PCN Reporting- Current Problems and Future Research Plans

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Outline

- Current Problems in PCN Determination
  - Effect of traffic
  - Over-designed pavement PCN
  - Composite pavement- rigid or flexible?
  - Sensitivity to pavement parameters
  - Incompatibility with new design software

- ICAO Pavement Sub-group activity
  - Updates to Part 3- Pavements related to PCN
  - Overload testing

- New ACN/PCN Procedure- Multi-Layered Linear Elastic Method

- Closing Comments

Current Problems in ACN/PCN Reporting

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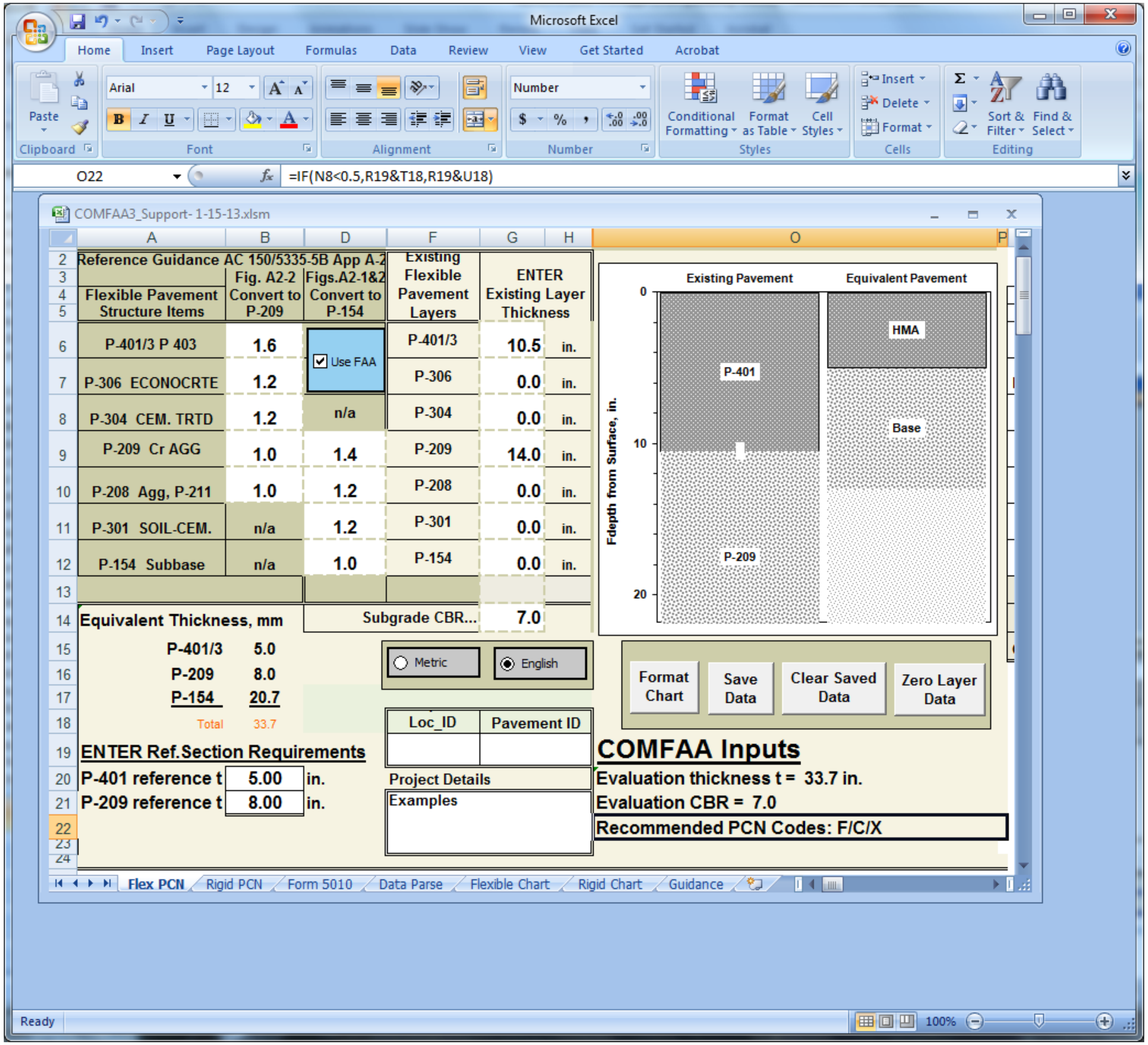
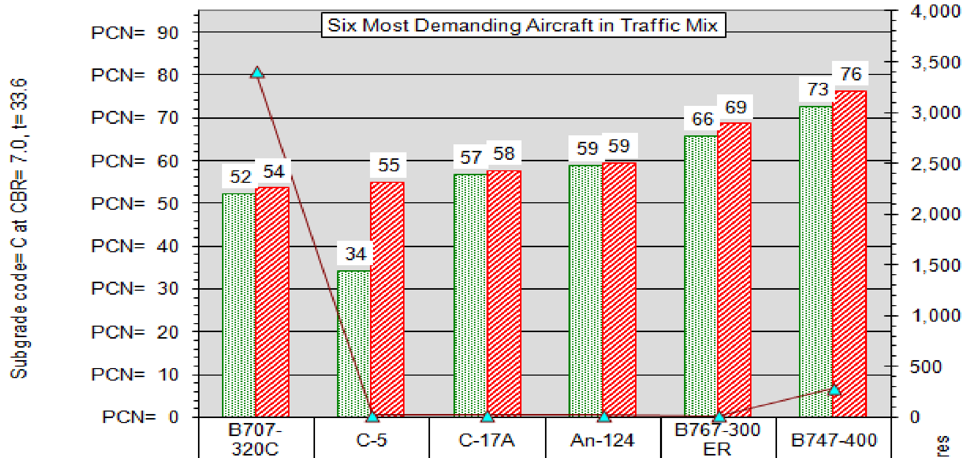
- PCN rating is not static- change in traffic, especially adding a new aircraft in the mix, will change the PCN value. Pavement must be re-evaluated and PCN updated.
- PCN ratings typically not updated when overlays are applied. A typical 2 inch (5 cm) asphalt overlay can provide additional structural benefit, PCN increase of 10 % or more depending on subgrade. Uncertainty on how to handle overlays on rigid pavement (composite pavement)
- Overdesigned pavements- reluctance to publish unusually high PCN value
- PCN sensitivity to pavement parameters (i.e. CBR, k value, MR)
- New design using Faarfield – incompatibility with COMFAA PCN in some cases
- Runway has multiple PCN's due to cross section variation-what should be reported in AIP?
    - Reporting lowest value not always recommended (i.e. section outside keel area or not within the critical static loading zone).
    - Tradeoff between allowing traffic and additional maintenance that may result

