PCN DETERMINATION – CASE STUDIES AND OBSERVATIONS OF THE FAA PCN METHODOLOGY

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ABSTRACT

The ACN/PCN system for rating airport pavements in the United States is currently based on the procedures set forth in the draft FAA advisory circular AC 150/5335-5B, "Standardized Method of Reporting Airport Pavement Strength - PCN". This document was the result of the efforts of an industry PCN working group, consisting of Boeing, FAA and several private consultants.

AC 150/5335-5B proposes a method of PCN calculation that contains a number of variables which contribute to the final PCN number in varying degrees of significance. This paper, through the use of several case studies performed by Boeing for U.S. airports, describes the sensitivity of the PCN calculation to these variables. Selecting the appropriate final PCN for a pavement entails both engineering judgment and a certain degree of conservatism. The effect of pavement thickness, layer equivalencies, subgrade strength, and traffic mixture on the final PCN rating is covered in detail.

1. BACKGROUND

The PCN or Pavement Classification Number method for rating airport pavements was adopted by the FAA as a means of alleviating some of the confusion frequently seen with the gear type rating system, which was the standard U. S. pavement rating system for many years. In the FAA gear rating system, a pavement was rated according to its gear type and an allowable total aircraft load. For example, a DT350 rating, would allow any dual tandem gear aircraft to operate on a given pavement at an allowable gross weight of 350,000 pounds. One problem encountered with this type of rating is that it does not account for the effect of gear geometry. Therefore, a 757 aircraft with dual tandem geometry of 34 inches by 45 inches was considered equivalent in loading intensity to a 767 aircraft with 45 inch by 56 inch wheel spacing. Additionally, many newer aircraft, such as the six-wheel 777, did not have any type of gear rating available to assess their pavement loading impact.

The FAA released advisory circular AC 150/5335-5A in September 2006, "Standardized Method of Reporting Airport Pavement Strength-PCN" [1]. It was based in part on the 1998 Boeing PCN document D6-82203, "Precise Methods for Estimating Pavement Classification Number" [2]. As airports began using the new FAA PCN methodology, it became apparent that the procedure for determining the critical aircraft in a traffic mix was somewhat flawed, primarily for rigid pavements with high levels of dual wheel aircraft traffic as compared to the widebody traffic. The method assumed that the critical aircraft should be chosen based on the greatest thickness requirement as compared to all the aircraft in the traffic mix. In many cases the smaller dual wheel aircraft were determined to be critical due to their high traffic volume. When used for the PCN determination, the resulting number was much too low to allow all traffic to operate, even when the design thickness chosen was sufficient to handle all traffic in the mix. Clearly, the method was unsound, due in part to undocumented gear and wheel load conversion factors used in the equivalent traffic calculation.

To resolve this dilemma a PCN industry working group was formed in May 2008, consisting of FAA, Boeing and outside consultants. The group devised a new methodology which became the new FAA PCN standard with the draft release of advisory circular AC 150/5335-5B in October 2009 [3]. The new method makes use of the cumulative damage factor (CDF) approach in which each aircraft in a traffic mix contributes some percentage to the overall damage of a pavement during its assumed 20-year design life. Rather than choosing a single critical aircraft, PCN's are computed for all traffic in the mix, and the highest PCN is reported. This CDF methodology also solves the problems encountered with the gear and wheel load factor conversions. The failure models used in the CDF computation are based on the S-77-1 Corps of Engineers CBR method for flexible pavements and the Westergaard edge case method for rigid pavements. Both of these methods account for gear geometry in predicting failure coverages.

The current situation throughout the industry is a general lack of guidance on how to compute PCN. It is stated in ICAO Annex 14 that the PCN computation is left to the discretion of the individual country. The lack of a standard outside the United States leads to wide variation in the PCN computation and often times PCN values that do not reflect the true bearing capability of the pavement. One reporting procedure is simply to note the highest ACN of the current using aircraft and call that the PCN. Other techniques assume a single aircraft at some arbitrary pass level and determine an allowable weight based PCN based on that pass level. Neither of these techniques accounts for the actual traffic operating on the pavement, and hence the resulting PCN may be in question.

2. DESCRIPTION OF THE PCN CUMULATIVE DAMAGE FACTOR METHOD

The cumulative damage factor or CDF method is based on the principle of Miner's Rule, which states that the damage induced in a structure or pavement is proportional to the number of load applications divided by the number of load applications required to fail the pavement. In the PCN analysis each aircraft CDF is simply its 20-year coverages divided by the number of failure coverages. The failure models as noted previously are the CBR method for flexible pavements and Westergaard edge case method for rigid pavements.

Since a single aircraft cannot be designated as the critical aircraft in this new method, each aircraft in the traffic mix is considered critical and evaluated using the equivalent coverages of all the remaining traffic. Equivalent coverages are computed for the critical aircraft by taking the ratio of the coverages to failure of the critical aircraft and all remaining aircraft in the mix, and then multiplying by each remaining aircraft's 20-year coverages. The total summation determines the equivalent coverages and is different for each aircraft in the mix.

For each aircraft's total equivalent coverages, a pavement design thickness can be calculated using the COMFAA software [4]. If the resulting required design thickness for all aircraft in the mix is less than the actual pavement thickness, then the pavement can handle all the traffic, and the resulting PCN should be greater than the highest ACN values. Likewise, if the actual pavement thickness is less than that required by the COMFAA design thickness computation, then the PCN would be lower than some of the ACN values, thereby possibly restricting some operations.

The PCN values for each aircraft in the mix are automatically calculated by the COMFAA program. The PCN is merely the aircraft ACN at its maximum allowable weight. The maximum allowable weight is based on the total equivalent coverages of each aircraft and the actual pavement thickness, and it is an indication of the true bearing strength of the pavement.

Figure 1 shows an example of a COMFAA output file and the details of the terms described in the PCN CDF methodology. Although the subgrade category is C in this example, PCN's for all four categories are calculated by the program. The user should pick the correct subgrade category and the highest PCN in that category. In this case report the PCN as 82/R/C/W/T. Note that the thickness for total equivalent coverages is not only greater than the -6D thickness, but it is less than the evaluation thickness in all cases, indicating that the calculated PCN is adequate for all aircraft.

Evaluation pavement type is flexible and design procedure is CBR
Alpha Values are those approved by the ICAO in 2007.

