APPENDIX C – AIRPORT PAVEMENT STRUCTURAL EVALUATION

INTRODUCTION

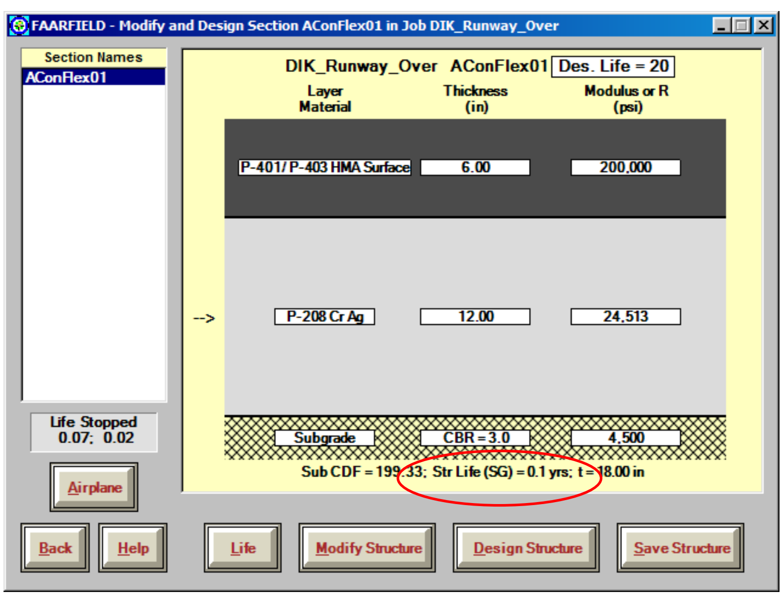
The status of the existing primary runway pavement with current aircraft operations is important to understand in order to determine if reconstruction is a possible alternative. A report was commissioned by the North Dakota Aeronautics Commission and completed for Dickinson Theodore Roosevelt Regional Airport in March 2013. The report provides the Pavement Classification Number and Aircraft Classification Number for the airport based on the flight activity through 2012 and projected by the North Dakota Aeronautics Commission at the time.

The most notable element of the report is this statement found on page 8 of the report:

> When the Embraer ERJ-145LR was included in the analyzed traffic for Runway 14-32, the calculated PCN decreased to 12 F/D/W/T. The Embraer ERJ-145LR has an ACN of 17 for pavements with a subgrade category of D, which exceeds the PCN determined for Runway 14-32 when it is included in the traffic mix. Because this aircraft is being considered for regular operations and its ACN exceeds the PCN, ***it is not recommended that the Embraer ERJ-145LR operate on a regular basis without increasing the structural capacity of Runway 14-32.***

Since this report was completed, the airport is now served by 6 round trips per day with these 53,000 pound regional aircraft (ERJ 145 and CRJ 200). The report is included as follows in this appendix.

In addition KLJ evaluated the existing pavement design using the FAA's FAARFIELD software and determined the ***expected structural life of the pavement to be 0.1 years***.



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MEMO

To: North Dakota Aeronautics Commission
From: Kyle Potvin
CC:
Date: 3/28/2013
Re: Airport Pavement Condition Index Study
Task 5. Structural Evaluation
Dickinson Theodore Roosevelt Regional Airport Runway PCN Results

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Under Work Order 11.02369.02 Airport Pavement Condition Index Study, Ulteig Engineers and Applied Pavement Technology (APTech) have performed the structural evaluation to determine pavement classification numbers (PCNs) for Dickinson Theodore Roosevelt Regional Airport (DIK) Runways 14-32 and 7-25. The Federal Aviation Administration (FAA) Advisory Circular (AC) 150/5335-5B, *Standardized Method of Reporting Airport Pavement Strength – PCN*, which provides guidelines for assessing pavement strength, was followed throughout the evaluation. This AC and supporting COMFAA 3.0 software were followed for the pavement strength analysis at Dickinson Airport.

PCN Overview

The Aircraft Classification Number/Pavement Classification Number (ACN-PCN) system of reporting pavement strength was developed by the International Civil Aviation Organization (ICAO). Since the United States is a member of this organization, the FAA is obligated to adhere to this system and provides guidance to comply with the ICAO standards.

The ACN-PCN procedure is structured so that a pavement with a given PCN can support an aircraft that has an ACN equal to or less than the PCN. Likewise, the pavement cannot, according to the procedure, handle frequent loadings from an aircraft with an ACN exceeding the PCN.

