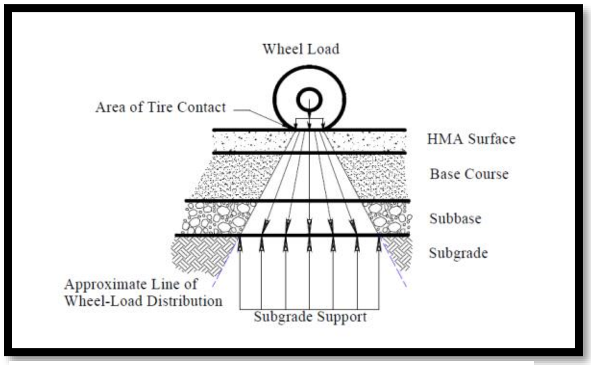
APPENDIX G - AIRFIELD PAVEMENTS

Pavement is one of the most important infrastructure features of an airport. If an airport has failing pavement (runway, taxiway, or apron), aircraft operations will suffer and can affect aircraft safety. Implementing an effective airport pavement maintenance-management program airport is a grant assurance requirement for airport owners that accept Federal funds.

When considering pavement design, construction and maintenance, certain elements need to be considered in order to develop pavement surfaces. Some of these elements include but are not limited to the design aircraft that serves the airport, economic factors, weather conditions, the location of the airport, and personal preference of the owner/operator. This appendix highlights general knowledge of airfield pavements and things to consider when viewing the pavement at Minot International Airport (MOT).

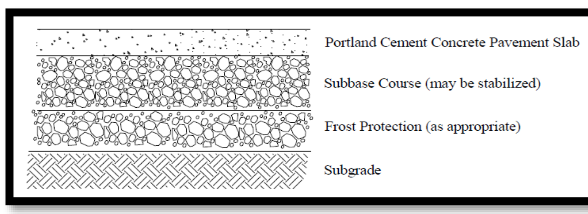
Types

There are two main types of pavement on an airfield; one type is Hot-Mix Asphalt (HMA). HMA is a flexible-type of pavement, and distributes aircraft weight through the layers below the asphalt surface (See exhibit to right). When constructed, the HMA surface is in a smooth state. This is a result of the application method of rolling the surface for proper compaction.



Source: FAA Advisory Circular 150/5380-6B

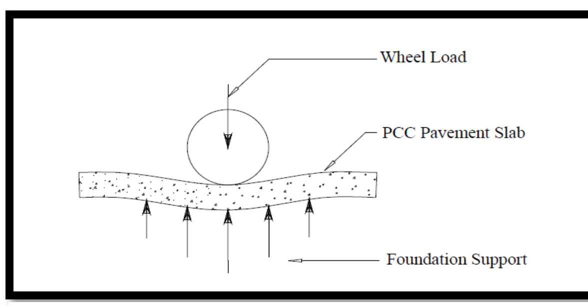
The second type of pavement found at an airport is Portland Cement Concrete (PCC). This type of pavement is known as rigid pavement, and distributes weight evenly across the surface (See exhibit to right). When initially poured, the PCC surface is a smooth surface.



Source: FAA Advisory Circular 150/5380-6B

Both HMA and PCC have FAA specifications and design criteria. HMA is typically referred to as “P-401”, and PCC is typically referred to as “P-501”. P-401 and P-501 are FAA specifications that contain requirements for the materials used in the pavement such as aggregate, bituminous or cement material, or any admixtures. These specifications also contain requirements for proper construction, quality control, and quality assurance. For further details, refer to the current version of FAA Advisory Circular 150/5370-10, *Standards for Specifying Construction of Airports*.

The typical pavement sections for the airfield pavements at MOT are identified in **Table G-1**. Please note that these are average thicknesses of surface and base materials and may not be reflective of actual conditions for all portions of the pavements.