CBR = 8.00 (Subgrade Category is C)
Evaluation pavement thickness = 33.00 in
Pass to Traffic Cycle (PtoTC) Ratio = 1.00
Maximum number of wheels per gear = 4
Maximum number of gears per aircraft = 4

Results Table 1. Input Traffic Data

No.	Aircraft Name	Gross Weight	Percent Gross Wt	Tire Press	Annual Deps	20-yr Coverages	6D Thick
1	B737-400	138,500	93.82	185.0	208	1,132	19.78
2	MD83	160,000	94.76	195.0	416	2,425	23.98
3	B727-200 Option	209,500	92.96	173.0	2,412	16,080	30.71
4	B747-200B Combi	833,000	90.96	190.0	24	272	21.64
5	B747-400ER	910,000	93.60	230.0	108	1,179	27.35
6	B767-200 ER	395,000	90.82	190.0	12	131	19.03
7	DC8-63/73	355,000	96.12	196.0	1,872	22,372	31.10

Results Table 2. PCN Values

No.	Aircraft Name	Critical Aircraft Total Equiv. Covs.	Thickness for Total Equiv. Covs.	Maximum Allowable Gross Weight	PCN at Indicated Code A(15)	B(10)	C(6)	D(3)	CDF	COV to failure
1	B737-400	>5,000,000	32.67	140,865	34.2	36.3	40.6	44.5	0.0000	42 E6
2	MD83	456,549	32.45	164,674	43.6	47.3	51.3	54.4	0.0033	738,325
3	B727-200 Option	34,652	32.14	218,613	54.6	58.4	65.1	69.9	0.2869	56,039
4	B747-200B Combi	77,565	32.38	853,981	49.4	54.9	67.0	88.0	0.0022	125,438
5	B747-400ER	10,422	32.11	943,910	59.4	66.4	81.8	104.1	0.0700	16,854
6	B767-200 ER	239,228	32.48	403,078	45.9	50.8	61.5	82.1	0.0003	386,877
7	DC8-63/73	54,115	32.38	364,618	49.5	56.5	67.4	83.3	0.2556	87,514

Results Table 3. Flexible ACN at Indicated Gross Weight and Strength

No.	Aircraft Name	Gross Weight	% GW on Main Gear	Tire Pressure	A(15)	B(10)	C(6)	D(3)
1	B737-400	138,500	93.82	185.0	33.5	35.4	39.7	43.7
2	MD83	160,000	94.76	195.0	42.1	45.6	49.6	52.7
3	B727-200 Option	209,500	92.96	173.0	51.9	55.0	61.9	66.8
4	B747-200B Combi	833,000	90.96	190.0	47.9	53.1	64.5	85.2
5	B747-400ER	910,000	93.60	230.0	56.5	63.1	77.4	99.3
6	B767-200 ER	395,000	90.82	190.0	44.7	49.4	59.6	79.9
7	DC8-63/73	355,000	96.12	196.0	47.7	54.3	64.9	80.5

Figure 1 - Example COMFAA Output

3. RIGID PAVEMENT CASE STUDIES

Following are case studies of actual airports along with existing traffic. Complete analyses are shown along with detailed steps so that the results can be replicated. Each case presents its own set of unique problems, meaning that there are no clear-cut steps that can be followed for every case. Rather, each PCN calculation is a reflection of engineering judgment along with the required computer calculations.

3.1. Rigid Case Study No. 1 – Slightly Over-designed Pavement

The first rigid case considers an airport that has a slightly over designed pavement for the traffic that operates on it. Traffic, in terms of annual departures, at this airport is as follows in Table 1.

Figure 2 shows how the effective subgrade strength is calculated from the FAA support spreadsheet. Each supporting layer below the slab contributes towards the effective k-value, with the final PCN subgrade code being based on this computation.

The pavement characteristics are:

- Remaining pavement structural life of 20 years
- 17 inches of portland cement pavement (P-501, MR = 700 psi)
- 6 inches of Econocrete stabilized base (P-306)
- Existing subgrade (average k-value = 193 pci)
- Effective k-value calculated to be 310 pci – Code B (See Figure 2)

Table 1- Rigid Case No. 1 Traffic

Aircraft	**Gear Type**	**MTOW, lb**	**Departures**
MD-80	D	161,000	450
A300-B4	2D	363,763	1,260
A340-300	2D	566,575	502
B747-400ER	2D/2D2	750,000	2,330
B747-8F	2D/2D2	978,000	175
B787-8	2D	503,500	4,098
MD-11ER	2D	633,000	733
A319-100	D	154,322	8,432
A320-200	D	162,000	13,131
A321-100	D	181,220	3,798
B727-200	D	209,500	371
B717-200	D	119,000	4,253
B737-500	D	133,500	6,461
B737-700/800	D	155,500	45,953
B757-200	2D	255,000	28,436
B767-300ER	2D	407,000	5,598
B777-300ER	3D	750,000	2,330
Regional Jet	D	75,000	12,499
L1011	2D	496,000	5
A380-800	2D/3D2	1,239,000	373
Total Annual Departures			141,188

The six most demanding aircraft in the traffic mix are shown in the COMFAA output of Figure 3. Note that the -6D thickness requirements are considerably less than the evaluation thickness, but the CDF thickness is about one inch less. This indicates that the pavement is slightly over-designed for the traffic. One advantage of being slightly over designed is that if traffic increases significantly, there is only a marginal effect on PCN as compared to the existing ACN's. Another is that pavement life is not usually a problem.