In the ACN-PCN procedure, the PCN is assigned to a pavement and expresses the relative load-carrying capacity of that pavement in terms of allowable load for unrestricted operations based on aircraft departures (frequency and weight) and pavement layer properties. The PCN should be recalculated if the aircraft mix or volume changes significantly. Each aircraft in the traffic mix is analyzed as the critical aircraft to establish the PCN. The PCN has a minimum value of 0 and has no upper limit. In addition to the numerical value, the PCN is reported with four codes, which represent the following categories:

- Pavement Type
    - R = Rigid
    - F = Flexible
- Subgrade Strength Category
    - A = High (k-value ≥ 442 psi/in or CBR ≥ 13)
    - B = Medium (221 psi/in < k-value ≤ 442 psi/in or 8 < CBR ≤ 13)
    - C = Low (92 psi/in < k-value ≤ 221 psi/in or 4 < CBR ≤ 8)
    - D = Ultra Low (k-value ≤ 92 psi/in or CBR ≤ 4)

- Maximum Allowable Tire Pressure
  - W = High (no pressure limit)
  - X = Medium (146 to 218 psi)
  - Y = Low (74 to 145 psi)
  - Z = Ultra Low (pressure limited to 73 psi)
- Pavement Evaluation Method
  - T = Technical Evaluation
  - U = Using Aircraft Evaluation

The analysis approach using COMFAA 3.0 is based on the conventional design procedure (outlined in FAA AC 150/5320-6D, *Airport Pavement Design and Evaluation*). It incorporates the California Bearing Ratio (CBR) design procedure for flexible pavements, which determines the required thickness of pavement layers to protect the underlying layers from rutting.

The aircraft data, subgrade support values (CBR for flexible pavements), and pavement evaluation thicknesses are used directly in COMFAA. Using these inputs, COMFAA iteratively adjusts the critical aircraft weight until the required pavement thickness determined using the software matches the existing pavement cross section. This process is repeated within COMFAA, such that each aircraft in the mix is analyzed as the critical aircraft.

Pavement Condition Evaluation

As part of the North Dakota statewide airport management system (APMS) update, Ulteig Engineers and APTech evaluated the pavements using the PCI procedure, which is described in FAA AC 150/5380-6B and ASTM Standard D5340. Table 1 presented the results of the pavement condition survey. In addition, figure 1 shows the location of the sections being analyzed and their inspected PCI.

Condition data are not directly used in a structural analysis; however, it should be considered when determining the final PCN to publish. For example, if a pavement is exhibiting a significant amount of load-related distresses, it is an indication that the current traffic is already exceeding the limits that the structure can support.

Table 1. Pavement evaluation results.

Branch[1]	Section[1]	Section Area (sf)	LCD[2]	2012 PCI	% Distress due to: Load[3]	% Distress due to: Climate, Durability, or Other[4]	Load Related Distress Types Present
RW1432-DK	5	510,000	8/3/2001	80	0	100	None Observed
	10	97,500	8/2/2001	75	0	100	None Observed
	15	32,500	8/3/2001	84	0	100	None Observed
RW725-DK	5	75,000	8/3/1998	85	0	100	None Observed
	10	263,550	8/3/1998	77	0	100	None Observed
	12	7,725	8/3/2001	68	0	100	None Observed

[1] See figure 1 for the location of the branch and section.
[2] LCD = last construction date.
[3] Distress due to load includes distresses attributed to a structural deficiency in the pavement, such as alligator cracking and rutting.
[4] Distress due to climate or durability includes those distresses attributed to either the aging of the pavement and the effects of the environment or to a materials-related problem, such as block cracking, raveling, or weathering. Other refers to distresses not attributed to one factor but may be caused by a combination of factors, such as depressions, jet-blast erosion, oil spill damage, and swelling.