Source: FAA Advisory Circular 150/5380-6B

Surface Texturing/Measuring

Because both HMA and PCC initially have a smooth surface when constructed, it is important to look at methods that increase the friction of the surface. This can be completed for either surface type by grooving. Grooving tends to be the most common type of surface treatment, and is typically constructed by cutting transverse grooves, 1 1/2 inches apart, and 1/4 inch deep the entire length of the runway after the pavement has set. These saw cut grooves help with water runoff and reduce the risk of aircraft hydroplaning during wet runway conditions.

Moreover, contractors can also use a brush/broom finish, burlap dragging, or wire combing to increase the friction of PCC surfaces on taxiways and aprons. Other methods to increase surface friction for HMA consist of Porous Friction Course (PFC), Chip Seals, and Aggregate Slurry Seals. The ultimate goal in this process is to give the aircraft greater friction and better maneuverability during adverse weather conditions.

Table G-1 – MOT Typical Pavement Sections

Area	Surface	Base	Aggregate Base	Subbase
Runway 13-31	13” Concrete (P-501)	-	6” (P-209)	10” (P-165)
Runway 8-26 (East Extension)	6.5” Asphalt (P-401)	-	6” (P-209)	10” (P-156 & P-165)
Taxiway B	13.5” Asphalt (P-401)	3” (P-201)	6”	-
Taxiway B2	4.5” Asphalt (P-401)	-	9” (P-208)	-
Taxiway C	6.5” Asphalt (P-401)	-	10” (Blended)	16” (P-154)
Taxiway C3 (West of Taxiway B)	6.5” Asphalt (P-401)	-	8” (P-209)	-
Taxiway C3 (East of Taxiway B)	9.5” Asphalt (P-401)	12” (P-201)	-	-
Taxiway D (West of 13-31)	12.5” Asphalt (P-401)	-	24” (P-209)	-
Taxiway D (East of 13-31)	6.5” Asphalt (P-401)	-	6” (P-209)	20” (P-154)
Taxiway E	5.5” Asphalt (P-401)	-	6” (Gravel)	-
Taxiway F	4” Asphalt (P-401)	-	9” (Blended)	-
Old Airline Apron	15” Concrete (P-501)	4” (P-407)	9” (P-208)	-
New Airline Apron	16” Concrete (P-501)	6” (P-306)	14” (P-209)	-
GA Apron (Central)	12” Concrete (P-501)	-	6” (Blended)	-
GA Apron	4” Asphalt (P-401)	-	9” (Blended)	-
GA Taxilanes	4” Asphalt (P-401)	-	7” (P-208)	-
Cargo Apron	5.5” Asphalt (P-401)	-	6” (Gravel)	-

Source: MOT PCN Summary Condition Report (2013), North Dakota Aeronautics Commission Pavement Condition Assessment (2012), *KLJ Construction Plans. NOTE: Least robust sections shown for each area*

At commercial service airports, it is a requirement to monitor the level of friction provided by pavements during adverse weather conditions. This can be completed by operations personnel on the field monitoring the braking action of various surfaces with friction measurement equipment. On runways and taxiways used by commercial service aircraft, Continuous Friction Measurement Equipment (CFME) or Decelerometers are utilized to give specific values of friction that are associated with a piece of pavement. This value, known as a “M_u”, is a percentage from 0-100 percent (100 percent being absolute friction and 0 percent no friction whatsoever). A Mu reading of less than 40 requires that a Notice To Airman (NOTAM) be issued to alert aircraft using the airport that less than optimal friction is available for braking action.

A CFME can be used when calculating the general friction of the runway. When aircraft continually land on a section of pavement, a build-up of rubber can occur. This build up, known as rubber-reversion, collects rubber on the pavement section and decreases the M_u value.
At an airport serving general aviation aircraft only, pavement friction is not required to be monitored by friction measuring equipment during adverse weather conditions. This pavement is monitored by operations personnel and presented with values of braking action reported as good, fair, poor, or nil. The surface treatment for runways at MOT is identified in **Table G-2** below:

Table G-2 – MOT Runway Surface Treatment

Runway	Surface Treatment
Runway 13-31	Grooved Concrete
Runway 8-26	Grooved Asphalt

Source: FAA Airport Master Record

Strength

Pavement strength is driven by multiple factors. Initially, the airport needs to determine the design aircraft that will be using the airport. The design aircraft can be determined by one single-most demanding aircraft, or a mix of the most demanding aircraft that drive similar standards. By identifying the design aircraft, the airport can determine the pavement strength needed for the pavement surfaces on the airfield.

