maintenance to account for the need to repair and maintain the landside pavements at the airport. This report proposes a project prioritization, which is discussed in the Recommendations section.

The proposed project prioritization schedule, **Table 1 – Annual Maintenance Costs,** shows the projected annual maintenance costs through the year 2040. After the planned projects occur in 2022 and 2023, the average estimated annual maintenance costs is on average approximately $100,000, as proposed in the CIP. For this reason, the estimated annual maintenance cost is set at $100,000. This estimated annual maintenance cost should allow the Duluth Airport Authority (DAA) to be able to repair and maintain the landside pavement at the airport.

Table 1 – Annual Maintenance Costs

	Year	Estimated Annual Maintenance Cost
2021-2025	2021	$ -
	2022	$ 20,300.00
	2023	$ 458,500.00
	2024	$ 197,000.00
	2025	$ 90,340.00
	5-year total	***$ 766,140.00***
2026-2030	2026	$ 84,100.00
	2027	$ 139,200.00
	2028	$ 149,600.00
	2029	$ 84,100.00
	2030	$ 4,600.00
	5–10-year total	***$ 461,600.00***
2031+	2031	$ 100,000.00
	2032	$ 102,000.00
	2033	$ 104,040.00
	2034	$ 106,120.80
	2035	$ 108,243.22
	2036	$ 110,408.08
	2037	$ 112,616.24
	2038	$ 114,868.57
	2039	$ 117,165.94
	2040	$ 119,509.26
	10+ year total	***$ 1,094,972.10***

Landside Pavement Assessment

Duluth Airport Authority

Introduction

A landside pavement assessment was completed at the Duluth International Airport (DLH) in August 2019 as part of the Duluth International Airport Vision 2040 Master Plan. This report contains the pavement assessment results which were used to create a pavement maintenance plan and develop a prioritization schedule.

The main goal of this pavement assessment was to identify current pavement conditions and create a pavement maintenance plan. This pavement maintenance plan was then used to develop a maintenance and rehabilitation (M&R) prioritization schedule. A pavement maintenance plan, along with a high-level M&R prioritization schedule, provides the airport sponsor with a planning tool to help identify pavement needs as well as a way to determine the most cost effective way to allocate available M&R funds over a multi-year period.

In addition to the benefits mentioned above, a pavement maintenance plan provides several other benefits such as increasing the useful life of pavements, providing an objective and consistent evaluation of the condition of a network of pavements, and the ability to track pavement conditions over time. A detailed overall Capital Improvement Plan (CIP) and implementation schedule is discussed in the Airport Master Plan. This CIP and schedule takes into account potential development and redevelopment sites and ensures pavement maintenance is cost effective and aligns with the long term development and redevelopment goals of the Airport.

The DAA provided information regarding pavement usage, age, ownership and responsibility for this report. Ownership and responsibility information was also provided by City and County staff. Please see the individual Pavement Condition Assessment Reports for more information and further discussion on ownership.

Figure 1 – Pavement Assessment Overview gives an overview of the pavement that was included in this pavement assessment.

Procedure

The landside pavement conditions were assessed using the Pavement Condition Index (PCI) procedure as outlined in the Federal Aviation Administration (FAA) Advisory Circular (AC) 150/5380-7B and ASTM D6433 for road and parking lot pavements.

Identifying the optimal repair/treatment time of a pavement section, which is the point at which the rate of deterioration begins to increase at a much faster rate, is critical in order to avoid higher rehabilitation costs caused by excess deterioration. As stated in the AC, maintaining and preserving a pavement in good condition versus rehabilitating a pavement in fair to poor condition is four to five times less expensive and increases pavement useful life.

To start, the landside pavement was divided up into five pavement branches: aprons, general roads, parking lots, perimeter roads, and service roads. Each branch was then subdivided into pavement sections based on several criteria such as location, pavement structure, and pavement type.

The pavements were subdivided into the following sections:

Table 2 – Pavement Sections

Branch	Section	Common Name
Apron	APRON-01	SRE APRON
	APRON-02	SRE APRON
	APRON-03	TERMINAL ARPON
	APRON-04	ARFF RAMP
General Road	RDGEN-01	NORTH BUSINESS DEVELOPMENT AREA
	RDGEN-02A	STEBNER RD (SRE ACCESS)
	RDGEN-02B	MALSTROM ST
	RDGEN-02C	FBO ENTERANCE RD
	RDGEN-03A	AIRPORT APPROACH RD
	RDGEN-03B	TOWER RD
	RDGEN-04	GRINDEN RD
Parking Lot	PARK-04A	LEASED PARKING
	PARK-04B	ACCESS
	PARK-05	DEDA/CIRRUS PUBLIC LOT
	PARK-06	LSC LOT
	PARK-07	HANGAR 101 LOT
	PARK-08	SRE LOT
	PARK-09	MONACO LOT
	PARK-10	HANGAR 311 LOT
	PARK-11	CAR RENTAL LOT
	PARK-12	EMPLOYEE LOT
	PARK-13	SURFACE LOT
Perimeter Road	RDPER-01	PERIMETER ROAD NORTH
	RDPER-02	PERIMETER ROAD SOUTH
	RDPER-03	PERIMETER ROAD WEST
Service Road	RDSER-01A	RWY 27 GLIDESLOPE/TACAN RD
	RDSER-01B	RWY 27 GLIDESLOPE/TACAN RD
	RDSER-02A	RWY 9 GLIDESLOPE RD
	RDSER-02B	RWY 9 GLIDESLOPE RD

Some larger sections were then further subdivided to include multiple sample areas as shown in **Table 3 – Unit Costs for Localized Maintenance Treatments**.

Table 3 – Unit Costs for Localized Maintenance Treatments

Work Description	Unit Cost	Unit
Crack Sealing - AC	$ 1.45	LF
Crack Sealing - PCC	$ 2.21	LF
Grinding (Localized)	$ 5.73	LF
Joint Seal (Localized)	$ 2.21	LF
Patching - AC Deep	$ 13.59	SF
Patching - AC Shallow	$ 9.14	SF
Patching - PCC Full Depth	$ 85.47	SF
Patching - PCC Partial Depth	$ 12.28	SF
Slab Replacement - PCC	$ 46.00	SF
Surface Treatment	$ 0.60	SF
Monitor	-	

During the assessment, visible signs of pavement deterioration were noted for each sample area within a pavement section. **Appendix B** and **Appendix C** were used as guides for determining the types of distresses present for each section of pavement. The collected data was then entered into the FAA PAVEAIR program and a PCI value was calculated for each assessed pavement section. PAVEAIR is a public, web-based application designed to assist organizations in the evaluation, management, and maintenance of pavement networks that fulfills the requirements identified in the AC. The PCI value is a numerical indicator of the overall pavement condition and is calculated based on the distress types, the distress severities, and the distress quantities observed during the assessment. The PCI value ranges from 0 to 100, with 100 representing pavement in excellent condition, and provides insight into the level of maintenance that will be needed to repair a give pavement section.

Using the PCI value, the pavement sections were given a PCI rating ranging from failed to excellent. The following PCI rating scale was used to determine the rating of the pavement sections:

- 85-100 = excellent
- 71-85 = very good
- 56-70 = good
- 41-55 = fair
- 26-40 = poor
- 11-25 = very poor
- 0-10 = failed

Again, using the PCI value, a recommended work repair level was determined ranging from preventative maintenance to full reconstruction. Similarly to the Applied Research Associates, Inc (ARA) 2018 Airside Pavement Condition Report for the Duluth International Airport (**Appendix A**), the following scale was used to determine the recommended work repair level:

- 61-100 = preventative maintenance
- 40-60 = major rehabilitation
- 0-39 = reconstruction

Results

Table 4 – PCI Summary presents the PCI summary for each evaluated landside pavement section. A detailed written summary of the results for each pavement section can be found in **Appendix A**.

Table 4 – PCI Summary

Branch	Section	Common Name	Current Age of Pavement	Usage*	PCI Value	PCI Rating	Work Repair Level	Distress Types	Surface Type
Apron	APRON-01	SRE Apron	Middle	High	71	Very Good	Preventative Maintenance	L & T Cracking	AC
	APRON-02	SRE Apron	Old	High	53	Fair	Major Rehabilitation	Depression, L & T Cracking, Patching, Swelling	AC
	APRON-03	Terminal Apron	Old	Middle	84	Very Good	Preventative Maintenance	L & T Cracking, Weathering	AC
	APRON-04	ARFF Ramp	Middle	High	91	Excellent	Preventative Maintenance	L & T Cracking, Swelling, Weathering	AC
General Road	RDGEN-01	North Business Development Area	Middle	Middle	87	Excellent	Preventative Maintenance	L & T Cracking	AC
	RDGEN-02A	Stebner Rd (SRE Access)	Old	Low	7	Failed	Reconstruction	Alligator Cracking, Bumps/Sags, Edge Cracking, L & T Cracking, Patching, Potholes	AC
	RDGEN-02B	Malstrom St	Old	Low	3	Failed	Reconstruction	Alligator Cracking, Depression, L & T Cracking, Potholes, Swelling, Raveling	AC
	RDGEN-02C	FBO Entrance Rd	New	Middle	85	Very Good	Preventative Maintenance	L & T Cracking	AC
	RDGEN-03A	Airport Approach Rd	Middle	Middle	49	Fair	Major Rehabilitation	L & T Cracking	AC
	RDGEN-03B	Tower Rd	Old	Middle	44	Fair	Major Rehabilitation	Durability Crack, Faulting, Linear Cracking, Patching - Large & Small	PCC
	RDGEN-04	Grinden Rd	Middle	High	84	Very Good	Preventative Maintenance	L & T Cracking	AC
Parking Lot	PARK-04A	Leased Parking	Old	Low	50	Fair	Major Rehabilitation	Alligator Cracking, L & T Cracking, Potholes, Swelling	AC
	PARK-04B	Access	Old	Middle	52	Fair	Major Rehabilitation	Block Cracking, L & T Cracking, Potholes	AC
	PARK-05	DEDA/Cirrus Public Lot	New	High	86	Excellent	Preventative Maintenance	L & T Cracking	AC
	PARK-06	LSC Lot	Old	High	43	Fair	Major Rehabilitation	Alligator Cracking, Block Cracking, Patching, Potholes	AC
	PARK-07	Hangar 101 Lot	Old	Low	18	Very Poor	Reconstruction	Alligator Cracking, Block Cracking, Bumps/Sags, Depression, L & T Cracking, Patching, Potholes, Swelling	AC
	PARK-08	SRE Lot	Middle	High	65	Good	Preventative Maintenance	L & T Cracking	AC
	PARK-09	Monaco Lot	New	High	76	Very Good	Preventative Maintenance	Alligator Cracking, L & T Cracking, Swelling	AC
	PARK-10	Hangar 311 Lot	Old	High	39	Poor	Reconstruction	Alligator Cracking, Edge Cracking, L & T Cracking, Rutting	AC
	PARK-11	Car Rental Lot	Middle	High	91	Excellent	Preventative Maintenance	L & T Cracking	AC
	PARK-12	Employee Lot	Middle	High	81	Very Good	Preventative Maintenance	L & T Cracking, Weathering	AC
	PARK-13	Surface Lot	Middle	High	85	Very Good	Preventative Maintenance	L & T Cracking	AC
Perimeter Road	RDPER-01	Perimeter Road North	Middle	High	75	Very Good	Preventative Maintenance	Alligator Cracking, Edge Cracking, L & T Cracking	AC
	RDPER-02	Perimeter Road South	Old	High	72	Very Good	Preventative Maintenance	L & T Cracking	AC
	RDPER-03	Perimeter Road West	Middle	High	73	Very Good	Preventative Maintenance	Edge Cracking, L & T Cracking	AC
Service Road	RDSER-01A	Rwy 27 Glideslope/Tacan Rd	Old	Low	91	Excellent	Preventative Maintenance	Edge Cracking	AC
	RDSER-01B	Rwy 27 Glideslope/Tacan Rd	Old	Low	54	Fair	Major Rehabilitation	Block Cracking, Depression, Edge Cracking	AC
	RDSER-02A	Rwy 9 Glideslope Rd	Old	Low	97	Excellent	Preventative Maintenance	L & T Cracking	AC
	RDSER-02B	Rwy 9 GLIDESLOPE RD	Old	Low	54	Fair	Major Rehabilitation	L & T Cracking, Rutting	AC

Figure 2 – PCI Results presents a visual representation of the PCI results. As discussed above, using the PCI value, each pavement section was assigned a PCI rating ranging from failed to excellent. Colors were assigned to each PCI rating range to provide a visual.

Figure 3 – 3A and 3B Sample Locations illustrates all the sample locations for each pavement section.

Figure 4 – Work Repair Levels presents the recommended work repair level for each pavement section which was also determined based on its respective PCI values.

The results of this pavement assessment will be included as part of the larger CIP and implementation schedule included in the Airport Master Plan.

Recommendations

Based on the pavement assessment results, a pavement maintenance plan and an M&R prioritization schedule has been developed for the landside pavement at the Duluth International Airport. This maintenance plan and prioritization schedule will help the airport sponsor determine what pavement sections have the greatest maintenance need and also help them with a more efficient allocation of available M&R funds.

Similar to the ARA 2018 Airside pavement Condition Report, the maintenance recommendations were divided into two categories – localized maintenance and major rehabilitation/reconstruction. Localized maintenance, such as crack sealing and patching, are considered near-term maintenance treatments that help slow down the rate of further pavement deterioration and are applied “locally” (to small pavement sections). Major rehabilitation/ reconstruction is applied globally to an entire pavement section and helps to return the pavement section to a nearly distress free-state.

Table 5 – Localized Maintenance Policies for AC and PCC Surfaces lists the recommended localized maintenance treatment policies for both Asphalt Concrete (AC) and Portland Cement Concrete (PCC) surfaces. The treatment policies are not solely determined by distress type but also look at the distress severity.

Table 5 – Localized Maintenance Policies for AC and PCC Surfaces

Distress Type	Distress Severity	Maintenance Treatment	PaveAir Code
AC Treatment			
Alligator Cracking	L	Crack Sealing - AC	CS-AC
	M	Patching - AC Deep	PA-AD
	H	Patching - AC Deep	PA-AD
Block Cracking	L	Monitor	-
	M	Crack Sealing - AC	CS-AC
	H	Crack Sealing - AC	CS-AC
Bumps / Sags	L	Patching - AC Shallow	PA-AS
	M	Patching - AC Deep	PA-AD
	H	Patching - AC Deep	PA-AD
Depression	L	Monitor	-

Distress Type	Distress Severity	Maintenance Treatment	PaveAir Code
	M	Patching - AC Shallow	PA-AS
	H	Patching - AC Deep	PA-AD
Edge Cracking	L	Monitor	-
	M	Monitor	-
	H	Monitor	-
L & T Cracking	L	Monitor	-
	M	Crack Sealing - AC	CS-AC
	H	Crack Sealing - AC	CS-AC
Patching	L	Monitor	-
	M	Patching - AC Shallow	PA-AS
	H	Patching - AC Deep	PA-AD
Raveling	L	Monitor	-
	M	Surface Treatment	-
	H	Patching - AC Shallow	PA-AS
Rutting	L	Monitor	-
	M	Patching - AC Deep	PA-AD
	H	Patching - AC Deep	PA-AD
Potholes	L	Patching - AC Shallow	PA-AS
	M	Patching - AC Deep	PA-AD
	H	Patching - AC Deep	PA-AD
Swelling	L	Monitor	-
	M	Patching - AC Deep	PA-AD
	H	Patching - AC Deep	PA-AD
Weathering	L	Monitor	-
	M	Surface Treatment	-
	H	Patching - AC Shallow	PA-AS
PCC Treatment			
Durability Crack	L	Monitor	-
	M	Patching - PCC Full Depth	PA-PF
	H	Slab Replacement - PCC	SL-PC
Faulting	L	Monitor	-
	M	Grinding (Localized)	GR-PP
	H	Grinding (Localized)	GR-PP
Linear Cracking	L	Monitor	-
	M	Crack Sealing - PCC	CS-PC
	H	Patching - PCC Full Depth	PA-PF
Patching - Small	L	Monitor	-
	M	Patching - PCC Partial Depth	PA-PP
	H	Patching - PCC Partial Depth	PA-PP
	L	Monitor	-

Distress Type	Distress Severity	Maintenance Treatment	PaveAir Code
Patching - Large	M	Patching - PCC Full Depth	PA-PF
	H	Patching - PCC Full Depth	PA-PF
L = Low M = Medium H = High			

Table 6 – Unit Costs for Localized Maintenance Treatments identifies the unit costs used to determine the cost for implementing localized maintenance treatments and **Table 7 – Unit Costs for Major Rehabilitation and Reconstruction** identifies the unit costs used to determine the cost for performing major rehabilitation/reconstruction work. The costs identified in these tables are similar to the ones used in the ARA 2018 Airside Pavement Condition Report but include a markup to account for the engineering design fees that would be associated with this work. As stated in the ARA 2018 Airside Pavement Condition Report, the costs are based on industry averages and may have to be adjusted to account for local costs. It should also be noted that, over time, these costs will increase.

Any pavement sections that require major rehabilitation/reconstruction will require a more in-depth analysis to determine exactly how to fix each pavement.

Detailed cost estimates for each pavement section based on the recommended maintenance treatments can be found in **Appendix D**.

Table 6 – Unit Costs for Localized Maintenance Treatments

Work Description	Unit Cost	Unit
Crack Sealing - AC	$ 1.45	LF
Crack Sealing - PCC	$ 2.21	LF
Grinding (Localized)	$ 5.73	LF
Joint Seal (Localized)	$ 2.21	LF
Patching - AC Deep	$ 13.59	SF
Patching - AC Shallow	$ 9.14	SF
Patching - PCC Full Depth	$ 85.47	SF
Patching - PCC Partial Depth	$ 12.28	SF
Slab Replacement - PCC	$ 46.00	SF
Surface Treatment	$ 0.60	SF
Monitor	-	

Table 7 – Unit Costs for Major Rehabilitation and Reconstruction

PCI Range	Unit Cost	Unit
0-30	$ 12.56	SF
31-40	$ 10.74	SF
41-50	$ 8.91	SF
51-60	$ 7.43	SF
61-70	$ 5.24	SF
71-80	$ 3.33	SF
> 80	$ 1.63	SF

Table 8 – Prioritization Schedule shows the proposed timeframe for each repair or preventative maintenance to take place. Lessees are responsible for the pavement maintenance on several sections of pavement that were assessed, therefore these repairs along with subsequent cracks seals were not included in the prioritization schedule. Various other pavement sections will be improved as part of a larger development, or redevelopment area. Similarly, these repairs and their subsequent crack seals were not included in the prioritization schedule. The remaining pavement sections were prioritized based on current age and condition of pavement, usage, available funding, and proximity to other proposed projects for that year. During 2022 and 2023 various landside pavement maintenance and rehabilitation projects are called out specifically on the CIP and starting in 2024, the CIP plans for $100,000 of funds to go towards landside pavement maintenance annually to account for the need to repair and maintain the landside pavements at the airport. Repair work was grouped to best fit these requirements. A summary of the estimated annual maintenance cost can be found in **Table 9 – Annual Maintenance Costs**.

It should be noted that the maintenance plan and M&R prioritization schedule are based on the results from the 2019 landside pavement assessment. As time progresses, field conditions can change and the plan and schedule will become less accurate. This plan and schedule should be used as a baseline only but re-evaluated on a regular basis.

Table 8 – Prioritization Schedule

Estimated Years to Perform Repair	Branch	Section	Common Name	Current Age of Pavement	PCI Value	Development/ Redevelopment Area	Usage*	Recommended Work Repair Level	Full Repair	Year to Perform Crack Seal	Cost to Perform Crack Seal[1]
2022	General Road	RDGEN-04	Grinden Rd	Middle	84		High	Preventative Maintenance	$ 20,300.00	2025	$ 28,800.00
2023	Perimeter Road	RDPER-01	Perimeter Road North	Middle	75		High	Preventative Maintenance	$ 131,400.00	2026	$ 43,300.00
2023	Perimeter Road	RDPER-03	Perimeter Road West	Middle	73		High	Preventative Maintenance	$ 151,900.00	2026	$ 39,300.00
2023	General Road	RDGEN-03A	Airport Approach Rd	Middle	49		Middle	Major Rehabilitation	$ 175,200.00	2026	$ 1,500.00
2024	General Road	RDGEN-02A	Stebner Rd (SRE Access)	Old	7		Low	Reconstruction	$ 197,000.00	2027	$ 1,200.00
2025	Apron	APRON-01	SRE Apron	Middle	71		High	Preventative Maintenance	$ 6,400.00	2028	$ 6,300.00
2025	Parking Lot	PARK-08	SRE Lot	Middle	65		High	Preventative Maintenance	$ 1,600.00	2028	$ 1,300.00
2025	Parking Lot	PARK-11	Car Rental Lot	Middle	91		High	Preventative Maintenance	$ 5,200.00	2028	$ 13,700.00
2025	Parking Lot	PARK-12	Employee Lot	Middle	81		High	Preventative Maintenance	$ 4,900.00	2028	$ 8,300.00
2025	Perimeter Road	RDPER-02	Perimeter Road South	Old	72		High	Preventative Maintenance	$ 17,500.00	2028	$ 15,800.00
2025	Apron	APRON-03	Terminal Apron	Old	84		Middle	Preventative Maintenance	$ 4,400.00	2028	$ 7,300.00
2025	General Road	RDGEN-02C	FBO Entrance Rd	New	85		Middle	Preventative Maintenance	$ 300.00	2028	$ 2,100.00
2025	Apron	APRON-04	ARFF Ramp	Middle	91		High	Preventative Maintenance	$ 11,100.00	2028	$ 10,300.00
2025	General Road	RDGEN-01	North Business Development Area	Middle	87		Middle	Preventative Maintenance	$ 10,000.00	2028	$ 15,900.00
2025	Service Road	RDSER-02A	Rwy 9 Glideslope Rd	Old	97		Low	Preventative Maintenance	$ 140.00	2028	$ 900.00
2027	Service Road	RDSER-02B	Rwy 9 Glideslope Rd	Old	54		Low	Major Rehabilitation	$ 38,300.00	2030	$ 400.00
2027	Service Road	RDSER-01A	Rwy 27 Glideslope/Tacan Rd	Old	91		Low	Preventative Maintenance	$ 5,200.00	2030	$ 2,000.00
2027	Service Road	RDSER-01B	Rwy 27 Glideslope/Tacan Rd	Old	54		Low	Major Rehabilitation	$ 94,500.00	2030	$ 1,000.00
2	Apron	APRON-02	SRE Apron	Old	53	Development Area	High	Major Rehabilitation	$ 172,000.00	2028	$ 1,700.00
3	Parking Lot	PARK-13	Surface Lot	Middle	85	Development Area	High	Preventative Maintenance	$ 29,800.00	2028	$ 35,000.00
3	General Road	RDGEN-03B	Tower Rd	Old	44	Redevelopment Area	Middle	Major Rehabilitation	$ 170,400.00	2028	$ 2,200.00
4	Parking Lot	PARK-07	Hangar 101 Lot	Old	18	Redevelopment Area	Low	Reconstruction	$ 286,800.00	-	$ 1,700.00
4	General Road	RDGEN-02B	Malstrom St	Old	3	Redevelopment Area	Low	Reconstruction	$ 112,200.00	-	$ 700.00
4	Parking Lot	PARK-04A	Leased Parking	Old	50	Redevelopment Area	Low	Major Rehabilitation	$ 596,400.00	-	$ 4,900.00
4	Parking Lot	PARK-04B	Access	Old	52	Redevelopment Area	Middle	Major Rehabilitation	$ 20,400.00	-	$ 200.00
5	Parking Lot	PARK-06	LSC Lot	Old	43	LSC Leased	High	Major Rehabilitation	$ 397,200.00	-	$ 3,300.00
5	Parking Lot	PARK-05	DEDA/Cirrus Public Lot	New	86	DEDA Leased	High	Preventative Maintenance	$ 18,500.00	-	$ 24,000.00
5	Parking Lot	PARK-09	Monaco Lot	New	76	Monaco Leased	High	Preventative Maintenance	$ 4,500.00	-	$ 2,300.00
5	Parking Lot	PARK-10	Hangar 311 Lot	Old	39	Cirrus Leased	High	Reconstruction	$ 502,900.00	-	$ 3,400.00

Note: [1]Crackseal should be performed 3 years following a full repair

Note: [2]Part of Taxiway A Phase 4 (Construction in 2025)

Note: [3]Part of ATCT (Construction in 2025-2026)

Note: [4]Pavement will be reconstructed during future site redevelopment

Note: [5]Lessee is responsible for pavement maintenance

*Usage provided by DAA Staff

Table 9 – Annual Maintenance Costs

	Year	Estimated Annual Maintenance Cost
2021-2025	2021	$ -
	2022	$ 20,300.00
	2023	$ 458,500.00
	2024	$ 197,000.00
	2025	$ 90,340.00
	5-year total	***$ 766,140.00***
2026-2030	2026	$ 84,100.00
	2027	$ 139,200.00
	2028	$ 149,600.00
	2029	$ 84,100.00
	2030	$ 4,600.00
	5–10-year total	***$ 461,600.00***
2031+	2031	$ 100,000.00
	2032	$ 102,000.00
	2033	$ 104,040.00
	2034	$ 106,120.80
	2035	$ 108,243.22
	2036	$ 110,408.08
	2037	$ 112,616.24
	2038	$ 114,868.57
	2039	$ 117,165.94
	2040	$ 119,509.26
	10+ year total	***$ 1,094,972.10***

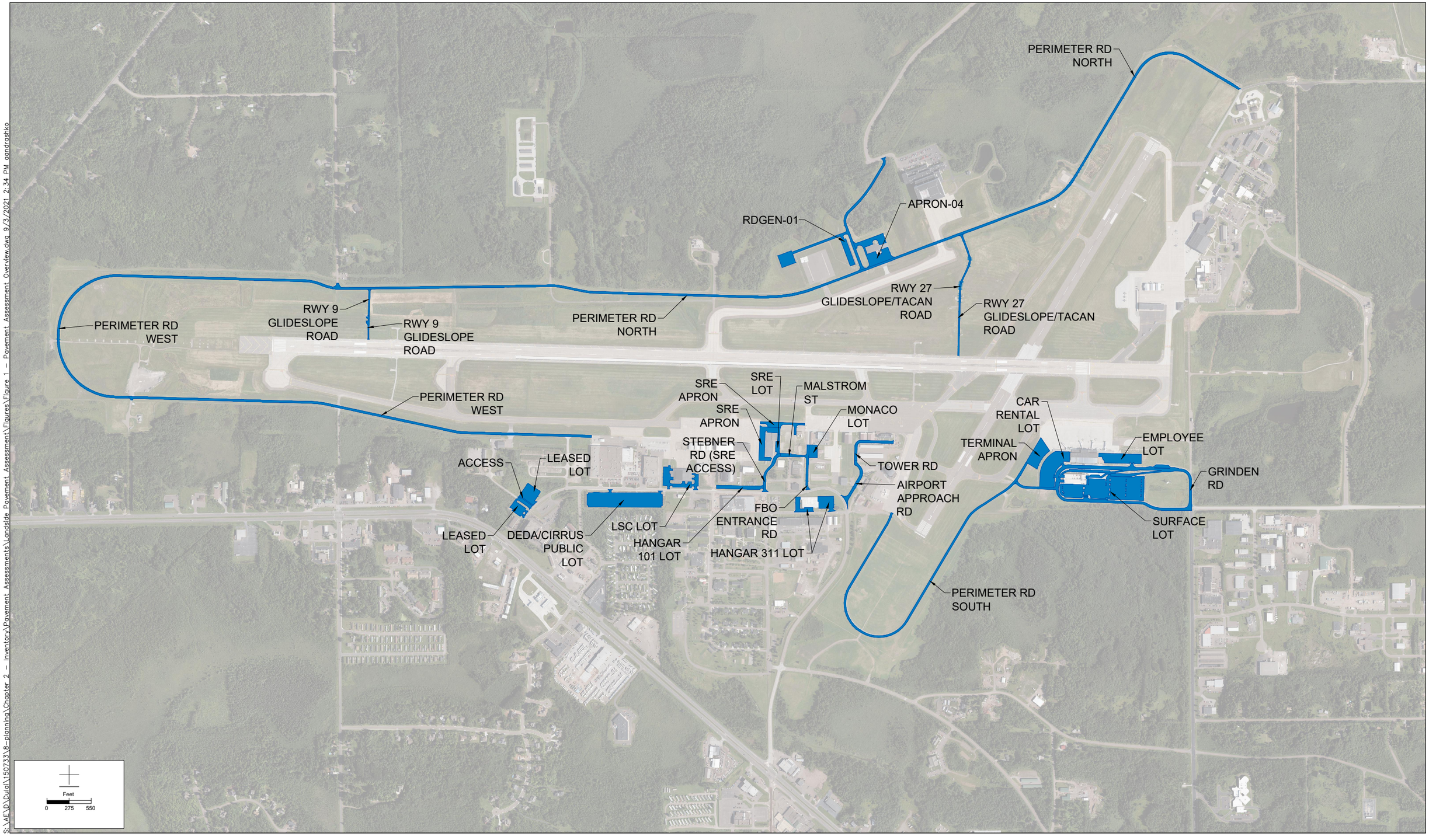
Figures

Landside Pavement Assessment

Figure 1

Duluth International Airport
Duluth, Minnesota

Landside Pavement Assessment Overview
09/2021; DULAI 150733



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Landside Pavement Assessment

Duluth International Airport

Duluth, MN

Figure 2

PCI Results

Date: 09/2021; Project: 150733

Branch	Section	PCI Value	PCI Color	Common Name
Apron	APRON-01	71		SRE APRON
	APRON-02	53		SRE APRON
	APRON-03	84		TERMINAL ARPON
	APRON-04	91		ARFF RAMP
General Road	RDGEN-01	87		NORTH BUSINESS DEVELOPMENT AREA
	RDGEN-02A	7		STEBNER RD (SRE ACCESS)
	RDGEN-02B	3		MALSTROM ST
	RDGEN-02C	85		FBO ENTERANCE RD
	RDGEN-03A	49		AIRPORT APPROACH RD
	RDGEN-03B	44		TOWER RD
	RDGEN-04	84		GRINDEN RD
Parking Lot	PARK-04A	50		LEASED PARKING
	PARK-04B	52		ACCESS
	PARK-05	86		DEDA/CIRRUS PUBLIC LOT
	PARK-06	43		LSC LOT
	PARK-07	18		HANGAR 101 LOT
	PARK-08	65		SRE LOT
	PARK-09	76		MONACO LOT
	PARK-10	39		HANGAR 311 LOT
	PARK-11	91		CAR RENTAL LOT
	PARK-12	81		EMPLOYEE LOT
	PARK-13	85		SURFACE LOT
Perimeter Road	RDPER-01	75		PERIMETER ROAD NORTH
	RDPER-02	72		PERIMETER ROAD SOUTH
	RDPER-03	73		PERIMETER ROAD WEST
Service Road	RDSER-01A	91		RWY 27 GLIDESLOPE/TACAN RD
	RDSER-01B	54		RWY 27 GLIDESLOPE/TACAN RD
	RDSER-02A	97		RWY 9 GLIDESLOPE RD
	RDSER-02B	54		RWY 9 GLIDESLOPE RD

RDPER-01
RDGEN-01
NORTH BUSINESS DEVELOPMENT AREA
APRON-04
ARFF RAMP
RDSER-01A
RWY 27 GLIDESLOPE/TACAN RD
RDSER-01B
RWY 27 GLIDESLOPE/TACAN RD
RDSER-02A
RWY 9 GLIDESLOPE RD
RDSER-02B
RWY 9 GLIDESLOPE RD
RDPER-01
RDPER-03
RDPER-03
PARK-08
SRE LOT
APRON-02
SRE APRON
RDGEN-02B
MALSTROM ST
PARK-06
LSC LOT
APRON-01
SRE APRON
PARK-09
MONACO LOT
PARK-11
CAR RENTAL LOT
RDGEN-04
GRINDEN DR
APRON-03
TERMINAL
PARK-12
EMPLOYEE LOT
PARK-04A
LEASED PARKING
RDGEN-02A
STEBNER RD
RDGEN-03B
TOWER RD
RDGEN-04
GRINDEN DR
PARK-04B
ACCESS
RDGEN-03A
AIRPORT APPROACH RD
PARK-07
HANGAR 101 LOT
PARK-13
SURFACE LOT
PARK-04A
LEASED PARKING
RDGEN-04
GRINDEN DR
PARK-05
DEDA/CIRRUS PUBLIC LOT
RDGEN-02C
FBO ENTRANCE RD
PARK-10
HANGAR 311 LOT
RDPER-02

Legend

- 0-10: Failed
- 11-25: Very Poor
- 26-40: Poor
- 41-55: Fair
- 56-70: Good
- 71-85: Very Good
- 86-100: Excellent