Effect of Traffic on PCN- Flexible Case Study

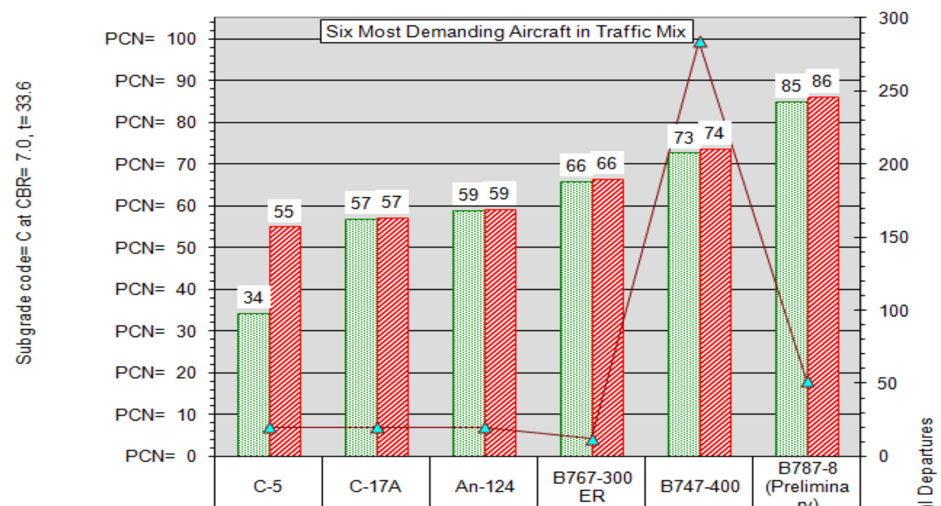


Effect of Traffic on PCN- Adding new aircraft to the mix



	B707-320C	C-5	C-17A	An-124	B767-300 ER	B747-400
1. Aircraft ACN at traffic mix GW	52.3	34.2	56.8	58.8	65.8	72.6
2. Calculated PCN at CDF max. GW	53.6	54.9	57.7	59.4	68.6	76.3
3. Annual Departures from traffic mix	3,400	20	20	20	12	284

Original Design Traffic- PCN 76 FCWT



	C-5	C-17A	An-124	B767-300 ER	B747-400	B787-8 (Preliminary)
1. Aircraft ACN at traffic mix GW	34.2	56.8	58.8	65.8	72.6	84.8
2. Calculated PCN at CDF max. GW	54.9	57.0	59.0	66.4	73.5	86.0
3. Annual Departures from traffic mix	20	20	20	12	284	52

Addition of new aircraft- PCN 86 FCWT

Effect of Traffic on PCN- CDF Evaluation

ICAO ACN Computation, Detailed Output

Unit Conversions | Show Alpha | Show Ext File | Single Aircraft ACN: Flexible, Rigid | Other Calculation Modes: PCN, ACN Batch, Thickness, Life, MGW | Back

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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
1	An-124	286,328	33.43	882,991	40.6	46.7	59.4	83.4	0.0015
2	C-5	>5,000,000	26.49	1,050,536	38.6	43.8	54.9	78.1	0.0000
3	C-17A	154,087	33.35	591,102	43.4	48.4	57.7	75.3	0.0014
4	B707-320C	145,410	33.20	327,903	39.6	44.2	53.6	68.6	0.1878
5	C-130	>5,000,000	33.44	156,300	26.9	30.5	32.7	38.0	0.0000
6	MD90-30 ER	274,661	33.15	154,023	39.8	42.8	46.9	50.1	0.0063
7	MD83	91,169	33.09	165,293	43.9	47.5	51.5	54.6	0.0281
8	B767-300 ER	11,231	32.90	424,281	50.5	56.0	68.6	89.8	0.0082
9	B737-800	80,763	33.03	179,567	44.2	46.9	52.0	56.9	0.0014
10	B737-400	437,408	33.17	153,800	38.0	40.3	45.2	49.1	0.0001
11	B717-200 HGW	>5,000,000	33.34	123,697	31.3	33.0	37.1	40.1	0.0000
12	B757-200	>5,000,000	33.45	257,507	29.9	33.3	40.7	53.3	0.0000
13	B747-400	4,900	32.79	905,412	55.5	62.0	76.3	98.2	[illegible]
							Total CDF =		0.7010

CDF=.70

ICAO ACN Computation, Detailed Output

Unit Conversions | Show Alpha | Show Ext File | Single Aircraft ACN: Flexible, Rigid | Other Calculation Modes: PCN, ACN Batch, Thickness, Life, MGW | Back

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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
1	B787-8 (Preliminary)	2,356	33.35	508,113	62.7	69.4	86.0	111.2	0.2182
2	An-124	375,463	33.56	878,699	40.3	46.3	59.0	82.8	0.0015
3	C-5	>5,000,000	26.49	1,050,536	38.6	43.8	54.9	78.1	0.0000
4	C-17A	202,055	33.54	586,399	43.0	47.8	57.0	74.4	0.0014
5	B707-320C	190,677	33.51	323,742	39.0	43.4	52.6	67.5	0.1878
6	C-130	>5,000,000	33.58	155,174	26.7	30.2	32.4	37.7	0.0000
7	MD90-30 ER	360,164	33.49	151,312	38.9	41.8	46.0	49.2	0.0063
8	MD83	119,551	33.48	162,003	42.7	46.3	50.3	53.4	0.0281
9	B767-300 ER	14,727	33.44	415,577	49.2	54.4	66.4	87.4	0.0082
10	B737-800	105,905	33.47	175,829	43.2	45.7	50.7	55.6	0.0014
11	B737-400	573,576	33.50	151,261	37.3	39.5	44.3	48.2	0.0001
12	B717-200 HGW	>5,000,000	33.54	122,394	30.9	32.6	36.6	39.6	0.0000
13	B757-200	>5,000,000	33.57	256,348	29.8	33.1	40.4	53.0	0.0000
14	B747-400	6,426	33.41	883,469	53.7	59.9	73.5	95.1	0.4660
							Total CDF =		0.9192