After determining the design aircraft, the FAA has identified a standard method to report pavement strength at an airport. In the aviation world, there are two types of pavement strength classification; Utility and Other-Than-Utility. Utility pavements are capable of handling aircraft of up to 12,500 pounds maximum gross weight, while Other-Than-Utility pavements are capable of handling aircraft greater than 12,500 pounds.

If the design aircraft is 12,500 pounds or less, the pavement strength reporting remains fairly simple and straight forward. However, if the design aircraft is determined to have a maximum gross weight of greater than 12,500 pounds, the ACN-PCN[1] method is used to calculate what the pavement is capable of handling. Aircraft Classification Number (ACN) is the number that expresses relative effect of an aircraft at a given configuration on a pavement structure for a specified subgrade strength. The Pavement Classification Number (PCN) is a number that expresses the load-carrying capacity of a pavement for unrestricted operations. A technical evaluation of PCN uses pavement type, subgrade strength and fleet mix data. The ACN-PCN method of determining pavement strength does have some drawbacks. It is only intended to report relative pavement strength (so airport operators can evaluate acceptable operations of aircraft), but it is not intended for pavement design. **Table G-3** identifies the standard ACN-PCN reporting format.

[1] Refer to FAA Advisory Circular 150/5335-5C "Standardized Method of Reporting Airport Pavement Strength – PCN" for additional background.

Table G-3 - ACN-PCN Reporting Format

	Pavement Type	Subgrade Strength (CBR)	Tire Pressure (psi)	Method of Determination
Numerical Value	R - Rigid	A - High (≥ 13 CBR)	W - no limit	T - Technical Study
		B - Medium (>8 but < 13 CBR)	X - 182-254	
	F - Flexible	C - Low (>4 but ≤ 8 CBR)	Y - 74-181	U - Using Aircraft
		D - Ultralow (≤ 4 CBR)	Z - 0-73	
###	/ R or F	/ A, B, C or D	/ W, X, Y or Z	/ T or U

Source: FAA Advisory Circular 150/5335-5C

Airports certificated under FAR Part 139 are required to publish PCN values for air carrier runways. A PCN determination was prepared for MOT in 2013 as a deliverable from the 2012 Airport Pavement Condition Index Study completed for the North Dakota Aeronautics Commission. The PCN calculations from this report are identified in **Table G-4**.

Table G-4 - Published ACN-PCN for MOT Runways

	Runway 13/31	Runway 8/26
Pavement Classification Number (PCN)	43/R/C/W/T	34/F/D/W/T

Source: FAA Airport Master Record, MOT PCN Summary Condition Report (2013)

Despite the requirement to publish PCN values for runways at certificated airports, many runways including those at MOT still publish a weight bearing capacity rating based on single-wheel (SW), dual-wheel (DW), dual-tandem (DTW) and/or dual double-tandem (DDTW). **Table G-5** identifies the current published MOT weight bearing capacity on runways.

Table G-5 - Published Weight Bearing Capacity for MOT Runways

Runway	Weight Bearing Capacity		
	SW	DW	DTW
Runway 13-31	120,000 lbs.	150,000 lbs.	240,000 lbs.
Runway 8-26	120,000 lbs.	150,000 lbs.	240,000 lbs.

Source: FAA Airport Master Record

Utilizing the technical ACN-PCN method for evaluating pavements and updated aircraft fleet mix data from this master plan study, the following PCN values and weight bearing capacities identified in **Table G-6** are recommended to be published in the MOT Airport Master Record.