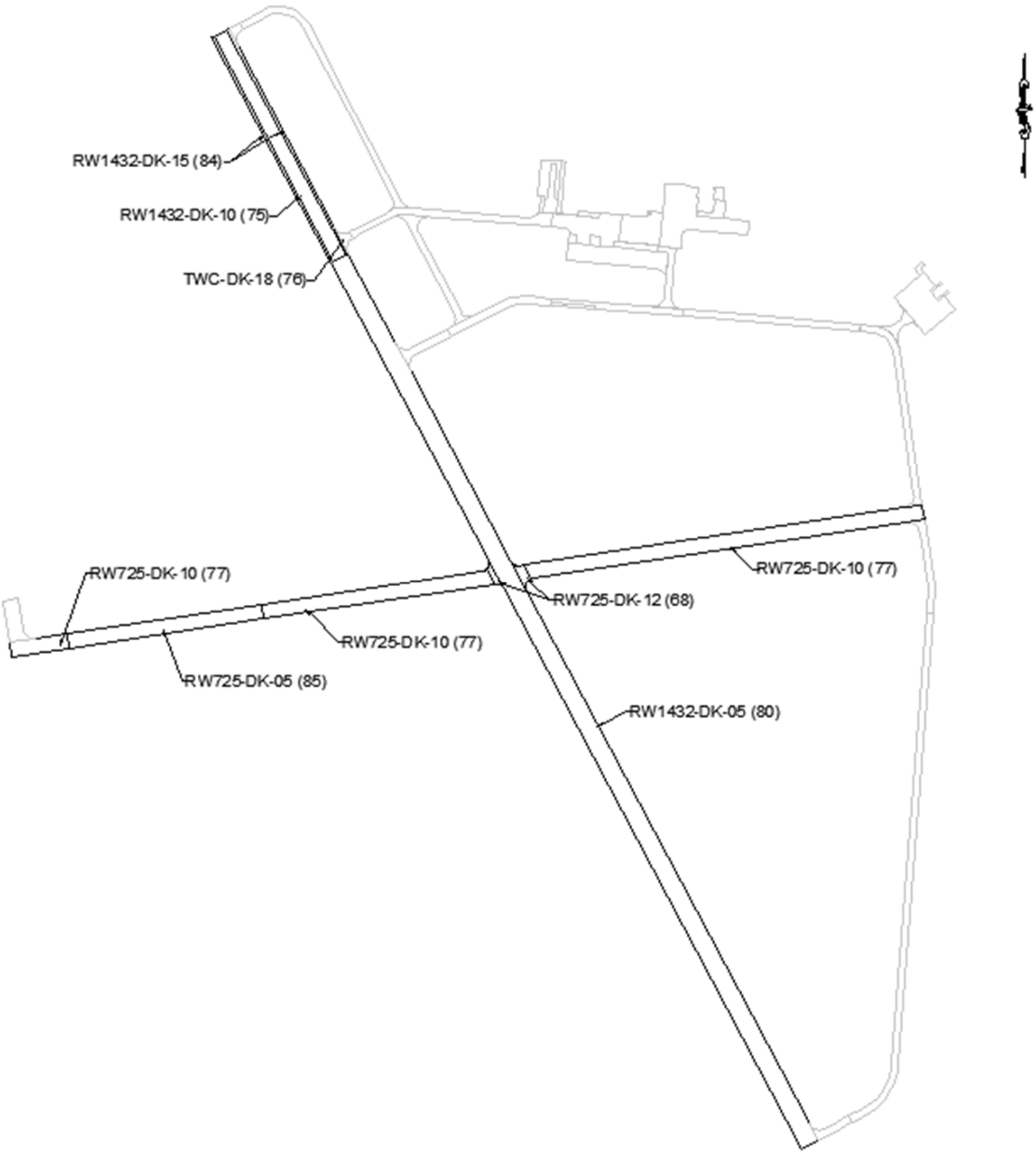

Figure 1. Runway PCN section map with PCIs.

Pavement Inputs for COMFAA

The COMFAA software input values were established through a detailed records review and falling weight deflectometer (FWD) pavement test data. The pavement layer thicknesses were determined from the records maintained in the APMS database. The in-situ properties of the pavement and subgrade, including the California Bearing Ratio (CBR), were calculated using FWD data. The thicknesses of each pavement layer were then used to develop a pavement evaluation thickness; this and the subgrade strength data were used in the COMFAA software in accordance with FAA AC 150/5335-5B, as shown in table 2.

For flexible pavements, the existing cross section is converted to an equivalent standard flexible pavement thickness (the pavement evaluation thickness used by COMFAA) using layer equivalency factors. The CBR and equivalent thickness is not reported for Runway 14-32 Section 15 and Runway 7-25 Section 12 because:

- Section 15 represents the outer 12.5 feet of pavement along the edge of Section 10, which does not see the majority of the traffic loadings. Additionally, records indicate that the structure of section 15 is the same as Section 05; therefore these sections are assumed to have a similar load capacity.
- Section 12 is a small transition section near the intersection of the two runways. The structure of this section exceeds the thickness of the other Runway 7-25 sections and therefore would not be the determining section for the structural capacity of this runway.