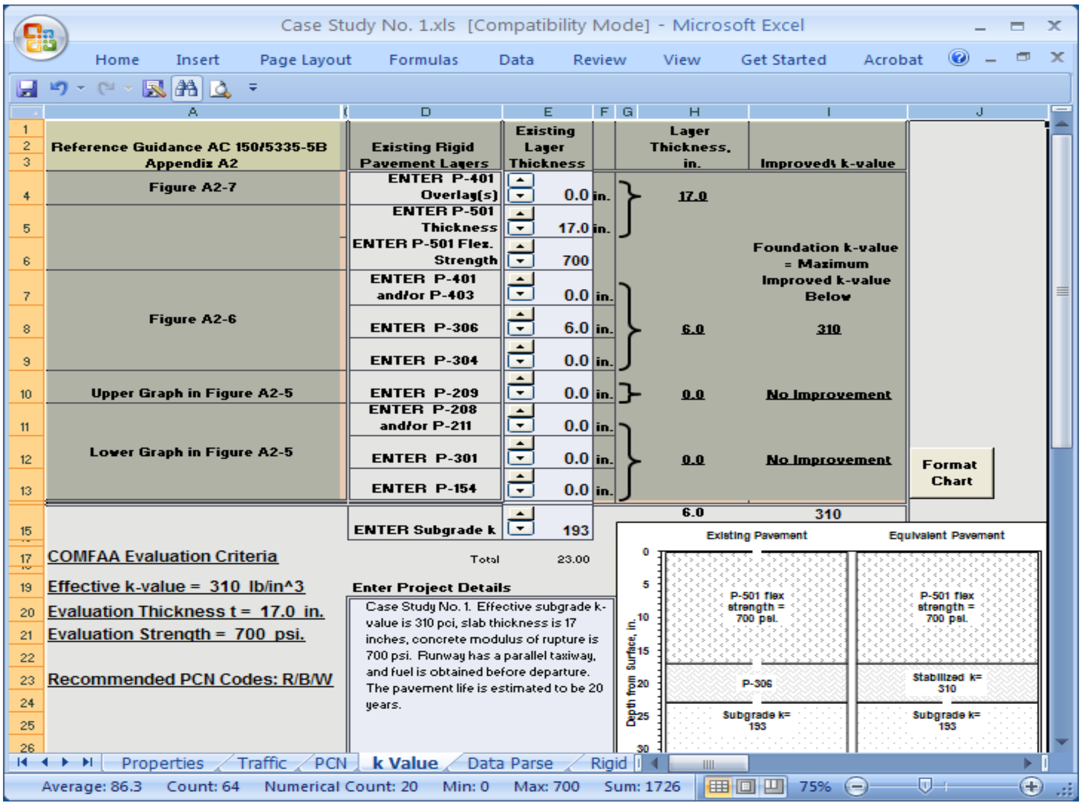
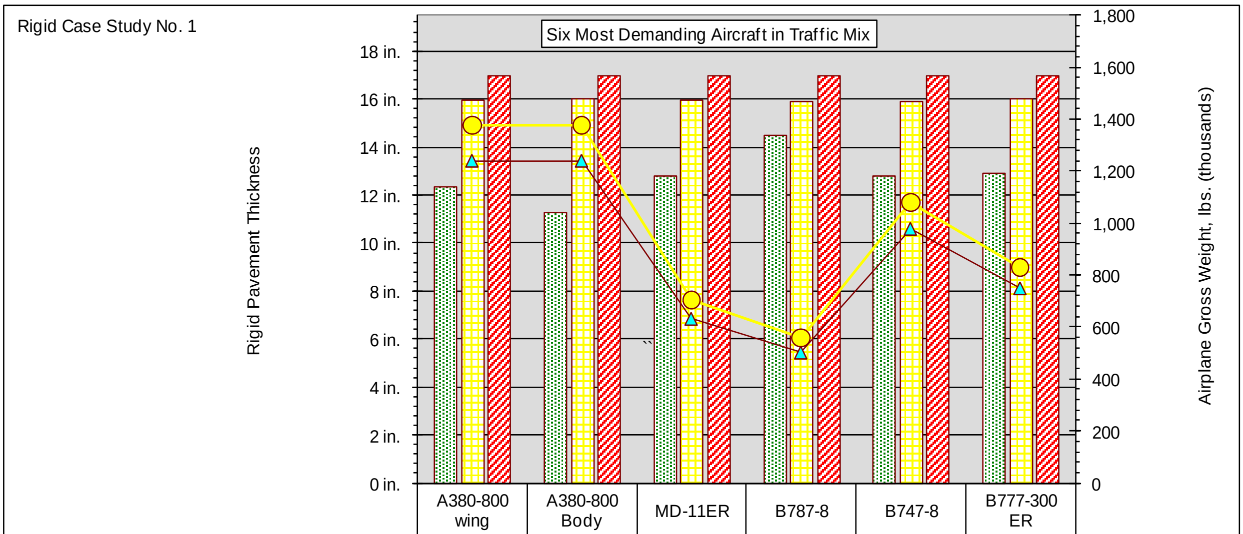


Figure 2 - Calculation of Effective k-value



	A380-800 wing	A380-800 Body	MD-11ER	B787-8	B747-8	B777-300 ER
1. 6D thickness at traffic mix GW	12.3	11.3	12.8	14.5	12.8	12.9
2. CDF thickness at max. GW	16.0	16.1	16.0	15.9	15.9	16.0
3. Evaluation thickness from equivalent pavement	17.0	17.0	17.0	17.0	17.0	17.0
4. Max.Allowable Aircraft GW from CDF	1,377,805	1,374,711	702,485	558,529	1,079,950	827,346
5. Aircraft GW from traffic mix	1,239,000	1,239,000	633,000	503,500	978,000	750,000

Figure 3 - Rigid Pavement Properties

Figure 4 shows the resulting PCN's for each of the six most demanding aircraft as compared to the ACN's. The maximum PCN shown in Figure 4 is 95/R/C/W/T, which is based on the 777-300ER. The "Max. Allowable Aircraft GW from CDF" of 827,346 lb for the 777-300ER, as noted in Figure 3, is the basis for the PCN calculation. In this case the 777-300ER aircraft maximum ACN at this weight is 95/R/C, which reflects the true bearing capacity of the pavement. Note that the ACN's in Figure 4 are based on the evaluation weight in the traffic mix of Table 1 and not the maximum CDF weight.