N

Feet

0 250 500 1,000

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Landside Pavement Assessment

Figure 3A

Duluth International Airport
Duluth, MN

Sample Locations
Date: 09/2021; Project: 150733

RDPER-01
SAMPLE 02

RDPER-01
SAMPLE 01

RDGEN-01
SAMPLE 01

RDGEN-01
SAMPLE 02

APRON-04
SAMPLE 01

RDSER-01A
SAMPLE 01

RDPER-01
SAMPLE 03

RDSER-01B
SAMPLE 01

RDPER-03
SAMPLE 01

RDSER-02A
SAMPLE 01

RDSER-02B
SAMPLE 01

RDPER-01
SAMPLE 04

RDPER-03
SAMPLE 02

PARK-04B
SAMPLE 01

PARK-04A
SAMPLE 01

PARK-04A
SAMPLE 03

PARK-04A
SAMPLE 02

PARK-05
SAMPLE 01

PARK-05
SAMPLE 02

PARK-05
SAMPLE 03

SEE FIGURE 3B

LEGEND

Branch ID	Description	Approx. Area	Sections
RDPER	Perimeter Road	679,000 SF	3
RDSER	Service Road	37,500 SF	4
RDGEN	General Road	385,000 SF	7
PARK	Parking Lot	766,000 SF	11
APRON	Apron	187,000 SF	4

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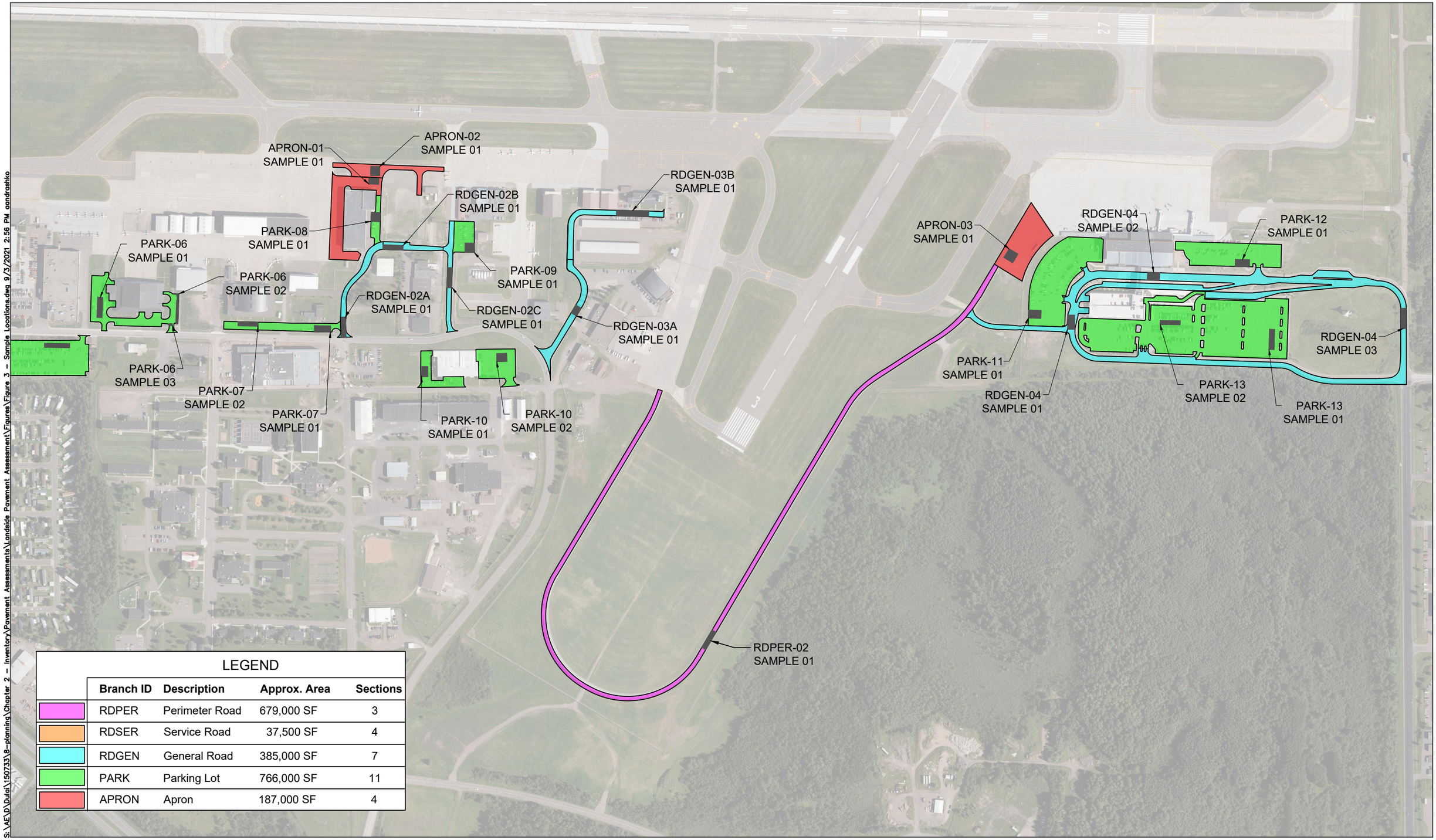
Landside Pavement Network

Figure 3B

Duluth International Airport
Duluth, MN

Sample Locations
Date: 09/2021; Project: 150733



LEGEND

	Branch ID	Description	Approx. Area	Sections
	RDPER	Perimeter Road	679,000 SF	3
	RDSER	Service Road	37,500 SF	4
	RDGEN	General Road	385,000 SF	7
	PARK	Parking Lot	766,000 SF	11
	APRON	Apron	187,000 SF	4

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Landside Pavement Assessment

Figure 4

Duluth International Airport
Duluth, MN

Work Repair Levels
Date: 09/2021; Project: 150733

RDPER-01
RDGEN-01
APRON-04
RDSER-01A
RDSER-01B
RDPER-01
RDSER-02A
RDSER-02B
RDPER-03
RDPER-03
APRON-02
PARK-08
RDGEN-02B
APRON-01
PARK-09
RDGEN-02C
RDGEN-04
PARK-11
APRON-03
PARK-12
RDGEN-04
PARK-04B
PARK-04A
RDGEN-02A
RDGEN-03B
RDGEN-03A
PARK-04A
PARK-10
PARK-06
PARK-05
PARK-07
RDGEN-04
PARK-13
RDPER-02

LEGEND

Work Repair Level
Preventative Maintenance
Major Rehabilitation
Reconstruction

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Appendix A

Pavement Condition Assessment Reports

Building a Better World for All of Us®

PAVEMENT CONDITION ASSESSMENT

INTRODUCTION

Pavement Network: Duluth International Airport
Pavement Branch: Apron
Pavement Section: APRON-01
Surface Type: AC
Ownership: Duluth Airport Authority (DAA)
Usage: High

Area: 43,031 SF
Pavement Age: Middle
Pavement Condition Index (PCI) Value: 71
PCI Rating: Very Good
Work Repair Level: Preventative Maintenance

SITE OVERVIEW

This apron section is located on the south side of the airport, adjacent to the SRE Building, and is for use by vehicles only. The Asphalt Concrete pavement in this section is in very good condition, and currently only requires preventative maintenance.

OWNERSHIP AND RESPONSIBILITY

The apron located east of the SRE building is owned and maintained by the Duluth Airport Authority (DAA). The Business Development Manager for the DAA confirmed there were no active leases for this pavement at the time the report was written.

PRIMARY DISTRESS TYPES

The primary distress types found in this sample of the apron are low and medium severity longitudinal and transverse cracking. See **Appendix B** for asphalt surfaced distress definitions.

Specifically, the following were observed in the sample: 85 LF of low severity longitudinal and transverse cracking and 71 LF of medium severity longitudinal and transverse cracking.

In order to get a distress representation for the entire section, a weighted-average scale factor of the sample was used to extrapolate distress totals. This resulted in the following distress quantities for the section: 2,400 LF of low severity longitudinal and transverse cracking and 2,000 LF of medium severity longitudinal and transverse cracking.

RECOMMENDATIONS

Based on the PCI value, a work repair level of preventative maintenance is recommended. However, based on some of the severity levels of the observed distress types, the localized maintenance policy recommends to just monitor the low severity longitudinal and transverse cracks at this time and to only repair the medium severity longitudinal and transverse cracks. It is not very practical to assess the severity of each crack while performing maintenance, so all severities of pavement distress will be repaired at the same time.

Based on the localized maintenance policies listed in **Table 2 – Localized Maintenance Policies for AC and PCC Surfaces** in the main report, the following maintenance treatments are recommended: crack sealing for longitudinal and transverse cracking. Refer to **Appendix F** for preventative maintenance repair guidelines.

If ongoing pavement maintenance is used over the next 5-10 years, a more substantial rehabilitation or reconstruction may not be required within the next 15 years. It is recommended that crack sealing is performed every other year, or at least every third year.

ESTIMATED COSTS

Table 6 – Repair Cost Summary is the table which shows the estimated costs to perform the repair and then subsequent crack sealing. As discussed above, the low severity longitudinal and transverse cracking only requires monitoring at this time, however, it is not practical to assess the severity of each crack while performing maintenance. In this case, all severities of cracking will be repaired at the same time, so the total cost of preventative maintenance is estimated to be $6,400. This is based on the following unit costs: $1.45 per LF for crack sealing. Refer to **Table 3 – Unit Costs for Localized Maintenance Treatments**, in the main report, for a complete list of unit costs.

The recommended crack sealing cost estimate for this section of pavement is $6,300 to be performed every other year, or at least every third year.

Refer to **Appendix D** for a detailed treatment cost estimate.

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PAVEMENT CONDITION ASSESSMENT

INTRODUCTION

Pavement Network: Duluth International Airport
Pavement Branch: Apron
Pavement Section: APRON-02
Surface Type: AC
Ownership: Duluth Airport Authority (DAA)
Usage: High

Area: 23,160 SF
Pavement Age: Old
Pavement Condition Index (PCI) Value: 53
PCI Rating: Fair
Work Repair Level: Major Rehabilitation

SITE OVERVIEW

This apron section is located on the south side of the airport, in front of the SRE Building, and is for use by vehicles only. The Asphalt Concrete pavement in this section is in fair condition, and requires major rehabilitation.

OWNERSHIP AND RESPONSIBILITY

The apron located adjacent to the SRE building that connects the Midfield and Monaco Ramps is owned and maintained by the Duluth Airport Authority (DAA). The Business Development Manager for the DAA confirmed there were no active leases for this pavement at the time the report was written.

PRIMARY DISTRESS TYPES

The primary distress types found in this sample of the apron are a medium severity depression, medium severity longitudinal and transverse cracking, medium severity patching, and medium severity swelling. See **Appendix B** for asphalt surfaced distress definitions.

Specifically, the following were observed in the sample: 40 SF of medium severity depression, 110 LF of medium severity longitudinal and transverse cracking, 20 SF of medium severity patching, and 80 SF of medium severity swelling.

In order to get a distress representation for the entire section, a weighted-average scale factor of the sample was used to extrapolate distress totals. This resulted in the following distress quantities for the

section: 500 SF of medium severity depression, 1,300 LF of medium severity longitudinal and transverse cracking, 200 SF of medium severity patching, and 900 SF of medium severity swelling.

RECOMMENDATIONS

Based on the PCI value, major rehabilitation is recommended for this section of pavement in order to repair the high levels of distress. It is also recommended that crack sealing is performed every other year, or at least every third year.

ESTIMATED COSTS

Table 6 – Repair Cost Summary shows the estimated costs to perform the rehabilitation and subsequent crack sealing. To repair these distresses using major rehabilitation methods, the costs for these repairs are estimated to be $172,000. This is based on the following unit cost: $7.43 per SF for pavement sections in the PCI range of 51-60. Refer to **Table 3 – Unit Costs for Localized Maintenance Treatments** in the main report, for a complete list of unit costs.

The recommended crack sealing cost estimate for this section of pavement is $1,700, to be performed every other year, or at least every third year.

Refer to **Appendix D** for a detailed treatment cost estimate.

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PAVEMENT CONDITION ASSESSMENT

INTRODUCTION

Pavement Network: Duluth International Airport
Pavement Branch: Apron
Pavement Section: APRON-03
Surface Type: AC
Ownership: Duluth Airport Authority (DAA)
Usage: Middle

Area: 50,296 SF
Pavement Age: Old
Pavement Condition Index (PCI) Value: 84
PCI Rating: Very Good
Work Repair Level: Preventative Maintenance

SITE OVERVIEW

This apron section is located on the southeast side of the airport adjacent to the terminal ramp. The Asphalt Concrete pavement in this section is in very good condition, and currently only requires preventative maintenance.

OWNERSHIP AND RESPONSIBILITY

The pavement located southwest of the Terminal Apron is owned and maintained by the DAA. The Business Development Manager for the DAA confirmed there were no active leases for this pavement at the time the report was written.

PRIMARY DISTRESS TYPES

The primary distress types found in this sample of the apron are low severity longitudinal and transverse cracking and low severity weathering. See **Appendix B** for asphalt surfaced distress definitions.

Specifically, the following were observed in the sample: 141 LF of low severity longitudinal and transverse cracking and 25 SF of low severity weathering.

In order to get a distress representation for the entire section, a weighted-average scale factor of the sample was used to extrapolate distress totals. This resulted in the following distress quantities for the section: 2,800 LF of low severity longitudinal and transverse cracking and 500 SF of low severity weathering.

RECOMMENDATIONS

Based on the PCI value, a work repair level of preventative maintenance is recommended. However, based on the severity levels of the observed distress types, the localized maintenance policy recommends to just monitor the pavement condition at this time.

Eventually, some preventative maintenance will be required and should be utilized to maintain the pavement in suitable condition. Based on the localized maintenance policies listed in **Table 2 – Localized Maintenance Policies for AC and PCC Surfaces** in the main report, the following maintenance treatments are recommended, once necessary: crack sealing for longitudinal and transverse cracking, and surface treatment for weathering. Refer to **Appendix F** for preventative maintenance repair guidelines.

If ongoing pavement maintenance is used over the next 5-10 years, a more substantial rehabilitation or reconstruction may not be required within the next 15 years. It is recommended that crack sealing is performed every other year, or at least every third year.

ESTIMATED COSTS

Table 6 – Repair Cost Summary shows the estimated costs to perform the eventual preventative maintenance, and crack sealing. Although this pavement section only requires monitoring at this time, if the preventative maintenance repairs are carried out, the cost for these repairs are estimated to be $4,400. This is based on the following unit costs: $1.45 per LF for crack sealing and $0.60 per SF for surface treatment. Refer to **Table 3 – Unit Costs for Localized Maintenance Treatments**, in the main report, for a complete list of unit costs.

The recommended crack sealing cost estimate for this section of pavement is $7,300 to be performed every other year, or at least every third year.

Refer to **Appendix D** for a detailed treatment cost estimate.

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PAVEMENT CONDITION ASSESSMENT

INTRODUCTION

Pavement Network: Duluth International Airport
Pavement Branch: Apron
Pavement Section: APRON-04
Surface Type: AC
Ownership: Duluth Airport Authority (DAA)
Usage: High

Area: 70,882 SF
Pavement Age: Middle
Pavement Condition Index (PCI) Value: 91
PCI Rating: Excellent
Work Repair Level: Preventative Maintenance

SITE OVERVIEW

This apron section is located on the north side of the airport adjacent to the Aircraft Rescue and Fire Fighting (ARFF) building. The Asphalt Concrete pavement in this section is in excellent condition, and currently only requires preventative maintenance.

OWNERSHIP AND RESPONSIBILITY

The parking lot and ARFF apron pavements are owned by the Duluth Airport Authority (DAA) and has an Airport Joint Use Agreement (AJUA) with the United State of America and the State of Minnesota for the operation of the 148th Air National Guard (ANG). The 148th plows and maintains their ramp and parking lots. The 2014 AJUA states the148th are responsible for removing snow, ice and other hazards from runways and taxiways exclusively used by the Government to include access roads and Government aircraft parking ramps.

PRIMARY DISTRESS TYPES

The primary distress types found in this sample of the apron were low severity longitudinal and transverse cracking, low severity swelling, and low severity weathering. See **Appendix B** for detailed definitions of asphalt surfaced distresses.

Specifically, the following were observed in the sample: 22 LF of low severity longitudinal and transverse cracking, 20 SF of low severity swelling, and 28 SF of low severity weathering.

In order to get a distress representation for the entire section, a weighted-average scale factor of the sample was used to extrapolate distress totals. This resulted in the following distress quantities for the section: 700 LF of low severity longitudinal and transverse cracking, 700 SF of low severity swelling, and 900 SF of low severity weathering.

RECOMMENDATIONS

Based on the PCI value, a work repair level of preventative maintenance is recommended. However, based on the severity levels of the observed distress types, the localized maintenance policy recommends to just monitor the pavement condition at this time.

Eventually, some preventative maintenance will be required and should be utilized to maintain the pavement in suitable condition. Based on the localized maintenance policies listed in **Table 2 – Localized Maintenance Policies for AC and PCC Surfaces** in the main report, the following maintenance treatments are recommended, once necessary: crack sealing for longitudinal and transverse cracking, patching for swelling, and surface treatment for weathering. Refer to **Appendix F** for preventative maintenance repair guidelines.

If ongoing pavement maintenance is used over the next 5-10 years, a more substantial rehabilitation or reconstruction may not be required within the next 15 years. It is recommended that crack sealing is performed every other year, or at least every third year.

ESTIMATED COSTS

Table 6 – Repair Cost Summary shows the estimated costs to perform the eventual maintenance and subsequent crack sealing. Although this pavement section only requires monitoring at this time, if the preventative maintenance repairs are carried out, the cost for these repairs are estimated to be $11,100. This is based on the following unit costs: $1.45 per LF for crack sealing, $13.59 per SF for patching, and $0.60 per SF for surface treatment. Refer to Table 3, in the main report, for a complete list of unit costs.

The recommended crack sealing cost estimate for this section is $10,300 and is to be performed every other year, or at least every third year.

Refer to **Appendix D** for a detailed treatment cost estimate.

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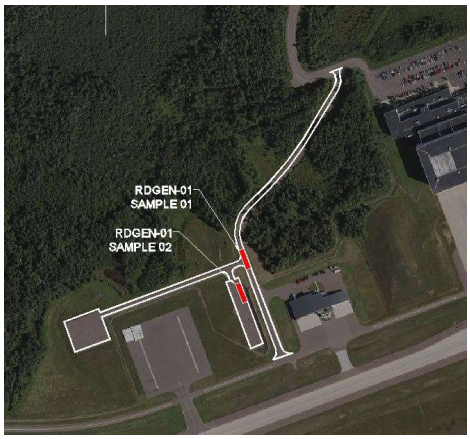
PAVEMENT CONDITION ASSESSMENT

INTRODUCTION

Pavement Network: Duluth International Airport
Pavement Branch: General Road
Pavement Section: RDGEN-01
Surface Type: AC
Ownership: Duluth Airport Authority (DAA)
Usage: Middle
Area: 109,693 SF
Pavement Age: Middle
Pavement Condition Index (PCI) Value: 87
PCI Rating: Excellent
Work Repair Level: Preventative Maintenance

SITE OVERVIEW

This general road section is located on the north side of the airport allowing access to the airport entrance. The Asphalt Concrete pavement in this section is in excellent overall condition, and currently only requires preventative maintenance.



OWNERSHIP AND RESPONSIBILITY

The access road leading from Stebner Road to the North Business Development Area (NBDA) parking lot is owned by the Duluth Airport Authority (DAA). Monaco Air currently has development right to this area, however, the Business Development Manager confirmed that there were no active leases for these pieces of pavement at the time this report was written. The 148th will typically plow the road leading from Stebner Road to the ARFF parking lot.

PRIMARY DISTRESS TYPES

The primary distress type found in these samples of the general road section is low severity longitudinal and transverse cracking. See **Appendix B** for asphalt surfaced distress definitions.

Specifically, the following was observed in the samples: 314 LF of low severity longitudinal and transverse cracking.

In order to get a distress representation for the entire section, a weighted-average scale factor of the samples was used to extrapolate distress totals. This resulted in the following distress quantities for the section: 6,900 LF of low severity longitudinal and transverse cracking.

RECOMMENDATIONS

Based on the PCI value, a work repair level of preventative maintenance is recommended. However, based on the severity levels of the observed distress types, the localized maintenance policy recommends to just monitor the pavement condition at this time.

Eventually, some preventative maintenance will be required and should be utilized to maintain the pavement in suitable condition. Based on the localized maintenance policies listed in **Table 2 – Localized Maintenance Policies for AC and PCC Surfaces** in the main report, the following maintenance treatments are recommended, once necessary: crack sealing for longitudinal and transverse cracking. Refer to **Appendix F** for preventative maintenance repair guidelines.

If ongoing pavement maintenance is used over the next 5-10 years, a more substantial rehabilitation or reconstruction may not be required within the next 15 years. It is recommended that crack sealing is performed every other year, or at least every third year.

ESTIMATED COSTS

Table 6 – Repair Cost Summary shows the estimated costs to perform the repair and then subsequent crack sealing. Although this pavement section only requires monitoring at this time, if the preventative maintenance repairs are carried out, the cost for these repairs are estimated to be $10,000. This is based on the following unit costs: $1.45 per LF for crack sealing. Refer to **Table 3 – Unit costs for Localized Maintenance Treatments**, in the main report, for a complete list of unit costs.

The recommended crack sealing cost estimate for this section of pavement is $15,900 to be performed every other year, or at least every third year.

Refer to **Appendix D** for a detailed treatment cost estimate.

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PAVEMENT CONDITION ASSESSMENT

INTRODUCTION

Pavement Network: Duluth International Airport
Pavement Branch: General Road
Pavement Section: RDGEN-02A
Surface Type: AC
Ownership: TBD
Usage: Low

Area: 15,679 SF
Pavement Age: Old
Pavement Condition Index (PCI) Value: 7
PCI Rating: Failed
Work Repair Level: Reconstruction

SITE OVERVIEW

This general road section is located on the south side of the airport allowing vehicle access to several surrounding buildings. The Asphalt Concrete pavement in this section is in a failed condition and requires total reconstruction.

OWNERSHIP AND RESPONSIBILITY

The road leading from Airport Road to the SRE parking lot is owned by St. Louis County. Records from the City of Duluth indicate this section of roadway is St. Louis County's responsibility for snow removal. However, the Duluth Airport Authority indicated that the SRE maintenance team typically plows this section of roadway. It was indicated in meetings with DAA staff that County plows generally do not turn off of Airport Road.

PRIMARY DISTRESS TYPES

The primary distress types found in this sample of the general road section are medium severity alligator cracking, low severity edge cracking, medium severity longitudinal and transverse cracking, high severity longitudinal and transverse cracking, high severity patching, a high severity pothole, and a medium severity bump. See **Appendix B** for asphalt surfaced distress definitions.

Specifically, the following were observed in the sample: 107.5 SF of medium severity alligator cracking, 45 LF of low severity edge cracking, 207 LF of medium severity longitudinal and transverse cracking, 180

LF of high severity longitudinal and transverse cracking, 252 SF of high severity patching, 1 high severity pothole, and 5 LF of medium severity bumps.

In order to get a distress representation for the entire section, a weighted-average scale factor of the sample was used to extrapolate distress totals. This resulted in the following distress quantities for the section: 700 LF of medium severity alligator cracking, 300 LF of low severity edge cracking, 1,300 LF of medium severity longitudinal and transverse cracking, 1,100 LF of high severity longitudinal and transverse cracking, 1,600 SF of high severity patching, 10 high severity potholes, and 30 LF of medium severity bumps.

RECOMMENDATIONS

Based on the PCI value, a complete reconstruction is recommended for this section of pavement in order to repair the high levels of distress. It is also recommended that crack sealing is performed every other year, or at least every third year.

ESTIMATED COSTS

Table 6 – Repair Cost Summary shows the estimated costs for the repairs and subsequent crack sealing. To repair the high level of distresses found in this section and using total reconstruction methods, the costs for these repairs are estimated to be $197,000. This is based on the following unit cost: $12.56 per SF for pavement sections in the PCI range of 0-30. Refer to **Table 4 – Unit Costs for Major Rehabilitation and Reconstruction**, in the main report, for a complete list of unit costs.

The recommended crack sealing cost estimate for this section of pavement is $1,200 to be performed every other year, or at least every third year.

Refer to **Appendix D** for a detailed treatment cost estimate.

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PAVEMENT CONDITION ASSESSMENT

INTRODUCTION

Pavement Network: Duluth International Airport
Pavement Branch: General Road
Pavement Section: RDGEN-02B
Surface Type: AC
Ownership: Duluth Airport Authority (DAA)
Usage: Low

Area: 8,929 SF
Pavement Age: Old
Pavement Condition Index (PCI) Value: 3
PCI Rating: Failed
Work Repair Level: Reconstruction

SITE OVERVIEW

This general road section is located on the south side of the airport allowing vehicle access to several surrounding buildings. The Asphalt Concrete pavement in this section is in a failed condition and requires total reconstruction.

OWNERSHIP AND RESPONSIBILITY

The road that connects the SRE parking lot the Monaco Air entrance road, Malstrom St, is owned and maintained by the Duluth Airport Authority (DAA). The Business Development Manager for the DAA confirmed there were no active leases at the time this report was written.

PRIMARY DISTRESS TYPES

This primary distress types found in this sample of the general road section are medium severity alligator cracking, high severity depressions, medium severity longitudinal and transverse cracking, high severity potholes, high severity swelling, and high severity raveling. See **Appendix B** for asphalt surfaced distress definitions.

Specifically, the following were observed in the sample: 140 SF of medium severity alligator cracking, 128 SF of high severity depressions, 4 LF of medium severity longitudinal and transverse cracking, 3 high severity potholes, 102 SF of high severity swelling, and 1,900 SF of high severity raveling.

In order to get a distress representation for the entire section, a weighted-average scale factor of the sample was used to extrapolate distress totals. This resulted in the following distress quantities for the section: 500 SF of medium severity alligator cracking, 500 SF high severity depressions, 20 LF of medium severity longitudinal and transverse cracking, 10 high severity potholes, 350 SF of high severity swelling, and 7,400 SF of high severity raveling.

RECOMMENDATIONS

Based on the PCI value, a complete reconstruction is recommended for this section of pavement in order to repair the high levels of distress. It is also recommended that crack sealing is performed every other year, or at least every third year.

ESTIMATED COSTS

Table 6 – Repair Cost Summary shows the estimated costs to perform the reconstruction and then subsequent crack sealing. To repair the high level of distresses found in this section and using total reconstruction methods, the costs for these repairs are estimated to be $112,200. This is based on the following unit cost: $12.56 per SF for pavement sections in the PCI range of 0-30. Refer to **Table 4 – Unit Costs for Major Rehabilitation and Reconstruction**, in the main report, for a complete list of unit costs.

The recommended crack sealing cost estimate for this section of pavement is $700 to be performed every other year, or at least every third year.

Refer to **Appendix D** for a detailed treatment cost estimate.

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PAVEMENT CONDITION ASSESSMENT

INTRODUCTION

Pavement Network: Duluth International Airport
Pavement Branch: General Road
Pavement Section: RDGEN-02C
Surface Type: AC
Ownership: Duluth Airport Authority (DAA)
Usage: Middle
Area: 14,189 SF
Pavement Age: New
Pavement Condition Index (PCI) Value: 85
PCI Rating: Very Good
Work Repair Level: Preventative Maintenance

SITE OVERVIEW

This general road section is located on the south side of the airport allowing vehicle access to several surrounding buildings. The Asphalt Concrete pavement in this section is in a very good condition, and currently only requires preventative maintenance.

OWNERSHIP AND RESPONSIBILITY

The roadway leading from Airport Road to Monaco Air is currently maintained by the DAA. However records from the City of Duluth noted that St. Louis County was responsible for plowing this roadway. St. Louis County stated they are not responsible for plowing this roadway. The Business Development Manager for the DAA confirmed that there were no active leases for this pavement at the time this report was written.

PRIMARY DISTRESS TYPES

The primary distress types found in this section are medium and high severity longitudinal and transverse cracking. See **Appendix B** for asphalt surfaced distress definitions.

Specifically, the following were observed in the sample: 12 LF of medium severity longitudinal and transverse cracking and 12 LF of high severity longitudinal and transverse cracking.

In order to get a distress representation for the entire section, a weighted-average scale factor of the sample was used to extrapolate distress totals. This resulted in the following distress quantities for the

section: 100 LF of medium severity longitudinal and transverse cracking and 100 LF of high severity longitudinal and transverse cracking.

RECOMMENDATIONS

Based on the PCI value, a work repair level of preventative maintenance is recommended.

For the next several years, preventative maintenance techniques should be utilized to maintain the pavement in a suitable condition. Based on the localized maintenance policies listed in **Table 2 – Localized Maintenance Policies for AC and PCC Surfaces** in the main report, the following maintenance treatment is recommended: crack sealing for longitudinal and transverse cracking. Refer to **Appendix F** for preventative maintenance repair guidelines.

If ongoing pavement maintenance is used over the next 5-10 years, a more substantial rehabilitation or reconstruction may not be required within the next 15 years. It is recommended that crack sealing is performed every other year, or at least every third year.

ESTIMATED COSTS

The preventative maintenance cost for these repairs is estimated to be $300. This is based on the following unit costs: $1.45 per LF for crack sealing. Refer to **Table 3 – Unit Costs for Localized Maintenance Treatments**, in the main report, for a complete list of unit costs.

The recommended crack sealing cost estimate for this section of pavement is $2,100 to be permorned every other year, or at least every third year.

Refer to **Appendix D** for a detailed treatment cost estimate.

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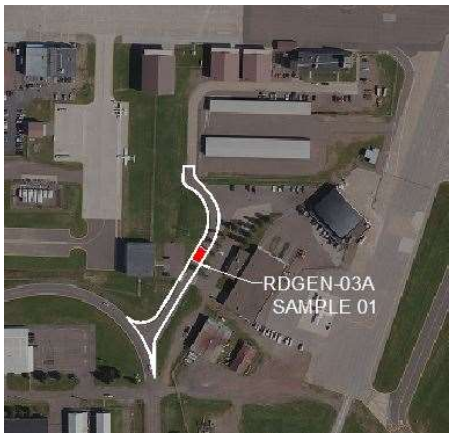
PAVEMENT CONDITION ASSESSMENT

INTRODUCTION

Pavement Network: Duluth International Airport
Pavement Branch: General Road
Pavement Section: RDGEN-03A
Surface Type: AC
Ownership: Duluth Airport Authority (DAA)
Usage: Middle
Area: 19,655 SF
Pavement Age: Middle
Pavement Condition Index (PCI) Value: 49
PCI Rating: Fair
Work Repair Level: Major Rehabilitation

SITE OVERVIEW

This general road section is located on the south side of the airport allowing vehicle access to several surrounding buildings. The Asphalt Concrete pavement in this section is in a fair condition and requires major rehabilitation.



OWNERSHIP AND RESPONSIBILITY

The southern portion of Airport Approach Road is owned the Duluth Airport Authority (DAA). Records from the City of Duluth indicate this section of roadway is St. Louis County's responsibility for snow removal, however St. Louis County stated they do not plow the portion of Airport Approach Road. Also, the Duluth Airport Authority indicated that the SRE maintenance team typically plows this section of roadway. It was indicated in meetings with DAA staff that County plows generally do not turn off of Airport Road. The Business Development Manager for the DAA confirmed there are no active leases for this pavement at the time this report was written.

PRIMARY DISTRESS TYPES

The primary distress types found in this sample of the general road section are medium and high severity longitudinal and transverse cracking. See **Appendix B** for asphalt surfaced distress definitions.

Specifically, the following were observed in the sample: 160 LF of medium severity longitudinal and transverse cracking and 45 LF of high severity longitudinal and transverse cracking.

In order to get a distress representation for the entire section, a weighted-average scale factor of the sample was used to extrapolate distress totals. This resulted in the following distress quantities for the section: 2,300 LF of medium severity longitudinal and transverse cracking and 700 LF of high severity longitudinal and transverse cracking.

RECOMMENDATIONS

Based on the PCI value, major rehabilitation is recommended for this section of pavement in order to repair the high levels of distress. It is also recommended that crack sealing is performed every other year, or at least every third year.

ESTIMATED COSTS

Table 6 – Repair Cost Summary shows the estimated costs to perform the rehabilitation and subsequent crack sealing. To repair these distresses using major rehabilitation methods, the costs for these repairs are estimated to be $175,200. This is based on the following unit cost: $8.91 per SF for pavement sections in the PCI range of 41-50. Refer to **Table 4 – Unit Costs for Major Rehabilitation and Reconstruction**, in the main report, for a complete list of unit costs.

The recommended crack sealing cost estimate for this section of pavement is $1,500 to be performed every other year, or at least every third year.

Refer to **Appendix D** for a detailed treatment cost estimate.