Table 2. Pavement cross section, subgrade strength, and equivalent thickness for COMFAA analysis.

	Runway 14-32			Runway 7-25		
Property/Feature	**05**	**10**	**15**	**05**	**10**	**12**
P401	6 in	7 in	6 in	4 in	4.5 in	6 in
P208	12 in	9 in	12 in	6 in	-	12 in
P154	-	-	-	6 in	14 in	-
Subgrade Strength (CBR)	2.4	2.3	-	2.1	1.2	-
Subgrade Category	D	D	-	D	D	-
Evaluation Thickness	19.3 in	18.6 in	-	17.3 in	17.6 in	-

Airport Traffic Mix

The entire aircraft traffic mix, in terms of 20-year average annual departures, is entered directly into COMFAA. Information on the traffic mix, distribution, and future projections were provided by Ulteig Engineers using the FAA's Terminal Area Forecast and Air Traffic Activity Data System. The traffic mix specifying the aircraft type/model, maximum take-off weight (MTOW), aircraft gear configuration, tire pressure, and 20-year average annual departures for each runway is summarized in table 3.

It should be noted that for the portion of Runway 14-32 that contains the intersection of the two runways, the entire traffic mix was considered. A second analysis included the addition of an Embraer ERJ 145LR (48,500 lb MTOW) to the traffic mix to evaluate the impact of 2 daily departures with 95% use being on Runway 14-32 and 5% use on Runway 7-25.

Table 3. Projected 20-year average annual departures.

Aircraft Type	MTOW, lbs	Gear Config.	Tire Pressure, psi	20-Year Average Annual Departures	
				Runway 14-32	Runway 7-25
B-52 Stratofortress	488,000	D2	286	1	0
B707-300	336,000	2D	180	1	0
B737-700	155,000	D	205	1	0
BAe HS 125/Hawker 800	27,520	D	135	39	0
Beechcraft 1900/C-12J	17,100	D	92	143	8
Beechcraft 35 Bonanza	3,412	S	40	43	21
Beechcraft 58 Baron	5,424	S	56	46	23
Cessna 172 Skyhawk	2,558	S	50	26	13
Cessna 182 Skylane	3,110	S	50	26	13
Cessna 206 Stationair	3,612	S	52	24	12
Cessna 208 Grand Caravan	8,750	S	75	322	107
Cessna 210 Centurion	4,100	S	50	14	7
Cessna 414 Chancellor	6,750	S	62	56	28
Cessna Citation II/Bravo	15,000	S	130	98	0
Cessna Citation III/VI/VII	23,200	D	168	30	1
Cessna Citation Sovereign	30,300	D	160	7	0
Cessna Citation V/Ultra/Encore	16,500	S	130	146	0
Cessna Citation X	36,000	D	189	10	0
Cessna CitationJet/CJ1	10,500	S	98	119	6
Cessna Conquest	9,925	S	95	65	11
Challenger 600/601/604	48,200	D	145	5	0
Dash 8/DHC8-300	43,000	D	107	1	0
EMB-120 Brasilia	25,300	D	94	1563	0
Dassault Falcon 2000	41,000	D	145	1	0
Dassault Falcon 900	45,500	D	145	4	0
Dassault Falcon/Mystère 50	38,800	D	208	98	0
Gulfstream Commander	10,250	S	50	23	2
Gulfstream G200/IAI 1126 Galaxy	66,000	D	169	2	0
Gulfstream III/G300	70,200	D	175	1	0
Gulfstream IV/G400	75,000	D	185	4	0
Gulfstream V/G500	90,900	D	188	7	0
King Air 100	11,500	D	52	16	7
King Air 90	9,710	S	58	58	19
Learjet 35/36	18,000	D	171	19	0
Learjet 55	21,500	D	201	19	0
North American Rockwell Sabre 75	20,372	S	214	37	0
Pilatus PC-12 Spectre	10,450	S	75	87	29
Piper 31/32/34	6,536	S	66	192	94
Ratheon T-1/BeechJet 400	15,500	S	90	9	0
Super King Air 200	12,590	D	98	70	23
Super King Air 350	15,100	D	92	91	30
Swearingen SA-226T/TB Merlin 3	13,230	D	62	267	89

ACN Overview

According to FAA AC 150/5335-5B, the ACN is defined as a number that expresses the relative effect of an aircraft at a given weight on a pavement structure for specified standard subgrade strength. Higher ACNs indicate an aircraft has a more severe effect on the pavement, while lower values indicate a less severe effect. ACNs are reported for each subgrade strength category. Stronger subgrade support conditions (e.g., granular subgrade soils with higher CBRs) result in a lower ACN than weaker subgrade support conditions. The ACN has a minimum value of 0 and no upper limit.