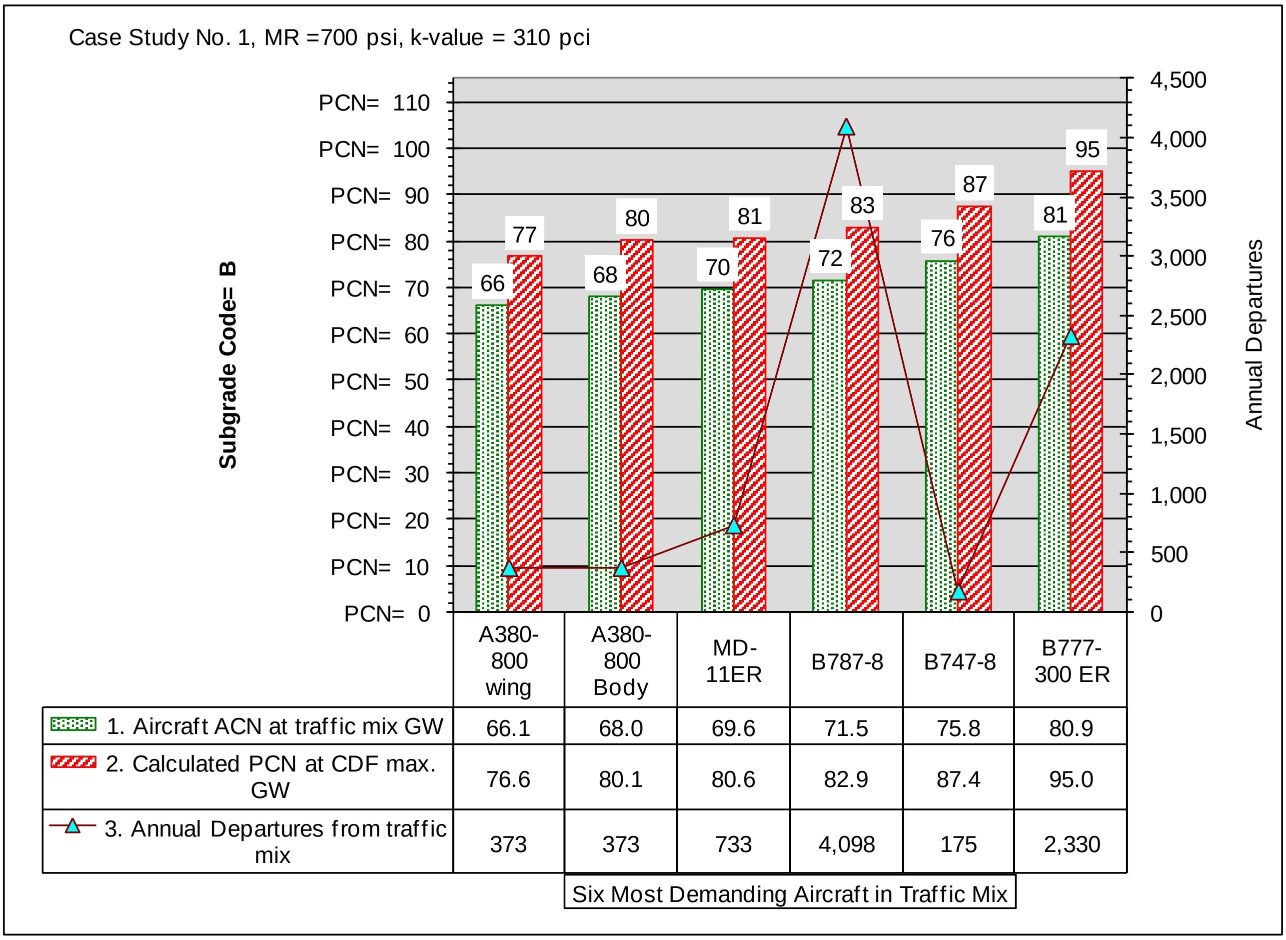


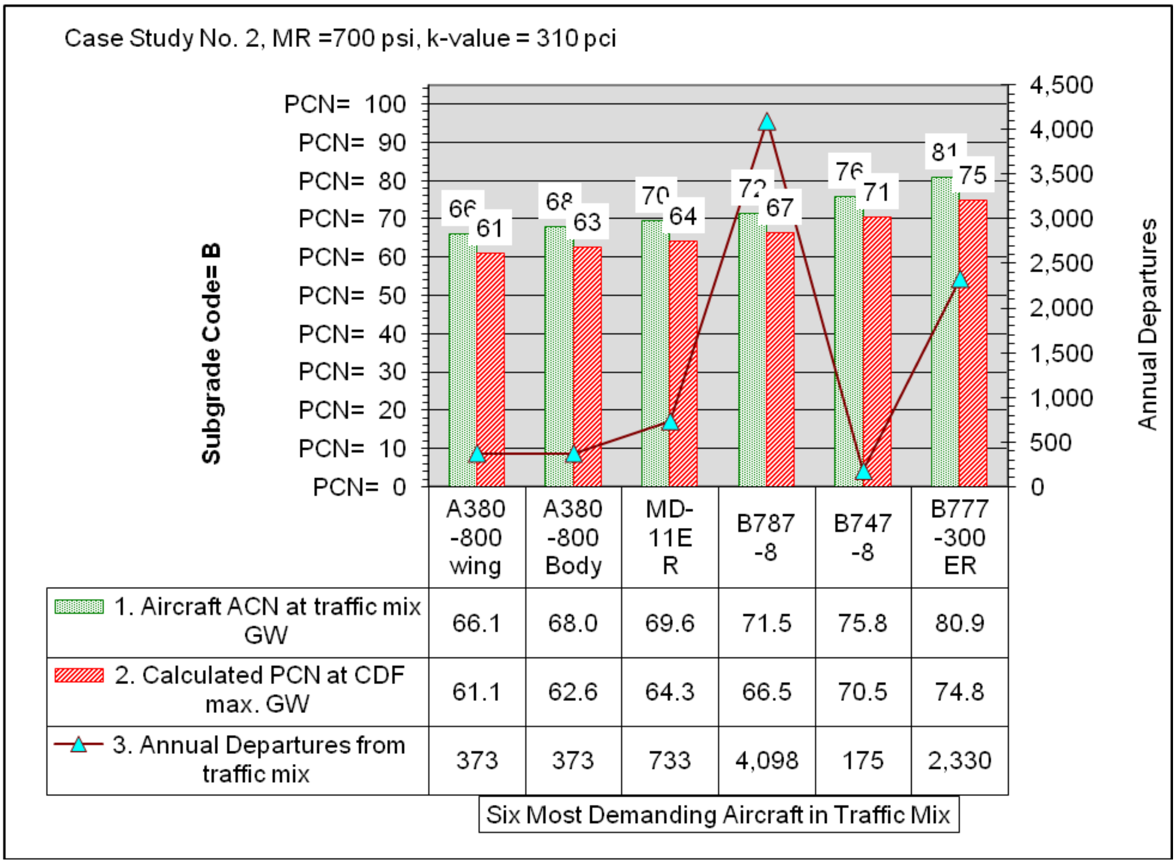
Figure 4 - PCN Results for Rigid Case Study No. 1

3.2. Rigid Case Study No. 2 – Slightly Underdesigned Pavement

This case study uses the same traffic and pavement characteristics as rigid case study no. 1 except that the slab thickness is reduced to 15.5 inches. Results of the PCN calculation are shown in Figure 5. Note that the calculated PCN for each of the aircraft is less than the respective ACN's. This indicates that the pavement will not support the applied traffic for the expected design life in that the PCN of 75/R/C/W/T would potentially restrict the 747-8 and 777-300ER aircraft.

3.3. Rigid Case Study – Sensitivity to Flexural Strength and Slab Thickness

The effect of slab thickness and flexural strength variation on PCN is seen in Figure 6. The slab thickness varies from 15.5 to 17.5 inches, while the flexural strength ranges from 600 to 800 psi. A change in flexural strength from 650 to 700 psi results in a 13 count increase in PCN at a thickness of 17 inches (shown by the dashed lines). Likewise, a decrease from 17 to 16 inches in thickness results in a comparable decrease in PCN (not shown). This points out the importance of reporting accurate thickness and flexural strength in PCN determination.



	A380 -800 wing	A380 -800 Body	MD-11E R	B787 -8	B747 -8	B777 -300 ER
1. Aircraft ACN at traffic mix GW	66.1	68.0	69.6	71.5	75.8	80.9
2. Calculated PCN at CDF max. GW	61.1	62.6	64.3	66.5	70.5	74.8
3. Annual Departures from traffic mix	373	373	733	4,098	175	2,330

Figure 5 - PCN Results for Rigid Case Study No. 2

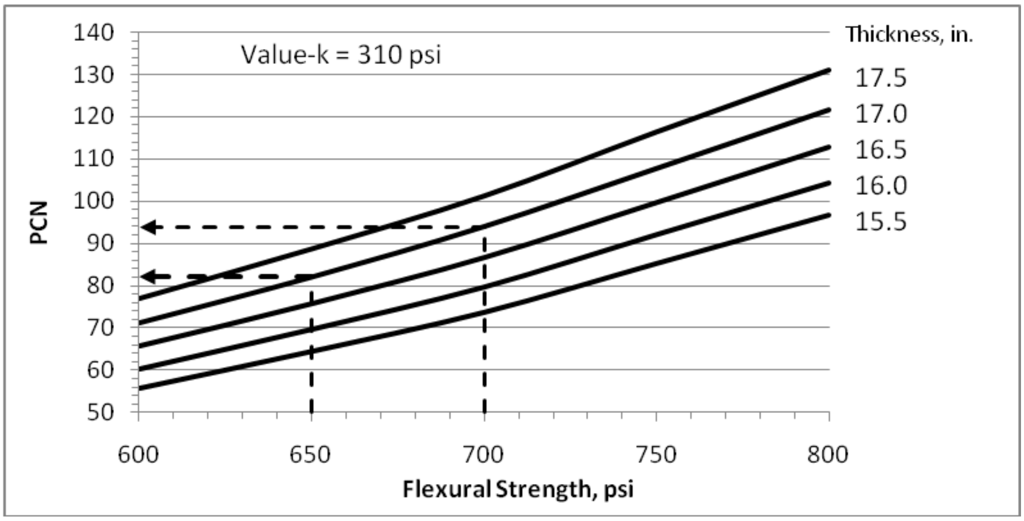


Figure 6 - Effect of Flexural Strength and Slab Thickness on PCN

In Figure 7 the effect of traffic volume and effective subgrade modulus is shown. Changes in these variables have less effect on PCN than do the flexural strength and slab thickness. For example, a reduction of 50 pci in k-value results in only a reduction in 5 PCN counts. The traffic was varied in this example by multiplying all movements by the factors shown. When the traffic is doubled, the PCN drops by about 9 counts at a k-value of 350 pci.