CDF=.92

PCN for Over-Designed Pavement

Surface HMA	8	in.	P-401
Base	10	in.	P-209
Subbase	17	in.	P-154
Evaluation thickness	40	in.	Figure 33
CBR	16		Code A

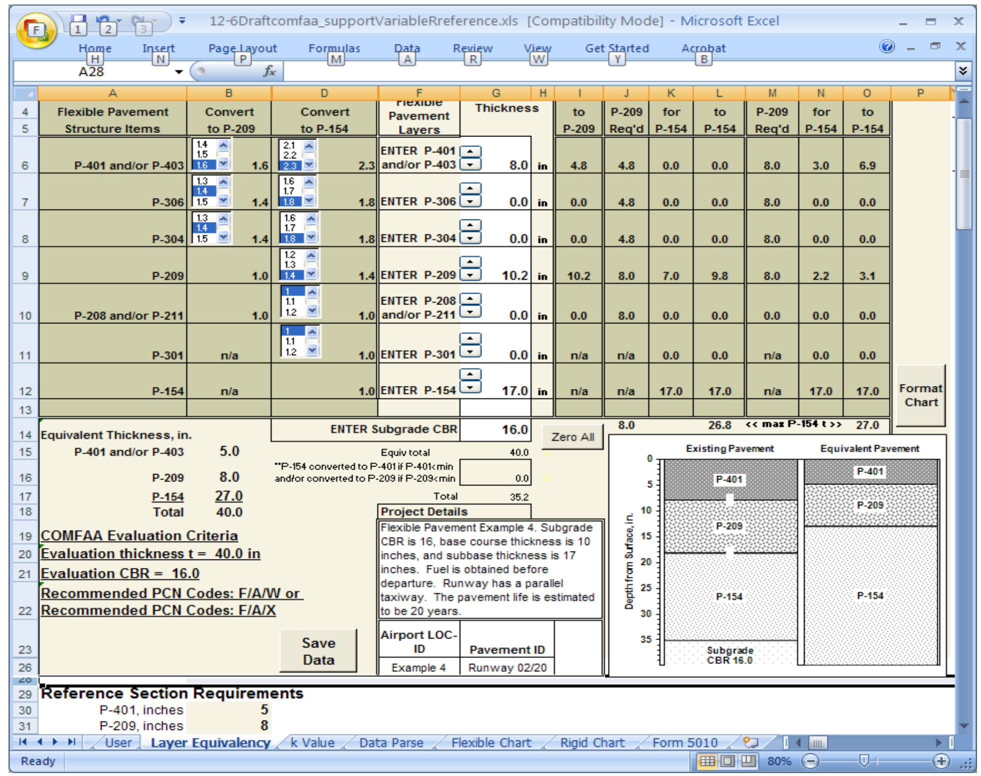


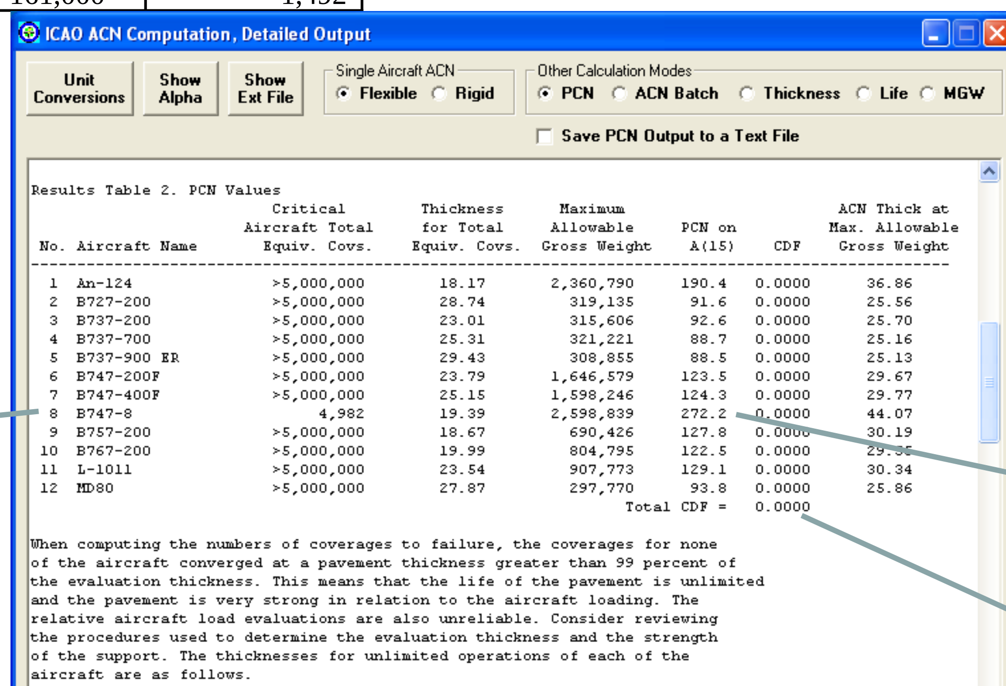
Figure 33- COMFAA Support Spreadsheet Inputs

PCN for Over-Designed Pavement

Aircraft	Gear Type	Gross Weight (lb)	Average Annual Departures
AN-124	5D	877,430	3
B727-200	D	185,200	205
B737-200	D	128,600	3,580
B737-700	D	155,000	1,632
B737-900ER	D	188,200	874
B747-200F	2D/2D2	836,000	581
B747-400F	2D/2D2	877,000	444
B747-8F	2D/2D2	990,000	444
B757-200	2D	256,000	874
B767-200	2D	317,000	874
L-1011	2D	432,000	32
MD-80	D	161,000	1,492

For extremely over-designed pavements, Total CDF < .10-.15, the PCN should be set at 1.25 * highest ACN aircraft. This should accommodate any future aircraft added to the mix.

747-8 ACN=63 FA PCN= 78 FAWT Recommended