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PAVEMENT CONDITION ASSESSMENT

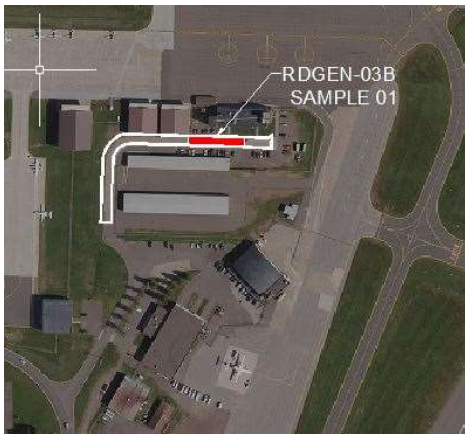
INTRODUCTION

Pavement Network: Duluth International Airport
Pavement Branch: General Road
Pavement Section: RDGEN-03B
Surface Type: PCC
Ownership: Duluth Airport Authority (DAA)
Usage: Middle

Area: 19,114
Pavement Age: Old
Pavement Condition Index (PCI) Value: 44
PCI Rating: Fair
Work Repair Level: Major Rehabilitation

SITE OVERVIEW

This general road section is located on the south side of the airport, providing vehicle access to the Air Traffic Control Tower and surrounding. The Portland Cement Concrete pavement in this section is in fair condition and requires major rehabilitation.



OWNERSHIP AND RESPONSIBILITY

The northern portion of Airport Approach Road is owned the Duluth Airport Authority (DAA). Records from the City of Duluth indicate this section of roadway is St. Louis County's responsibility for snow removal, however St. Louis County stated they do not plow the portion of Airport Approach Road. Also, the Duluth Airport Authority indicated that the SRE maintenance teams typically plows this section of roadway. It was indicated in meetings with DAA staff that County plows generally do not turn off of Airport Road. The Business Development Manager for the DAA confirmed there are no active leases for this pavement at the time this report was written.

PRIMARY DISTRESS TYPES

The primary distress types found in this sample of the general road section are medium severity durability cracking, medium severity faulting, medium severity linear cracking, medium severity large patching, and high severity small patching. See **Appendix C** for concrete surfaced distress definitions.

Specifically, the following were observed in the sample: 11 slabs with medium severity durability cracking, 3 slabs with medium severity faulting, 9 slabs with medium severity linear cracking, 1 slab with medium severity large patching, and 1 slab with high severity small patching.

Since this section requires major rehabilitation, the distresses were not extrapolated for the entire road section.

RECOMMENDATIONS

Based on the PCI value, major rehabilitation is recommended for this section of pavement in order to repair the high levels of distress. It is also recommended that crack sealing is performed every other year, or at least every third year.

ESTIMATED COSTS

Table 6 – Repair Cost Summary shows the estimated costs to perform the rehabilitation and then subsequent crack sealing. To repair these distresses using major rehabilitation methods, the costs for these repairs are estimated to be $170,400. This is based on the following unit cost: $8.91 per SF for pavement sections in the PCI range of 41-50. Refer to **Table 4 – Unit Costs for Major Rehabilitation and Reconstruction**, in the main report, for a complete list of unit costs.

The recommended crack sealing cost estimate for this section of pavement is $2,200 to be performed every other year, or at least every third year.

Refer to **Appendix D** for a detailed treatment cost estimate.

Photo 1

Photo 2

Photo 3

Photo 4

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PAVEMENT CONDITION ASSESSMENT

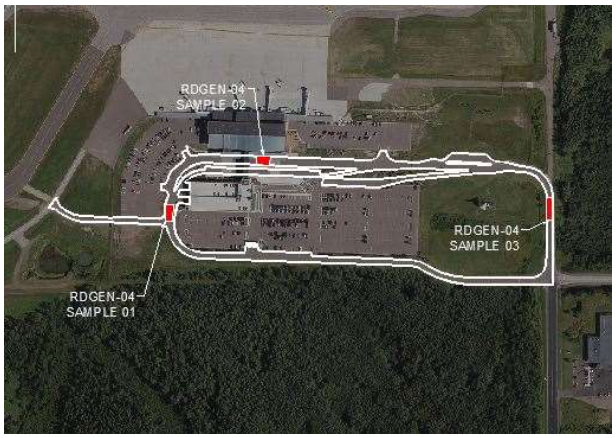
INTRODUCTION

Pavement Network: Duluth International Airport
Pavement Branch: General Road
Pavement Section: RDGEN-04
Surface Type: AC
Ownership: Duluth Airport Authority (DAA)
Usage: High

Area: 198,082 SF
Pavement Age: Middle
Pavement Condition Index (PCI) Value: 84
PCI Rating: Very Good
Work Repair Level: Preventative Maintenance

SITE OVERVIEW

This general road section is located on the southeast side of the airport providing vehicle access to the airport terminal and parking lots. The Asphalt Concrete pavement in this section is in very good condition and will require preventative maintenance.



OWNERSHIP AND RESPONSIBILITY

Grinden Road is owned and maintained by the Duluth Airport Authority. Records from the City of Duluth indicate that St. Louis County is responsible for snow plowing on the airport access road, not including the parking lots or service roads to the terminal vehicle gate granting access to the secure side of the perimeter fence. St. Louis County stated they do not plow the terminal roadway.

PRIMARY DISTRESS TYPES

The primary distress types found in the samples of this general road section are low and medium severity longitudinal and transverse cracking. See **Appendix B** for asphalt surfaced distress definitions.

Specifically, the following were observed in the sample: 300 LF of low severity longitudinal and transverse cracking and 200 LF of medium severity longitudinal and transverse cracking.

In order to get a distress representation for the entire section, a weighted-average scale factor of the sample was used to extrapolate distress totals. This resulted in the following distress quantities for the

section: 8,400 LF of low severity longitudinal and transverse cracking and 5,600 LF of medium severity longitudinal and transverse cracking.

RECOMMENDATIONS

Based on the PCI value, a work repair level of preventative maintenance is recommended. However, based on some of the severity levels of the observed distress types, the localized maintenance policy recommends to just monitor the low severity longitudinal and transverse cracks at this time and to only repair the medium severity longitudinal and transverse cracks. It is not very practical to assess the severity of each crack while performing maintenance, so repair of all cracks is recommended at the time of repair.

Based on the localized maintenance policies listed in **Table 2 – Localized Maintenance Policies for AC and PCC Surfaces** in the main report, the following maintenance treatments are recommended: crack sealing for longitudinal and transverse cracking. Refer to **Appendix F** for preventative maintenance repair guidelines.

If ongoing pavement maintenance is used over the next 5-10 years, a more substantial rehabilitation or reconstruction may not be required within the next 15 years. It is recommended that crack sealing is performed every other year, or at least every third year.

ESTIMATED COSTS

Table 6 – Repair Cost Summary shows the estimated costs to perform the repair and subsequent crack sealing. As discussed above, the low severity longitudinal and transverse cracking only requires monitoring at this time, however it is not practical to assess the severity of each crack while performing maintenance, so all cracks will be repaired at the time maintenance occurs. If all severities of cracking are repaired at the same time, both low and medium longitudinal and transverse cracks, the total cost is estimated to be $20,300. This is based on the following unit costs: $1.45 per LF for crack sealing. Refer to **Table 3 – Unit Costs for Localized Maintenance Treatments**, in the main report, for a complete list of unit costs.

The recommended crack sealing cost estimate for this section of pavement is $28,800 to be performed every other year, or at least every third year.

Refer to **Appendix D** for a detailed treatment cost estimate.

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PAVEMENT CONDITION ASSESSMENT

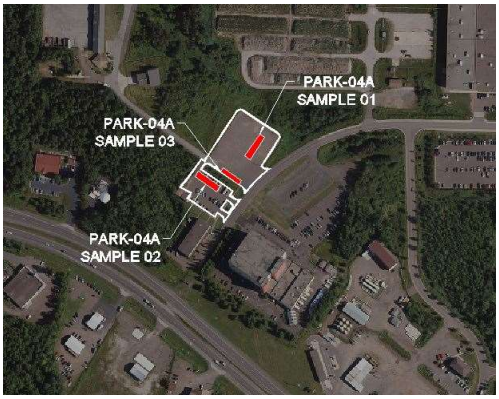
INTRODUCTION

Pavement Network: Duluth International Airport
Pavement Branch: Parking Lot
Pavement Section: PARK-04A
Surface Type: AC
Ownership: Duluth Airport Authority (DAA)
Usage: Low

Area: 66,916 SF
Pavement Age: Old
Pavement Condition Index (PCI) Value: 50
PCI Rating: Fair
Work Repair Level: Major Rehabilitation

SITE OVERVIEW

This parking lot section is located on the southwest side of the airport. The Asphalt Concrete pavement in this section is in fair condition, and requires major rehabilitation.



OWNERSHIP AND RESPONSIBILITY

The parking lot located on the west end of Airport Road is owned and maintained by the Duluth Airport Authority (DAA). Portions of the parking lot are part of the DRMO site located closer to the airfield. Following cleanup by the United States Government this portion of pavement will be turned over to the DAA. The Business Development Manager for the DAA confirmed that there is a lease agreement with Chad's Pad LLC in place for the southern parking lot. This lease expires in April of 2024.

PRIMARY DISTRESS TYPES

The primary distress types found in the samples of this parking lot are medium severity longitudinal and transverse cracking, medium severity swelling, low severity alligator cracking, and high severity potholes. See **Appendix B** for asphalt surfaced distress definitions.

Specifically, the following were observed in the samples: 1,044 LF of medium severity longitudinal and transverse cracking, 30 SF of medium severity swelling, 1,200 SF of low severity alligator cracking, and 2 high severity potholes.

In order to get a distress representation for the entire section, a weighted-average scale factor of the sample was used to extrapolate distress totals. This resulted in the following distress quantities for the

section: 10,700 LF of medium severity longitudinal and transverse cracking, 300 SF of medium severity swelling, 12,300 SF of low severity alligator cracking, and 20 high severity potholes.

RECOMMENDATIONS

Based on the PCI value, major rehabilitation is recommended for this section of pavement in order to repair the high levels of distress. It is also recommended that crack sealing is performed every other year, or at least every third year.

ESTIMATED COSTS

Table 6 – Repair Cost Summary shows the estimated costs to perform the rehabilitation and subsequent crack sealing. To repair these distresses using major rehabilitation methods, the costs for these repairs are estimated to be $596,400. This is based on the following unit cost: $8.91 per SF for pavement sections in the PCI range of 41-50. Refer to **Table 4 – Unit Costs for Major Rehabilitation and Reconstruction**, in the main report, for a complete list of unit costs.

The recommended crack sealing cost estimate for this section of pavement is $4,900 to be performed every other year, or at least every third year.

Refer to **Appendix D** for a detailed treatment cost estimate

Photo 1

Photo 2

Photo 3

Photo 4

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PAVEMENT CONDITION ASSESSMENT

INTRODUCTION

Pavement Network: Duluth International Airport
Pavement Branch: Parking Lot
Pavement Section: PARK-04B
Surface Type: AC
Ownership: Duluth Airport Authority (DAA)
Usage: Middle

Area: 2,754 SF
Pavement Age: Old
Pavement Condition Index (PCI) Value: 52
PCI Rating: Fair
Work Repair Level: Major Rehabilitation

SITE OVERVIEW

This parking lot section is located on the southwest side of the airport. The Asphalt Concrete pavement in this section is in fair condition and requires major rehabilitation.

OWNERSHIP AND RESPONSIBILITY

This roadway is owned and maintained by the Duluth Airport Authority (DAA).

PRIMARY DISTRESS TYPES

The primary distress types found in this sample of the parking lot are medium severity block cracking, low severity longitudinal and transverse cracking, and medium severity potholes. See **Appendix B** for asphalt surfaced distress definitions.

Specifically, the following were observed in the sample: 27 SF of medium severity block cracking, 564 LF of low severity longitudinal and transverse cracking, and 1 medium severity pothole.

In order to get a distress representation for the entire section, a weighted-average scale factor of the sample was used to extrapolate distress totals. This resulted in the following distress quantities for the section: 30 SF of medium severity block cracking, 630 LF of low severity longitudinal and transverse cracking, and 1 medium severity pothole.

RECOMMENDATIONS

Based on the PCI value, major rehabilitation is recommended for this section of pavement in order to repair the high levels of distress. It is also recommended that crack sealing is performed every other year, or at least every third year.

ESTIMATED COSTS

Table 6 – Repair Cost Summary shows the estimated costs to perform the repair and then subsequent crack sealing. To repair these distresses using major rehabilitation methods, the costs for these repairs are estimated to be $20,400. This is based on the following unit cost: $7.43 per SF for pavement sections in the PCI range of 51-60. Refer to **Table 4 – Unit Costs for Major Rehabilitation and Reconstruction**, in the main report, for a complete list of unit costs.

The recommended crack sealing cost estimate for this section of pavement is $200 to be performed every other year, or at least every third year.

Refer to **Appendix D** for a detailed treatment cost estimate.

Photo 1

Photo 2

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PAVEMENT CONDITION ASSESSMENT

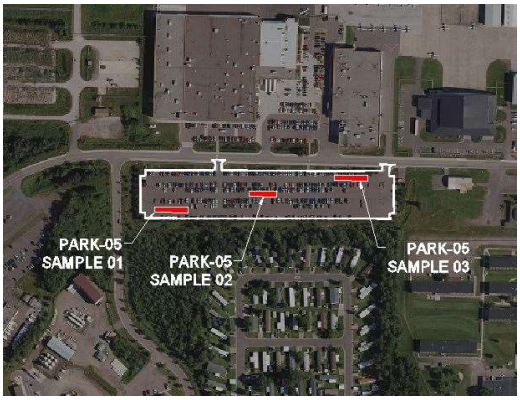
INTRODUCTION

Pavement Network: Duluth International Airport
Pavement Branch: Parking Lot
Pavement Section: PARK-05
Surface Type: AC
Ownership: Duluth Economic Development Authority (DEDA)

Usage: High
Area: 165,345 SF
Pavement Age: New
Pavement Condition Index (PCI) Value: 86
PCI Rating: Excellent
Work Repair Level: Preventative Maintenance

SITE OVERVIEW

This parking lot section is located on the southwest side of the airport. The Asphalt Concrete pavement in this section is in excellent condition and currently only requires preventative maintenance.



OWNERSHIP AND RESPONSIBILITY

The parking lot located on the western portion of Airport Road is owned by the Duluth Economic Development Authority (DEDA). The Duluth Airport Authority (DAA) owns and leases the land to DEDA for the parking lot. DEDA is responsible for the pavement.

PRIMARY DISTRESS TYPES

The primary distress type found in these samples of the parking lot are low severity longitudinal and transverse cracking. See **Appendix B** for asphalt surfaced distress definitions.

Specifically, the following was observed in the samples: 537 LF of low severity longitudinal and transverse cracking.

In order to get a distress representation for the entire section, a weighted-average scale factor of the samples was used to extrapolate distress totals. This resulted in the following distress quantities for the section: 12,800 LF of low severity longitudinal and transverse cracking.

RECOMMENDATIONS

Based on the PCI value, a work repair level of preventative maintenance is recommended. However, based on the severity levels of the observed distress types, the localized maintenance policy recommends to just monitor the pavement condition at this time.

Eventually, some preventative maintenance will be required and should be utilized to maintain the pavement in suitable condition. Based on the localized maintenance policies listed in **Table 2 – Localized Maintenance Policies for AC and PCC Surfaces** in the main report, the following maintenance treatments are recommended, once necessary: crack sealing for longitudinal and transverse cracking. Refer to **Appendix F** for preventative maintenance repair guidelines.

If ongoing pavement maintenance is used over the next 5-10 years, a more substantial rehabilitation or reconstruction may not be required within the next 15 years. It is recommended that crack sealing is performed every other year, or at least every third year.

ESTIMATED COSTS

Table 6 – Repair Cost Summary shows the estimated costs to perform the maintenance and subsequent crack sealing. Although this pavement section only requires monitoring at this time, if the preventative maintenance repairs are carried out, the cost for these repairs are estimated to be $18,500. This is based on the following unit costs: $1.45 per LF for crack sealing. Refer to **Table 3 – Unit Costs for Localized Maintenance Treatments**, in the main report, for a complete list of unit costs.

The recommended crack sealing cost estimate for this section of pavement is $24,000 to be performed every other year, or at least every third year.

Refer to **Appendix D** for a detailed treatment cost estimate.

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PAVEMENT CONDITION ASSESSMENT

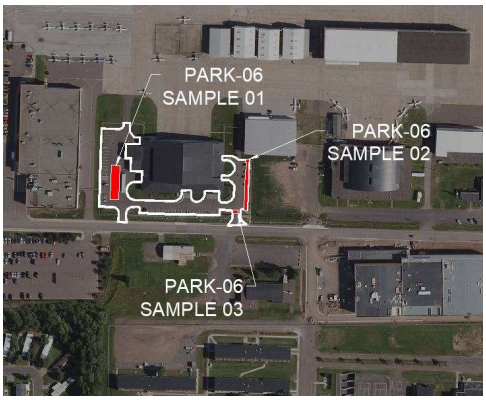
INTRODUCTION

Pavement Network: Duluth International Airport
Pavement Branch: Parking Lot
Pavement Section: PARK-06
Surface Type: AC
Ownership: Duluth Airport Authority (DAA)
Usage: High

Area: 44,568 SF
Pavement Age: Old
Pavement Condition Index (PCI) Value: 43
PCI Rating: Fair
Work Repair Level: Major Rehabilitation

SITE OVERVIEW

This parking lot section is located on the southwest side of the airport. The Asphalt Concrete pavement in this section is in fair condition and requires major rehabilitation.



OWNERSHIP AND RESPONSIBILITY

The parking lot that surrounds building 103 is owned by the Duluth Airport Authority (DAA). Building 103 is leased to the Minnesota State College and Universities (MNSCU) and Lake Superior College (LSC). The 2014 Lease and 2015 Lease Amendment state the parking lot is listed as part of the “Leased Premises” and LSC is responsible for operating costs and maintenance.

PRIMARY DISTRESS TYPES

The primary distress types found in the samples of this parking lot are medium and high severity block cracking, medium severity alligator cracking, medium severity patching, and medium severity potholes. See **Appendix B** for asphalt surfaced distress definitions.

Specifically, the following were observed in the samples: 9 SF of high severity block cracking, 3,870 SF of medium severity block cracking, 148 SF of medium severity alligator cracking, 72 SF of medium severity patching, and 3 medium severity potholes.

In order to get a distress representation for the entire section, a weighted-average scale factor of the sample was used to extrapolate distress totals. This resulted in the following distress quantities for the section: 100 SF of high severity block cracking, 42,700 SF of medium severity block cracking, 1,423 SF of

medium severity alligator cracking, 433 SF of medium severity patching, and 12 medium severity potholes. The section quantities for sample 3 are the same as the sample quantities since this was an additional sample rather than a random sample.

RECOMMENDATIONS

Based on the PCI value, major rehabilitation is recommended for this section of pavement in order to repair the high levels of distress. It is also recommended that crack sealing is performed every other year, or at least every third year.

ESTIMATED COSTS

Table 6 – Repair Cost Summary shows the estimated costs to perform the rehabilitation and subsequent crack sealing. To repair these distresses using major rehabilitation methods, the costs for these repairs are estimated to be $397,200. This is based on the following unit cost: $8.91 per SF for pavement sections in the PCI range of 41-50. Refer to **Table 4 – Unit Costs for Major Rehabilitation and Reconstruction**, in the main report, for a complete list of unit costs.

The recommended crack sealing cost estimate for this section of pavement is $3,300 to be performed every other year, or at least every third year.

Refer to **Appendix D** for a detailed treatment cost estimate.

Photo 1

Photo 2

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PAVEMENT CONDITION ASSESSMENT

INTRODUCTION

Pavement Network: Duluth International Airport
Pavement Branch: Parking Lot
Pavement Section: PARK-07
Surface Type: AC
Ownership: Duluth Airport Authority (DAA)
Usage: Low

Area: 22,833 SF
Pavement Age: Old
Pavement Condition Index (PCI) Value: 18
PCI Rating: Very Poor
Work Repair Level: Reconstruction

SITE OVERVIEW

This parking lot section is located on the southwest side of the airport. The Asphalt Concrete pavement in this section is in very poor condition and requires reconstruction.

OWNERSHIP AND RESPONSIBILITY

The parking lot in front of Hangar 101 is owned and maintained by the Duluth Airport Authority (DAA).

PRIMARY DISTRESS TYPES

The primary distress types found in the samples of this parking lot are medium severity alligator cracking, medium severity depressions, medium and high severity longitudinal and transverse cracking, low and medium severity patching, medium and high severity potholes, high severity bumps/sags, medium severity block cracking, and high severity swelling. See **Appendix B** for asphalt surfaced distress definitions.

Specifically, the following were observed in the samples: 1,269 SF of medium severity alligator cracking, 17.5 SF of medium severity depressions, 318 LF medium severity longitudinal and transverse cracking, 87 LF of high severity longitudinal and transverse cracking, 5 SF of low severity patching, 6 SF of medium severity patching, 2 medium severity potholes, 1 high severity potholes, 2.5 LF of high severity bumps/sags, 1,000 SF of medium severity block cracking, and 45 SF of high severity swelling.

In order to get a distress representation for the entire section, a weighted-average scale factor of the sample was used to extrapolate distress totals. This resulted in the following distress quantities for the section: 6,600 SF of medium severity alligator cracking, 100 SF of medium severity depressions, 1,700

LF medium severity longitudinal and transverse cracking, 500 LF of high severity longitudinal and transverse cracking, 30 SF of low severity patching, 30 SF of medium severity patching, 10 medium severity potholes, 10 high severity potholes, 10 LF of high severity bumps/sags, 5,200 SF of medium severity block cracking, and 200 SF of high severity swelling.

RECOMMENDATIONS

Based on the PCI value, a complete reconstruction is recommended for this section of pavement in order to repair the high levels of distress. It is also recommended that crack sealing is performed every other year, or at least every third year.

ESTIMATED COSTS

Table 6 – Repair Cost Summary shows the estimated costs to perform the reconstruction and subsequent crack sealing. To repair the high level of distresses found in this section and using total reconstruction methods, the costs for these repairs are estimated to be $268,800. This is based on the following unit cost: $12.56 per SF for pavement sections in the PCI range of 0-30. Refer to **Table 4 – Unit Costs for Major Rehabilitation and Reconstruction**, in the main report, for a complete list of unit costs.

The recommended crack sealing cost estimate for this section of pavement is $1,700 to be performed every other year, or at least every third year.

Refer to **Appendix D** for a detailed treatment cost estimate.

Photo 1

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PAVEMENT CONDITION ASSESSMENT

INTRODUCTION

Pavement Network: Duluth International Airport
Pavement Branch: Parking Lot
Pavement Section: PARK-08
Surface Type: AC
Ownership: Duluth Airport Authority (DAA)
Usage: High

Area: 8,694 SF
Pavement Age: Middle
Pavement Condition Index (PCI) Value: 65
PCI Rating: Good
Work Repair Level: Preventative Maintenance

SITE OVERVIEW

This parking lot section is located on the southwest side of the airport. The Asphalt Concrete pavement in this section is in good condition and requires preventative maintenance.

OWNERSHIP AND RESPONSIBILITY

The parking lot located east of the SRE Building is owned and maintained by the Duluth Airport Authority (DAA).

PRIMARY DISTRESS TYPES

The primary distress type found in this sample of the parking lot is medium severity longitudinal and transverse cracking. See **Appendix B** for asphalt surfaced distress definitions.

Specifically, the following were observed in the sample: 247 LF of medium severity longitudinal and transverse cracking.

In order to get a distress representation for the entire section, a weighted-average scale factor of the sample was used to extrapolate distress totals. This resulted in the following distress quantities for the section: 1,100 LF of medium severity longitudinal and transverse cracking.

RECOMMENDATIONS

Based on the PCI value, a work repair level of preventative maintenance is recommended.

For the next several years, preventative maintenance techniques should be utilized to maintain the pavement in a suitable condition. Based on the localized maintenance policies listed in **Table 2 – Localized Maintenance Policies for AC and PCC Surfaces** in the main report, the following maintenance treatment is recommended: crack sealing for longitudinal and transverse cracking. Refer to **Appendix F** for preventative maintenance repair guidelines.

If ongoing pavement maintenance is used over the next 5-10 years, a more substantial rehabilitation or reconstruction may not be required within the next 15 years. It is recommended that crack sealing is performed every other year, or at least every third year.

ESTIMATED COSTS

Table 6 – Repair Cost Summary shows the estimated costs to perform the maintenance and subsequent crack sealing. The preventative maintenance cost for these repairs is estimated to be $1,600. This is based on the following unit costs: $1.45 per LF for crack sealing. Refer to **Table 3 – Unit Costs for Localized Maintenance Treatments**, in the main report, for a complete list of unit costs.

The recommended crack sealing cost estimate foe this section of pavement is $1,300 to be performed every other year, or at least every third year.

Refer to **Appendix D** for a detailed treatment cost estimate.

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PAVEMENT CONDITION ASSESSMENT

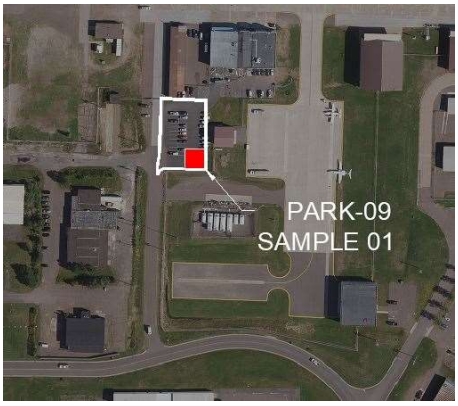
INTRODUCTION

Pavement Network: Duluth International Airport
Pavement Branch: Parking Lot
Pavement Section: PARK-09
Surface Type: AC
Ownership: Duluth Airport Authority (DAA)
Usage: High

Area: 15,705 SF
Pavement Age: New
Pavement Condition Index (PCI) Value: 76
PCI Rating: Very Good
Work Repair Level: Preventative Maintenance

SITE OVERVIEW

This parking lot section is located on the southwest side of the airport. The Asphalt Concrete pavement in this section is in very good condition and currently only requires preventative maintenance.



OWNERSHIP AND RESPONSIBILITY

The parking lot located south of Monaco Air is owned by the Duluth Airport Authority (DAA) and is leased to Monaco Air as referenced in Exhibit A from the December 2008 lease agreement. Monaco Air is responsible for the maintenance of this parking lot.

PRIMARY DISTRESS TYPES

The primary distress types found in this sample of the parking lot are low severity alligator cracking, medium severity longitudinal and transverse cracking, and medium severity swelling. See **Appendix B** for asphalt surfaced distress definitions.

Specifically, the following were observed in the sample: 21 SF of low severity alligator cracking, 18 LF of medium severity longitudinal and transverse cracking, and 45 SF of medium severity swelling.

In order to get a distress representation for the entire section, a weighted-average scale factor of the sample was used to extrapolate distress totals. This resulted in the following distress quantities for the section: 200 SF of low severity alligator cracking, 100 LF of medium severity longitudinal and transverse cracking, and 300 SF of medium severity swelling.

RECOMMENDATIONS

Based on the PCI value, a work repair level of preventative maintenance is recommended.

For the next several years, preventative maintenance techniques should be utilized to maintain the pavement in a suitable condition. Based on the localized maintenance policies listed in **Table 2 – Localized Maintenance Policies for AC and PCC Surfaces** in the main report, the following maintenance treatment is recommended: crack sealing for longitudinal and transverse cracking. Refer to **Appendix F** for preventative maintenance repair guidelines.

If ongoing pavement maintenance is used over the next 5-10 years, a more substantial rehabilitation or reconstruction may not be required within the next 15 years. It is recommended that crack sealing is performed every other year, or at least every third year.

ESTIMATED COSTS

Table 6 – Repair Cost Summary shows the estimated costs to perform the maintenance and subsequent crack sealing. The preventative maintenance cost for these repairs is estimated to be $4,500. This is based on the following unit costs: $1.45 per LF for crack sealing and $13.59 per SF for deep patching. Refer to **Table 3 – Unit Costs for Localized Maintenance Treatments**, in the main report, for a complete list of unit costs.

The recommended crack sealing cost estimate for this section of pavement is $2,300 to be performed every other year, or at least every third year.

Refer to **Appendix D** for a detailed treatment cost estimate.

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PAVEMENT CONDITION ASSESSMENT

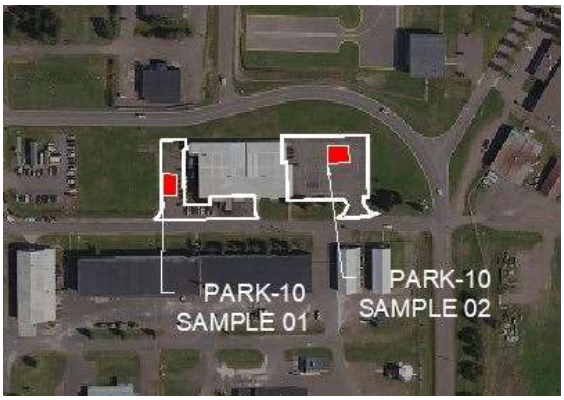
INTRODUCTION

Pavement Network: Duluth International Airport
Pavement Branch: Parking Lot
Pavement Section: PARK-10
Surface Type: AC
Ownership: Duluth Airport Authority (DAA)
Usage: High

Area: 46,839 SF
Pavement Age: Old
Pavement Condition Index (PCI) Value: 39
PCI Rating: Poor
Work Repair Level: Reconstruction

SITE OVERVIEW

This parking lot section is located on the southwest side of the airport. The Asphalt Concrete pavement in this section is in poor condition and requires reconstruction.



OWNERSHIP AND RESPONSIBILITY

The parking lots surrounding Building 311 are owned by the Duluth Airport Authority (DAA). Cirrus Aircraft currently leases the building and parking lot and is responsible for the pavement.

PRIMARY DISTRESS TYPES

The primary distress types found in these samples of the parking lot are medium severity alligator cracking, low severity edge cracking, low severity rutting, and medium severity longitudinal and transverse cracking. See **Appendix B** for asphalt surfaced distress definitions.

Specifically, the following were observed in the sample: 778 SF of medium severity alligator cracking, 50 LF low severity edge cracking, 100 SF low severity rutting, and 202 SF of medium severity longitudinal and transverse cracking.

In order to get a distress representation for the entire section, a weighted-average scale factor of the sample was used to extrapolate distress totals. This resulted in the following distress quantities for the section: 10,400 SF of medium severity alligator cracking, 700 LF low severity edge cracking, 1,300 SF low severity rutting, and 2,700 SF of medium severity longitudinal and transverse cracking.

RECOMMENDATIONS

Based on the PCI value, a complete reconstruction is recommended for this section of pavement in order to repair the high levels of distress. It is also recommended that crack sealing is performed every other year, or at least every third year.

ESTIMATED COSTS

Table 6 – Repair Cost Summary shows the estimated costs to perform the reconstruction and subsequent crack sealing. To repair the high level of distresses found in this section and using total reconstruction methods, the costs for these repairs are estimated to be $502,900. This is based on the following unit cost: $10.74 per SF for pavement sections in the PCI range of 31-40. Refer to **Table 4 – Unit Costs for Major Rehabilitation and Reconstruction**, in the main report, for a complete list of unit costs.

The recommended crack sealing cost estimate for this section of pavement is $3,400 to be performed every other year, or at least every third year.

Refer to **Appendix D** for a detailed treatment cost estimate.

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PAVEMENT CONDITION ASSESSMENT

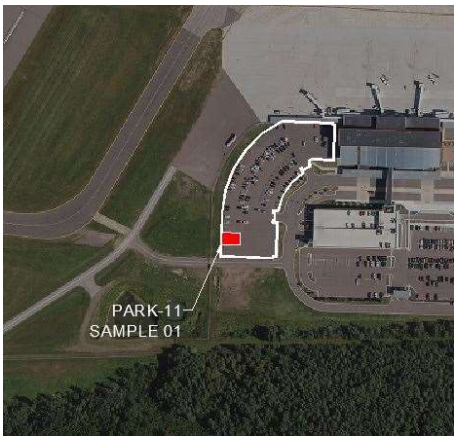
INTRODUCTION

Pavement Network: Duluth International Airport
Pavement Branch: Parking Lot
Pavement Section: PARK-11
Surface Type: AC
Ownership: Duluth Airport Authority (DAA)
Usage: High

Area: 94,136 SF
Pavement Age: Middle
Pavement Condition Index (PCI) Value: 91
PCI Rating: Excellent
Work Repair Level: Preventative Maintenance

SITE OVERVIEW

This parking lot section is located on the southeast side of the airport adjacent to the airport terminal. The Asphalt Concrete pavement in this section is in excellent overall condition and will require preventative maintenance.



OWNERSHIP AND RESPONSIBILITY

The parking lot located west of the Terminal Building is owned and maintained by the Duluth Airport Authority (DAA). The Business Development Manager with the DAA indicated that car rental agencies lease parking spaces to park their vehicles in the center portion of the parking lot. The southernmost portion of the parking lost is available on an as needed basis for the car rental agencies.