The variations shown in both figures show that, for the conditions indicated, it is more critical to ensure that the flexural strength and slab thickness are correct. While traffic contributes towards the PCN, large increases may not be that critical. However, when a large, heavy aircraft is introduced into an original traffic mix containing only smaller and lighter aircraft, then the effect on PCN will be more substantial.

These parametric examples are for the specific instances shown, and results will be different for other conditions. However, the trends should be similar.

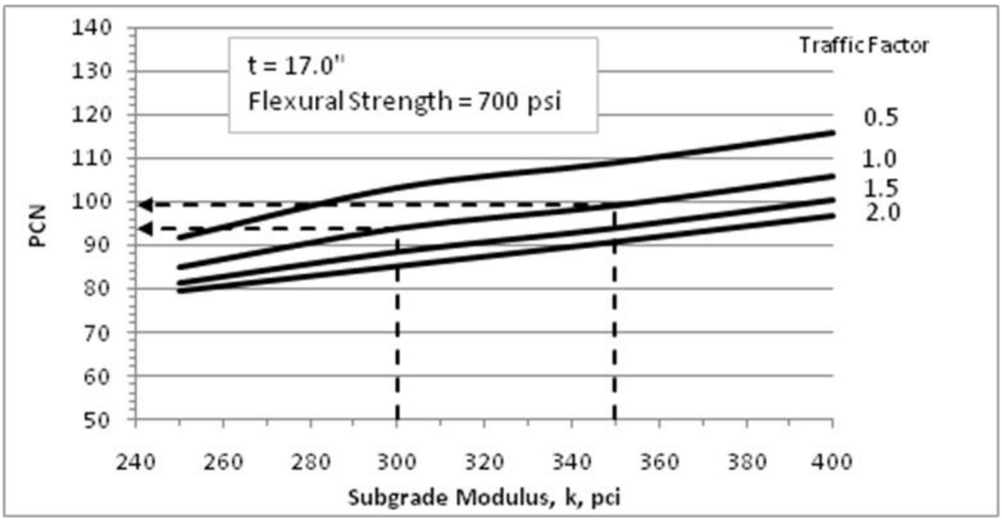


Figure 7- Effect of Traffic and Subgrade Modulus on PCN

4. FLEXIBLE PAVEMENT CASE STUDY

4.1. Flexible Case Study No. 1 – Correctly-designed Pavement

The first flexible case considers an airport that has a correctly designed pavement for the traffic that operates on it. Traffic, in terms of annual departures, at this airport is as follows in Table 2:

Table 2 - Flexible Case No. 1 Traffic

Aircraft	Gear Type	MTOW, lb	Departures
747-400	2D/2D2	877,000	284
747-8	2D/2D2	978,000	27
757-200	2D	256,000	178
717-200	D	122,000	131
737-400	D	150,500	12
737-800	D	174,700	29
767-300	2D	413,000	12
MD-83	D	161,000	626
MD-88	D	150,500	438
C-130	2S	155,000	3,182
KC-135	2D	322,500	3,400
C-5	C5	769,000	20
C-17	2T	575,000	20
An-124	5D	877,400	20
Total Annual Departures			**8,380**

Figure 8 shows how the equivalent thickness is calculated from the FAA support spreadsheet. The equivalency factors used for P-401 and P-209 are 1.6 and 1.4, respectively, which is in line with the current FAA recommendations [5]. Use of other factors can affect the pavement thickness, which in turn has an effect on the PCN.

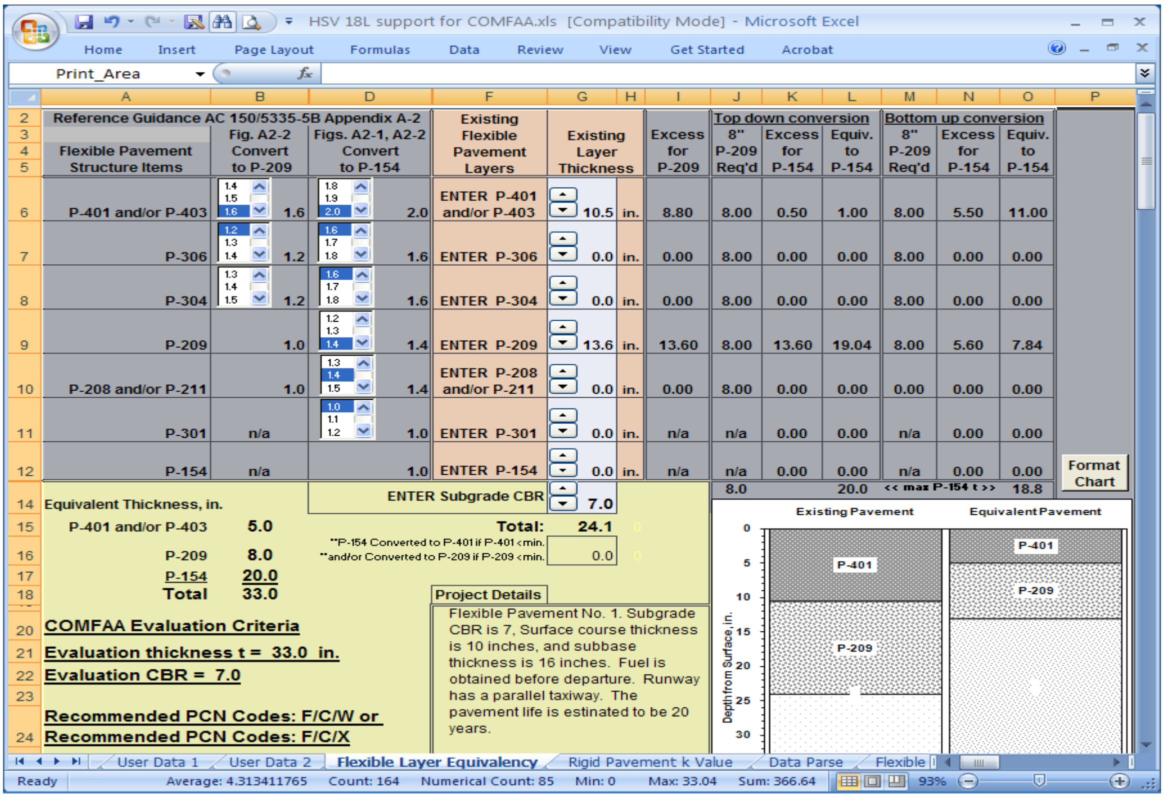


Figure 8 – Determination of Equivalent Thickness

Note how the equivalent thickness is divided into three parts in Figure 8:

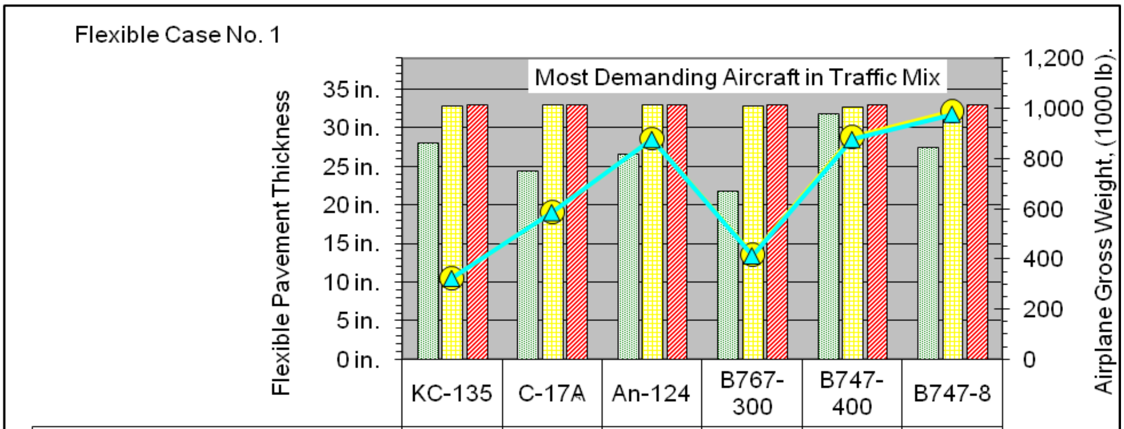
1. P-401 and/or P403: 5.0 inches
2. P-209: 8.0 inches
3. P-154: 20.0 inches

The first two numbers reflect the conditions that were utilized in the National Airport Pavement Test Facility [5], and these do not change, even though the evaluation thicknesses are different. The excess of P-401 thickness and other stabilized layers are first converted into P-209 through the equivalency factors. The excess of P-209 is then converted into P-154 as seen in the figure.

The pavement characteristics for this example are:

- Remaining pavement structural life of 20 years
- 10.5 inches of HMA (P-401)
- 13.6 inches of crushed gravel (P-209)
- 33.0 inches equivalent thickness (see Figure 8)
- Subgrade strength = CBR 7

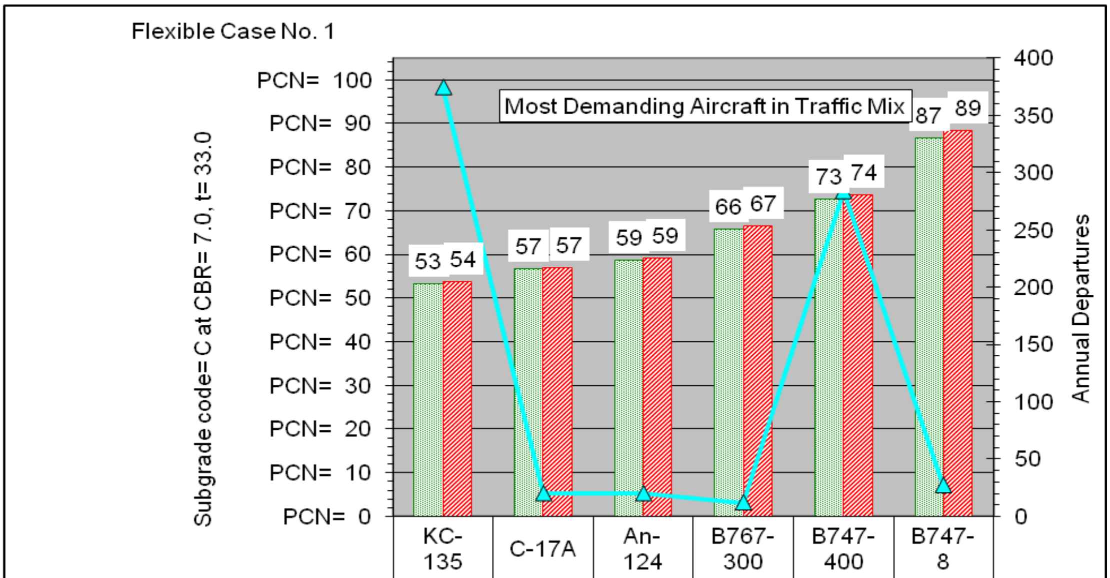
Note that in Figure 9, the -6D thickness requirements are considerably less than the evaluation thickness; however, the CDF thickness is uniform and very close to the evaluation thickness for each aircraft, which indicates that the pavement is correctly designed for the traffic. The six most demanding aircraft in the traffic mix are shown in Figure10.



	KC-135	C-17A	An-124	B767-300	B747-400	B747-8
1. 6D thickness at traffic mix GW	28.1	24.4	26.5	21.7	31.8	27.5
2. CDF thickness at max. GW	32.9	32.9	32.9	32.8	32.8	32.7
3. Evaluation thickness from equivalent pavement	33.0	33.0	33.0	33.0	33.0	33.0
4. Max.Allowable Aircraft GW from CDF	324,340	587,154	879,608	416,506	885,749	990,199
5. Aircraft GW from traffic mix	322,500	585,000	877,430	413,000	877,000	978,000

Figure 9 - Flexible Pavement Properties

Figure 10 shows the resulting PCN's for each of the six most demanding aircraft as compared to the ACN's. In this case the margin of acceptability is just adequate for the traffic mix in that the resulting PCN 89/F/C/W/T would allow all traffic to operate unrestricted.



	KC-135	C-17A	An-124	B767-300	B747-400	B747-8
1. Aircraft ACN at traffic mix GW	53.3	56.8	58.8	65.8	72.6	86.8
2. Calculated PCN at CDF max. GW	53.8	57.1	59.1	66.6	73.8	88.5
3. Annual Departures from traffic mix	375	20	20	12	284	27

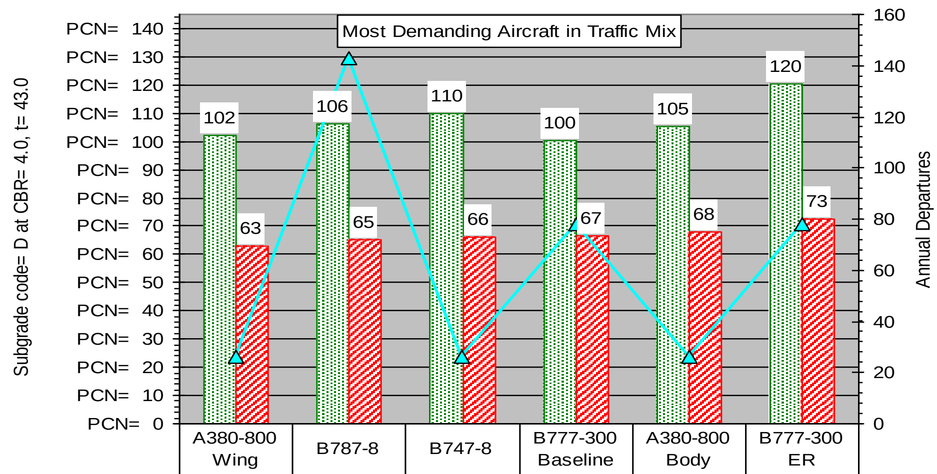
Figure 10 - PCN Results for Flexible Case No. 1