Results Table 2. PCN Values

No.	Aircraft Name	Critical Aircraft Total Equiv. Covs.	Thickness for Total Equiv. Covs.	Maximum Allowable Gross Weight	PCN on A(15)	CDF	ACN Thick at Max. Allowable Gross Weight
1	An-124	>5,000,000	18.17	2,360,790	190.4	0.0000	36.86
2	B727-200	>5,000,000	28.74	319,135	91.6	0.0000	25.56
3	B737-200	>5,000,000	23.01	315,606	92.6	0.0000	25.70
4	B737-700	>5,000,000	25.31	321,221	88.7	0.0000	25.16
5	B737-900 ER	>5,000,000	29.43	308,855	88.5	0.0000	25.13
6	B747-200F	>5,000,000	23.79	1,646,579	123.5	0.0000	29.67
7	B747-400F	>5,000,000	25.15	1,598,246	124.3	0.0000	29.77
8	B747-8	4,982	19.39	2,598,839	272.2	0.0000	44.07
9	B757-200	>5,000,000	18.67	690,426	127.8	0.0000	30.19
10	B767-200	>5,000,000	19.99	804,795	122.5	0.0000	29.[illegible]
11	L-1011	>5,000,000	23.54	907,773	129.1	0.0000	30.34
12	MD80	>5,000,000	27.87	297,770	93.8	0.0000	25.86
				Total CDF =		0.0000	