PRIMARY DISTRESS TYPES

The primary distress type found in the sample of this parking lot is low severity longitudinal and transverse cracking. See **Appendix B** for asphalt surfaced distress definitions.

Specifically, the following was observed in the sample: 94 LF of low severity longitudinal and transverse cracking.

In order to get a distress representation for the entire section, a weighted-average scale factor of the samples was used to extrapolate distress totals. This resulted in the following distress quantities for the section: 3,600 LF of low severity longitudinal and transverse cracking.

RECOMMENDATIONS

Based on the PCI value, a work repair level of preventative maintenance is recommended. However, based on the severity levels of the observed distress types, the localized maintenance policy recommends to just monitor the pavement condition at this time. It is not very practical to assess the severity of each crack while performing the maintenance, so once the maintenance activities take place, all cracks on this section of pavement will be repaired.

Eventually, some preventative maintenance will be required and should be utilized to maintain the pavement in suitable condition. Based on the localized maintenance policies listed in **Table 2 – Localized Maintenance Policies for AC and PCC Surfaces** in the main report, the following maintenance treatments are recommended, once necessary: crack sealing for longitudinal and transverse cracking. Refer to **Appendix F** for preventative maintenance repair guidelines.

If ongoing pavement maintenance is used over the next 5-10 years, a more substantial rehabilitation or reconstruction may not be required within the next 15 years. It is recommended that crack sealing is performed every other year, or at least every third year.

ESTIMATED COSTS

Table 6 – Repair Cost Summary shows the estimated costs of the repairs and subsequent crack sealing. As discussed above, the low severity cracking only required monitoring at this time, however, it is not practical to assess the severity of each crack while performing maintenance. In this case, all severities of cracking will be repaired at the same time, so the total cost of preventative maintenance is estimated to be $5,200. This is based on the following unit costs: $1.45 per LF for crack sealing. Refer to **Table 3 – Unit Costs for Localized Maintenance Treatments**, in the main report, for a complete list of unit costs.

The recommended crack sealing cost estimate for this section of pavement is $13,700 to be performed every other year, or at least every third year.

Refer to **Appendix D** for a detailed treatment cost estimate.

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PAVEMENT CONDITION ASSESSMENT

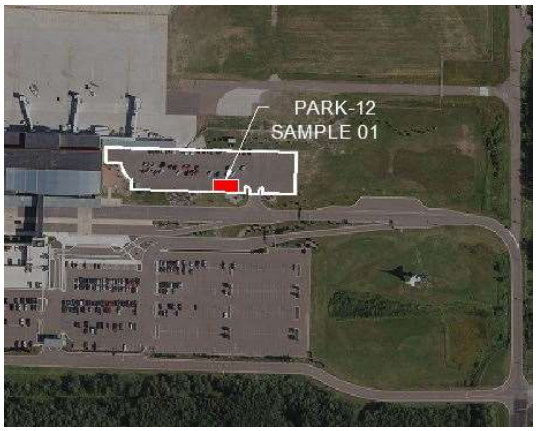
INTRODUCTION

Pavement Network: Duluth International Airport
Pavement Branch: Parking Lot
Pavement Section: PARK-12
Surface Type: AC
Ownership: Duluth Airport Authority (DAA)
Usage: High

Area: 56,792 SF
Pavement Age: Middle
Pavement Condition Index (PCI) Value: 81
PCI Rating: Very Good
Work Repair Level: Preventative Maintenance

SITE OVERVIEW

This parking lot section is located on the southeast side of the airport adjacent to the airport terminal. The Asphalt Concrete pavement in this section is in very good overall condition, and currently only requires preventative maintenance.



OWNERSHIP AND RESPONSIBILITY

The employee parking lot east of the terminal is owned and maintained by the Duluth Airport Authority (DAA).

PRIMARY DISTRESS TYPES

The primary distress types found in this sample of the parking lot are low and medium severity longitudinal and transverse cracking, and low severity weathering. See **Appendix B** for asphalt surfaced distress definitions.

Specifically, the following were observed in the sample: 60 LF of low severity longitudinal and transverse cracking, 70 LF of medium severity longitudinal and transverse cracking, and 40 SF of low severity weathering.

In order to get a distress representation for the entire section, a weighted-average scale factor of the sample was used to extrapolate distress totals. This resulted in the following distress quantities for the

section: 1,400 LF of low severity longitudinal and transverse cracking, 1,600 LF of medium severity longitudinal and transverse cracking, and 900 SF of low severity weathering.

RECOMMENDATIONS

Based on the PCI value, a work repair level of preventative maintenance is recommended. However, based on some of the severity levels of the observed distress types, the localized maintenance policy recommends to just monitor the low severity longitudinal and transverse cracks and the low severity weathering at this time and to only repair the medium severity longitudinal and transverse cracks. It is not very practical to assess the severity of each crack while performing maintenance, so all cracks will be repaired at the time maintenance occurs.

Based on the localized maintenance policies listed in **Table 2 – Localized Maintenance Policies for AC and PCC Surfaces** in the main report, the following maintenance treatments are recommended: crack sealing for longitudinal and transverse cracking, and surface treatment for weathering. Refer to **Appendix F** for preventative maintenance repair guidelines.

If ongoing pavement maintenance is used over the next 5-10 years, a more substantial rehabilitation or reconstruction may not be required within the next 15 years. It is recommended that crack sealing is performed every other year, or at least every third year.

ESTIMATED COSTS

Table 6 – Repair Cost Summary shows the estimated costs of the repairs and subsequent crack sealing. As discussed above, the low severity longitudinal and transverse cracking and the low severity weathering only require monitoring at this time, however, it is not practical to assess the severity of each crack while performing maintenance. In this case, all severities of cracking will be repaired at the same time, so the total cost of preventative maintenance is $4,900. This is based on the following unit costs: $1.45 per LF for crack sealing and $0.60 per SF of surface treatment. Refer to **Table 3 – Unit Costs for Localized Maintenance Treatments**, in the main report, for a complete list of unit costs.

The recommended crack sealing cost estimate for this section of pavement is $8,300 to be performed every other year, or at least every third year.

Refer to **Appendix D** for a detailed treatment cost estimate.

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PAVEMENT CONDITION ASSESSMENT

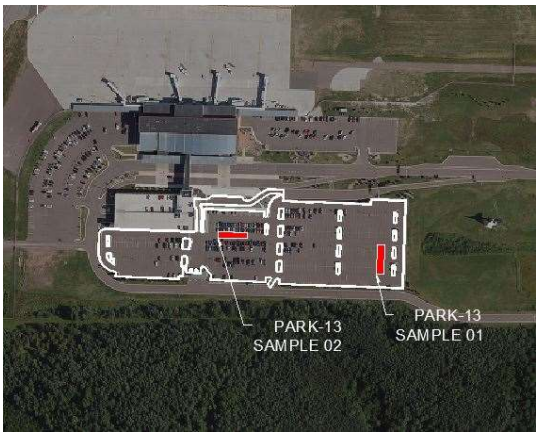
INTRODUCTION

Pavement Network: Duluth International Airport
Pavement Branch: Parking Lot
Pavement Section: PARK-13
Surface Type: AC
Ownership: Duluth Airport Authority (DAA)
Usage: High

Area: 240,889 SF
Pavement Age: Middle
Pavement Condition Index (PCI) Value: 85
PCI Rating: Very Good
Work Repair Level: Preventative Maintenance

SITE OVERVIEW

This parking lot section is located on the southeast side of the airport adjacent to the airport terminal. The Asphalt Concrete pavement in this section is in very good condition, and currently only requires preventative maintenance.



OWNERSHIP AND RESPONSIBILITY

The surface lot is owned and maintained by the Duluth Airport Authority (DAA).

PRIMARY DISTRESS TYPES

The primary distress types found in these samples of the parking lot are low and medium severity longitudinal and transverse cracking. See **Appendix B** for asphalt surfaced distress definitions.

Specifically, the following were observed in the samples: 284 LF of low severity longitudinal and transverse cracking, and 100 LF of medium severity longitudinal and transverse cracking.

In order to get a distress representation for the entire section, a weighted-average scale factor of the sample was used to extrapolate distress totals. This resulted in the following distress quantities for the section: 15,200 LF of low severity longitudinal and transverse cracking, and 5,400 LF of medium severity longitudinal and transverse cracking.

RECOMMENDATIONS

Based on the PCI value, a work repair level of preventative maintenance is recommended. However, based on some of the severity levels of the observed distress types, the localized maintenance policy recommends to just monitor the low severity longitudinal and transverse cracks at this time and to only repair the medium severity longitudinal and transverse cracks. It is not practical to assess the severity of each crack wile performing the maintenance, so once the maintenance activities take place, all crack of this section of pavement will be repaired.

Based on the localized maintenance policies listed in **Table 2 – Localized Maintenance Policies for AC and PCC Surfaces** in the main report, the following maintenance treatments are recommended: crack sealing for longitudinal and transverse cracking. Refer to **Appendix F** for preventative maintenance repair guidelines.

If ongoing pavement maintenance is used over the next 5-10 years, a more substantial rehabilitation or reconstruction may not be required within the next 15 years. It is recommended that crack sealing is performed every other year, or at least every third year.

ESTIMATED COSTS

Table 6 – Repair Cost Summary shows the estimated costs of the repairs and subsequent crack sealing. As discussed above, the low severity longitudinal and transverse cracking only requires monitoring at this time, however, it is not practical to assess the severity of each crack while performing maintenance. In this case, all severities of cracking will be repaired at the same time, so the total cost of preventative maintenance is estimated to be $29,800. This is based on the following unit costs: $1.45 per LF for crack sealing. Refer to **Table 3 – Unit Costs for Localized Maintenance Treatments**, in the main report, for a complete list of unit costs.

The recommended crack sealing cost estimate for this section of pavement is $35,000 to be performed every other year, or at least every third year.

Refer to **Appendix D** for a detailed treatment cost estimate.

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PAVEMENT CONDITION ASSESSMENT

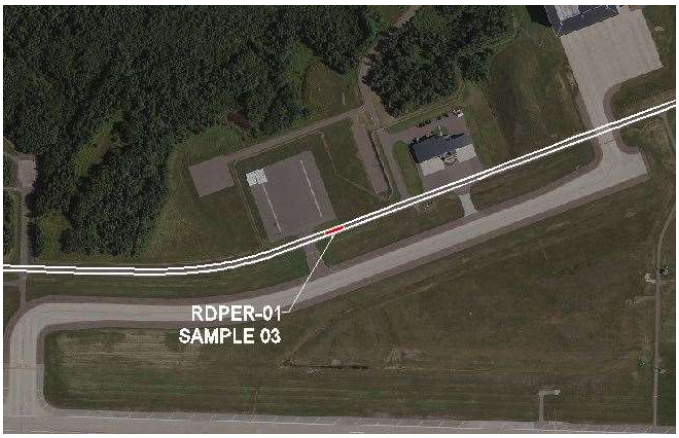
INTRODUCTION

Pavement Network: Duluth International Airport
Pavement Branch: Perimeter Road
Pavement Section: RDPER-01
Surface Type: AC
Ownership: Duluth Airport Authority (DAA)
Usage: High

Area: 298,685 SF
Pavement Age: Middle
Pavement Condition Index (PCI) Value: 75
PCI Rating: Very Good
Work Repair Level: Preventative Maintenance

SITE OVERVIEW

This perimeter road section is located on the north and northeast sides of the airport. The Asphalt Concrete pavement in this section is in very good condition, and currently only requires preventative maintenance.



OWNERSHIP AND RESPONSIBILITY

The perimeter road is owned and maintained by the Duluth Airport Authority (DAA).

PRIMARY DISTRESS TYPES

The primary distress types found in the samples of this perimeter road section are low and medium severity longitudinal and transverse cracking, low severity alligator cracking, and low severity edge cracking. See **Appendix B** for asphalt surfaced distress definitions.

Specifically, the following were observed in the samples: 430 LF of low severity longitudinal and transverse cracking, 347 LF of medium severity longitudinal and transverse cracking, 14 SF of low severity alligator cracking, and 200 LF of low severity edge cracking.

In order to get a distress representation for the entire section, a weighted-average scale factor of the sample was used to extrapolate distress totals. This resulted in the following distress quantities for the section: 14,500 LF of low severity longitudinal and transverse cracking, 11,800 LF of medium severity longitudinal and transverse cracking, 500 SF of low severity alligator cracking, and 6,800 LF of low severity edge cracking.

RECOMMENDATIONS

Based on the PCI value, a work repair level of preventative maintenance is recommended. However, based on some of the severity levels of the observed distress types, the localized maintenance policy recommends to just monitor the low severity longitudinal and transverse cracks and the low severity edge cracking at this time and to only repair the medium severity longitudinal and transverse cracks and the low severity alligator cracking. It is not practical to assess the severity of each crack while performing maintenance activities, so all severities of cracking should be repaired at the same time.

Based on the localized maintenance policies listed in **Table 2 – Localized Maintenance Policies for AC and PCC Surfaces** in the main report, the following maintenance treatments are recommended: crack sealing for medium longitudinal and transverse cracking and crack sealing for low severity alligator cracking. Eventually, some preventative maintenance will be required on those areas that are only being monitored. Refer to **Appendix F** for preventative maintenance repair guidelines.

If ongoing pavement maintenance is used over the next 5-10 years, a more substantial rehabilitation or reconstruction may not be required within the next 15 years. It is recommended that crack sealing is performed every other year, or at least every third year.

ESTIMATED COSTS

Table 6 – Repair Cost Summary shows the estimated costs of the repairs and subsequent crack sealing. As discussed above, the low severity longitudinal and transverse cracking and the low severity edge cracking only require monitoring at this time, however, it is not practical to assess the severity of each crack while performing maintenance. In this case, all severities of cracking will be repaired at the same time, so the total repair cost is estimated to be $131,400. This includes a major rehabilitation to repair the edge cracking (i.e. full-depth pavement removal). This estimate is based on the same $/LF cost for crack sealing and $3.33 per SF (PCI range of 71-80) to perform major rehabilitation on the areas of the pavement section that present edge cracking. Refer to **Table 3 – Unit Costs for Localized Maintenance Treatments** & **Table 4 – Unit Costs for Major Rehabilitation and Reconstruction**, in the main report, for a complete list of unit costs. Note that since alligator cracking is measured in SF, the cost for the alligator cracking repair is calculated with the assumption that roughly 3-inch-thick cracks are required to be repaired. The cost for the edge cracking repair is calculate with the assumption that roughly 4-foot sections would be removed (4 LF x 6,800 LF = 27,200 SF).

The recommended crack sealing cost estimate for this section of pavement is $43,300 to be performed every other year, or at least every third year.

Refer to **Appendix D** for a detailed treatment cost estimate.

Photo 1

Photo 2

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PAVEMENT CONDITION ASSESSMENT

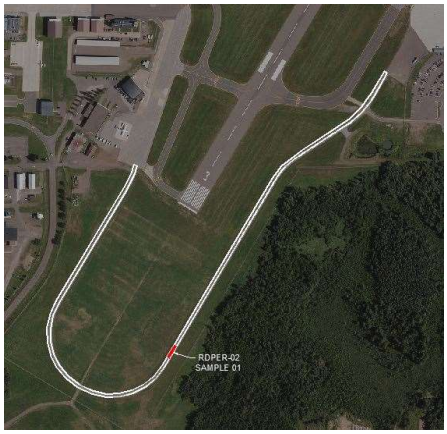
INTRODUCTION

Pavement Network: Duluth International Airport
Pavement Branch: Perimeter Road
Pavement Section: RDPER-02
Surface Type: AC
Ownership: Duluth Airport Authority (DAA)
Usage: High

Area: 108,575 SF
Pavement Age: Old
Pavement Condition Index (PCI) Value: 72
PCI Rating: Very Good
Work Repair Level: Preventative Maintenance

SITE OVERVIEW

This perimeter road section is located on the southeast side of the airport. The Asphalt Concrete pavement in this section is in very good overall condition, and currently only requires preventative maintenance.



OWNERSHIP AND RESPONSIBILITY

The perimeter road is owned and maintained by the Duluth Airport Authority (DAA).

PRIMARY DISTRESS TYPES

The primary distress types found in this sample of the perimeter road section are low and medium severity longitudinal and transverse cracking. See **Appendix B** for asphalt surfaced distress definitions.

Specifically, the following were observed in the sample: 100 LF of low severity longitudinal and transverse cracking, and 145 LF of medium severity longitudinal and transverse cracking.

In order to get a distress representation for the entire section, a weighted-average scale factor of the sample was used to extrapolate distress totals. This resulted in the following distress quantities for the section: 4,900 LF of low severity longitudinal and transverse cracking, and 7,200 LF of medium severity longitudinal and transverse cracking.

RECOMMENDATIONS

Based on the PCI value, a work repair level of preventative maintenance is recommended. However, based on some of the severity levels of the observed distress types, the localized maintenance policy recommends to just monitor the low severity longitudinal and transverse cracks at this time and to only repair the medium severity longitudinal and transverse cracks. It is not practical to assess the severity of each crack while performing the maintenance, so all severity of cracks will be repaired at the time maintenance occurs.

Based on the localized maintenance policies listed in **Table 2 – Localized Maintenance Policies for AC and PCC Surfaces** in the main report, the following maintenance treatments are recommended: crack sealing for longitudinal and transverse cracking. Refer to **Appendix F** for preventative maintenance repair guidelines.

If ongoing pavement maintenance is used over the next 5-10 years, a more substantial rehabilitation or reconstruction may not be required within the next 15 years. It is recommended that crack sealing is performed every other year, or at least every third year.

ESTIMATED COSTS

Table 6 – Repair Cost Summary shows the estimated costs of the repairs and subsequent crack sealing. As discussed above, the low severity longitudinal and transverse cracking only requires monitoring at this time, however, it is not practical to assess the severity of each crack while performing maintenance. In this case, all severities of cracking will be repaired at the same time, so the total cost of preventative maintenance is estimated to be $17,500. This is based on the following unit costs: $1.45 per LF for crack sealing. Refer to **Table 3 – Unit Costs for Localized Maintenance Treatments**, in the main report, for a complete list of unit costs.

The recommended crack sealing cost estimate for this section of pavement is $15,800 to be performed every other year, or at least every third year.

Refer to **Appendix D** for a detailed treatment cost estimate.

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PAVEMENT CONDITION ASSESSMENT

INTRODUCTION

Pavement Network: Duluth International Airport
Pavement Branch: Perimeter Road
Pavement Section: RDPER-03
Surface Type: AC
Ownership: Duluth Airport Authority (DAA)
Usage: High

Area: 271,218 SF
Pavement Age: Middle
Pavement Condition Index (PCI) Value: 73
PCI Rating: Very Good
Work Repair Level: Preventative Maintenance

SITE OVERVIEW

This perimeter road section is located on the north and west sides of the airport. The Asphalt Concrete pavement in this section is in very good condition, and currently only requires preventative maintenance.

OWNERSHIP AND RESPONSIBILITY

The perimeter road is owned and maintained by the Duluth Airport Authority (DAA).

PRIMARY DISTRESS TYPES

The primary distress types found in the samples of this perimeter road section are low severity edge cracking, and low and medium severity longitudinal and transverse cracking. See **Appendix B** for asphalt surfaced distress definitions.

Specifically, the following were observed in the sample: 147 LF of low severity longitudinal and transverse cracking, 196 LF of medium severity longitudinal and transverse cracking, and 120 LF of low severity edge cracking.

In order to get a distress representation for the entire section, a weighted-average scale factor of the sample was used to extrapolate distress totals. This resulted in the following distress quantities for the section: 10,700 LF of low severity longitudinal and transverse cracking, 14,300 LF of medium severity longitudinal and transverse cracking, and 8,700 LF of low severity edge cracking.

RECOMMENDATIONS

Based on the PCI value, a work repair level of preventative maintenance is recommended. However, based on some of the severity levels of the observed distress types, the localized maintenance policy recommends to just monitor the low severity longitudinal and transverse cracks and the low severity edge cracking at this time and to only repair the medium severity longitudinal and transverse cracks. It is not practical to assess the severity of pavement distresses while maintenance activities are being performed, so all pavement distresses will be repaired at the time maintenance occurs.

Based on the localized maintenance policies listed in **Table 2 – Localized Maintenance Policies for AC and PCC Surfaces** in the main report, the following maintenance treatments are recommended: crack sealing for longitudinal and transverse cracking. Refer to **Appendix F** for preventative maintenance repair guidelines.

If ongoing pavement maintenance is used over the next 5-10 years, a more substantial rehabilitation or reconstruction may not be required within the next 15 years. It is recommended that crack sealing is performed every other year, or at least every third year.

ESTIMATED COSTS

Table 6 – Repair Cost Summary shows the estimated costs of the repairs and subsequent crack sealing. As discussed above, the low severity longitudinal and transverse cracking and the low severity edge cracking only require monitoring at this time, however, it is not practical to assess the severity of each pavement distress while the maintenance activities are being performed. In this case, all pavement distresses will be repaired at the same time so the total cost of preventative maintenance is estimated to be $151,900. This includes a major rehabilitation to repair the edge cracking (i.e. full-depth pavement removal). This estimate is based on the same $/LF cost for crack sealing and $3.33 per SF (PCI range of 71-80) to perform major rehabilitation on the areas of the pavement section that present edge cracking. Refer to **Table 3 – Unit Costs for Localized Maintenance Treatments** & **Table 4 - Unit Costs for Major Rehabilitation and Reconstruction**, in the main report, for a complete list of unit costs. The cost for the edge cracking repair is calculate with the assumption that roughly 4-foot sections would be removed (4 LF x 8,700 LF = 34,800 SF).

The recommended crack sealing cost estimate for this section of pavement is $39,300 to be performed every other year, or at least every third year.

Refer to **Appendix D** for a detailed treatment cost estimate.

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PAVEMENT CONDITION ASSESSMENT

INTRODUCTION

Pavement Network: Duluth International Airport
Pavement Branch: Service Road
Pavement Section: RDSER-01A
Surface Type: AC
Ownership: Duluth Airport Authority (DAA)
Usage: Low

Area: 13,522 SF
Pavement Age: Old
Pavement Condition Index (PCI) Value: 91
PCI Rating: Excellent
Work Repair Level: Preventative Maintenance

SITE OVERVIEW

This service road section is located on the east side of the airport and provides vehicle access to the north of Runway 9-27. The Asphalt Concrete pavement in this section is in excellent overall condition, and currently only requires preventative maintenance.

OWNERSHIP AND RESPONSIBILITY

The service road is owned and maintained by the Duluth Airport Authority (DAA).

PRIMARY DISTRESS TYPES

The primary distress type found in this sample of the service road section is low severity edge cracking. See **Appendix B** for asphalt surfaced distress definitions.

Specifically, the following were observed in the sample: 100 LF of low severity edge cracking.

In order to get a distress representation for the entire section, a weighted-average scale factor of the sample was used to extrapolate distress totals. This resulted in the following distress quantities for the section: 800 LF of low severity edge cracking.

RECOMMENDATIONS

Based on the PCI value, a work repair level of preventative maintenance is recommended. However, based on the severity levels of the observed distress types, the localized maintenance policy recommends to just monitor the pavement condition at this time.

Eventually, maintenance will be required such as a full-depth removal and replacement (major rehabilitation). It is also recommended that crack sealing is performed every other year, or at least every third year.

ESTIMATED COSTS

Table 6 – Repair Cost Summary shows the estimated costs of repairs and the subsequent crack sealing. Although this pavement section only requires monitoring at this time, if maintenance repairs such as a full depth removal and replacement are carried out, the cost for these repairs are estimated to be $5,200. This costs is determined under the assumption that roughly 4 foot sections would be removed (4 LF x 800 LF = 3,200 SF). The cost is based on the following unit cost: $1.63 per SF for pavement sections with a PCI greater than 80. Refer to **Table 4 – Unit Costs for Major Rehabilitation and Reconstruction**, in the main report, for a complete list of unit costs.

The recommended crack sealing cost estimate for this section of pavement is $2,000 to be performed every other year, or at least every third year.

Refer to **Appendix D** for a detailed treatment cost estimate.

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PAVEMENT CONDITION ASSESSMENT

INTRODUCTION

Pavement Network: Duluth International Airport
Pavement Branch: Service Road
Pavement Section: RDSER-01B
Surface Type: AC
Ownership: Duluth Airport Authority (DAA)
Usage: Low

Area: 12,727 SF
Pavement Age: Old
Pavement Condition Index (PCI) Value: 54
PCI Rating: Fair
Work Repair Level: Major Rehabilitation

SITE OVERVIEW

This service road section is located on the east side of the airport providing vehicle access to the north of Runway 9-27. The Asphalt Concrete pavement in this section is in fair condition and requires major rehabilitation.

OWNERSHIP AND RESPONSIBILITY

The service road is owned and maintained by the Duluth Airport Authority (DAA).

PRIMARY DISTRESS TYPES

The primary distress types found in this sample of the service road section are medium severity block cracking, a medium severity depression, and medium severity edge cracking. See **Appendix B** for asphalt surfaced distress definitions.

Specifically, the following were observed in the sample: 1,488 SF of medium severity block cracking, a 12 SF medium severity depression, and 50 of medium severity edge cracking.

In order to get a distress representation for the entire section, a weighted-average scale factor of the sample was used to extrapolate distress totals. This resulted in the following distress quantities for the section: 11,800 SF of medium severity block cracking, 100 SF medium severity depressions, and 400 SF of medium severity edge cracking.

RECOMMENDATIONS

Based on the PCI value, major rehabilitation is recommended for this section of pavement in order to repair the high levels of distress. It is also recommended that crack sealing is performed every other year, or at least every third year.

ESTIMATED COSTS

Table 6 – Repair Cost Summary shows the estimated costs of the repairs and subsequent crack sealing. To repair these distresses using major rehabilitation methods, the costs for these repairs are estimated to be $94,500. This is based on the following unit cost: $7.43 per SF for pavement sections in the PCI range of 51-60. Refer to **Table 4 – Unit Costs for Major Rehabilitation and Reconstruction**, in the main report, for a complete list of unit costs.

The recommended crack sealing cost estimate for this section of pavement is $1,000 to be performed every other year, or at least every third year.

Refer to **Appendix D** for a detailed treatment cost estimate.

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PAVEMENT CONDITION ASSESSMENT

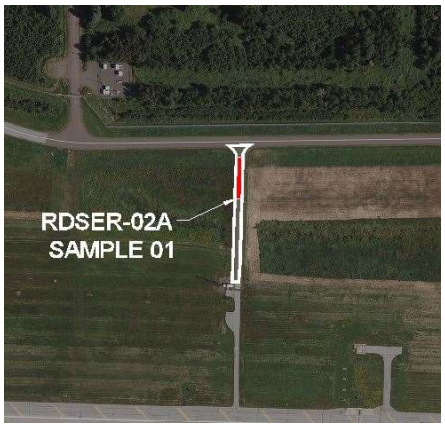
INTRODUCTION

Pavement Network: Duluth International Airport
Pavement Branch: Service Road
Pavement Section: RDSER-02A
Surface Type: AC
Ownership: Duluth Airport Authority (DAA)
Usage: Low

Area: 5,752 SF
Pavement Age: Old
Pavement Condition Index (PCI) Value: 97
PCI Rating: Excellent
Work Repair Level: Preventative Maintenance

SITE OVERVIEW

This service road section is located on the west side of the airport providing vehicle access to the north of Runway 9-27. The Asphalt Concrete pavement in this section is in excellent condition, and currently only requires preventative maintenance.



OWNERSHIP AND RESPONSIBILITY

The service road is owned and maintained by the Duluth Airport Authority (DAA).

PRIMARY DISTRESS TYPES

The primary distress types found in this sample of the service road section are medium severity longitudinal and transverse cracking. See **Appendix B** for asphalt surfaced distress definitions.

Specifically, the following were observed in the sample: 16 LF of medium severity longitudinal and transverse cracking.

In order to get a distress representation for the entire section, a weighted-average scale factor of the sample was used to extrapolate distress totals. This resulted in the following distress quantities for the section: 100 LF of medium severity longitudinal and transverse cracking.

RECOMMENDATIONS

Based on the PCI value, a work repair level of preventative maintenance is recommended.

For the next several years, preventative maintenance techniques should be utilized to maintain the pavement in a suitable condition. Based on the localized maintenance policies listed in **Table 2 – Localized Maintenance Policies for AC and PCC Surfaces** in the main report, the following maintenance treatment is recommended: crack sealing for longitudinal and transverse cracking. Refer to **Appendix F** for preventative maintenance repair guidelines.

If ongoing pavement maintenance is used over the next 5-10 years, a more substantial rehabilitation or reconstruction may not be required within the next 15 years. It is recommended that crack sealing is performed every other year, or at least every third year.

ESTIMATED COSTS

Table 6 – Repair Cost Summary shows the estimated costs of the repairs and subsequent crack sealing. The preventative maintenance cost for these repairs is estimated to be $140. This is based on the following unit costs: $1.45 per LF for crack sealing. Refer to **Table 3 – Unit Costs for Localized Maintenance Treatments**, in the main report, for a complete list of unit costs.

The recommended crack sealing cost estimate for this section of pavement is $900 to be performed every other year, or at least every third year.

Refer to **Appendix D** for a detailed treatment cost estimate.

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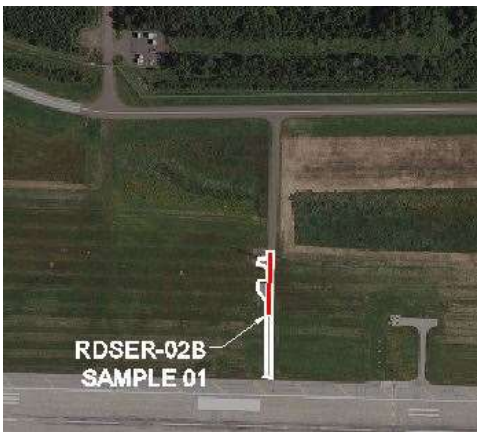
PAVEMENT CONDITION ASSESSMENT

INTRODUCTION

Pavement Network: Duluth International Airport
Pavement Branch: Service Road
Pavement Section: RDSER-02B
Surface Type: AC
Ownership: Duluth Airport Authority (DAA)
Usage: Low
Area: 5,154 SF
Pavement Age: Old
Pavement Condition Index (PCI) Value: 54
PCI Rating: Fair
Work Repair Level: Major Rehabilitation

SITE OVERVIEW

This service road section is located on the west side of the airport providing vehicle access to the north of Runway 9-27. The Asphalt Concrete pavement in this section is in fair condition, and requires major rehabilitation.



OWNERSHIP AND RESPONSIBILITY

The service road is owned and maintained by the Duluth Airport Authority (DAA).

PRIMARY DISTRESS TYPES

The primary distress types found in this sample of the service road section are low and medium severity longitudinal and transverse cracking, and low severity rutting. See **Appendix B** for asphalt surfaced distress definitions.

Specifically, the following were observed in the sample: 156 LF of low severity longitudinal and transverse cracking, 31 LF of medium severity longitudinal and transverse cracking, and 600 SF of low severity rutting.

In order to get a distress representation for the entire section, a weighted-average scale factor of the sample was used to extrapolate distress totals. This resulted in the following distress quantities for the section: 400 LF of low severity longitudinal and transverse cracking, 100 LF of medium severity longitudinal and transverse cracking, and 1,700 SF of low severity rutting.

RECOMMENDATIONS

Based on the PCI value, major rehabilitation is recommended for this section of pavement in order to repair the high levels of distress. It is also recommended that crack sealing is performed every other year, or at least every third year.

ESTIMATED COSTS

Table 6 – Repair Cost Summary shows the estimated costs of the repairs and subsequent crack sealing. To repair these distresses using major rehabilitation methods, the costs for these repairs are estimated to be $38,300. This is based on the following unit cost: $7.43 per SF for pavement sections in the PCI range of 51-60. Refer to **Table 4 – Unit Costs for Major Rehabilitation and Reconstruction**, in the main report, for a complete list of unit costs.

The recommended crack sealing cost estimate for this section of pavement is $400 to be performed every other year, or at least every third year.

Refer to **Appendix D** for a detailed treatment cost estimate.

Appendix B

Asphalt Surfaced Airfields Distress Manual

ASPHALT SURFACED AIRFIELDS

PAVER™ DISTRESS IDENTIFICATION MANUAL

DEVELOPED BY:

US ARMY CORPS OF ENGINEERS
ERDC-CERL

SPONSORED BY:

FOREWORD

Funding for this project was provided by the U.S. Air Force Civil Engineering Support Agency (AFCESA/CESC), Tyndall Air Force Base, Florida.

This manual contains definitions and measuring methods for determining the Pavement Condition Index of Asphalt Surfaced Airfields. This UFC implements STANAG 7181 ED 1 RD 1, Standard Method For Airfield Pavement Condition Index (PCI) Surveys.