Table G-6 - Calculated Existing PCN/Pavement Strength for MOT Runways

Runway	PCN	Weight Bearing Capacity		
		SW	DW	DTW
Runway 13-31	43/R/C/W/T	110,000 lbs.	148,000 lbs.	234,000 lbs.
Runway 8-26	27/F/D/W/T	69,000 lbs.	88,000 lbs.	-

Source: KLJ Analysis

The calculated PCN values resulted in no change to Runway 13-31. Runway 8-26 calculations resulted in a lower PCN based on the current fleet mix of regional jets. This value will reduce if in the future the runway continues to be subjected to this aircraft fleet mix. Both runways should have calculated weight bearing capacity figures adjusted accordingly.

According to FAA AC 150/5335-5C for flexible (HMA) pavements, aircraft in excess of 10 percent of the reported PCN should be restricted from operating at their maximum takeoff weight to avoid potential damage to the pavement. For rigid (PCC) pavements, aircraft in excess of 5 percent of their reported PCN should be restricted. The annual number of overload traffic cycles should not exceed five percent of the total annual aircraft traffic cycles. Regular use of aircraft that exceed the PCN can cause severe shortening of pavement life or require major rehabilitation of the pavement.

The ACN values of common aircraft at their maximum takeoff weight that may regularly operate at MOT are identified below in **Table G-7** for reference. The actual ACN values vary based on the individual aircraft's loading characteristics.

Table G-7 - ACN Values for MOT Critical Design Aircraft

Aircraft Type	Subgrade Strength	Flexible Pavement ACN Value	Subgrade Strength	Rigid Pavement ACN Value
ATR-72	D	15	C	14
Embraer E-145	D	16	C	15
CRJ-200	D	17	C	17
CRJ-700	D	24	C	23
Embraer E-175	D	26	C	25
CRJ-900	D	26	C	26
Runway 8-26 PCN: 27 (Overload: 30)				
Gulfstream V	D	**30**	C	32
Embraer E-195	D	**35**	C	35
Airbus A319-100	D	**36**	C	39
Boeing 757-200	D	**60**	C	45
Runway 13-31 PCN: 43 (Overload: 46)				
Airbus A320-200	D	**51**	C	**48**
MD-83	D	**53**	C	**52**
Boeing 737-800	D	**56**	C	**56**
Airbus A321-200	D	**63**	C	**62**

Source: Transport Canada. Red cells exceed recommended overload ACN values.

For Runway 13-31, a fully-loaded Airbus A320-200 and MD-83 exceed the calculated PCN value. These aircraft currently operate at MOT frequently. This will accelerate pavement damage and wear for regular aircraft operations. Runway 8-26 can accommodate regular use of aircraft as large as a CRJ-900 and Embraer E-175 jet without accelerated pavement damage.

In addition to the runway weight limits described in the previous sections, other airfield pavement have weight limits as described in **Table G-8.** Areas where the pavement does not meet the design aircraft standards include:

- Taxiway E where 41,000 lbs. DW strength is required for regular use of the ATR-42 aircraft (20,000 lbs. existing SW strength)
- Cargo Apron where 41,000 lbs. DW strength is required for regular use of the ATR-42 aircraft (20,000 lbs. existing SW strength)

Per the Airport Master Record, Taxiways B2, D (east of Runway 13-31) and E are limited to aircraft with maximum weight of 12,500 pounds.