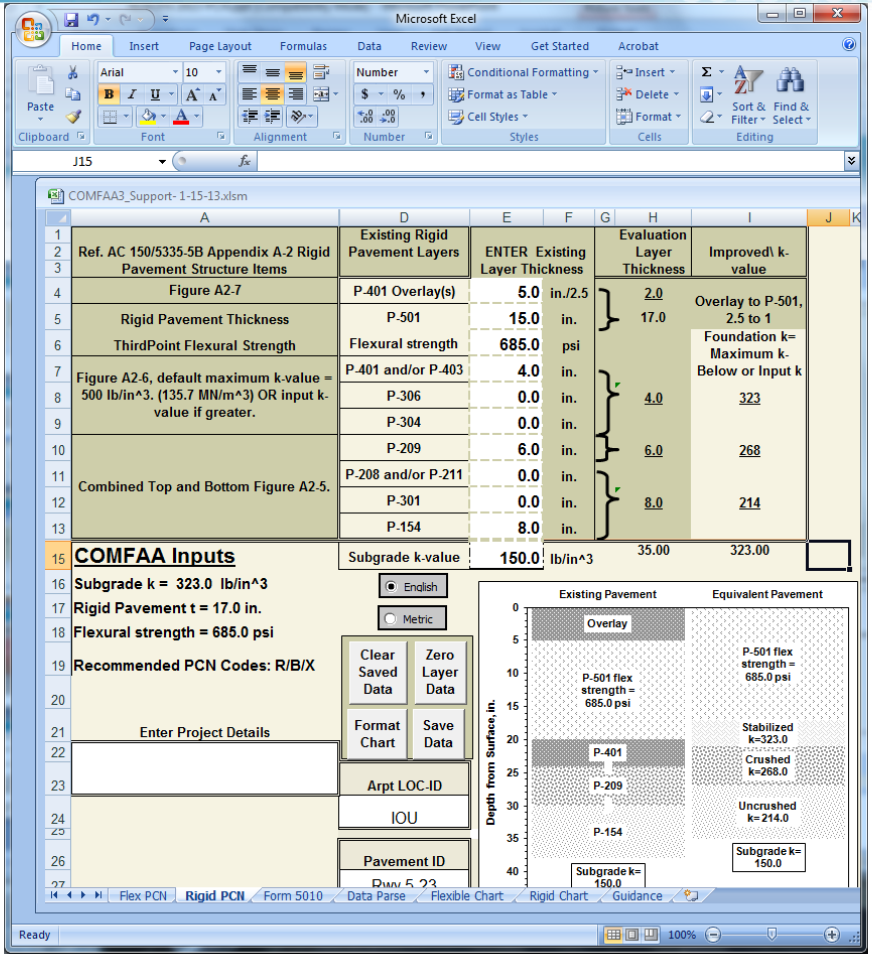
When computing the numbers of coverages to failure, the coverages for none of the aircraft converged at a pavement thickness greater than 99 percent of the evaluation thickness. This means that the life of the pavement is unlimited and the pavement is very strong in relation to the aircraft loading. 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.