4.2. Flexible Case Study No. 2 – Sensitivity to CBR

The importance of correctly determining the CBR value for the subgrade of a flexible pavement and the sensitivity of PCN to CBR is noted in this case study. In this instance, the airport had not undertaken a thorough evaluation of the subgrade, either by HWD testing or in-situ tests. The pavement characteristics are:

- 19 inches of HMA (P-401)
- 8 inches of cement treated base (P-304)
- 43 inches of equivalent thickness
- Subgrade strength = CBR 5.2, average for all of the airport pavements

The sensitivity of PCN to the CBR variation can be seen in the results for the six most demanding aircraft for CBR values in the range of 4 to 6, as noted in Figures 11 and 12. The resulting PCN 80/F/C/W/T for the CBR 5.2 pavement, Figure 13, could potentially restrict the 747-8, 787-8 and 777-300ER from operating since the aircraft ACN values exceed the PCN. If the CBR was determined to be 6, then all aircraft could operate at the PCN 103/F/C/W/T rating. Furthermore, the sensitivity of PCN to subgrade CBR is seen in the case of CBR 4, in which all six of the most demanding aircraft would be restricted at the PCN 73/F/D/W/T rating.

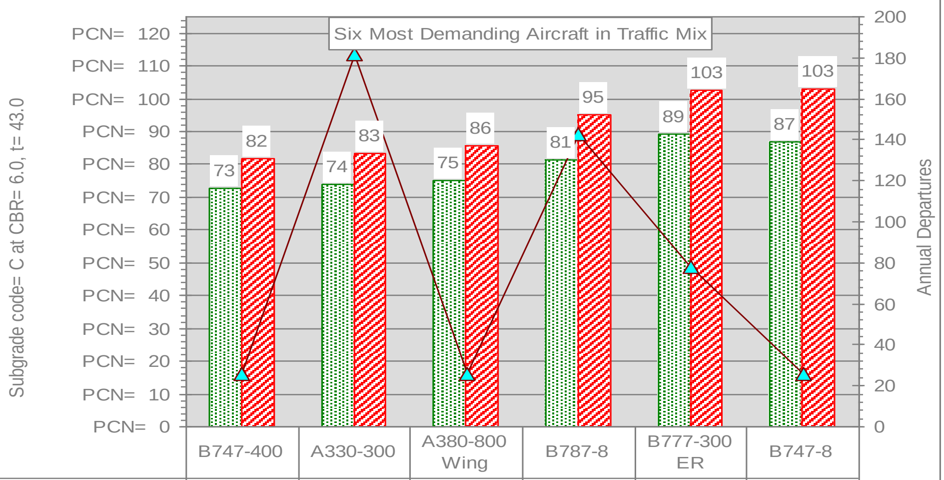


	A380-800 Wing	B787-8	B747-8	B777-300 Baseline	A380-800 Body	B777-300 ER
1. Aircraft ACN at traffic mix GW	102.1	106.2	109.9	100.2	105.2	120.3
2. Calculated PCN at CDF max. GW	62.8	65.0	66.3	66.5	67.8	72.5
3. Annual Departures from traffic mix	26	143	26	78	26	78

Figure 11 – PCN for CBR 4 Subgrade

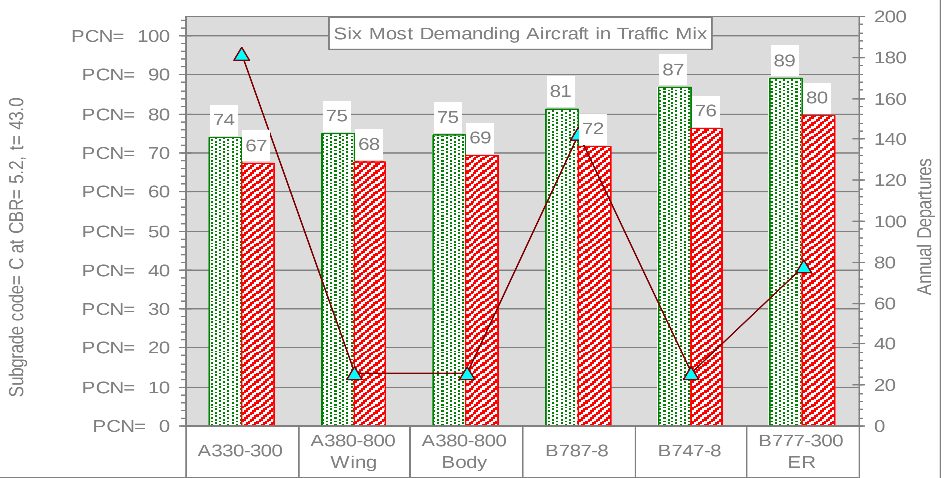
4.3. Flexible Case Study – Sensitivity to Equivalent Thickness Computation

The thickness of a flexible pavement to be used in the PCN computation must be referenced to the FAA standard section which assumes minimum thickness values for the asphalt surface and base layers. If the pavement has excess material or improved materials, the total pavement thickness can be increased to an equivalent thickness for the structural evaluation. Appendix 2 [3] lists the FAA equivalency factors for various materials. The FAA support spreadsheet, [6], which calculates equivalent thickness, assumes a minimum baseline cross section of 5 inches of P-401 and 8 inches of P-209 base layer. The excess material is converted into P-154 granular subbase.



	B747-400	A330-300	A380-800 Wing	B787-8	B777-300 ER	B747-8
1. Aircraft ACN at traffic mix GW	72.6	74.0	75.1	81.2	89.3	86.8
2. Calculated PCN at CDF max. GW	81.9	83.2	85.7	95.2	102.6	102.9
3. Annual Departures from traffic mix	26	182	26	143	78	26

Figure 12 – PCN for CBR 6 Subgrade



	A330-300	A380-800 Wing	A380-800 Body	B787-8	B747-8	B777-300 ER
1. Aircraft ACN at traffic mix GW	74.0	75.1	74.7	81.2	86.8	89.3
2. Calculated PCN at CDF max. GW	67.3	67.8	69.2	71.7	76.3	79.7
3. Annual Departures from traffic mix	182	26	26	143	26	78

Figure 13 – PCN for CBR 5.2 Subgrade

The FAA support spreadsheet allows for a range of equivalency factors to be selected for the excess material conversion. The case studies indicate that the PCN computation is extremely sensitive to the equivalency factors chosen. The COMFAA program flexible pavement CBR failure model is based on the most recent alpha factor design curves, determined by the FAA report [5]. The new four and six wheel gear alpha factors determined in the report were arrived at by converting the test sections into equivalent thicknesses based upon a factor of 1.6 for the P-401 to P-209 conversion, and 1.4 for the P-209 to P-154 conversion. The case studies all show that these factors provide the most reasonable PCN values.