This manual was prepared by Dr. M. Y. Shahin, U. S. Army Engineering Research and Development Center - Construction Engineering Research Laboratory, Champaign, IL.

June 2009

REFERENCES

Shahin, M.Y., Darter, M.I., and Kohn, S.D. (1976-1977) Development of a Pavement Maintenance Management System, Vol. I-V. U.S. Air Force Engineering Services Center (AFESC), Tyndall AFB.

TABLE OF CONTENTS

OBJECTIVE AND SCOPE OF THIS MANUAL

This manual contains distress definitions and measurement methods for asphalt surfaced airfields. This information is used to determine the Pavement Condition Index (PCI).

FREQUENTLY OCCURRING PROBLEMS IN ASPHALT PAVEMENT DISTRESS IDENTIFICATION

Situation	Action	Remarks
1. Alligator cracking and rutting in same area	Record each separately at respective severity level	
2. Bleeding counted in area	Polished aggregate is not counted in same area	
3. Polished aggregate in very small amount	Do not count	Polished aggregate is only counted when there is a significant amount
4. Any distress (including cracking) in a patched area	Do not record	Effect of distress is considered in patch severity level
5. Block cracking is recorded	Neither longitudinal nor transverse cracking should be recorded	
6. Asphalt overlay over concrete	Block cracking and joint reflection cracking are recorded separately	AC over PCC could have, for example, 100 percent block cracking and 100 feet of joint reflection cracking

ALLIGATOR OR FATIGUE CRACKING (41)*

Description

Alligator or fatigue cracking is a series of interconnecting cracks caused by fatigue failure of the asphalt surface under repeated traffic loading. The cracking initiates at the bottom of the asphalt surface (or stabilized base) where tensile stress and strain is highest under a wheel load. The cracks propagate to the surface initially as a series of parallel cracks. After repeated traffic loading, the cracks connect and form multi-sided, sharp-angled pieces that develop a pattern resembling chicken wire or the skin of an alligator. The pieces are less than 2 feet (0.6 meters) on the longest side. Alligator cracking occurs only in areas that are subjected to repeated traffic loadings, such as wheel paths. Therefore, it would not occur over an entire area unless the entire area was subjected to traffic loading. (Pattern-type cracking, which occurs over an entire area that is not subject to loading, is rated as block cracking, which is not a load associated distress.) Alligator cracking is considered a major structural distress.

Severity Levels

Fine, longitudinal hairline cracks running parallel to each other with no or only a few interconnecting cracks. The cracks are not spalled.

Further development of light alligator cracking into a pattern or network of cracks that may be lightly spalled. Medium severity alligator cracking is defined by a well-defined pattern of interconnecting cracks, where all pieces are securely held in place (good aggregate interlock between pieces).

Network or pattern cracking progressed so that pieces are well-defined and spalled at the edges; some of the pieces rock under traffic and may cause FOD potential.

How To Measure

Alligator cracking is measured in square feet (square meters) of surface area. The major difficulty in measuring this type of distress is that many times two or three levels of severity exist within one distressed area. If these portions can be easily distinguished from each other, they should be measured and recorded separately. However, if the different levels of severity cannot be easily divided, the entire area should be rated at the highest severity level present. If alligator cracking and rutting occur in the same area, each is recorded separately at its respective severity level.

**PAVER Distress Code*

41 ALLIGATOR

BLEEDING (42)

Description

Bleeding is a film of bituminous material on the pavement surface which creates a shiny, glass-like, reflecting surface that usually becomes quite sticky. Bleeding is caused by excessive amounts of asphalt cement or tars in the mix and/ or low air-void content. It occurs when asphalt fills the voids of the mix during hot weather and then expands onto the surface of the pavement. Since the bleeding process is not reversible during cold weather, asphalt or tar will accumulate on the surface.

Severity Levels

No degrees of severity are defined. Bleeding should be noted when it is extensive enough to cause a reduction in skid resistance.

How To Measure

Bleeding is measured in square feet (square meters) of surface area. If bleeding is counted, polished aggregate is not counted in the same area.

42 BLEEDING

BLOCK CRACKING (43)

Description

Block cracks are interconnected cracks that divide the pavement into approximately rectangular pieces. The blocks may range in size from approximately 1 by 1 foot to 10 by 10 feet (0.3 by 0.3 meters to 3 by 3 meters). Block cracking is caused mainly by shrinkage of the asphalt concrete (AC) and daily temperature cycling (which results in daily stress/strain cycling). It is not load associated. The occurrence of block cracking usually indicates that the asphalt has hardened significantly. Block cracking normally occurs over a large proportion of pavement area but sometimes will occur in non-traffic areas. This type of distress differs from alligator cracking in that alligator cracks form smaller, multi-sided pieces with sharp angles. Also, unlike block cracks, alligator cracks are caused by repeated traffic loadings and, therefore, are located only in traffic areas (i.e., wheel paths).

Severity Levels

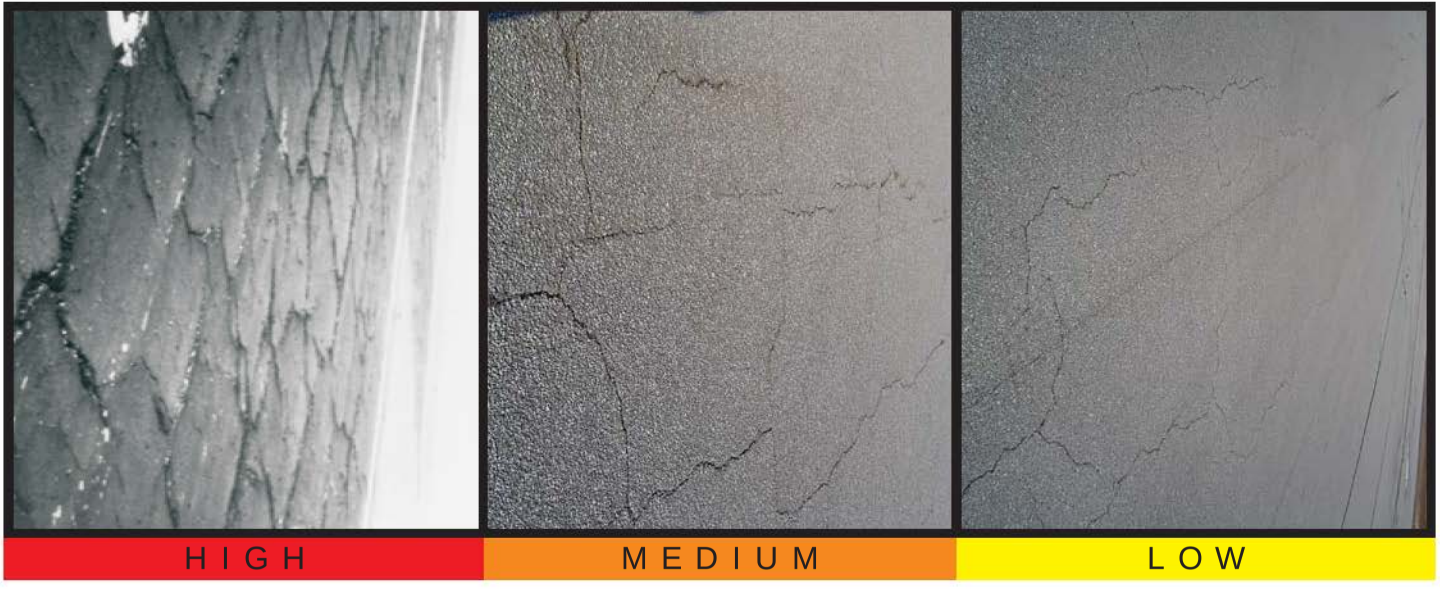
Blocks are defined by cracks that are non-spalled (sides of the crack are vertical) or only lightly spalled, causing no FOD potential. Non-filled cracks have 1/4 inch (6 mm) or less mean width, and filled cracks have filler in satisfactory condition.

Blocks are defined by either: (1) Filled or non-filled cracks that are moderately spalled (some FOD potential); (2) Non-filled cracks that are not spalled or have only minor spalling (some FOD potential), but have a mean width greater than approximately 1/4 inch (6 mm); or (3) Filled cracks that are not spalled or have only minor spalling (some FOD potential), but have filler in unsatisfactory condition.

Blocks are well-defined by cracks that are severely spalled, causing a definite FOD potential.

How To Measure

Block cracking is measured in square feet (square meters) of surface area. It usually occurs at one severity level in a given pavement section; however, any areas of the pavement section having distinctly different levels of severity should be measured and recorded separately. For asphalt pavements, not including AC over PCC, if block cracking is recorded, no longitudinal and transverse cracking should be recorded in the same area. For asphalt overlay over concrete, block cracking, joint reflection cracking, and longitudinal and transverse cracking reflected from old concrete should all be recorded separately.



43 BLOCK CRACKING

CORRUGATION (44)

Description

Corrugation is a series of closely spaced ridges and valleys (ripples) occurring at fairly regular intervals, usually less than 5 feet (1 1/2 meters) along the pavement. The ridges are perpendicular to the traffic direction. Traffic action combined with an unstable pavement surface or base usually causes this type of distress.

Severity Levels

L — Corrugations are minor and do not significantly affect ride quality (see measurement criteria below).

M — Corrugations are noticeable and significantly affect ride quality (see measurement criteria below).

H — Corrugations are easily noticed and severely affect ride quality (see measurement criteria below).

How To Measure

Corrugation is measured in square feet (square meters) of surface area. The mean elevation difference between the ridges and valleys of the corrugations indicates the level of severity. To determine the mean elevation difference, a 10 foot (3 meter) straightedge should be placed perpendicular to the corrugations so that the depth of the valleys can be measured in inches (mm). The mean depth is calculated from five such measurements.

Measurement Criteria

Severity	Runways & High-Speed Taxiways	Taxiways & Aprons
L	< 1/4 in. (< 6 mm)	< 1/2 in. (< 13 mm)
M	1/4 to 1/2 in. (6 to 13 mm)	1/2 to 1 in. (13 to 25 mm)
H	> 1/2 in. (> 13 mm)	> 1 in. (> 25 mm)

A
B
C
D
E
DIRECTION OF TRAFFIC
ASPHALT CONCRETE
MEAN DEPTH = A+B+C+D+E / 5

DEPRESSION (45)

Description

Depressions are localized pavement surface areas having elevations slightly lower than those of the surrounding pavement. In many instances, light depressions are not noticeable until after a rain, when ponding water creates "birdbath" areas; but the depressions can also be located without rain because of stains created by ponding water. Depressions can be caused by settlement of the foundation soil or can be "built up" during construction. Depressions cause roughness and, when filled with water of sufficient depth, can cause hydroplaning of aircraft.

Severity Levels

Depression can be observed or located by stained areas, only slightly affects pavement riding quality, and may cause hydroplaning potential on runways (see measurement criteria below).

The depression can be observed, moderately affects pavement riding quality, and causes hydroplaning potential on runways (see measurement criteria below).

The depression can be readily observed, severely affects pavement riding quality, and causes definite hydroplaning potential (see measurement criteria below).

How To Measure

Depressions are measured in square feet (square meters) of surface area. The maximum depth of the depression determines the level of severity. This depth can be measured by placing a 10 foot (3 meter) straightedge across the depressed area and measuring the maximum depth in inches (mm). Depressions larger than 10 feet (3 meters) across must be measured by either visual estimation or direct measurement when filled with water.

Maximum Depth of Depression

Severity	Runways & High-Speed Taxiways	Taxiways & Aprons
L	1/8 to 1/2 in. (3 to 13 mm)	1/2 to 1 in. (13 to 25 mm)
M	1/2 to 1 in. (13 to 25 mm)	1 to 2 in. (25 to 51 mm)
H	> 1 in. (> 25 mm)	> 2 in. (> 51 mm)

45 DEPRESSION

JET BLAST EROSION (46)

Description

Jet blast erosion causes darkened areas on the pavement surface when bituminous binder has been burned or carbonized; localized burned areas may vary in depth up to approximately 1/2 inch (13 mm).

Severity Levels

No degrees of severity are defined. It is sufficient to indicate that jet blast erosion exists.

How To Measure

Jet blast erosion is measured in square feet (square meters) of surface area.

46 JET BLAST

JOINT REFLECTION CRACKING FROM PCC (47)

Description

This distress occurs only on pavements having an asphalt or tar surface over a PCC slab. This category does not include reflection cracking from any other type of base (i.e., cement stabilized, lime stabilized); such cracks are listed as longitudinal and transverse cracks. Joint reflection cracking is caused mainly by movement of the PCC slab beneath the AC surface because of thermal and moisture changes; it is not load related. However, traffic loading may cause a breakdown of the AC near the crack, resulting in spalling and FOD potential. If the pavement is fragmented along a crack, the crack is said to be spalled. A knowledge of slab dimensions beneath the AC surface will help to identify these cracks.

Severity Levels

Cracks have only light spalling (little or no FOD potential) or no spalling and can be filled or non-filled. If non-filled, the cracks have a mean width of 1/4 inch (6 mm) or less. Filled cracks are of any width, but their filler material is in satisfactory condition.

One of the following conditions exists: (1) cracks are moderately spalled (some FOD potential) and can be either filled or non-filled of any width; (2) filled cracks are not spalled or are only lightly spalled, but the filler is in unsatisfactory condition; (3) non-filled cracks are not spalled or are only lightly spalled, but the mean crack width is greater than 1/4 inch (6 mm); or (4) light random cracking exists near the crack or at the corner of intersecting cracks.

Cracks are severely spalled (definite FOD potential) and can be either filled or non-filled of any width.

How To Measure

Joint reflection cracking is measured in linear feet (linear meters). The length and severity level of each crack should be identified and recorded. If the crack does not have the same severity level along its entire length, each portion should be recorded separately. For example, a crack that is 50 feet (15 meters) long may have 10 feet (3 meters) of high severity, 20 feet (6 meters) of medium severity, and 20 feet (6 meters) of low severity; these would all be recorded separately. If the different levels of severity in a portion of a crack cannot be easily divided, that portion should be rated at the highest severity present.

47 JOINT REFLECTION

LONGITUDINAL AND TRANSVERSE CRACKING (48) (NON-PCC JOINT REFLECTIVE)

Description

Longitudinal cracks are parallel to the pavement's centerline or laydown direction. They may be caused by (1) a poorly constructed paving lane joint, (2) shrinkage of the AC surface due to low temperatures or hardening of the asphalt, or (3) a reflective crack caused by cracks beneath the surface course, including cracks in PCC slabs (but not at PCC joints). Transverse cracks extend across the pavement at approximately right angles to the pavement centerline or direction of laydown. They may be caused by items 2 or 3 above. These types of cracks are not usually load associated. If the pavement is fragmented along a crack, the crack is said to be spalled.

Severity Levels

Cracks have either minor spalling (little or no FOD potential) or no spalling. The cracks can be filled or non-filled. Non-filled cracks have a mean width of 1/4 inch (6 mm) or less; filled cracks are of any width, but their filler material is in satisfactory condition.

One of the following conditions exists: (1) Cracks are moderately spalled (some FOD potential) and can be either filled or non-filled of any width; (2) Filled cracks are not spalled or are only lightly spalled, but the filler is in unsatisfactory condition; (3) Non-filled cracks are not spalled or are only lightly spalled, but mean crack width is greater than 1/4 inch (6 mm); or (4) Lightly random cracking exists near the crack or at the corners of intersecting cracks.

Cracks are severely spalled, causing definite FOD potential. They can be either filled or non-filled of any width.

How To Measure

Longitudinal and transverse cracks are measured in linear feet (linear meters). The length and severity of each crack should be identified and recorded. If the crack does not have the same severity level along its entire length, each portion of the crack having a different severity level should be recorded separately. For an example, see joint reflection cracking. If block cracking is recorded, longitudinal and transverse cracking is not recorded in the same area.

48 LONG. CRACKING

LONGITUDINAL AND TRANSVERSE CRACKING (48) (NON-PCC JOINT REFLECTIVE) (CONTINUED)

Porous Friction Course Severity Levels

Note: These severity levels are in addition to the existing definitions.

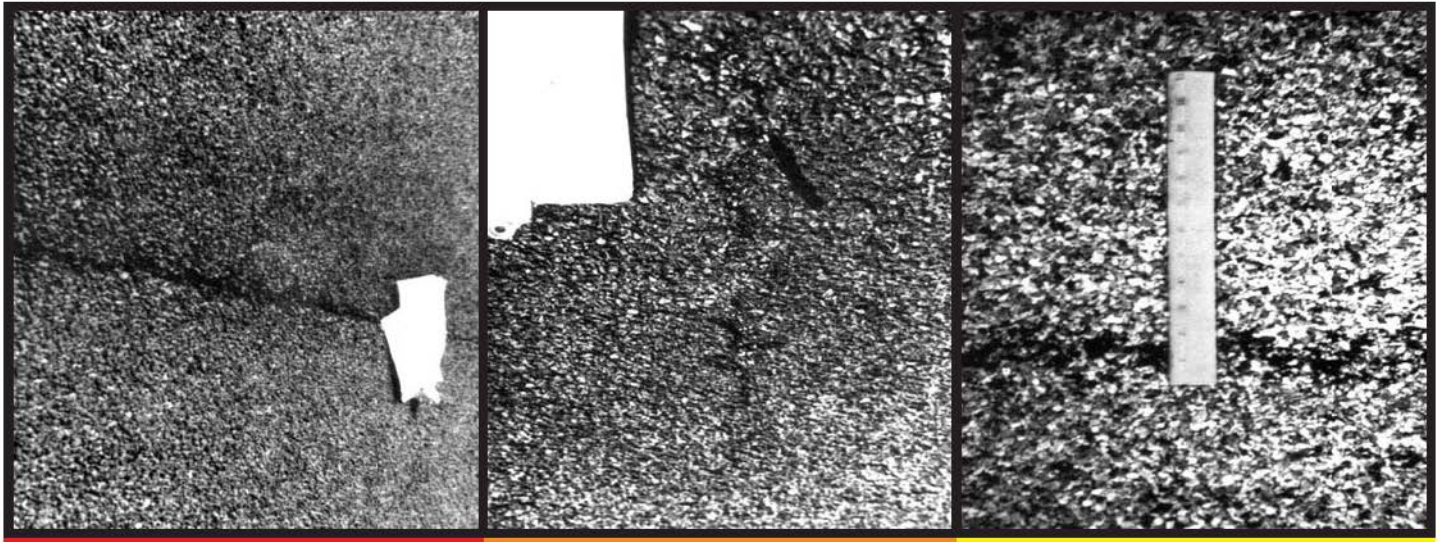
Average raveled area around the crack is less than 1/4 inch (6 mm) wide.

Average raveled area around the crack is 1/4 to 1 inch (6 to 25 mm) wide.

Average raveled area around the crack is greater than 1 inch (25 mm) wide.

How To Measure

Longitudinal and transverse cracks are measured in linear feet (linear meters). The length and severity of each crack should be identified and recorded. If the crack does not have the same severity level along its entire length, each portion of the crack having a different severity level should be recorded separately. For an example, see Joint Reflection Cracking. If Block Cracking is recorded, Longitudinal and Transverse Cracking is not recorded in the same area.


HIGH
MEDIUM
LOW

OIL SPILLAGE (49)

Description

Oil spillage is the deterioration or softening of the pavement surface caused by the spilling of oil, fuel, or other solvents.

Severity Levels

No degrees of severity are defined. It is sufficient to indicate that oil spillage exists.

How To Measure

Oil spillage is measured in square feet (square meters) of surface area. A stain is not a distress unless material has been lost or binder has been softened. If hardness is approximately the same as on surrounding pavement, and if no material has been lost, do not record as a distress.

49 OIL SPILLAGE

PATCHING AND UTILITY CUT PATCH (50)

Description

A patch is considered a defect, regardless of how well it is performing.

Severity Levels

L Patch is in good condition and is performing satisfactorily. Little or no FOD potential.

M Patch is somewhat deteriorated and affects riding quality to some extent. Some FOD potential.

H Patch is badly deteriorated and affects riding quality significantly or has high FOD potential. Patch needs replacement.

The use of dense-graded AC patches in PCC surfaces causes a water damming effect at the patch that contributes to differential skid resistance of the surface. Low severity, dense-graded patches should be rated as medium severity because of the differential friction problem. Medium and high severity patches are rated the same as above.

How To Measure

Patching is measured in square feet (square meters) of surface area. However, if a single patch has areas of differing severity levels, these areas should be measured and recorded separately. For example, a 25 ft^2 (2 1/2 m^2) patch may have 10 ft^2 (1 m^2) medium severity and 15 ft^2 (1 1/2 m^2) of low severity. These areas would be recorded separately. Any distress found in a patched area will not be recorded; however, its effects on the patch will be considered when determining the patch's severity level.

A very large patch (area > 2500 ft^2 (230 m^2)), or feathered-edge pavement, may qualify as an additional sample unit or a separate section.

50 PATCHING

POLISHED AGGREGATE (51)

Description

Aggregate polishing is caused by repeated traffic applications. Polished aggregate is present when close examination of a pavement reveals that the portion of aggregate extending above the asphalt is either very small or there are no rough or angular aggregate particles to provide good skid resistance. Existence of this type of distress is also indicated when the number on a skid resistance rating test is low or has dropped significantly from previous ratings.

Severity Levels

No degrees of severity are defined. However, the degree of polishing should be significant before it is included in the condition survey and rated as a defect.

How To Measure

Polished aggregate is measured in square feet (square meters) of surface area. If bleeding is counted, polished aggregate is not counted in the same area.

51 POLISHED AGG.

RAVELING (52)

Description

Raveling is the dislodging of coarse aggregate particles from the pavement surface.

Dense Mix Severity Levels

As used herein, coarse aggregate refers to predominant coarse aggregate sizes of the asphalt mix. Aggregate clusters refer to when more than one adjoining coarse aggregate piece is missing. If in doubt about a severity level, three representative areas of 1 square yard (1 square meter) each should be examined and the number of missing coarse aggregate particles counted.

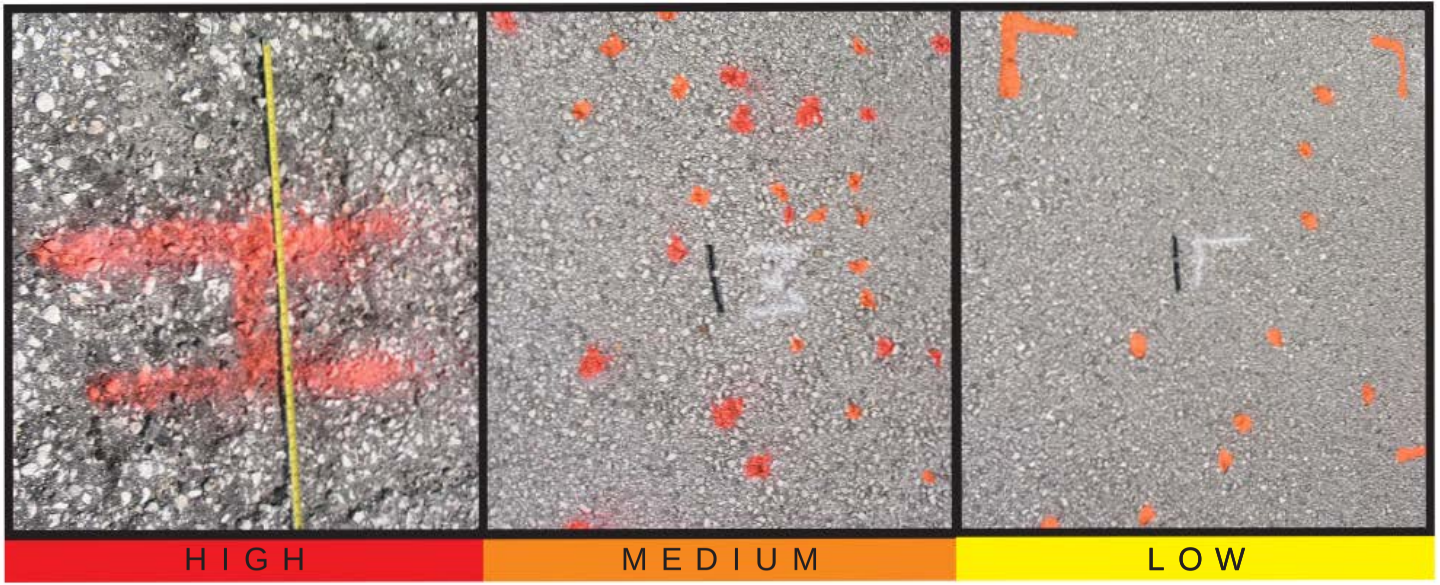
L — Low severity occurs if any one of these conditions exist: (1) In a square yard (square meter) representative area, the number of coarse aggregate particles missing is between 5 and 20. (2) Missing aggregate clusters is less than 2 percent of the examined square yard (square meter) area. In low severity raveling, there is little or no FOD potential.

M — Medium severity occurs if any one of these conditions exist: (1) In a square yard (square meter) representative area, the number of coarse aggregate particles missing is between 21 and 40. (2) Missing aggregate clusters is between 2 and 10 percent of the examined square yard (square meter) area. In medium severity raveling, there is some FOD potential.

H — High severity occurs if any one of these conditions exist: (1) In a square yard (square meter) representative area, the number of coarse aggregate particles missing is over 40. (2) Missing aggregate clusters is more than 10 percent of the examined square yard (square meter) area. In high severity raveling, there is significant FOD potential.

How To Measure

Raveling is measured in square feet (square meters) of surface area. Mechanical damage caused by hook drags, tire rims, or snowplows is counted as areas of high severity raveling.



52 RAVELING

RAVELING (52) (CONTINUED)

Slurry Seal/ Coal Tar Over Dense Mix Severity Levels

L — (1) The scaled area is less than 1 percent. (2) In the case of coal tar where pattern cracking has developed, the surface cracks are less than 1/4 inch (6 mm) wide.

M — (1) The scaled area is between 1 and 10 percent. (2) In the case of coal tar where pattern cracking has developed, the cracks are 1/4 inch (6 mm) wide or greater.

H — (1) The scaled area is over 10 percent. (2) In the case of coal tar the surface is peeling off.

How To Measure

Raveling is measured in square feet (square meters) of surface area. Mechanical damage caused by hook drags, tire rims, or snowplows is counted as areas of high severity raveling.


HIGH
MEDIUM
LOW

RAVELING (52) (CONTINUED)

Porous Friction Course Severity Levels

In a 1 square foot (1/10 square meter) representative sample, the number of aggregate pieces missing is between 5 and 20 and/ or the number of missing aggregate clusters does not exceed 1.

In a 1 square foot (1/10 square meter) representative sample, the number of aggregate pieces missing is between 21 and 40 and/ or the number of missing aggregate clusters is greater than 1 but does not exceed 25 percent of the area.

In a 1 square foot (1/10 square meter) representative sample, the number of aggregate pieces missing is over 40 and/ or the number of missing aggregate clusters is greater than 25 percent of the area.

How To Measure

Raveling is measured in square feet (square meters) of surface area. Mechanical damage caused by hook drags, tire rims, or snowplows is counted as areas of high severity raveling.


HIGH
MEDIUM
LOW

RUTTING (53)

Description

A rut is a surface depression in the wheel path. Pavement uplift may occur along the sides of the rut; however, in many instances ruts are noticeable only after a rainfall, when the wheel paths are filled with water. Rutting stems from a permanent deformation in any of the pavement layers or subgrade. It is usually caused by consolidation or lateral movement of the materials due to traffic loads. Significant rutting can lead to major structural failure of the pavement.

Severity Levels

Mean Rut Depth Criteria

Severity	All Pavement Sections
L	1/4 to 1/2 in. (6 to 13 mm)
M	1/2 to 1 in. (13 to 25 mm)
H	> 1 in. (> 25 mm)

How To Measure

Rutting is measured in square feet (square meters) of surface area, and its severity is determined by the depth of the rut. To determine the rut depth, a straightedge should be laid across the rut and the depth measured. The mean depth in inches (mm) should be computed from measurements taken along the length of the rut. If alligator cracking and rutting occur in the same area, each is recorded at its respective severity level.

53 RUTTING

SHOVING OF ASPHALT PAVEMENT BY PCC SLABS (54)

Description

PCC pavements occasionally increase in length at ends where they adjoin flexible pavements (commonly referred to as “pavement growth”). This “growth” shoves the asphalt or tar surfaced pavements, causing them to swell and crack. The PCC slab “growth” is caused by a gradual opening of the joints as they are filled with incompressible materials that prevent them from reclosing.

Severity Levels

As a guide, the swell table below may be used to determine the severity levels of shoving. At the present time, no significant research has been conducted to quantify levels of severity of shoving.

Shoving Criteria

Severity	Height Differential
L	< 3/4 in. (< 19 mm)
M	3/4 in. to 1 1/2 in. (19 mm to 38 mm)
H	> 1 1/2 in. (> 38 mm)

A slight amount of shoving has occurred, with little effect on ride quality and no breakup of the asphalt pavement.

A significant amount of shoving has occurred, causing moderate roughness or breakup of the asphalt pavement.

A large amount of shoving has occurred, causing severe roughness or breakup of the asphalt pavement.

How To Measure

Shoving is measured by determining the area in square feet (square meters) of the swell caused by shoving.

54 SHOVING

SLIPPAGE CRACKING (55)

Description

Slippage cracks are crescent or half-moon shaped cracks having two ends pointed in the direction of traffic. They are produced when braking or turning wheels cause the pavement surface to slide and deform. This usually occurs when there is a low strength surface mix or poor bond between the surface and next layer of pavement structure.

Severity Levels

No degrees of severity are defined. It is sufficient to indicate that a slippage crack exists.

How To Measure

Slippage cracking is measured in square feet (square meters) of surface area.

55 SLIPPAGE

SWELL (56)

Description

A swell is characterized by an upward bulge in the pavement's surface. A swell may occur sharply over a small area or as a longer, gradual wave. Either type of swell can be accompanied by surface cracking. A swell is usually caused by frost action in the subgrade or by swelling soil, but a small swell can also occur on the surface of an asphalt overlay (over PCC) as a result of a blowup in the PCC slab.

Severity Levels

L Swell is barely visible and has a minor effect on the pavement's ride quality as determined at the normal aircraft speed for the pavement section under consideration. (Low severity swells may not always be observable, but their existence can be confirmed by driving a vehicle over the section at the normal aircraft speed. An upward acceleration will occur if the swell is present).

M Swell can be observed without difficulty and has a significant effect on the pavement's ride quality as determined at the normal aircraft speed for the pavement section under consideration.

H Swell can be readily observed and severely affects the pavement's ride quality at the normal aircraft speed for the pavement section under consideration.

How To Measure

The surface area of the swell is measured in square feet (square meters). The severity rating should consider the type of pavement section (i. e., runway, taxiway, or apron). For example, a swell of sufficient magnitude to cause considerable roughness on a runway at high speeds would be rated as more severe than the same swell located on the apron or taxiway where the normal aircraft operating speeds are much lower. The following guidance is provided for runways:

Swell Criteria

Severity	Height Differential
L	< 3/4 in. (< 19 mm)
M	3/4 to 1 1/2 in. (19 to 38 mm)
H	> 1 1/2 in. (> 38 mm)

WEATHERING (SURFACE WEAR) - DENSE MIX ASPHALT (57)

Description

The wearing away of the asphalt binder and fine aggregate matrix from the pavement surface.

Severity Levels

L Asphalt surface beginning to show signs of aging which may be accelerated by climatic conditions. Loss of the fine aggregate matrix is noticeable and may be accompanied by fading of the asphalt color. Edges of the coarse aggregates are beginning to be exposed (less than 0.05 inches or 1 mm). Pavement may be relatively new (as new as 6 months old).

M Loss of fine aggregate matrix is noticeable and edges of coarse aggregate have been exposed up to ¼ width (of the longest side) of the coarse aggregate due to the loss of fine aggregate matrix.

H Edges of coarse aggregate have been exposed greater than ¼ width (of the longest side) of the coarse aggregate. There is considerable loss of fine aggregate matrix leading to potential or some loss of coarse aggregate.

How To Measure

Surface wear is measured in square feet (square meters). Surface wear is not recorded if medium or high severity raveling is recorded.

57 WEATHERING


0 cm.
1
2
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4
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7
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9
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11
12
13
14
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16
17
18


0 in.
1
2
3
4
5
6
7

Appendix C

Concrete Surfaced Airfields Distress Manual

CONCRETE SURFACED AIRFIELDS

PAVER™ DISTRESS IDENTIFICATION MANUAL

DEVELOPED BY:

US ARMY CORPS OF ENGINEERS
ERDC-CERL

SPONSORED BY:

SUSTAIN SUPPORT DEFEND

AIR FORCE CIVIL ENGINEER SUPPORT AGENCY

NAVFAC

FOREWORD

Funding for this project was provided by the U.S. Air Force Civil Engineering Support Agency (AFCESA/CESC), Tyndall Air Force Base, Florida.