Table G-8 – Estimated Weight Bearing Capacity for Other MOT Pavements

Component	Weight Bearing Capacity			PCN
	SW	DW	DTW	
Taxiway B	110,000 lbs.	150,000 lbs.	230,000 lbs.	48/F/D/Y/T
Taxiway B2	20,000 lbs.	-	-	7/F/D/Z/T
Taxiway C	120,000 lbs.	170,000 lbs.	250,000 lbs.	52/F/D/X/T
Taxiway C3 (West of Txy B)	30,000 lbs.	40,000 lbs.	-	12/F/D/Y/T
Taxiway C3 (East of Txy B)	100,000 lbs.	130,000 lbs.		19/F/D/Y/T
Taxiway D (West of 13-31)	120,000 lbs.	250,000 lbs.	420,000 lbs.	91/F/D/Y/T
Taxiway D (East of 13-31)	110,000 lbs.	150,000 lbs.	-	47/F/D/Y/T
Taxiway E	20,000 lbs.	-	-	7/F/D/Y/T
Taxiway F	20,000 lbs.	-	-	8/F/D/Z/T
Old Airline Apron	120,000 lbs.	200,000 lbs.	340,000 lbs.	65/R/C/Y/T
New Airline Apron	120,000 lbs.	250,000 lbs.	420,000 lbs.	82/R/B/Y/T
GA Apron	20,000 lbs.	-	-	7/F/D/Z/T
GA Apron (Central)	100,000 lbs.	125,000 lbs.	-	38/R/D/Y/T
GA Taxilanes	12,500 lbs.	-	-	5/F/D/Z/T
Cargo Apron	20,000 lbs.	-	-	7/F/D/Y/T

Source: KLJ Analysis. Red shaded cells do not meet design aircraft standards.

Markings

Pavement marking is an important aspect of pavement development. Not only does it give the pilot vital information on where they are located on the airfield, but it also can affect the surface friction of the pavement.

More specifically for runway markings, there are two types of paint applications; striated or solid. Striated markings are stripe-like patterns, while solid runway pavement markings do not have any spacing. Pavement heats quicker than paint and, as a result, any exposed pavement will melt any frozen contaminants quicker than what is on a painted surface. By striating the pavement, gaps of exposed pavement can help melt frozen contaminants quicker than if the pavement marking was solid. This increases friction and helps aircraft stop more consistently along the runway. As a result, striated pavement markings are more relevant in northern-climates, where weather contaminants can accumulate and freeze on runway surfaces. Furthermore, striated markings are only used for runway markings, as aircraft are operating at a higher speed. Additional details regarding pavement marking requirements can be found in **Appendix K – Navigational Aids**.

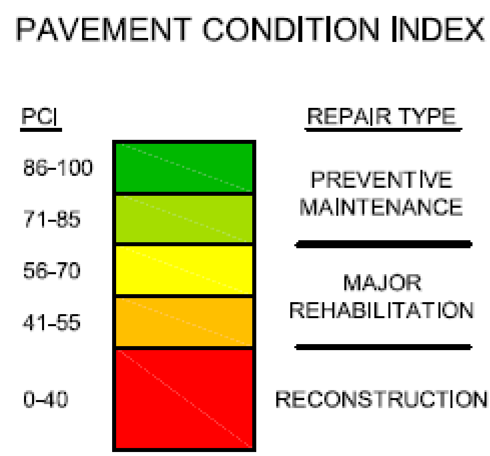
Maintenance

Maintenance is necessary throughout the useful life of the pavement. Moreover, per FAA Grant Assurance #11, federally-funded airports are required to implement a Pavement Preventative Maintenance program. This program assures an effective airport pavement maintenance-management program that will be used throughout the useful life of any pavement constructed, reconstructed, or repaired with federal funds. Pavement distress may include cracking, joint seal damage, disintegration, distortion, or loss of skid resistance. All of these distresses affect the aircraft's ability to maneuver around the airport safely. These distresses can also cause FOD (Foreign Object Debris) to accumulate on the pavement surface which can damage aircraft and compromise safety.

Pavement maintenance can either be contracted out, or serviced by operations/maintenance personnel on the airfield. Some pavement maintenance methodologies include, but are not limited to, patching, crack seals, mill and overlays, rejuvenators, spall-repairs, or slurry seals. Sometimes fabrics are added to HMA pavements, either during initial construction or as a pavement maintenance method (sometimes called pre-pave fabric), and add resistance to typical HMA pavement wear. Typical repair methods for flexible pavement (HMA) can include any of the above, but rigid pavement (PCC) typically is repaired by crack sealing. In the event that pavement has failed or reached the end of its useful life, a complete reconstruction is necessary.