Tables 4 and 5 provide ACNs for the most critical aircraft in the traffic mix for Runways 14-32 and 7-25, respectively. Only ACNs for subgrade strength category D, which is the subgrade support category determined for both runways, are shown, as determined using COMFAA 3.0.

Table 4. ACNs for most critical aircraft on Runway 14-32.

Aircraft Type	MTOW, lbs	Gear Config.	Tire Pressure, psi	ACN for Flexible Pavement with Subgrade Category D
B-52 Stratofortress	488,000	D2	286	91
B707-300	336,000	2D	180	71
B737-700	155,000	D	205	47
Gulfstream V/G500	90,900	D	188	31
Gulfstream IV/G400	75,000	D	185	25
Gulfstream III/G300	70,200	D	175	24

Table 5. ACNs for most critical aircraft on Runway 7-25.

Aircraft Type	MTOW, lbs	Gear Config.	Tire Pressure, psi	ACN for Flexible Pavement with Subgrade Category D
Embraer ERJ-145LR	48,500	D	160	17
Cessna Citation III/VI/VII	23,200	D	168	8
Beechcraft 1900/C-12J	17,100	D	92	5
Super King Air 350	15,100	D	92	5
Cessna CitationJet/CJ1	10,500	S	98	4
Cessna Conquest	9,925	S	95	4

A list of ACNs for common aircraft is shown in table 6 to assist decision makers with determining whether the pavements evaluated can realistically support other aircraft not currently included in the traffic mix. The ACNs were determined using COMFAA and are presented for the pavement types and subgrade strength categories associated with Runways 14-32 and 7-25 at Dickinson Regional Airport. As previously stated, the PCN should be recalculated if the aircraft mix or volume experiences significant changes.

Table 6. ACNs for typical aircraft not necessarily in traffic mix.

Aircraft Type	MTOW, lbs	Gear Config.	Tire Pressure, psi	ACN for Flexible Pavement with Subgrade Category D
B777-300ER	777,000	3D	221	120
B787-8 Dreamliner	502,500	2D	220	110
A380-800	1,235,000	2D/3D2	218	105
AN-225	1,322,750	7D	162	102
B767-400	451,000	2D	215	100
B747-400	877,000	2D/2D2	200	94
B-52 Stratofortress	488,000	D2	286	91
A300-B4-600	380,518	2D	194	85
DC-8-63	358,000	2D	196	81
C-17A Globemaster III	585,000	2T	138	74
KC-135 Stratotanker	322,500	2D	170	68
A310-200	315,041	2D	193	65
A321-100	183,866	D	197	59
C-5B Galaxy	837,000	C5	106	55
B727-100	170,000	D	165	53
B757-200	256,000	2D	183	53
A320-200	162,922	D	200	50
B737-700	155,000	D	205	47
A319-100	141,978	D	173	42
C130 Hercules	155,000	2S	105	38
Gulfstream V/G500	90,900	D	188	31
Embraer 170	79,700	D	126	26
F-16 Fighting Falcon	42,300	S	215	18
Falcon/Mystere 20	28,660	D	133	9
Super King Air 350	15,100	D	92	5
Cessna 182 Skylane	3,110	S	50	1

PCN Results

While the PCNs were calculated for each pavement section, a single PCN is typically reported to represent a given runway. The controlling PCN is normally the weakest segment of the pavement, but engineering judgment must also be considered (e.g., if the weakest segment is not in the most heavily used portion of the runway). Based on the structural capacity analysis, the PCNs for each runway are shown in table 7. These PCNs should be reported to the regional FAA Airports Division in writing using the document provided at the end of this appendix.

Table 7. PCN results by runway.