This manual contains definitions and measuring methods for determining the Pavement Condition Index of Concrete Surfaced Airfields. This UFC implements STANAG 7181 ED 1 RD 1, Standard Method For Airfield Pavement Condition Index (PCI) Surveys.

This manual was prepared by Dr. M. Y. Shahin, U. S. Army Engineering Research and Development Center- Construction Engineering Research Laboratory, Champaign, IL.

June 2009

REFERENCES

Kohn S.D. and Shahin, M.Y. (1984). Evaluation of the Pavement Condition Index for Use on Porous Friction Surfaces. Technical Report No. M-351, U.S. Army Construction Engineering Research Laboratory, Champaign, IL.

Shahin, M.Y., Darter, M.I., and Kohn, S.D. (1976-1977) Development of a Pavement Maintenance Management System, Vol. I-V. U.S. Air Force Engineering Services Center (AFESC), Tyndall AFB.

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OBJECTIVE AND SCOPE OF THIS MANUAL

This Manual contains distress definitions and measuring methods for concrete surfaced airfields. This information is used to determine the Pavement Condition Index (PCI).

FREQUENTLY OCCURRING PROBLEMS IN PAVEMENT DISTRESS IDENTIFICATION

Situation	Action	Remarks
1. Low severity scaling (i.e., crazing)	Count only if possible future scaling will occur within 2 to 3 years	
2. Joint seal damage	This is not counted on a slab-by-slab basis	A severity level based on the overall condition of the joint seal in the sample unit is assigned
3. Joint spall small enough to be filled during a joint seal repair	Do not record	
4. Medium or high severity intersecting crack (shattered slab)	No other distress should be counted	
5. Corner or joint spalling caused by “D” cracking	Only “D” cracking should be recorded	If spalls are caused by factors other than “D” cracking, record each factor separately
6. Crack repaired by a narrow patch (e.g. 100 to 250 millimeters wide)	Record only crack and not patch at appropriate severity level	
7. Original distress of patch more severe than patch itself	Original distress type should be recorded	If, for example, patch material present on scaled area of slab, only the scaling is counted
8. Hairline cracks that are only a few feet long and that do not extend across the entire slab	Should be rated as shrinkage cracks	

BLOWUP (61)*

Description

Blowups occur in hot weather, usually at a transverse crack or joint that is not wide enough to permit expansion by the concrete slabs. The insufficient width is usually caused by infiltration of incompressible materials into the joint space. When expansion cannot relieve enough pressure, a localized upward movement of the slab edges (buckling) or shattering will occur in the vicinity of the joint. Blowups can also occur at utility cuts and drainage inlets. This type of distress is almost always repaired immediately because of severe damage potential to aircraft. Blowups are included for reference when closed sections are being evaluated for reopening.

Severity Levels

Buckling or shattering has not rendered the pavement inoperative, and only a slight amount of roughness exists.

Buckling or shattering has not rendered the pavement inoperative, but a significant amount of roughness exists.

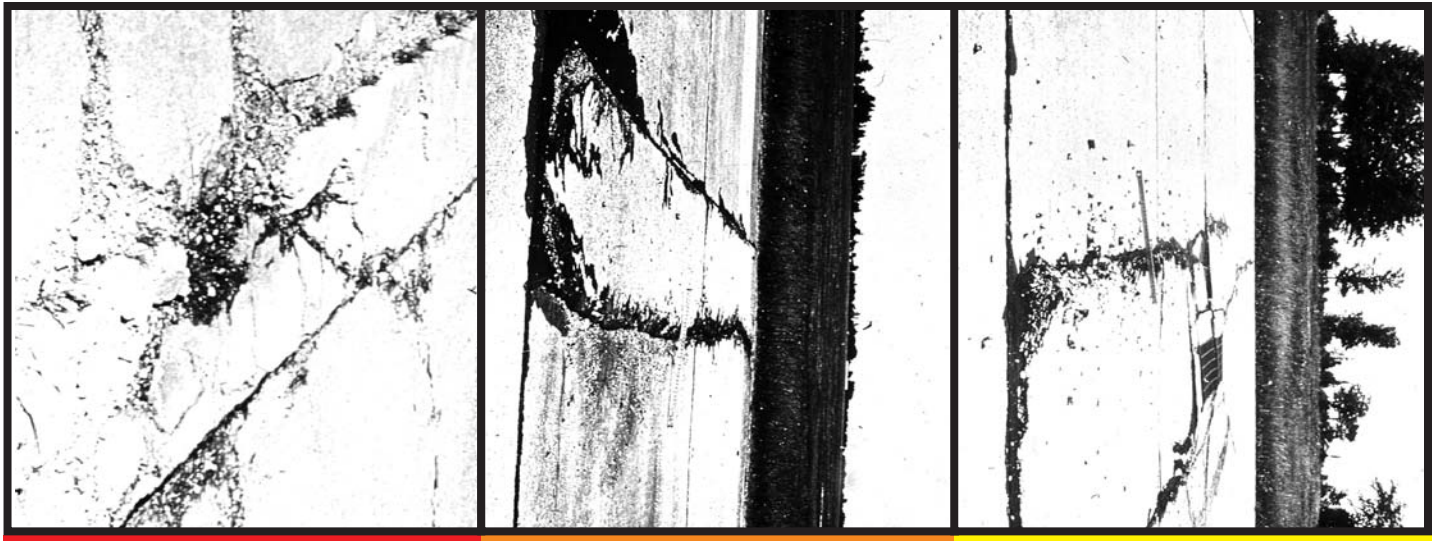
Buckling or shattering has rendered the pavement inoperative.

(Note: For pavements to be considered operational, all foreign material from blowups must have been removed.)

How To Count

A blowup usually occurs at a transverse crack or joint. At a crack, it is counted as being in one slab, but at a joint, two slabs are affected and the distress should be recorded as occurring in two slabs.

**PAVER™ Distress Code*


HIGH
MEDIUM
LOW

CORNER BREAK (62)

Description

A corner break is a crack that intersects the joints at a distance less than or equal to one-half the slab length on both sides, measured from the corner of the slab. For example, a slab with dimensions of 25 by 25 feet (7 1/2 by 7 1/2 meters) that has a crack intersecting the joint 5 feet (1 1/2 meters) from the corner on one side and 17 feet (5 meters) on the other side is not considered a corner break; it is a diagonal crack. However, a crack that intersects 7 feet (2 meters) on one side and 10 feet (3 meters) on the other is considered a corner break. A corner break differs from a corner spall in that the crack extends vertically through the entire slab thickness, while a corner spall intersects the joint at an angle. Load repetition combined with loss of support and curling stresses cause corner breaks.

Severity Levels

Crack has either no spalling or minor spalling (no FOD potential). If non-filled, it has a mean width less than approximately 1/8 inch (3 mm); a filled crack can be of any width, but the filler material must be in satisfactory condition. The area between the corner break and the joints is not cracked.

One of the following conditions exists: (1) filled or non-filled crack is moderately spalled (some FOD potential); (2) a non-filled crack has a mean width between 1/8 inch (3 mm) and 1 inch (25 mm); (3) a filled crack is not spalled or only lightly spalled, but the filler is in unsatisfactory condition; (4) the area between the corner break and the joints is lightly cracked. Lightly cracked means one low severity crack dividing the corner into two pieces.

One of the following conditions exists: (1) filled or non-filled crack is severely spalled, causing definite FOD potential; (2) a non-filled crack has a mean width greater than approximately 1 inch (25 mm), creating a tire damage potential; or (3) the area between the corner break and the joints is severely cracked.

How To Count

A distressed slab is recorded as one slab if it (1) contains a single corner break, (2) contains more than one break of a particular severity, or (3) contains two or more breaks of different severities. For two or more breaks, the highest level of severity should be recorded. For example, a slab containing both light and medium severity corner breaks should be counted as one slab with a medium severity corner break. Crack widths should be measured between vertical walls, not in spalled areas of the crack. If the corner break is faulted 1/8 inch (3 mm) or more, increase severity to the next higher level. If the corner is faulted more than 1/2 inch (13 mm), rate the corner break at high severity. If faulting in corner is incidental to faulting in the slab, rate faulting separately. The angle of crack into the slab is usually not evident at low severity. Unless the crack angle can be determined, to differentiate between the corner break and corner spall, use the following criteria. If the crack intersects both joints more than 2 feet (600 mm) from the corner, it is a corner break. If it is less than 2 feet, unless you can verify the crack is vertical, call it a spall.

62 CORNER BREAK

CRACKS (LONGITUDINAL, TRANSVERSE, AND DIAGONAL) (63)

Description

These cracks, which divide the slab into two or three pieces, are usually caused by a combination of load repetition, curling stresses, and shrinkage stresses. (For slabs divided into four or more pieces, see Shattered Slab/ Intersecting Cracks.) Low severity cracks are usually warping or friction related and are not considered major structural distresses. Medium or high severity cracks are usually working cracks and are considered major structural distresses.

Hairline cracks that are only a few feet long and do not extend across the entire slab are rated as shrinkage cracks.

Non-reinforced PCC Severity Levels

Crack has no spalling or minor spalling (no FOD potential). If non-filled, it is less than 1/8 inch (3 mm) wide. A filled crack can be of any width, but its filler material must be in satisfactory condition; or the slab is divided into three pieces by low severity cracks.

One of the following conditions exists: (1) a filled or non-filled crack is moderately spalled (some FOD potential); (2) a non-filled crack has a mean width between 1/8 inch (3 mm) and 1 inch (25 mm); (3) a filled crack has no spalling or minor spalling, but the filler is in unsatisfactory condition; or (4) the slab is divided into three pieces by two or more cracks, one of which is at least medium severity.

One of the following conditions exists: (1) a filled or non-filled crack is severely spalled (definite FOD potential); (2) a non-filled crack has a mean width approximately greater than 1 inch (25 mm), creating tire damage potential, or (3) the slab is divided into three pieces by two or more cracks, one of which is at least high severity.

How To Count

Once the severity has been identified, the distress is recorded as one slab. If a crack is repaired by a narrow patch (e.g., 4 to 10 inches wide (100 to 250 mm)), only the crack and not the patch should be recorded at the appropriate severity level.

Cracks used to define and rate corner breaks, “D” cracks, patches, shrinkage cracks, and spalls are not recorded as L/T/D cracks.

63 CRACKS

CRACKS (LONGITUDINAL, TRANSVERSE, AND DIAGONAL) (63) (CONTINUED)

Reinforced Concrete Severity Levels

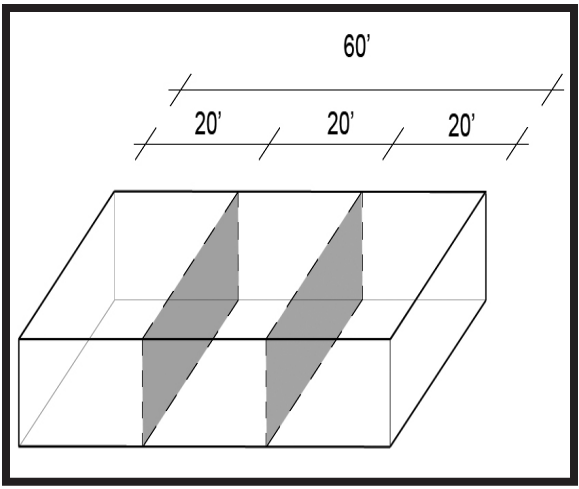
L (1) Non-filled crack, 1/8 inch (3 mm) to 1/2 inch (13 mm) wide, with no faulting or spalling; (2) filled or non-filled cracks of any width < 1/2 inch (13 mm), with low severity spalling; or (3) filled cracks of any width (filler satisfactory), with no faulting or spalling. (Note: Crack less than 1/8 inch (3 mm) wide with no spalling or faulting should be counted as shrinkage cracking.)

M (1) Non-filled cracks, 1/2 inch (13 mm) to 1 inch (25 mm) wide, no faulting or spalling; (2) filled cracks of any width, with faulting < 3/8 inch (10 mm) or medium severity spalling; or (3) non-filled cracks of width < 1 inch (25 mm) with faulting < 3/8 inch (10 mm) or medium severity spalling.

H (1) Non-filled cracks of width > 1 inch (25 mm); (2) non-filled cracks of any width, with faulting > 3/8 inch (10 mm) or medium severity spalling; or (3) filled cracks of any width, with faulting > 3/8 inch (10 mm) or high severity spalling.

How To Count

Once the severity has been identified, the distress is recorded as one slab. If a crack is repaired by a narrow patch (e.g., 4 to 10 inches wide (100 to 250 mm)), only the crack and not the patch should be recorded at the appropriate severity level. Slabs longer than 30 feet (9 meters) are divided into approximately equal length “slabs” having imaginary joints assumed to be in perfect condition.


60’
20’
20’
20’

DURABILITY (“D”) CRACKING (64)

Description

Durability cracking is caused by the inability of the concrete to withstand environmental factors such as freeze-thaw cycles. It usually appears as a pattern of cracks running parallel to a joint or linear crack. A dark coloring can usually be seen around the fine durability cracks. This type of cracking may eventually lead to disintegration of the concrete within 1 to 2 feet (0.3 to 0.6 meters) of the joint or crack.

Severity Levels

“D” cracking is defined by hairline cracks occurring in a limited area of the slab, such as one or two corners along one joint. Little or no disintegration has occurred. No FOD potential.

(1) “D” cracking has developed over a considerable amount of slab area with little or no disintegration or FOD potential; or (2) “D” cracking has occurred in a limited area of the slab, such as in one or two corners or along one joint, but pieces are missing and disintegration has occurred. Some FOD potential.

“D” cracking has developed over a considerable amount of slab area with disintegration or FOD potential.

How To Count

When the distress is located and rated at one severity, it is counted as one slab. If more than one severity level is found, the slab is counted as having the higher severity distress. If “D” cracking is counted, scaling on the same slab should not be recorded.

64 DURABILITY

JOINT SEAL DAMAGE (65)

Description

Joint seal damage is any condition which enables soil or rocks to accumulate in the joints or allows significant infiltration of water. Accumulation of incompressible materials prevents the slabs from expanding and may result in buckling, shattering, or spalling. A pliable joint filler bonded to the edges of the slabs protects the joints from accumulation of materials and also prevents water from seeping down and softening the foundation supporting the slab. Typical types of joint seal damage are (a) stripping of joint sealant, (b) extrusion of joint sealant, (c) weed growth, (d) hardening of the filler (oxidation), (e) loss of bond to the slab edges, and (f) lack or absence of sealant in the joint.

Severity Levels

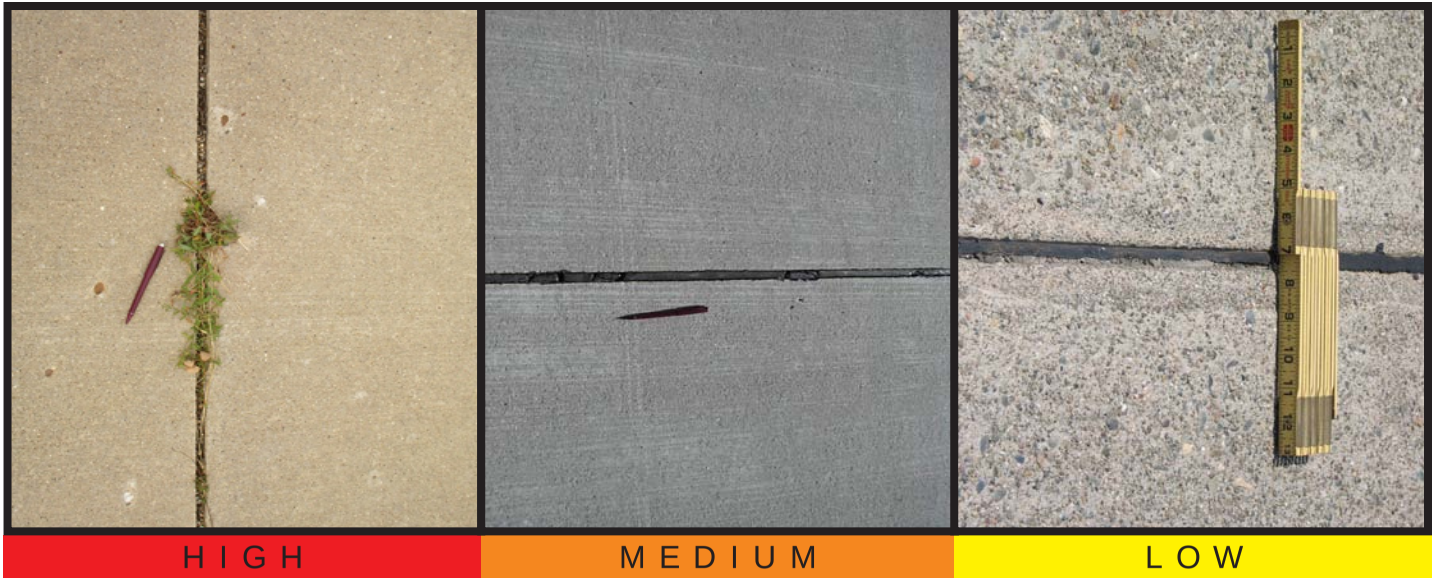
Joint sealer is in generally good condition throughout the sample. Sealant is performing well, with only a minor amount of any of the above types of damage present. Joint seal damage is at low severity if a few of the joints have sealer which has debonded from, but is still in contact with, the joint edge. This condition exists if a knife blade can be inserted between the sealer and joint face without resistance.

Joint sealer is in generally fair condition over the entire surveyed section, with one or more of the above types of damage occurring to a moderate degree. Sealant needs replacement within 2 years. Joint seal damage is at medium severity if a few of the joints have any of the following conditions: (1) joint sealer is in place, but water access is possible through visible openings no more than 1/8 inch (3 mm) wide. If a knife blade cannot be inserted easily between sealer and joint face, this condition does not exist; (2) pumping debris are evident at the joint; (3) joint sealer is oxidized and 'lifeless' but pliable (like a rope), and generally fills the joint opening; or (4) vegetation in the joint is obvious, but does not obscure the joint opening.

Joint sealer is in generally poor condition over the entire surveyed section, with one or more of the above types of damage occurring to a severe degree. Sealant needs immediate replacement. Joint seal damage is at high severity if 10% or more of the joint sealer exceeds limiting criteria listed above, or if 10% or more of sealer is missing.

How To Count

Joint seal damage is not counted on a slab-by-slab basis but is rated based on the overall condition of the sealant in the sample unit. Joint sealer is in satisfactory condition if it prevents entry of water into the joint, it has some elasticity, and if there is no vegetation growing between the sealer and joint face. Premolded sealer is rated using the same criteria as above except as follows: (1) premolded sealer must be elastic and must be firmly pressed against the joint walls; and (2) premolded sealer must be below the joint edge. If it extends above the surface, it can be caught by moving equipment such as snow plows or brooms and be pulled out of the joint. Premolded sealer is recorded at low severity if any part is visible above joint edge. It is at medium severity if 10% or more of the length is above joint edge or if any part is more than 1/2 inch (12 mm) above joint edge. It is at high severity if 20% or more is above joint edge or if any part is more than 1 inch (25 mm) above joint edge, or if 10% or more is missing. Rate joint sealer by joint segment. Sample unit rating is the same as the most severe rating held by at least 20% of segments rated. In rating oxidation, do not rate on appearance. Rate on resilience. Some joint sealer will have a very dull surface, and may even show surface cracks in the oxidized layer. If the sealer is performing satisfactorily and has good characteristics beneath the surface, it is satisfactory.



65 JOINT SEAL DAMAGE

PATCHING, SMALL (LESS THAN 5.5 FT^2 (0.5 M^2)) (66)

Description

A patch is an area where the original pavement has been removed and replaced by a filler material. For condition evaluation, patching is divided into two types: small (less than 5.5 square feet (0.5 square meters)) and large (over 5.5 square feet (0.5 square meters)). Large patches are described in the next section.

Severity Levels

Patch is functioning well, with little or no deterioration.

Patch has deteriorated, and/ or moderate spalling can be seen around the edges. Patch material can be dislodged, with considerable effort (minor FOD potential).

Patch has deteriorated, either by spalling around the patch or cracking within the patch, to a state which warrants replacement.

How To Measure

If one or more small patches having the same severity level are located in a slab, it is counted as one slab containing that distress. If more than one severity level occurs, it is counted as one slab with the higher severity level being recorded. If a crack is repaired by a narrow patch (e.g., 4 to 10 inches (100 to 250 mm) wide), only the crack and not the patch should be recorded at the appropriate severity level. If the original distress of a patch is more severe than the patch itself, the original distress type should be recorded.

66 PATCHING, SMALL

PATCHING, LARGE (OVER 5.5 FT^2 (0.5 M^2)) AND UTILITY CUT (67)

Description

Patching is the same as defined in the previous section. A utility cut is a patch that has replaced the original pavement because of placement of underground utilities. The severity levels of a utility cut are the same as those for regular patching.

Severity Levels

Patch is functioning well with very little or no deterioration.

Patch has deteriorated and/ or moderate spalling can be seen around the edges. Patch material can be dislodged with considerable effort, causing some FOD potential.

Patch has deteriorated to a state which causes considerable roughness and/ or high FOD potential. The extent of the deterioration warrants replacement of the patch.

How To Count

The criteria are the same as for small patches.

67 PATCHING, LARGE

POPOUTS (68)

Description

A popout is a small piece of pavement that breaks loose from the surface due to freeze-thaw action in combination with expansive aggregates. Popouts usually range from approximately 1 inch (25 mm) to 4 inches (100 mm) in diameter and from 1/2 inch (13 mm) to 2 inches (50 mm) deep.

Severity Levels

No degrees of severity are defined for popouts. However, popouts must be extensive before they are counted as a distress; i.e., average popout density must exceed approximately three popouts per square yard (square meter) over the entire slab area.

How To Count

The density of the distress must be measured. If there is any doubt about the average being greater than three popouts per square yard (square meter), at least three, random, 1 square yard (1 square meter) areas should be checked. When the average is greater than this density, the slab is counted.

68 POPOUTS

PUMPING (69)

Description

Pumping is the ejection of material by water through joints or cracks caused by deflection of the slab under passing loads. As the water is ejected, it carries particles of gravel, sand, clay, or silt and results in a progressive loss of pavement support. Surface staining and base or subgrade material on the pavement close to joints or cracks are evidence of pumping. Pumping near joints indicates poor joint sealer and loss of support which will lead to cracking under repeated loads. The joint seal must be identified as defective before pumping can be said to exist. Pumping can occur at cracks as well as joints.

Severity Levels

No degrees of severity are defined. It is sufficient to indicate that pumping exists.

How To Count

Slabs are counted as follows: one pumping joint between two slabs is counted as two slabs. However, if the remaining joints around the slab are also pumping, one slab is added per additional pumping joint.

69 PUMPING

SCALING (70)

Description

Surface deterioration caused by construction defects, material defects and environmental factors. Generally scaling is exhibited by delamination or disintegration of the slab surface to the depth of the defect.

Construction defects include: over-finishing, addition of water to the pavement surface during finishing, lack of curing, attempted surface repairs of fresh concrete with mortar. Generally this occurs over a portion of a slab.

Material defects include: inadequate air entrainment for the climate. Generally this occurs over several slabs that were affected by the concrete batches.

Environmental factors: freezing of concrete before adequate strength gained or thermal cycles from certain aircraft. Generally over a large area for freezing, and isolated areas for thermal effects.

Typically, the FOD from scaling is removed by sweeping, but the concrete will continue to scale until the affected depth is removed or expended.

Severity Levels

Minimal loss of surface paste that poses no FOD hazard. No FOD potential.

The loss of surface paste that poses some FOD potential including isolated fragments of loose mortar, exposure of the sides of coarse aggregate (less than 1/4 of the width of coarse aggregate), or evidence of coarse aggregate coming loose from the surface.

The high severity is associated with low durability concrete that will continue to pose a high FOD hazard; normally the layer of surface mortar is observable at the perimeter of the scaled area, and is likely to continue to scale due to environmental or other factors. Indication of high severity FOD is that routine sweeping is not sufficient to avoid FOD issues.

How To Count

If two or more levels of severity exist on a slab, the slab is counted as one slab having the maximum level of severity. If “D” cracking or ASR is counted, scaling is not counted.

70 SCALING

SETTLEMENT OR FAULTING (71)

Description

Settlement or faulting is a difference of elevation at a joint or crack caused by upheaval or consolidation.

Severity Levels

Severity levels are defined by the difference in elevation across the fault and the associated decrease in ride quality and safety as severity increases.

Difference In Elevation

Severity	Runways/ Taxiways	Aprons
L	< 1/4 inch (< 6 mm)	1/8 – 1/2 inch (3 – 13 mm)
M	1/4 – 1/2 inch (6 – 13 mm)	1/2 - 1 inch (13 – 25 mm)
H	> 1/2 inch (> 13 mm)	> 1 inch (> 25 mm)

How To Count

In counting settlement, a fault between two slabs is counted as one slab. A straightedge or level should be used to aid in measuring the difference in elevation between the two slabs.

Construction-induced elevation differential is not rated in PCI procedures. Where construction differential exists, it can often be identified by the way the high side of the joint was rolled down by finishers (usually within 6 inches (150 mm) of the joint) to meet the low-slab elevation.


HIGH
MEDIUM
LOW

SHATTERED SLAB/ INTERSECTING CRACKS (72)

Description

Intersecting cracks are cracks that break the slab into four or more pieces because of overloading and/ or inadequate support. The high severity level of this distress type, as defined below, is referred to as a shattered slab. If all pieces or cracks are contained within a corner break, the distress is categorized as a severe corner break.

Severity Levels

Slab is broken into four or five pieces predominantly defined by low severity cracks.

(1) Slab is broken into four or five pieces with over 15 percent of the cracks of medium severity (no high severity cracks); or (2) slab is broken into six or more pieces with over 85 percent of the cracks of low severity.

At this level of severity, the slab is called shattered: (1) slab is broken into four or five pieces with some or all of the cracks of high severity; (2) slab is broken into six or more pieces with over 15 percent of the cracks of medium or high severity.

How To Count

No other distress such as scaling, spalling, or durability cracking should be recorded if the slab is medium or high severity level, since the severity of this distress would affect the slab's rating substantially. Shrinkage cracks should not be counted in determining whether or not the slab is broken into four or more pieces.

72 SHATTERED SLAB

SHRINKAGE CRACKS (73)

Description

Shrinkage cracks are hairline cracks that are usually only a few feet long and do not extend across the entire slab. They are formed during the setting and curing of the concrete and usually do not extend through the depth of the slab.

Severity Levels

No degrees of severity are defined. It is sufficient to indicate that shrinkage cracks exist.

How To Count

If one or more shrinkage cracks exist on one particular slab, the slab is counted as one slab with shrinkage cracks.

73 SHRINKAGE

SPALLING (TRANSVERSE AND LONGITUDINAL JOINTS) (74)

Description

Joint spalling is the breakdown of the slab edges within 2 feet (60 mm) of the side of the joint. A joint spall usually does not extend vertically through the slab but intersects the joint at an angle. Spalling results from excessive stresses at the joint or crack caused by infiltration of incompressible materials or traffic loads. Weak concrete at the joint (caused by overworking) combined with traffic loads also causes spalling.

Frayed condition as used in this test method indicates material is no longer in place along a joint or crack. Spalling indicates material may or may not be missing along a joint or crack.

Severity Levels

	Spall Length	Description
L	< 2 feet (600 mm)	spall is broken into pieces or fragmented; little FOD or tire damage potential exists.
	> 2 feet (600 mm)	(a) spall is broken into no more than three pieces defined by low or medium severity cracks; little or no FOD potential exists; or (b) joint is lightly frayed; little or no FOD potential exists.
M	< 2 feet (600 mm)	spall is broken into pieces or fragmented, with some of the pieces loose or absent, causing considerable FOD or tire damage potential.
	> 2 feet (600 mm)	(a) spall is broken into more than three pieces defined by light or medium cracks; (b) spall is broken into no more than three pieces with one or more of the cracks being severe with some FOD potential existing; or (c) joint is moderately frayed, with some FOD potential.
H	> 2 feet (600 mm)	(1) spall is broken into more than three pieces defined by one or more high severity cracks with high FOD potential; or (2) joint is severely frayed, with high FOD potential.

How To Count

If the joint spall is located along the edge of one slab, it is counted as one slab with joint spalling. If spalling is located on more than one edge of the same slab, the edge having the highest severity is counted and recorded as one slab. Joint spalling can also occur along the edges of two adjacent slabs. If this is the case, each slab is counted as having joint spalling. If a joint spall is small enough to be filled during a joint seal repair, it should not be recorded.

74 SPALLING, JOINT

SPALLING (CORNER) (75)

Description

Corner spalling is the raveling or breakdown of the slab within approximately 2 feet (600 mm) of the corner. A corner spall differs from the corner break in that the spall angles downward to intersect the joint, while a break extends vertically through the slab.

Severity Levels

L — One of the following conditions exists: (1) spall is broken into one or two pieces defined by low severity cracks (little or no FOD potential), (2) spall is defined by one medium severity crack (little or no FOD potential).

M — One of the following conditions exists: (1) spall is broken into two or more pieces defined by medium severity crack(s), and a few small fragments may be absent or loose; (2) spall is defined by one severe, fragmented crack that may be accompanied by a few hairline cracks; or (3) spall has deteriorated to the point where loose material is causing some FOD potential.

H — One of the following conditions exists: (1) spall is broken into two or more pieces defined by high severity fragmented crack(s), with loose or absent fragments; (2) pieces of the spall have been displaced to the extent that a tire damage hazard exists; or (3) spall has deteriorated to the point where loose material is causing high FOD potential.

How To Count

If one or more corner spalls having the same severity level are located in a slab, the slab is counted as one slab with corner spalling. If more than one severity level occurs, it is counted as one slab having the higher severity level.

A corner spall smaller than 3 inches (76 mm) wide, measured from the edge of the slab and filled with sealant, is not recorded.

75 SPALLING, CORNER

ALKALI SILICA REACTION (ASR) (76)

Description

ASR is caused by chemical reaction between alkalis and certain reactive silica minerals which form a gel. The gel absorbs water, causing expansion which may damage the concrete and adjacent structures. Alkalis are most often introduced by the portland cement within the pavement. ASR cracking may be accelerated by chemical pavement deicers.

Visual indicators that ASR may be present include:

1. Cracking of the concrete pavement (often in a map pattern)
2. White, brown, gray or other colored gel or staining may be present at the crack surface
3. Aggregate popouts
4. Increase in concrete volume (expansion) that may result in distortion of adjacent or integral structures or physical elements. Examples of expansion include shoving of asphalt pavements, light can tilting, slab faulting, joint misalignment, and extrusion of joint seals or expansion joint fillers.

Because ASR is material-dependent, ASR is generally present throughout the pavement section. Coring and concrete petrographic analysis is the only definitive method to confirm the presence of ASR. The following should be kept in mind when identifying the presence of ASR through visual inspection:

1. Generally ASR distresses are not observed in the first few years after construction. In contrast, plastic shrinkage cracking can occur the day of construction and is apparent within the first year.
2. ASR is differentiated from D-Cracking by the presence of cracking perpendicular to the joint face. D-Cracking predominantly develops as a series of parallel cracks to joint faces and linear cracking within the slab.
3. ASR is differentiated from Map Cracking/ Scaling by the presence of visual signs of expansion.

Severity Levels

L Minimal to no Foreign Object Damage (FOD) potential from cracks, joints or ASR related popouts; cracks at the surface are tight (predominantly 1 mm or less). Little to no evidence of movement in pavement or surrounding structures or elements.

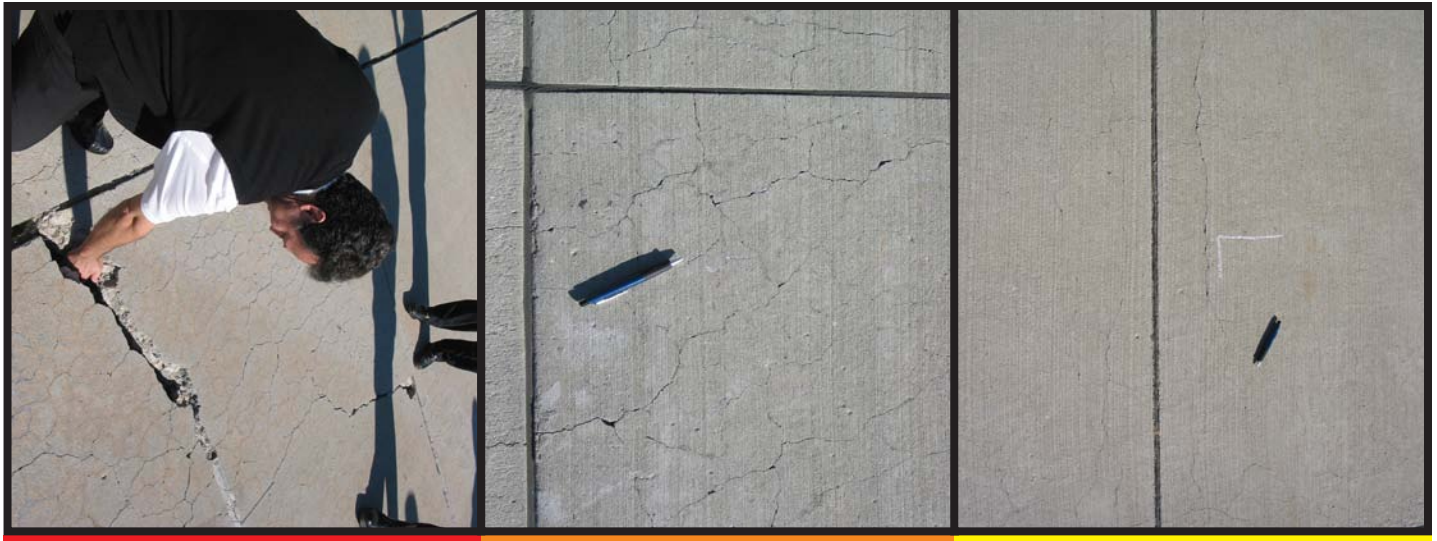
M Some FOD potential; increased sweeping or other FOD removal methods may be required. May be evidence of slab movement and/ or some damage to adjacent structures or elements.