PCN and aircraft gross weight extremely high

Total CDF= 0

Composite Pavement

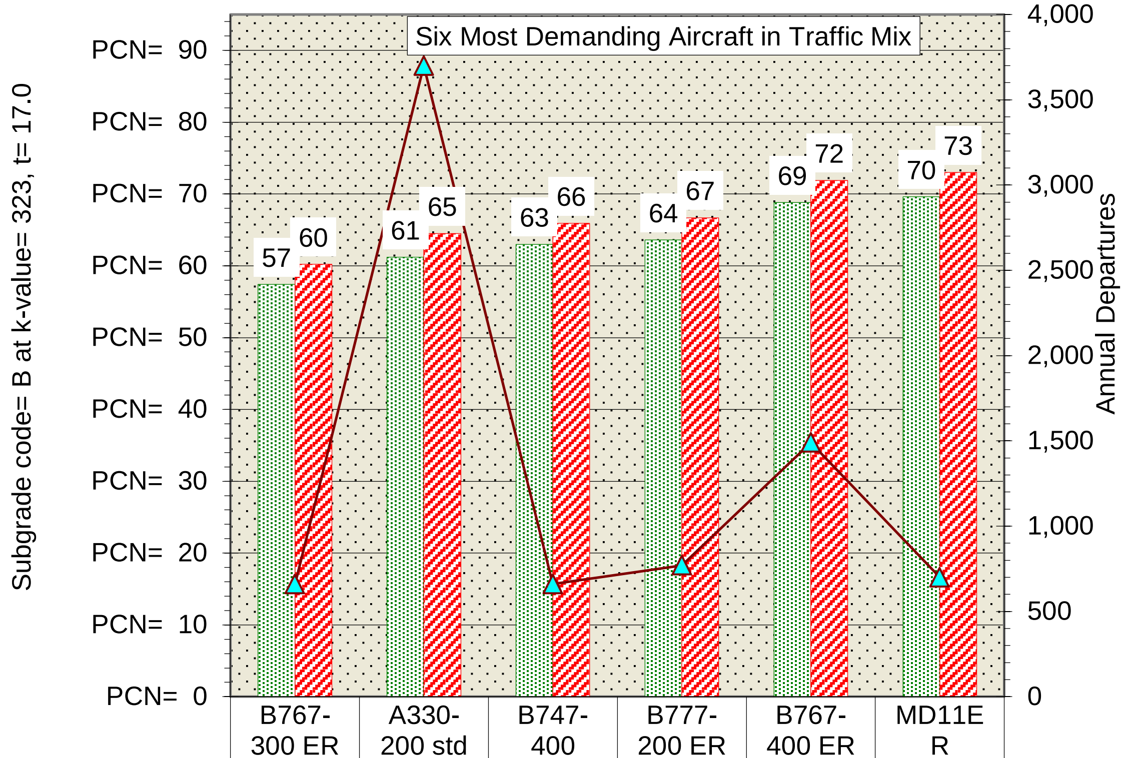
Aircraft	Gear Type	Gross Weight (lb)	Average Annual Departures
767-200ER	2D	271,000	28,105
MD11ER	2D/D	633,000	700
MD83	D	161,000	2,555
DC9-51	D	122,000	820
DC10-10	2D	458,000	1,200
B777-200ER	3D	657,000	770
B767-400ER	2D	451,000	1,490
B767-300ER	2D	413,000	660
B757-200	2D	256,000	1,095
B767-200	2D	317,000	460
B747-400	2D	877,000	660
B737-800	D	174,700	40,150
B737-700	D	155,000	32,120
B737-300	D	140,000	11,300
B727-200	D	185,200	600
A330-200	2D	509,047	3,700
A320-200 twin	D	162,922	7,200
A319-100	D	141,978	9,500



For a pavement of composite construction, the pavement type should be reported as the type that most accurately reflects the structural behavior of the pavement.

A general guideline is that when a bituminous overlay reaches 75 to 100 percent of the rigid pavement thickness, then it can be considered as a flexible pavement. Otherwise, consider as rigid and determine the equivalent slab thickness using the COMFAA support spreadsheet.

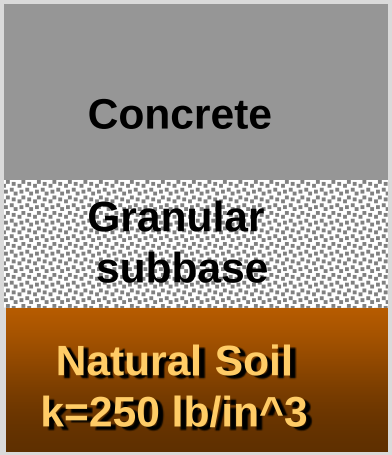
Composite Pavement PCN Results



	B767-300 ER	A330-200 std	B747-400	B777-200 ER	B767-400 ER	MD11ER
1. Aircraft ACN at traffic mix GW	57.4	61.2	63.0	63.6	68.8	69.6
2. Calculated PCN at CDF max. GW	60.2	64.5	65.9	66.7	71.9	73.0
3. Annual Departures from traffic mix	660	3,700	660	770	1,490	700