Runway	PCN Designation	
	Existing Traffic	Addition of Embraer ERJ 145LR
Runway 14-32	20 F/D/W/T	12 F/D/W/T
Runway 7-25	6 F/D/W/T	5 F/D/W/T

The resulting PCN for Runway 14-32 is 20 F/D/W/T based on the 20-year average annual departure traffic, excluding the Embraer ERJ-145LR. This PCN is based on the structural capacity of Section 10. There are several aircraft included in the traffic mix that have ACNs exceeding the calculated PCN for Runway 14-32, indicating that the existing structure is not adequate for the current traffic mix as shown in figure 2. However, the aircraft with ACNs exceeding the calculated PCN for Runway 14-32 have a limited number of annual departures (less than once a month). Overload guidance is provided at the end of this memorandum to assist with addressing these infrequent heavy aircraft.

When the Embraer ERJ-145LR was included in the analyzed traffic for Runway 14-32, the calculated PCN decreased to 12 F/D/W/T. The Embraer ERJ-145LR has an ACN of 17 for pavements with a subgrade category of D, which exceeds the PCN determined for Runway 14-32 when it is included in the traffic mix. Because this aircraft is being considered for regular operations and its ACN exceeds the PCN, it is not recommended that the Embraer ERJ-145LR operate on a regular basis without increasing the structural capacity of Runway 14-32.

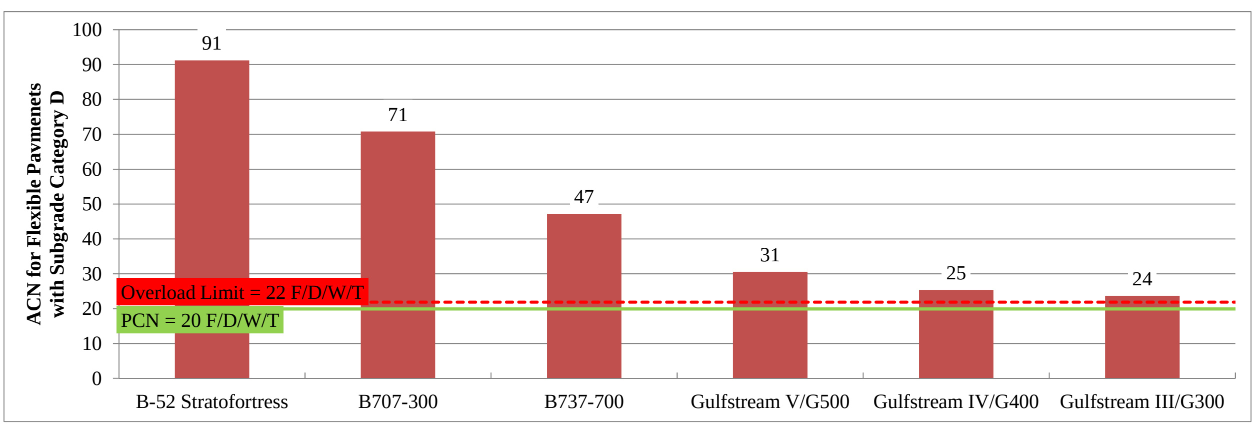

Figure 2. ACN-PCN comparison for Runway 14-32.

The recommended PCN for Runway 7-25 is 6 F/D/W/T, with Section 10 being the controlling section. The Cessna Citation III/VI/VII has an ACN greater than the report PCN of Runway 7-25 as shown in figure 3. The Cessna Citation III/VI/VII has only one average annual departure. The determined PCN for Runway 7-25 is 5

F/D/W/T if the Embraer ERJ 145LR is added to the traffic mix. With the Embraer ERJ-145LR having an ACN of 17, it should not operate on Runway 7-25 given the existing pavement structure.