The case study results shown in Table 3 are for a flexible pavement in which the resulting equivalent thicknesses varied depending on the material conversion factors assumed. The 31 inch pavement was based on the minimum conversion factors of 1.2 for the P-401 and P-209 materials. The 33 inch pavement was based on the recommended factors of 1.6 and 1.4 noted previously. Note that all aircraft in the mix require more than 31 inches based on their equivalent coverages. The resulting PCN of 70 would therefore potentially not allow the 747-400ER to operate since its ACN of 77 exceeds the PCN. However, the resulting 33 inch equivalent pavement results in a PCN of 82 which would allow all traffic to operate unrestricted. The cumulative CDF in this instance is less than 1.0, indicating sufficient pavement strength for the assumed traffic.

Table 3. Equivalent Thickness Sensitivity

Aircraft	Annual Dep	Coverages to failure	Thickness required	ACN	PCN	CDF
		31 inch Pavement				
737-400	208	3 E6	31.66	40	38	0.0003
727-200	2,412	18,715	32.41	62	57	0.8592
747-200	24	29,376	32.11	65	60	0.0093
767-200ER	12	68,805	31.96	60	56	0.0019
747-400ER	108	5,994	32.51	77	70	0.1967
DC-8/63	1,872	20,940	32.13	65	61	1.0684
MD83	416	145,487	31.99	50	47	0.0167
		33 inch Pavement				
737-400	208	42 E6	32.67	40	41	0.0000
727-200	2,412	56,039	32.14	62	65	0.2869
747-200	24	125,438	32.38	65	67	0.0022
767-200ER	12	386,877	32.48	60	62	0.0003
747-400ER	108	16,854	32.11	77	82	0.0700
DC-8/63	1,872	87,514	32.38	65	67	0.2556
MD83	416	738,325	32.45	50	51	0.0033

5. MISCELLANEOUS ISSUES

The PCN methodology herein described typically selects the highest PCN value of the six most demanding aircraft, and reports that PCN for the bearing strength of the pavement. Occasionally, the selection of the PCN to be used for reporting purposes is not clearly obvious and some engineering judgment must be used.

One of the case studies for a vastly overdesigned flexible pavement consisted of the following cross section:

- 8 inches of asphalt cement pavement (P-401, 5” PG 64-34 and 3” PG 52-34)
- 15 inches of P-209 base material
- 57 inches of P-154 subbase
- Existing compacted subgrade (CBR = 17)

From the results of the COMFAA analysis in Figure 14, the program notes that since the pavement is so strong it could not converge upon a value as to when the pavement would theoretically fail. Due to this fact, the resulting PCN computed is not reasonable for this over-designed pavement. For example, as indicated in Figure 14, the greatest thickness requirement for any of the aircraft in the traffic mix based on its equivalent coverages is only 28.2 inches. The actual thickness of 85.3 inches clearly indicates that the pavement is capable of handling the current and future traffic.

In this type of situation the PCN should be based on the highest ACN aircraft expected to utilize the airport, and increase it by a factor of 10-25% due to the true bearing strength of the pavement. This also provides for any future aircraft with higher ACN's. In this case the 747-8, with an ACN of 63/F/A, was used and the recommended PCN to be reported was in the range of 69 to 78/F/A/W/T.

CBR = 17.00 (Recommended ICAO Code Designation is A)
Evaluation pavement thickness = 85.30 in

No.	Aircraft Name	Gross Weight	Percent Gross Wt	Tire Press	Annual Deps	20-yr Coverages	6D Thick
1	An-124	877,430	95.00	149.0	3	95	11.52
2	B727-100	170,000	95.30	165.0	178	1,109	13.36
3	B727-200	185,200	96.00	148.0	27	186	11.37
4	B737-200	128,600	91.92	182.0	3,580	18,738	14.08
5	B737-700	155,000	91.70	205.0	1,632	8,561	14.74
6	B737-900 ER	188,200	94.58	220.0	874	4,949	16.25
7	B747-100	738,000	92.48	232.0	5	49	9.81
8	B747-200	836,000	90.96	190.0	1	11	7.66
9	B747-200F	836,000	90.96	190.0	575	6,523	16.60
10	B747-400	877,000	93.32	200.0	1	11	8.00
11	B747-400F	877,000	93.32	200.0	443	5,081	17.20
12	B747-8	978,000	94.69	221.0	443	4,971	18.55
13	B757-200	256,000	91.18	183.0	874	8,798	13.25
14	B767-200	317,000	92.30	190.0	874	8,604	14.32
15	DC-4	73,002	93.60	76.9	183	1,131	6.82
16	HS748	46,500	87.20	85.6	88	425	5.36
17	L-100	155,801	96.40	104.4	81	709	10.30
18	L-1011	432,000	94.80	192.9	3	32	9.78
19	MD80	161,000	94.76	195.0	1,492	8,723	15.87
20	Mk500	43,601	95.00	78.3	182	934	5.50

When computing the numbers of coverages to failure, the coverages for none of the aircraft converged at a pavement thickness greater than 99 percent of the evaluation thickness. This means that the life of the pavement is unlimited and the pavement is very strong in relation to the aircraft loading. The relative aircraft load evaluations are also unreliable. Consider reviewing the procedures used to determine the evaluation thickness and the strength of the support. The thicknesses for unlimited operations of each of the aircraft are as follows.

An-124	17.38
B727-100	26.08
B727-200	27.48
B737-200	22.04
B737-700	24.20
B737-900 ER	28.16
B747-100	21.41
B747-200	22.76
B747-200F	22.76
B747-400	23.98
B747-400F	23.98
B747-8	26.13
B757-200	17.87
B767-200	19.10
DC-4	12.78
HS748	10.90
L-100	19.63
L-1011	22.54
MD80	26.76

Figure 14 – Vastly Over-designed Pavement

6. CONCLUSIONS

1. PCN's calculated by the FAA AC 150/5335-5B CDF method yield numbers that are reasonable and logical.
2. This method is relatively easy to use, but must be supported by engineering judgment.
3. Pavements that are vastly over or under designed will not have an accurate PCN calculation by this method, but will need engineering judgment to arrive at a reasonable value.
4. For rigid pavements, PCN calculations are highly sensitive to flexural strength and thickness. They are less sensitive to k-value and traffic variations.
5. For flexible pavements, PCN calculations are highly sensitive to equivalent thickness and subgrade CBR. They are less sensitive to traffic variations.

REFERENCES

1. "Standardized Method of Reporting Airport Pavement Strength - PCN", FAA Advisory Circular AC 150/5335-5A, September 2006.
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3. "Standardized Method of Reporting Airport Pavement Strength – PCN", FAA Draft Advisory Circular AC 150/5335-5B, October 2009.
4. COMFAA 30 Computer Program, http://www.airporttech.tc.faa.gov/naptf/download/index1.asp
5. Hayhoe, G. F., "Alpha Factor Determination using Data Collected at the National Airport Pavement Test Facility", FAA/AR-06/7, 2006.
6. COMFAA Support Program (Excel spreadsheet), www.FAA.gov/airports