Medium ASR distress is differentiated from low by having one or more of the following: increased FOD potential, increased cracking of the slab, some fragments along cracks or at crack intersections present, surface popouts of concrete may occur, pattern of wider cracks (predominantly 1 mm or wider) that may be subdivided by tighter cracks.

H One or both of the following exist: 1) Loose or missing concrete fragments which pose high FOD potential, 2) Slab surface integrity and function significantly degraded and pavement requires immediate repair; may also require repairs to adjacent structures or elements.

How To Count

No other distresses should be recorded if high severity ASR is recorded.


HIGH
MEDIUM
LOW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Appendix D

Detailed Cost Estimates

Branch	Section	PCI Value	PCI Rating	Work Repair Level	Sample	Distress Type(s)	Distress Severity	Sample Quantity	Section Quantity	Unit	Treatment	Cost	Treatment	Cost
Apron	APRON-01	71	Very Good	Preventative Maintenance	1	L & T Cracking	L	85.00	2,400.00	LF	Monitor	$ -	Crack Sealing - AC	$ 3,477.60
						L & T Cracking	M	71.00	2,000.00	LF	Crack Sealing - AC	$ 2,898.00	Crack Sealing - AC	$ 2,898.00
											Rounded Total	**$ 2,900.00**	**Rounded Total**	**$ 6,400.00**

Branch	Section	PCI Value	PCI Rating	Work Repair Level	Sample	Distress Type(s)	Distress Severity	Sample Quantity	Section Quantity	Unit	Treatment	Cost
Apron	APRON-02	53	Fair	Major Rehabilitation	1	Depression	M	40.00	500.00	SF	Major Rehabilitation	$171,963.00
						L & T Cracking	M	110.00	1,300.00	LF		
						Patching	M	20.00	200.00	SF		
						Swelling	M	20.00	200.00	SF		
						Swelling	M	60.00	700.00	SF		
											Rounded Total	**$ 172,000.00**

Branch	Section	PCI Value	PCI Rating	Work Repair Level	Sample	Distress Type(s)	Distress Severity	Sample Quantity	Section Quantity	Unit	Treatment	Cost	Treatment	Cost
Apron	APRON-03	84	Very Good	Preventative Maintenance	1	L & T Cracking	L	141.00	2,800.00	LF	Monitor	$ -	Crack Sealing - AC	$ 4,057.20
						Weathering	L	25.00	500.00	SF	Monitor	$ -	Surface Treatment	$ 299.00
											Rounded Total	**$ -**	**Rounded Total**	**$ 4,400.00**

Branch	Section	PCI Value	PCI Rating	Work Repair Level	Sample	Distress Type(s)	Distress Severity	Sample Quantity	Section Quantity	Unit	Treatment	Cost	Treatment	Cost
Apron	APRON-04	91	Excellent	Preventative Maintenance	1	L & T Cracking	L	22.00	700.00	LF	Monitor	$ -	Crack Sealing - AC	$ 1,014.30
						Swelling	L	20.00	700.00	SF	Monitor	$ -	Patching - AC Deep	$ 9,515.10
						Weathering	L	28.00	900.00	SF	Monitor	$ -	Surface Treatment	$ 538.20
											Rounded Total	**$ -**	**Rounded Total**	**$ 11,100.00**

Branch	Section	PCI Value	PCI Rating	Work Repair Level	Sample	Distress Type(s)	Distress Severity	Sample Quantity	Section Quantity	Unit	Treatment	Cost	Treatment	Cost
General Road	RDGEN-01	87	Excellent	Preventative Maintenance	1	L & T Cracking	L	114.00	2,500.00	LF	Monitor	$ -	Crack Sealing - AC	$ 3,622.50
					2	L & T Cracking	L	200.00	4,400.00	LF	Monitor	$ -	Crack Sealing - AC	$ 6,375.60
											Rounded Total	**$ -**		**$ 10,000.00**

Branch	Section	PCI Value	PCI Rating	Work Repair Level	Sample	Distress Type(s)	Distress Severity	Sample Quantity	Section Quantity	Unit	Treatment	Cost
General Road	RDGEN-02A	7	Failed	Reconstruction	1	Alligator Cracking	M	107.50	700.00	SF	Reconstruction	$196,967.44
						Edge Cracking	L	45.00	300.00	LF		
						L & T Cracking	H	180.00	1,100.00	LF		
						L & T Cracking	M	207.00	1,300.00	LF		
						Patching	H	252.00	1,600.00	SF		
						Potholes	H	1.00	10.00	C		
						Bumps / Sags	M	5.00	30.00	LF		
											Rounded Total	**$ 197,000.00**

Branch	Section	PCI Value	PCI Rating	Work Repair Level	Sample	Distress Type(s)	Distress Severity	Sample Quantity	Section Quantity	Unit	Treatment	Cost
General Road	RDGEN-02B	3	Failed	Reconstruction	1	Alligator Cracking	M	140.00	500.00	SF	Reconstruction	$112,170.56
						Depression	H	128.00	500.00	SF		
						L & T Cracking	M	4.00	20.00	LF		
						Potholes	H	3.00	10.00	C		
						Swelling	H	90.00	300.00	SF		
						Swelling	H	12.00	50.00	SF		
						Raveling	H	1,900.00	7,400.00	SF		
											Rounded Total	**$ 112,200.00**

Branch	Section	PCI Value	PCI Rating	Work Repair Level	Sample	Distress Type(s)	Distress Severity	Sample Quantity	Section Quantity	Unit	Treatment	Cost
General Road	RDGEN-02C	85	Very Good	Preventative Maintenance	1	L & T Cracking	H	12.00	100.00	LF	Crack Sealing - AC	$ 144.90
						L & T Cracking	M	12.00	100.00	LF	Crack Sealing - AC	$ 144.90
											Rounded Total	**$ 300.00**

Branch	Section	PCI Value	PCI Rating	Work Repair Level	Sample	Distress Type(s)	Distress Severity	Sample Quantity	Section Quantity	Unit	Treatment	Cost
General Road	RDGEN-03A	49	Fair	Major Rehabilitation	1	L & T Cracking	H	45.00	700.00	LF	Major Rehabilitation	$175,175.19
						L & T Cracking	M	160.00	2,300.00	LF		
											Rounded Total	**$ 175,200.00**

Branch	Section	PCI Value	PCI Rating	Work Repair Level	Sample	Distress Type(s)	Distress Severity	Sample Quantity	Section Quantity	Unit	Treatment	Cost
General Road	RDGEN-03B	44	Fair	Major Rehabilitation	1	Durability Crack	M	11.00	-	Slabs	Major Rehabilitation	$170,353.53
						Faulting	M	3.00	-	Slabs		
						Linear Cracking	M	9.00	-	Slabs		
						Patching - Large	M	1.00	-	Slabs		
						Patching - Small	H	1.00	-	Slabs		
											Rounded Total	**$ 170,400.00**

Branch	Section	PCI Value	PCI Rating	Work Repair Level	Sample	Distress Type(s)	Distress Severity	Sample Quantity	Section Quantity	Unit	Treatment	Cost	Treatment	Cost
General Road	RDGEN-04	84	Very Good	Preventative Maintenance	1	L & T Cracking	L	20.00	600.00	LF	Monitor	$ -	Crack Sealing - AC	$ 869.40
					2	L & T Cracking	L	180.00	5,000.00	LF	Monitor	$ -	Crack Sealing - AC	$ 7,245.00
					3	L & T Cracking	L	100.00	2,800.00	LF	Monitor	$ -	Crack Sealing - AC	$ 4,057.20
						L & T Cracking	M	200.00	5,600.00	LF	Crack Sealing - AC	$ 8,114.40	Crack Sealing - AC	$ 8,114.40
											Rounded Total	**$ 8,100.00**		**$ 20,300.00**

Branch	Section	PCI Value	PCI Rating	Work Repair Level	Sample	Distress Type(s)	Distress Severity	Sample Quantity	Section Quantity	Unit	Treatment	Cost
Parking Lot	PARK-04A	50	Fair	Major Rehabilitation	1	L & T Cracking	M	642.00	6,600.00	LF	Major Rehabilitation	$596,388.85
					2	L & T Cracking	M	402.00	4,100.00	LF		
						Swelling	M	30.00	300.00	SF		
					3	Alligator Cracking	L	1,200.00	12,300.00	SF		
						Potholes	H	2.00	20.00	C		
											Rounded Total	**$ 596,400.00**

Branch	Section	PCI Value	PCI Rating	Work Repair Level	Sample	Distress Type(s)	Distress Severity	Sample Quantity	Section Quantity	Unit	Treatment	Cost
Parking Lot	PARK-04B	52	Fair	Major Rehabilitation	1	Block Cracking	M	27.00	30.00	SF	Major Rehabilitation	$ 20,448.45
						L & T Cracking	L	361.00	400.00	LF		
						L & T Cracking	L	203.00	230.00	LF		
						Potholes	M	1.00	1.00	C		
											Rounded Total	**$ 20,400.00**

Branch	Section	PCI Value	PCI Rating	Work Repair Level	Sample	Distress Type(s)	Distress Severity	Sample Quantity	Section Quantity	Unit	Treatment	Cost	Treatment	Cost
Parking Lot	PARK-05	86	Excellent	Preventative Maintenance	1	L & T Cracking	L	92.00	2,200.00	LF	Monitor	$ -	Crack Sealing - AC	$ 3,187.80
					2	L & T Cracking	L	155.00	3,700.00	LF	Monitor	$ -	Crack Sealing - AC	$ 5,361.30
					3	L & T Cracking	L	290.00	6,900.00	LF	Monitor	$ -	Crack Sealing - AC	$ 9,998.10
											Rounded Total	**$ -**		**$ 18,500.00**

Branch	Section	PCI Value	PCI Rating	Work Repair Level	Sample	Distress Type(s)	Distress Severity	Sample Quantity	Section Quantity	Unit	Treatment	Cost
Parking Lot	PARK-06	43	Fair	Major Rehabilitation	1	Block Cracking	H	9.00	100.00	SF	Major Rehabilitation	$397,212.30
						Block Cracking	M	2,491.00	27,500.00	SF		
					2	Alligator Cracking	M	125.00	1,400.00	SF		
						Block Cracking	M	1,379.00	15,200.00	SF		
						Patching	M	39.00	400.00	SF		
						Potholes	M	1.00	10.00	C		
					3	Alligator Cracking	M	23.00	23.00	SF		
						Potholes	M	2.00	2.00	C		
						Patching	M	33.00	33.00	SF		
											Rounded Total	**$ 397,200.00**

Branch	Section	PCI Value	PCI Rating	Work Repair Level	Sample	Distress Type(s)	Distress Severity	Sample Quantity	Section Quantity	Unit	Treatment	Cost
Parking Lot	PARK-07	18	Very Poor	Reconstruction	1	Alligator Cracking	M	1,269.00	6,600.00	SF	Reconstruction	$286,839.56
						Depression	M	17.50	100.00	SF		
						L & T Cracking	H	50.00	300.00	LF		
						Patching	L	5.00	30.00	SF		
						Patching	M	6.00	30.00	SF		
						Potholes	M	2.00	10.00	C		
						Potholes	H	1.00	10.00	C		
						Bumps / Sags	H	2.50	10.00	LF		
					2	Block Cracking	M	1,000.00	5,200.00	SF		
						L & T Cracking	H	37.00	200.00	LF		
						L & T Cracking	M	318.00	1,700.00	LF		
						Swelling	H	45.00	200.00	SF		
											Rounded Total	**$ 286,800.00**

Branch	Section	PCI Value	PCI Rating	Work Repair Level	Sample	Distress Type(s)	Distress Severity	Sample Quantity	Section Quantity	Unit	Treatment	Cost
Parking Lot	PARK-08	65	Good	Preventative Maintenance	1	L & T Cracking	M	247.00	1,100.00	LF	Crack Sealing - AC	$ 1,593.90
											Rounded Total	**$ 1,600.00**

Branch	Section	PCI Value	PCI Rating	Work Repair Level	Sample	Distress Type(s)	Distress Severity	Sample Quantity	Section Quantity	Unit	Treatment	Cost
Parking Lot	PARK-09	76	Very Good	Preventative Maintenance	1	Alligator Cracking	L	21.00	200.00	SF	Crack Sealing - AC	$ 289.80
						L & T Cracking	M	18.00	100.00	LF	Crack Sealing - AC	$ 144.90
						Swelling	M	45.00	300.00	SF	Patching - AC Deep	$ 4,077.90
											Rounded Total	**$ 4,500.00**

Branch	Section	PCI Value	PCI Rating	Work Repair Level	Sample	Distress Type(s)	Distress Severity	Sample Quantity	Section Quantity	Unit	Treatment	Cost
Parking Lot	PARK-10	39	Poor	Reconstruction	1	Alligator Cracking	M	600.00	8,000.00	SF	Reconstruction	$502,933.76
						Edge Cracking	L	50.00	700.00	LF		
						Rutting	L	100.00	1,300.00	SF		
					2	Alligator Cracking	M	178.00	2,400.00	SF		
						L & T Cracking	M	202.00	2,700.00	LF		
											Rounded Total	**$ 502,900.00**

Branch	Section	PCI Value	PCI Rating	Work Repair Level	Sample	Distress Type(s)	Distress Severity	Sample Quantity	Section Quantity	Unit	Treatment	Cost	Treatment	Cost
Parking Lot	PARK-11	91	Excellent	Preventative Maintenance	1	L & T Cracking	L	94.00	3,600.00	LF	Monitor	$ -	Crack Sealing - AC	$ 5,216.40
											Rounded Total	**$ -**		**$ 5,200.00**

Branch	Section	PCI Value	PCI Rating	Work Repair Level	Sample	Distress Type(s)	Distress Severity	Sample Quantity	Section Quantity	Unit	Treatment	Cost	Treatment	Cost
Parking Lot	PARK-12	81	Very Good	Preventative Maintenance	1	L & T Cracking	L	60.00	1,400.00	LF	Monitor	$ -	Crack Sealing - AC	$ 2,028.60
						L & T Cracking	M	70.00	1,600.00	LF	Crack Sealing - AC	$ 2,318.40	Crack Sealing - AC	$ 2,318.40
						Weathering	L	40.00	900.00	SF	Monitor	$ -	Surface Treatment	$ 538.20
											Rounded Total	**$ 2,300.00**		**$ 4,900.00**

Branch	Section	PCI Value	PCI Rating	Work Repair Level	Sample	Distress Type(s)	Distress Severity	Sample Quantity	Section Quantity	Unit	Treatment	Cost	Treatment	Cost
Parking Lot	PARK-13	85	Very Good	Preventative Maintenance	1	L & T Cracking	L	200.00	10,700.00	LF	Monitor	$ -	Crack Sealing - AC	$15,504.30
					2	L & T Cracking	L	84.00	4,500.00	LF	Monitor	$ -	Crack Sealing - AC	$ 6,520.50
						L & T Cracking	M	100.00	5,400.00	LF	Crack Sealing - AC	$ 7,824.60	Crack Sealing - AC	$ 7,824.60
											Rounded Total	**$ 7,800.00**		**$ 29,800.00**

Branch	Section	PCI Value	PCI Rating	Work Repair Level	Sample	Distress Type(s)	Distress Severity	Sample Quantity	Section Quantity	Unit	Treatment	Cost	Treatment	Cost
Perimeter Road	RDPER-01	75	Very Good	Preventative Maintenance	1	L & T Cracking	L	133.00	4,500.00	LF	Monitor	$ -	Crack Sealing - AC	$ 6,520.50
					2	Alligator Cracking	L	14.00	500.00	SF	Crack Sealing - AC	$ 2,898.00	Crack Sealing - AC	$ 2,898.00
						L & T Cracking	L	51.00	1,700.00	LF	Monitor	$ -	Crack Sealing - AC	$ 2,463.30
						L & T Cracking	M	100.00	3,400.00	LF	Crack Sealing - AC	$ 4,926.60	Crack Sealing - AC	$ 4,926.60
					3	Edge Cracking	L	100.00	3,400.00	LF	Monitor	$ -	Major Rehabilitation	$ 45,220.00
						L & T Cracking	L	225.00	7,600.00	LF	Monitor	$ -	Crack Sealing - AC	$ 11,012.40
						L & T Cracking	M	155.00	5,300.00	LF	Crack Sealing - AC	$ 7,679.70	Crack Sealing - AC	$ 7,679.70
					4	Edge Cracking	L	100.00	3,400.00	LF	Monitor	$ -	Major Rehabilitation	$ 45,220.00
						L & T Cracking	L	21.00	700.00	LF	Monitor	$ -	Crack Sealing - AC	$ 1,014.30
						L & T Cracking	M	92.00	3,100.00	LF	Crack Sealing - AC	$ 4,491.90	Crack Sealing - AC	$ 4,491.90
											Rounded Total	**$20,000.00**	**Rounded Total**	**$131,400.00**

Branch	Section	PCI Value	PCI Rating	Work Repair Level	Sample	Distress Type(s)	Distress Severity	Sample Quantity	Section Quantity	Unit	Treatment	Cost	Treatment	Cost
Perimeter Road	RDPER-02	72	Very Good	Preventative Maintenance	1	L & T Cracking	L	100.00	4,900.00	LF	Monitor	$ -	Crack Sealing - AC	$ 7,100.10
						L & T Cracking	M	145.00	7,200.00	LF	Crack Sealing - AC	$10,432.80	Crack Sealing - AC	$ 10,432.80
											Rounded Total	**$10,400.00**	**Rounded Total**	**$ 17,500.00**

Branch	Section	PCI Value	PCI Rating	Work Repair Level	Sample	Distress Type(s)	Distress Severity	Sample Quantity	Section Quantity	Unit	Treatment	Cost	Treatment	Cost
Perimeter Road	RDPER-03	73	Very Good	Preventative Maintenance	1	Edge Cracking	L	70.00	5,100.00	LF	Monitor	$ -	Major Rehabilitation	$ 67,830.00
						L & T Cracking	L	55.00	4,000.00	LF	Monitor	$ -	Crack Sealing - AC	$ 5,796.00
						L & T Cracking	M	96.00	7,000.00	LF	Crack Sealing - AC	$10,143.00	Crack Sealing - AC	$ 10,143.00
					2	Edge Cracking	L	50.00	3,600.00	LF	Monitor	$ -	Major Rehabilitation	$ 47,880.00
						L & T Cracking	L	92.00	6,700.00	LF	Monitor	$ -	Crack Sealing - AC	$ 9,708.30
						L & T Cracking	M	100.00	7,300.00	LF	Crack Sealing - AC	$10,577.70	Crack Sealing - AC	$ 10,577.70
											Rounded Total	**$20,700.00**	**Rounded Total**	**$151,900.00**

Branch	Section	PCI Value	PCI Rating	Work Repair Level	Sample	Distress Type(s)	Distress Severity	Sample Quantity	Section Quantity	Unit	Treatment	Cost	Treatment	Cost
Service Road	RDSER-01A	91	Excellent	Preventative Maintenance	1	Edge Cracking	L	100.00	800.00	LF	Monitor	$ -	Major Rehabilitation	$5,200.00
											Rounded Total	**$ -**	**Rounded Total**	**$ 5,200.00**

Branch	Section	PCI Value	PCI Rating	Work Repair Level	Sample	Distress Type(s)	Distress Severity	Sample Quantity	Section Quantity	Unit	Treatment	Cost
Service Road	RDSER-01B	54	Fair	Major Rehabilitation	1	Block Cracking	M	1,488.00	11,800.00	SF	Major Rehabilitation	$94,497.98
						Depression	M	12.00	100.00	SF		
						Edge Cracking	M	50.00	400.00	LF		
											Rounded Total	**$ 94,500.00**

Branch	Section	PCI Value	PCI Rating	Work Repair Level	Sample	Distress Type(s)	Distress Severity	Sample Quantity	Section Quantity	Unit	Treatment	Cost
Service Road	RDSER-02A	97	Excellent	Preventative Maintenance	1	L & T Cracking	M	16.00	100.00	LF	Crack Sealing - AC	$ 144.90
											Rounded Total	**$ 140.00**

Branch	Section	PCI Value	PCI Rating	Work Repair Level	Sample	Distress Type(s)	Distress Severity	Sample Quantity	Section Quantity	Unit	Treatment	Cost
Service Road	RDSER-02B	54	Fair	Major Rehabilitation	1	L & T Cracking	L	156.00	400.00	LF	Major Rehabilitation	$38,268.45
						L & T Cracking	M	31.00	100.00	LF		
						Rutting	L	600.00	1,700.00	SF		
											Rounded Total	**$ 38,300.00**

Appendix E

Maintenance Prioritization

Estimated Years to Perform Repair	Branch	Section	Common Name	Current Age of Pavement	PCI Value	Development/ Redevelopment Area	Usage*	Recommended Work Repair Level	Full Repair	Year to Perform Crack Seal	Cost to Perform Crack Seal[1]
2022	General Road	RDGEN-04	Grinden Rd	Middle	84		High	Preventative Maintenance	$ 20,300.00	2025	$ 28,800.00
2023	Perimeter Road	RDPER-01	Perimeter Road North	Middle	75		High	Preventative Maintenance	$ 131,400.00	2026	$ 43,300.00
2023	Perimeter Road	RDPER-03	Perimeter Road West	Middle	73		High	Preventative Maintenance	$ 151,900.00	2026	$ 39,300.00
2023	General Road	RDGEN-03A	Airport Approach Rd	Middle	49		Middle	Major Rehabilitation	$ 175,200.00	2026	$ 1,500.00
2024	General Road	RDGEN-02A	Stebner Rd (SRE Access)	Old	7		Low	Reconstruction	$ 197,000.00	2027	$ 1,200.00
2025	Apron	APRON-01	SRE Apron	Middle	71		High	Preventative Maintenance	$ 6,400.00	2028	$ 6,300.00
2025	Parking Lot	PARK-08	SRE Lot	Middle	65		High	Preventative Maintenance	$ 1,600.00	2028	$ 1,300.00
2025	Parking Lot	PARK-11	Car Rental Lot	Middle	91		High	Preventative Maintenance	$ 5,200.00	2028	$ 13,700.00
2025	Parking Lot	PARK-12	Employee Lot	Middle	81		High	Preventative Maintenance	$ 4,900.00	2028	$ 8,300.00
2025	Perimeter Road	RDPER-02	Perimeter Road South	Old	72		High	Preventative Maintenance	$ 17,500.00	2028	$ 15,800.00
2025	Apron	APRON-03	Terminal Apron	Old	84		Middle	Preventative Maintenance	$ 4,400.00	2028	$ 7,300.00
2025	General Road	RDGEN-02C	FBO Entrance Rd	New	85		Middle	Preventative Maintenance	$ 300.00	2028	$ 2,100.00
2025	Apron	APRON-04	ARFF Ramp	Middle	91		High	Preventative Maintenance	$ 11,100.00	2028	$ 10,300.00
2025	General Road	RDGEN-01	North Business Development Area	Middle	87		Middle	Preventative Maintenance	$ 10,000.00	2028	$ 15,900.00
2025	Service Road	RDSER-02A	Rwy 9 Glideslope Rd	Old	97		Low	Preventative Maintenance	$ 140.00	2028	$ 900.00
2027	Service Road	RDSER-02B	Rwy 9 Glideslope Rd	Old	54		Low	Major Rehabilitation	$ 38,300.00	2030	$ 400.00
2027	Service Road	RDSER-01A	Rwy 27 Glideslope/Tacan Rd	Old	91		Low	Preventative Maintenance	$ 5,200.00	2030	$ 2,000.00
2027	Service Road	RDSER-01B	Rwy 27 Glideslope/Tacan Rd	Old	54		Low	Major Rehabilitation	$ 94,500.00	2030	$ 1,000.00
2	Apron	APRON-02	SRE Apron	Old	53	Development Area	High	Major Rehabilitation	$ 172,000.00	2028	$ 1,700.00
3	Parking Lot	PARK-13	Surface Lot	Middle	85	Development Area	High	Preventative Maintenance	$ 29,800.00	2028	$ 35,000.00
3	General Road	RDGEN-03B	Tower Rd	Old	44	Redevelopment Area	Middle	Major Rehabilitation	$ 170,400.00	2028	$ 2,200.00
4	Parking Lot	PARK-07	Hangar 101 Lot	Old	18	Redevelopment Area	Low	Reconstruction	$ 286,800.00	-	$ 1,700.00
4	General Road	RDGEN-02B	Malstrom St	Old	3	Redevelopment Area	Low	Reconstruction	$ 112,200.00	-	$ 700.00
4	Parking Lot	PARK-04A	Leased Parking	Old	50	Redevelopment Area	Low	Major Rehabilitation	$ 596,400.00	-	$ 4,900.00
4	Parking Lot	PARK-04B	Access	Old	52	Redevelopment Area	Middle	Major Rehabilitation	$ 20,400.00	-	$ 200.00
5	Parking Lot	PARK-06	LSC Lot	Old	43	LSC Leased	High	Major Rehabilitation	$ 397,200.00	-	$ 3,300.00
5	Parking Lot	PARK-05	DEDA/Cirrus Public Lot	New	86	DEDA Leased	High	Preventative Maintenance	$ 18,500.00	-	$ 24,000.00
5	Parking Lot	PARK-09	Monaco Lot	New	76	Monaco Leased	High	Preventative Maintenance	$ 4,500.00	-	$ 2,300.00
5	Parking Lot	PARK-10	Hangar 311 Lot	Old	39	Cirrus Leased	High	Reconstruction	$ 502,900.00	-	$ 3,400.00

Note: [1]Crackseal should be performed 3 years following a full repair

Note: [2]Part of Taxiway A Phase 4 (Construction in 2025)

Note: [3]Part of ATCT (Construction in 2025-2026)

Note: [4]Pavement will be reconstructed during future site redevelopment

Note: [5]Lessee is responsible for pavement maintenance

*Usage provided by DAA Staff

Table 7 - Prioritization Schedule

Appendix F

ARA 2018 Pavement Condition Report, Appendix G

Appendix G

Maintenance Repair Guidelines

General Comments

Ongoing inspections are the cornerstone of a maintenance management program. Crack sealing prevents surface water from entering the pavement structure and helps prevent the introduction of incompressible material into the paving joints and cracks, reducing the chances for spalls and further pavement deterioration.

Preservation of a pavement system will require a combination of preventive, sustaining, and restorative maintenance repairs. Preventive maintenance is primarily an inspection program, sustaining maintenance is an ongoing maintenance function, whose purpose is to seal newly formed cracks in areas where the sealant is in otherwise satisfactory condition. Restorative repairs are major work items, often performed under contract that typically involves complete removal and replacement of existing sealant.

Maintenance Activities

Flexible (Asphalt) Pavement

Longitudinal and transverse (L&T) cracks at medium severity (>¼" wide) should be filled with a good quality crack filler material. High-severity cracks must normally be patched. Cracks rated at low severity may be narrow-unsealed cracks or sealed cracks up to 3 inches wide. The PCI procedure does not distinguish between narrow unfilled cracks and wider filled cracks. When 25 percent or more of total crack quantity is at medium or high severity, a restorative program becomes cost-effective. When medium- or high-severity cracking constitutes less than 25 percent of the total, sustaining maintenance is usually more cost-effective.

Medium- and high-severity existing patches should be replaced with new patches. Small areas (usually less than 100 square feet per patch) of alligator cracking and rutting at medium and high severity may also be repaired by patching. Larger patches should be considered if equipment can be made available to accomplish the work. Patching to repair up to 10 percent of the surface of a pavement section that is otherwise serviceable can result in significant cost savings as compared to rehabilitation of the entire section.

PCC (Concrete) Pavement

Joint seal damage at medium and high severity should be repaired. If medium- and high-severity damage is limited to less than about 25 percent of total joint length, sustaining maintenance is recommended. If medium and high-severity damage exceeds about 25 percent of the total joint length, joint sealant should be removed and replaced under a restorative repair project.

Longitudinal/transverse/diagonal (LTD) cracks at low and medium severity should be considered for sealing as part of the joint sealing project. High-severity LTD cracks require sealing, patching, or slab replacement, depending on the extent of deterioration.

Small patches are most often placed to repair medium- and high-severity spalls or to replace deteriorated older patches. Restorative small patches are typically partial depth repairs, usually to load transfer steel. Large patches and corner breaks at medium and high severity should be repaired by full-depth large patches.

High-severity LTD cracks and shattered slabs are candidates for patching and slab replacement. Low-severity shattered slabs can be left in place pending further deterioration.

Pavement Failure

Before maintenance and repairs are attempted, it helps to have an understanding of the way pavement performs and deteriorates.

Environmental/Age-Related Deterioration

Seasonal temperature changes cause expansion and contraction of the pavement materials, causing the pavement to move up to 1 foot per 1,000 feet. Much of this movement can be witnessed as the opening and closing of existing transverse cracks.

The pavement thickness and type of subgrade plays a large role in the formation and spacing interval of transverse cracks. If the subgrade material is smooth or rounded, the pavement surface will move relatively freely, the transverse cracks will usually be spaced far apart (>60 feet). If the subgrade material is rough or angular the pavement surface will not move freely and transverse cracks will be spaced more closely (<40 feet). The distance between transverse cracks will also depend on the pavement thickness, as a thicker pavement can resist cracking for longer lengths, but around 50 feet is typical for general aviation airport pavements.

Age related distress deals with the pavement oxidation or loss of volatile components to the atmosphere. An oxidized pavement becomes more brittle with time. Surface treatments and seal coats are designed, in part, to provide a protective barrier and prevent this type of oxidation.

Materials Related Deterioration

Subsurface water can have the greatest impact on pavement deterioration. A wet subgrade greatly reduces the ability of a pavement to support wheel loads, and the results often show up as rutting and cracking. The fine materials in a wet base can be pumped up through the cracks and eventually result in a loss of subgrade support. This loss of support can be evidenced as corner breaks and faulting. Moisture inside a pavement system expands when it freezes; creating stresses that push and tear at the pavement. The following thaw cycles will leave voids in the pavement structure that enable further rutting and breaking. Repeated freeze/thaw cycles will eventually cause pavement to disintegrate. One of the best ways to assure pavement longevity is to provide drainage and keep the subgrade dry.

Aggregate is the biggest component of any pavement structure, and it is the contact between the aggregate particles that actually transfers the load and provides the strength. Aggregate durability and shape are major factors affecting pavement performance. Durability is the ability of the aggregate to perform satisfactorily over time and resist the detrimental effect of nature. Sharp, well-angled aggregate that interlock, compact densely, and resists movement are the most desirable.

Air Voids

Well-distributed interconnected air voids allow escape paths for freezing water and generally reduce susceptibility to freeze/thaw damage. In PCC pavements, closely spaced interconnected air voids provide the greatest degree of protection.

Asphalt pavements, on the other hand, only tolerate air voids as necessary. Air voids allow for expansion of the asphalt binder, but also allow water penetration into the pavement. Interconnected air voids are undesirable here because the voids allow air to penetrate the asphalt layers and oxidize the binder. As air voids increase, durability and flexibility decrease, but stability and skid resistance increase. Asphalt pavements should be designed and compacted so that air voids are not interconnected. The air voids should allow only for the expansion of the asphalt and aggregate without, bleeding, and air voids should be kept low enough to prevent water and air from penetrating the asphalt layers.

Binders

Regardless of whether the pavement is asphalt or concrete, the binder material is mixed with the aggregate to coat all particles with a thin film. An asphalt coating allows the pavement to be flexible and still resist large movements. Durability of the asphalt pavement is increased by a thicker film because it is more resistant to age hardening; however, too thick of a film and the asphalt acts like a lubricant, promoting ruts, shoving, and bleeding. Specifications control aggregate and binder mix quantities, but each mix should be customized for materials available locally.