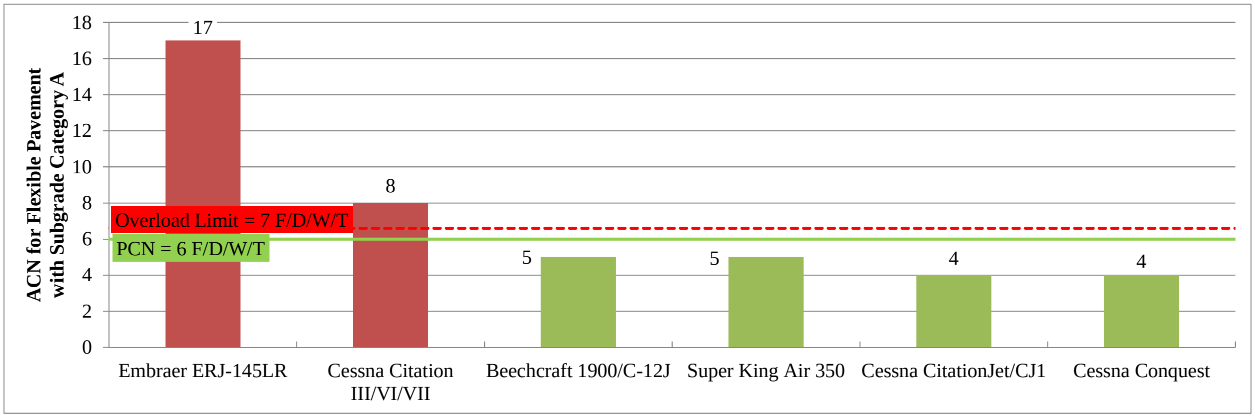

Figure 3. ACN-PCN comparison for Runway 7-25.

Additionally, the PCN of the runway intersections were calculated using the combined traffic of the runways analyzed. The resulting PCN did not decrease from 20 F/D/W/T, analyzing the structures associated with Runway 14-32 Section 10 and the additional traffic.

For aircraft with an ACN that exceed the recommended PCN, ICAO overload guidance can be referenced. While pavement overloads are expected to decrease pavement life, they do not typically cause immediate or catastrophic failures unless they are extremely excessive. Alternatively, the indicated aircraft may be able to safely use these facilities (following the ACN-PCN procedure) by operating at less than the MTOW. If these aircraft do not operate at the MTOWs, then the PCN should be recalculated using the revised weights.

Overload Guidance

In general, for flexible pavements, aircraft in excess of 10 percent of the reported PCN should be restricted. Exceeding these recommendations may result in a reduced pavement life. Appendix 4 of FAA Advisory Circular 150/5335-5B presents the following guidance for pavement overloads (taken from ICAO manual):

- For flexible pavements, occasional traffic cycles by aircraft with an ACN not exceeding 10 percent above the reported PCN should not adversely affect the pavement.
- The annual number of overload traffic cycles should not exceed approximately 5 percent of the total annual aircraft traffic cycles.
- Overloads should not normally be permitted on pavements exhibiting signs of [load-related] distress, during periods of thaw following frost penetration, or when the strength of the pavement or its subgrade could be weakened by water.

Where overload operations are conducted, the Airport should review the relevant pavement condition on a regular basis, as well as the criteria for overload operations periodically since excessive repetition of overloads can cause severe shortening of pavement life or require major rehabilitation of the pavement.

Project info

Pavement Classification Numbers for Dickinson Theodore Roosevelt Regional Airport (DIK) Runways

FLEXIBLE PAVEMENT

- ○ A Subgrade Category (CBR 15)
- ○ B Subgrade Category (CBR 10)
- ○ C Subgrade Category (CBR 6)
- ● D Subgrade Category (CBR 3)

RIGID PAVEMENT

- ○ A Subgrade Category (k 552 pci)
- ○ B Subgrade Category (k 295 pci)
- ○ C Subgrade Category (k 147 pci)
- ○ D Subgrade Category (k 74 pci)

TIRE PRESSURE

- ● W Unlimited
- ○ X 218 psi
- ○ Y 145 psi
- ○ Z 73 psi

METHOD USED

- ○ Using Aircraft
- ● Technical

AIRCRAFT GEAR TYPE IN TRAFFIC MIX

- ☑ S (single wheel gear)
- ☑ D (dual wheel gear)
- ☑ 2D (dual tandem wheel gear)
- ☐ 3D (triple tandem wheel gear) e.g B-777
- ☐ W/B (tandem gear under wing AND tandem gear under body) e.g. B-747, A-340-600, A-380

Enter PCN 19.9

FAA Form 5010 Data Element	Gross Weight and PCN
#35 S gear	51
#36 D gear	67
#37 DT gear	116
#38 DDT gear	
#39 PCN	20/F/D/W/T

Airport LOC-ID DIK

Pavement ID Runway 14-32

IF 3D or W/B Gear Checked, #38 = PCN

Please Add Data Element #38 Remark

3D	
2D/2D2	
2D/3D2W	
2D/3D2B	

} **Report Minimum Gross Weight**

Airport LOC-ID	Pavement ID	#35 S GW	#36 D GW	#37 DT GW	#38 DDT GW	#39 PCN
DIK	Runway14-32	51	67	116		20/F/D/W/T
DIK	Runway 7-25	16.5	<min			6/F/D/W/T

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