To monitor the distress of pavement at airports, Pavement Condition Index (PCI) Reports are completed periodically. These reports can sometimes be completed on a state-wide basis, and are updated every few years. PCI reports tell the airport owner how distressed their pavement is based on a percentage value from 100 to 0.

From this evaluation, each category of pavement distress requires a certain level of pavement maintenance. Although it may vary from state to state, a graphic depiction of the typical maintenance required for each category is shown below. In addition, the most recent analysis of MOT's pavements, conducted in 2012, is shown in **Table G-8**. Please note, most airport PCI reports include an estimate of costs to maintain or rehabilitate airfield pavements. With this information airport owners can plan for the financial needs of pavement management accordingly. The map of the findings from the 2012 PCI Report are provided in **Exhibit G-1**.



Generally, preventative maintenance is most cost effective when the pavement is still in very good to excellent condition. Pavement rehabilitation is generally required with a range in PCI values between 70 and 50. As PCI decreases, rehabilitation costs generally increase. When the PCI value drops below 40 or 50, rehabilitative actions such as thin asphalt mill and inlay no longer provide the desired performance, and complete reconstruction often becomes the most cost-effective means of repairing the pavement.

A planning-level review of the PCI values at MOT was completed to determine the need for pavement rehabilitation work. All recommendations are made based on existing pavement layout. An in-depth engineering review would be required to determine the actual project scope of work. New design standards or use may necessitate pavement to be rehabilitated to new standards or in at a different time period.

Based on the published 2012 PCI values, the following major pavement reconstruction/rehabilitation projects were recommended in the short-term (within 5 years):

- Cargo Apron (Sec. 50)
- Taxiway E (Sec. 05)
- General Aviation Apron (Sec. 08, 58)[2]
- General Aviation Taxilane (Sec. 02)[3]
- Terminal Apron (Sec. 05, 15)
- Taxiway C3 (Sec. 07, 08)
- Taxiway B2 (Sec. 08)[4]
- Taxiway B (Sec. 05, 10)[4]
- Taxiway D (Sec. 10, 15, 20)[5]
- Runway 8-26 (Sec. 07, 15, 20, 55)[4]

[2] Project was designed and bid in 2015. No AIP Discretionary available to complete the work.
[3] Consider with disposition of adjacent hangars.
[4] Needs to be addressed after solution to Runway 8/26 is determined.
[5] Section 20 and portion of section 15 were replaced with a new alignment of Taxiway D. Remainder of Section 15 still requires rehabilitation. Section 10 is now a component of the Cargo apron.

The following major pavement reconstruction/rehabilitation projects were determined in the mid-term (6 to 10 years) also based on the 2012 PCI values:

- Taxiway C3 (Sec. 05, 10)
- General Aviation Taxilane (Sec. 04)[3]
- General Aviation Apron (Sec. 05, 53)
- Taxiway B (Sec. 15)[4]
- Taxiway C (Sec. 17, 23[6], 30, 35)
- Runway 8-26 (Sec. 05, 10, 25, 30, 40, 50, 60)[4]

Table G-9 – Pavement Condition Index Summary

Component	Minimum Service Level	Lowest Area PCI	Highest Area PCI	LCD**
Runway 13-31	75	87	91	2000-2002
Runway 8-26	75	71	96	1999-2000
Taxiway B	65	57	72	1987-1990
Taxiway C	65	72	100	1998-2012
Taxiway D	65	100*	100*	2013
Old Airline Apron	65	63	65	1990
New Airline Apron	65	100*	100*	2015
General Aviation Apron	60	54	100	1994-2007
Cargo Apron	60	36	36	1987

Source: North Dakota Aeronautics Commission Pavement Condition Assessment (2012)
**Constructed/Reconstructed Subsequent to 2012 PCI Study*
***LCD = Last Construction Date*

[6] Section 23 was reconstructed with the rehabilitation of the northern portion of Taxiway C in 2012.

Exhibit G-1 - MOT Pavement Condition Index (2012)