With a concrete pavement, the aggregate supports the load, but the cement binder interlocks with the aggregate to inhibit all movement. Hydration is the term for the chemical reaction of portland cement with water, and in the hydration process, dry cement particles react with water, to form gels, and then crystals, that grow and bond with the aggregate to form a rigid interlocking structure. Hydration can continue for years, but much of the ultimate strength will be reached within 28 days. Hydration is a sensitive chemical process, and typically, any admixtures used to accelerate the hydration process will reduce durability, and their use should be considered carefully or avoided.

Stress Distribution/Load Related Deterioration

PCC (rigid) and asphalt (flexible) pavements differ in the way loads are distributed. A concrete slab resists bending and transfers loads evenly, an asphalt pavement is designed to bend, and gradually spreads loads over wider areas. Rutting is a subgrade failure caused by a compressive yielding of the subgrade.

Load-related cracks can start at the top or bottom of a pavement section. In asphalt sections, load-related (fatigue) cracks start at the bottom. If a load-related crack reaches the surface, it usually indicates significant structural deficiency. In PCC pavement, corner breaks are caused by top tension, and the crack propagates downward. Mid-slab LTD cracks are examples of bottom tension.

Spalls can be caused by either wheel loads or environmental factors, anytime there is movement between adjacent slabs. If a small rock is allowed into a joint, a differential movement between adjacent slabs can cause a spall. Spalling can be minimized by keeping joint and crack sealant intact.

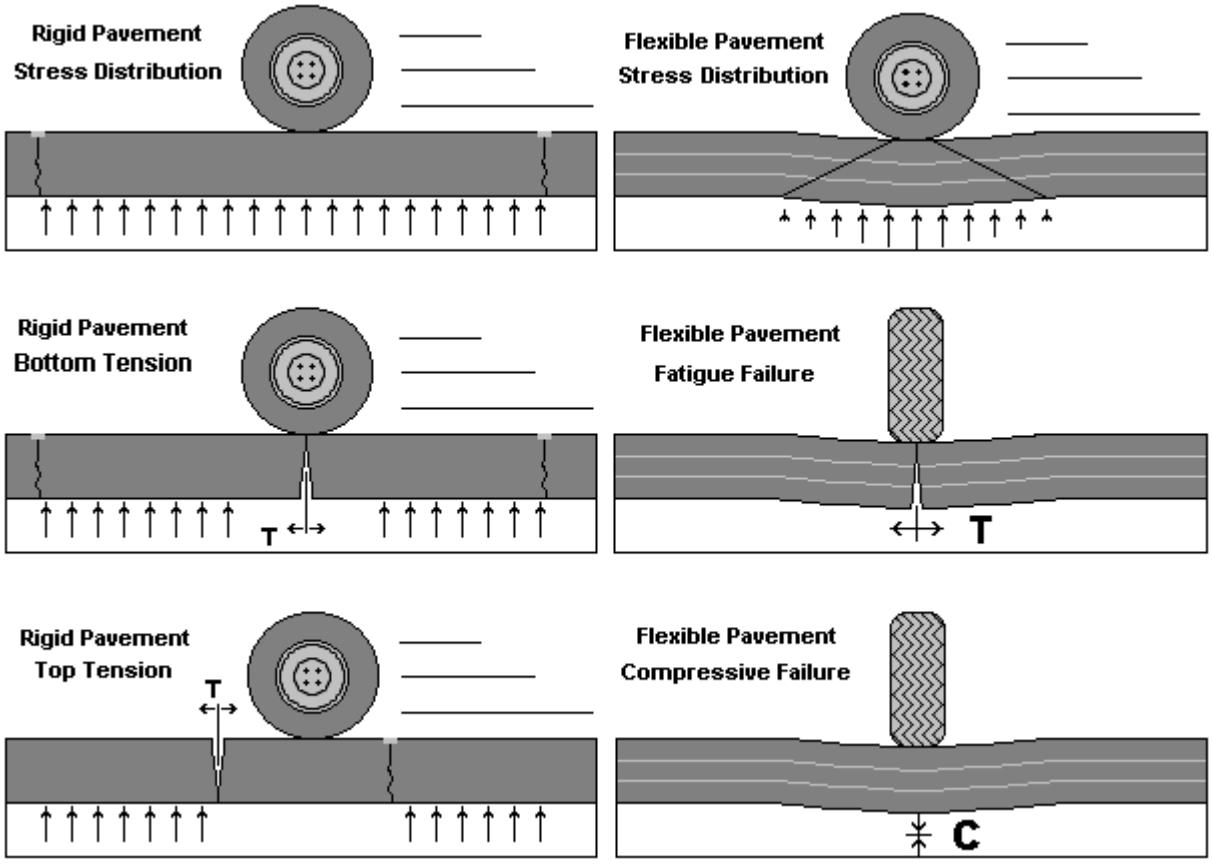

Figure 1. Pavement failure.

Points to Remember

Pavement wears out.

The longer a pavement remains in service, the greater the effort needed to keep it in service. A good maintenance and repair program will increase service life significantly, but cannot be expected to extend service life indefinitely.

Pavement moves.

Pavement moves in response to temperature changes. Transverse cracks can vary from nearly closed in the summer to open an inch or more in winter. This movement cannot be prevented. It must be understood and provided for during design and construction. The changing crack widths will dictate the reservoir size required for sealant. Measure cracks at their widest and narrowest states, then prepare adequate (½ - 1½ inch) sealant reservoirs for crack sealing projects.

Longitudinal joints and cracks are important.

The most important reason for sealing cracks is to deny surface water access to the pavement and subgrade. Most water drains from centerline to shoulders. Longitudinal cracks, which run parallel to the centerline provide the greatest potential to divert water into the pavement structure, and must be sealed.

Sealing is not always the best answer.

The FAA maximum allowable open trench width on aircraft movement areas is three-inches; therefore, any crack wider than three-inches should be patched. A severe spall or a crack that has settled below the pavement elevation indicates a failure. If the pavement has disintegrated to the point that aggregate interlock is lost, sealant alone will not be sufficient, and patching should be considered.

Maintenance and repairs must be done correctly.

To achieve optimum results from repairs, proper preparation, use of quality materials, and proper application are essential. Any shortcuts will reduce the quality and effectiveness of the repairs. A rule of thumb is that proper maintenance will last twice as long as an unprepared area. Good maintenance takes time and deserves high-quality materials.

Schedule maintenance and repair activities carefully.

Any pavement defect can be corrected. Concentrate on repairs that are cost-effective, operationally important, and that extend service life. Some surface blemishes can be ignored safely, and many structural problems are beyond economical correction. When future rehabilitation is imminent, maintenance activities should be limited to only those that ensure continued safety and minimize foreign object damage (FOD) potential.

Equipment

Many excellent pavement repair and sealing products are available. Specialized tools and equipment help ensure quality repairs. This section reviews equipment compatible with airport needs.

Air Compressor

Used to remove sand and debris from prepared cracks and joints, the compressor should have a sustained capacity of 120 cubic feet per minute with a nozzle velocity of 100 psi. Trailer-mounted compressors typically have capacities in this range.

Concrete Saw

A saw capable of making a minimum 3-inch deep cut is required. The saw should be capable of making cuts in asphalt or concrete. Gasoline-powered 5-25 hp wheel mounted saws typically are preferred for this type of work, but electric and pneumatic tools are also available.

Heating Kettle

Applying sealant is the most time-consuming operation, and a sealing machine with heating and pressure application capabilities is a critical item in a sealing program. The capacity of the sealing equipment dictates the rate at which a crew progresses. For large sealing projects, a minimum 100 gallons/per hour sustained capacity is recommended. The unit should be a double boiler type, with mechanical agitators or continuous recirculation.

Router

A concrete saw can be used to prepare joints, but for random cracking, a mechanical router with a vertical impact mechanism is preferred. When cracks are being routed, this activity will dictate speed of the crew. Crack routers in the 25hp range are commonly used and are available from a variety of manufacturers.

Sand Cleaner

A sand blaster helps to clean loose particles and dust from prepared cracks. The unit must have sufficient force to expose fresh, vital pavement to bond with sealant and patching materials.

Vibratory Roller or Plate Compactor

Required to properly compact plant mixed and packaged patching materials. Small rollers are best for pothole type applications, plate compactors are best for large areas.

Other Equipment

Other general use equipment that can be helpful in a maintenance program includes bucket loaders, dump trucks, water tanks, and a power sweeper unit.

Materials

Pavement repair materials are constantly being introduced and improved. This section provides information on products compatible with airport needs.

Joint and Crack Sealer

Hot poured, pressure injected, polymeric rubberized asphalt sealant meeting ASTM D3405 specifications is suitable for most joint and crack sealing requirements. This product is relatively inexpensive, durable, and suitable for both PCC and asphalt pavements. Other, more expensive, hot applied sealants that promise longer life are being developed for specialty applications, and twin component cold applied sealants, similar to URASEAL 200, have also been used with success. Contact your local distributor.

Flexible Pavement Patch

Long-term patches should be made with a high-quality plant mixed hot asphalt having a ¾-inch maximum aggregate size and meeting FAA P401, or highest quality highway specifications. High-performance plant mixed cold patching products that can be stockpiled on-site have been developed. Low-quality packaged materials available from local hardware type stores should be avoided and only be used for temporary patches that maintain safety and service.

PCC Pavement Patch

Permanent patches in PCC pavement should be made with a minimum 6-bag mix of hi-early air-entrained cement with 1-inch maximum size aggregate. Concrete should have zero slump and a coarse texture. As with asphalt patches, low-quality packaged materials should only be used as temporary patches to maintain safety and service until a more permanent repair can be made.

Techniques

Crack Sealing

- Cracks over ¼ inches wide should be sealed. Cracks wider than 3 inches should be patched.
- Sealant depth above the backer rope should be equal to the width of the reservoir, or as recommended by the manufacturer.
- Routed cracks should be sand blasted, to prepare the vertical edges for bonding with the sealant. Clean cracks with compressed air prior to sealing.
- Backing material should always be placed into the cracks. Commercial products are available, and several sizes of rope should always be available to accommodate various crack sizes.
- Apply sealant after placing the backer rope. Follow the manufacturer's instructions. Sealant should be applied to within ¼ inch of the pavement surface.
- The final activity is to clean the surrounding pavement areas. A vacuum sweeper works well for this. Allow the sealant time to set, before using a broom.

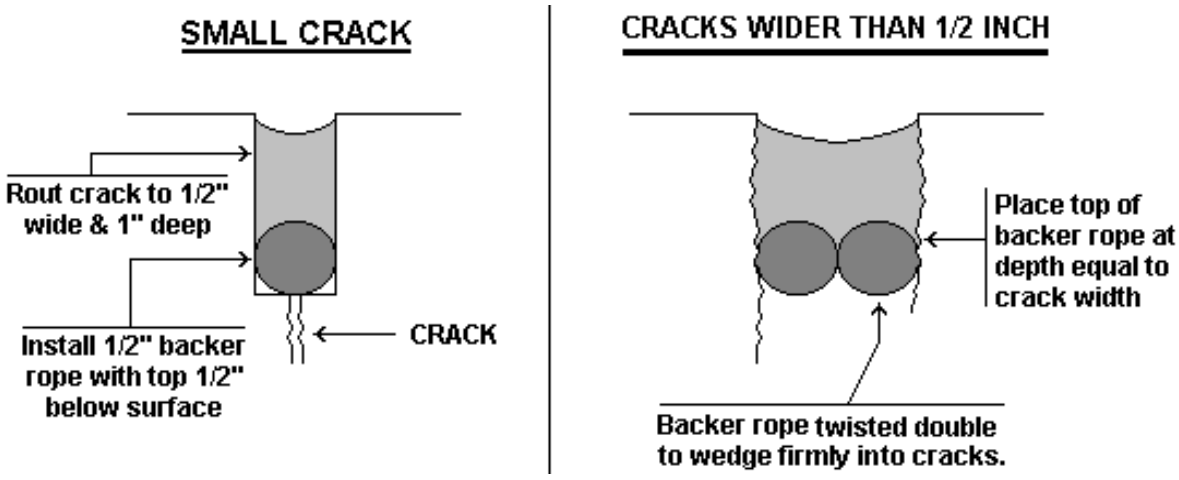

Figure 2. Crack sealing.

Note:
This crack sealing technique is meticulous in its design and procedure. It has a proven record of performance. Using backer rope forces the sealant into a predictable shape—narrow in the center and wide on the sides. This sealant profile allows the sealant to firmly bond with the vertical edges, yet stretch easily with pavement movement. In an effort to minimize labor requirements and reduce crack-sealing costs, an alternative procedure, the overband technique, is presented on the following page. This procedure can produce good results for up to 5 years.

Always remember that, within reasonable limits, thinner sealant material will stretch more easily with the pavement movement, and stay bonded longer.

Overband Technique

A latex modified, fiber reinforced, asphalt cement sealant using the techniques outlined below.

Material

- Blend grade 20 or equivalent asphalt cement with latex rubber at 5 percent by weight of asphalt.
- Again, at 5 percent by weight of asphalt, add polyester fibers into agitator tank.
- Maintain blended asphalt temperature at least 20 degrees below flash point.
- Continuously recycle hot blended asphalt through pumps and hoses when heating kettle is in standby mode.

Application

- Sealant should be applied to dry pavement, with ambient temperatures above 40 degrees.
- Cracks should be sand cleaned and blown free of debris immediately before sealing.
- Application of sealant immediately follows cleaning of the crack.
- Sealant should be pressure applied from a wand-type applicator with a special "overband" nozzle.
- Seat the sealant with a steel-wheeled roller immediately after placement.
- In wider cracks, a backer rope is recommended to limit material quantities required.

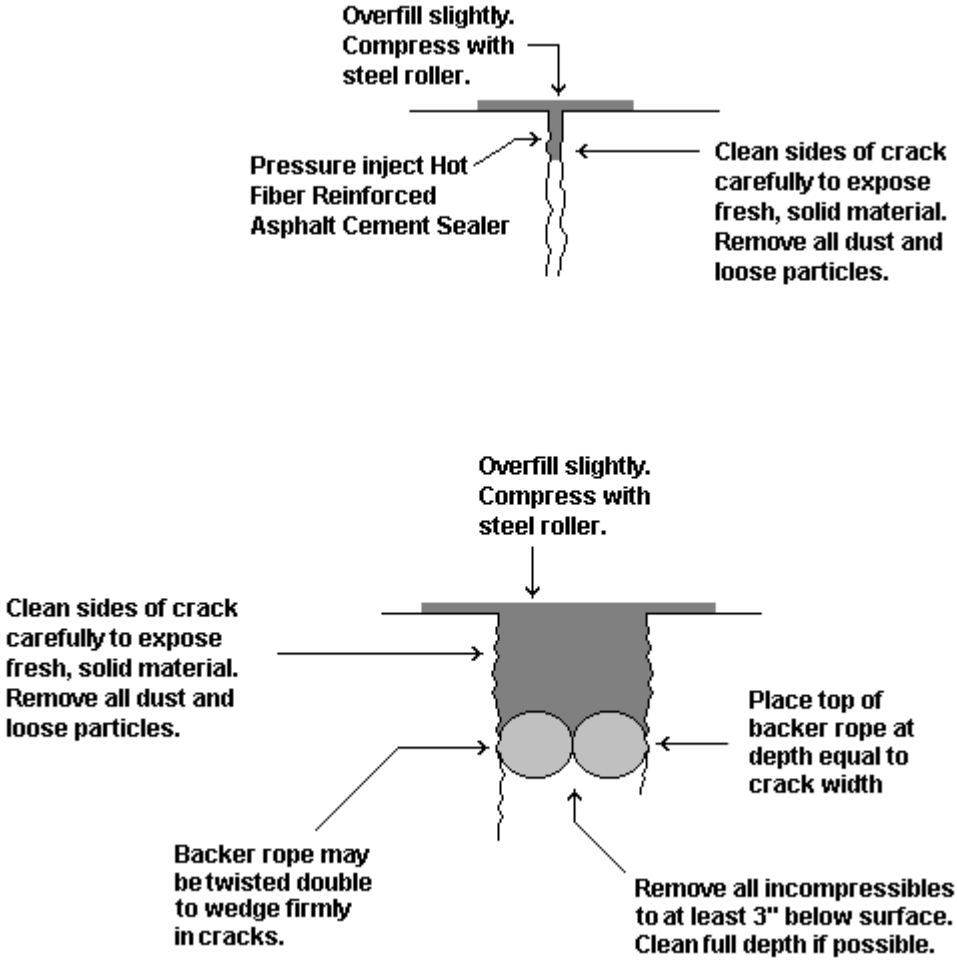

Figure 3. Overband sealing.

Patching (Asphalt Pavement)

Cracks wider than 3 inches should be patched. Cracks with secondary cracking and vertical movement should also be patched. Failed existing patches should be replaced. Patching can also repair small areas of alligator cracking and rutting. A patch differs from sealant in that it restores load-bearing capacity. Therefore, it must be constructed carefully to distribute stresses evenly and perform as an integral piece of the surrounding pavement. The patch must be wide enough to ensure that it bonds to fresh, vital pavement on all sides, and deep enough to reach fresh underlying layers, but never less than 3 inches.

- Examine the distressed area and mark the patch outline. This examination may require a pick or chisel to test the pavement integrity in and around the distressed area.
- The patch area should be cut out with a vertical saw cut not less than 3 inches deep.
- The enclosed pavement should then be removed, leaving the vertical sawed edges undamaged and providing a relatively even, flat floor at the appropriate depth.
- The sides and bottom should be sand cleaned and blown out with compressed air

- The sides and bottom should then be painted with a rapid curing asphalt tack coat. The tack coat may be sprayed on or applied with a brush or rag. Care should be taken to achieve complete coverage without allowing excess material to “pool” on the bottom.
- Allow tack coat to cure (about 2 to 4 hours) until it reaches a gummy consistency, which readily retains the impression of a fingerprint.
- Place hot mixed asphalt concrete evenly and mound slightly above surrounding pavement. Allow approximately ¼ inch of compaction for each inch of patch depth.
- Compact in place with vibratory roller or plate compactor. Asphalt concrete should not be compacted in layers greater than 6 inches. If patch depth is greater than 6 inches, asphalt concrete should be placed and compacted in successive layers.
- In deep, narrow patches such as at joint reflective cracks, a sand asphalt mix may be required in lower layers to allow movement and prevent bridging the adjacent slabs.
- Considerable judgment is required in placing the asphalt concrete to achieve a fully compacted patch without creating a bump or depression. The ¼ inch per inch factor is a rule of thumb. Actual compression will vary with the mix. Experimentation and experience are required to achieve optimum results.

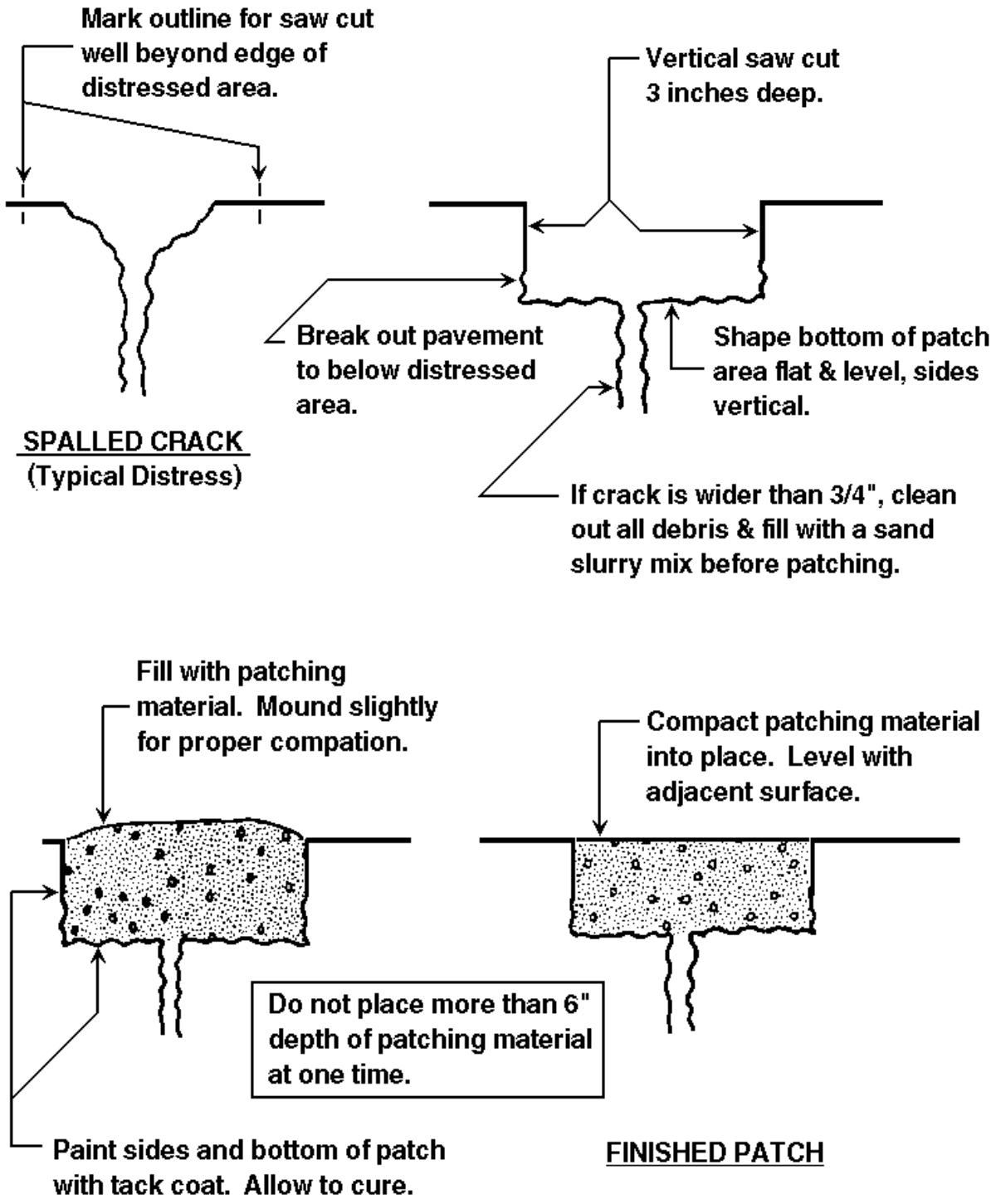

Figure 4. AC patch.

Patching (PCC)

The technique outlined here simulates a thin bonded PCC overlay. This procedure has been proven in service throughout the country.

- Examine the distressed area and mark the patch outline. This examination may require a pick or chisel to test pavement integrity in and around the distressed area.
- Saw cut the area to a depth of 2 inches. The enclosed area is then chipped or jack hammered to solid pavement, but not less than a 2-inch nominal depth.
- The sides and bottom are sand cleaned and air-blasted to expose vital, clean concrete.
- A 25 percent solution of muriatic acid is applied to all exposed surfaces within the patch.
- The muriatic acid solution is thoroughly flushed from the patch area with water.
- Compressed air is used to remove excess water from the area, but exposed concrete must be maintained in a moist condition.
- The sides and bottom of the area are then coated with approximately a 1/16-inch layer of cement grout applied at the consistency of paste. The grout acts as an adhesive to bond the fresh concrete to existing concrete.
- If the patch is adjacent to joints, the continuity of the joint must be maintained by placing inserts approximately the shape of the desired joint against the wall of the patch.
- Before concrete grout begins to dry, concrete is placed in the patch area and is compacted into position with hand tampers or a vibrating plate tamper.
- When the patch has been struck to the proper slope and elevation, a surface texture is applied to approximate the texture of adjacent pavement.
- Joint edges may be edged slightly to remove sharp edges. The patch should be covered with polyethylene or sprayed with a curing compound.
- Clean the surrounding pavement before concrete spillover has a chance to set up.
- The patch may be open to traffic in 72 hours.

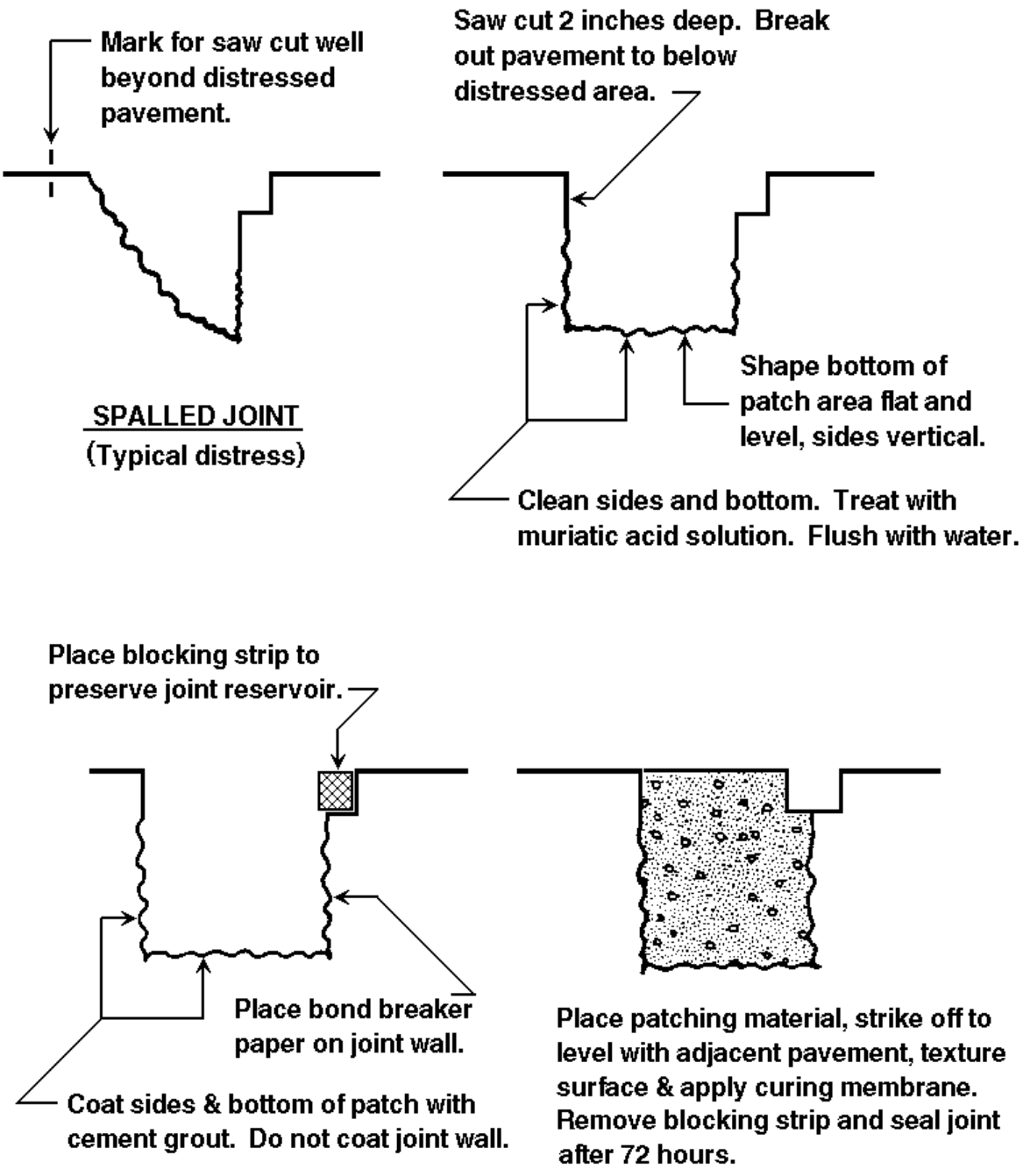

Figure 5. PCC patch.

Joint Repair (PCC)

Seal joints in PCC pavement when existing sealant has deteriorated to a degree that allows water and incompressibles to enter the joint. Hairline cracks are not yet candidates for sealing.

- Rout a reservoir for the sealant. Sealant reservoir should be ½ inch wide and 1 inch deep.
- For cracks wider than ½ inch, the reservoir should be ¼ inch wider than the crack. Depth should be such that sealant above the backer rope is at most equal to reservoir width, or as recommended by manufacturer.
- Routed cracks should be sand cleaned, using fine sand at reduced pressure. Proper cleaning will expose fresh, vital pavement on the vertical crack edge.
- Immediately prior to sealing, cracks should be cleaned with compressed air. Ensure that all sand, debris, and incompressibles are removed from the crack. A small hand-held hook or plowing tool may be needed to dislodge some particles. Water cleaning is not recommended, simply because the drying time delays the sealing operation.
- After cleaning with compressed air, a backing material should be placed into the crack. The backer rope may be any compressible substance compatible with bituminous sealant material that will wedge into cracks at a designated depth and support the sealant. Several sizes should be immediately available in the field to accommodate various crack sizes.
- Sealant should be pressure applied with a wand type applicator to within ¼ inch of the pavement surface. Follow the equipment manufacturer's instructions.
- The final activity is to clean the surrounding pavement area. A vacuum sweeper works well. Brooms should not be used until the sealant has taken an initial set.

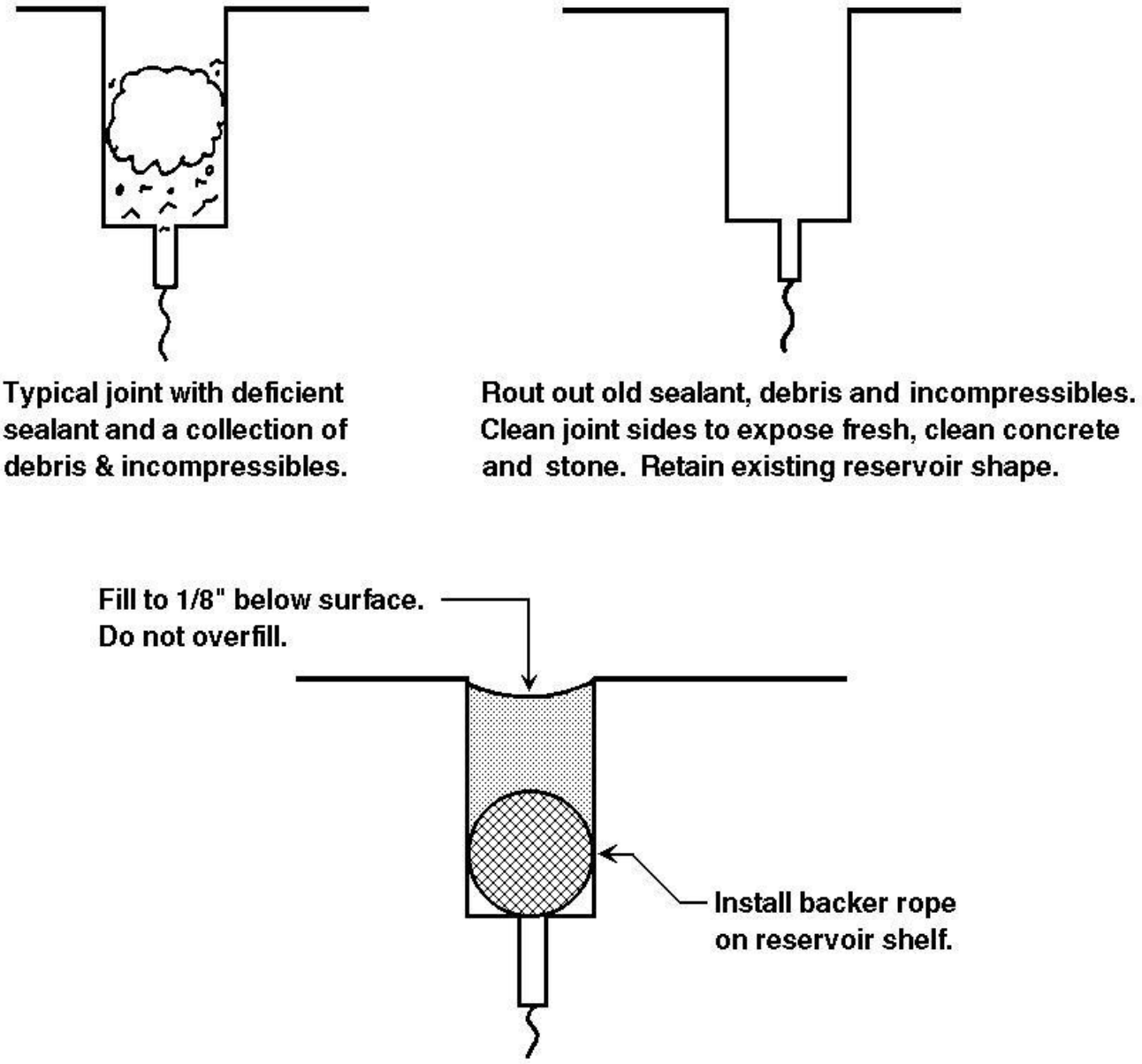

Figure 6. PCC joint/crack repair.

Table 1. Maintenance and “drive by” inspection log.

Inspection Date	Inspector	Pavement location (branch/section)	Change in condition (new distress type, increased quantity or severity)	Maintenance performed since last inspection

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