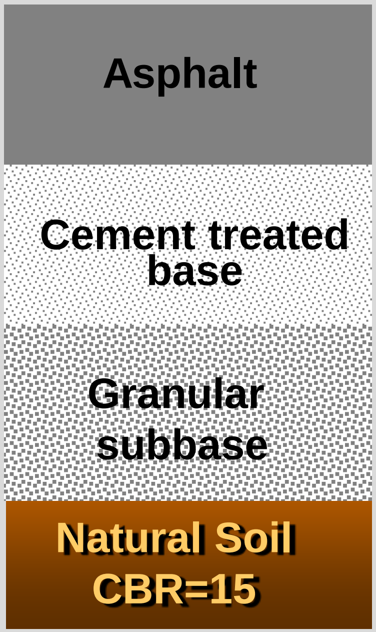
PCN= 73 RBWT based on the MD11ER

PCN Sensitivity to Pavement Parameters



PCN sensitive to concrete modulus of rupture- 50 psi difference could affect PCN by 15%

Simplistic estimate of subgrade k from NDT back calculation of subgrade modulus E can influence PCN

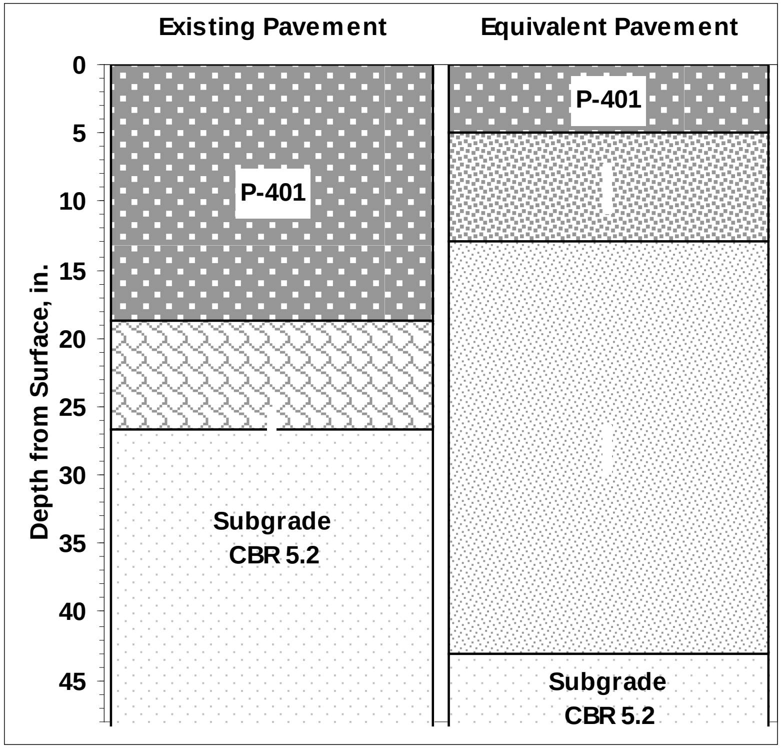


Equivalent thickness determination for higher quality materials affects PCN

PCN very sensitive to CBR of subgrade

Flexible Pavement – Subgrade CBR Sensitivity

	Airplane	GW	AD
1	A300-B4	365,747	130
2	A310-200	315,041	1,040
3	A319-100	150,796	1,222
4	A320 Twin	172,842	5,876
5	A330-300	515,661	182
6	A340-200	568,563	468
7	A380-800 Body	1,234,589	26
8	A380-800 Wing	1,234,589	26
9	B737-800	174,700	702
10	B747-8	978,000	26
11	B767-300 ER	413,000	78
13	B777-300	662,000	156
14	B777-300 ER	777,000	78
15	B787-8	503,500	143
16	MD90-30 ER	168,500	182
17	747-400	877,000	26



- Marginal design for anticipated traffic
- Existing airport with both narrow body & widebody traffic
- Airport not quite sure of soil strength variation throughout the airport, reported CBR=5.2 as average value.
- Equivalent thickness = 43"- 19" of P-401 on top of 8" CTB.

PCN Determination-CBR Sensitivity

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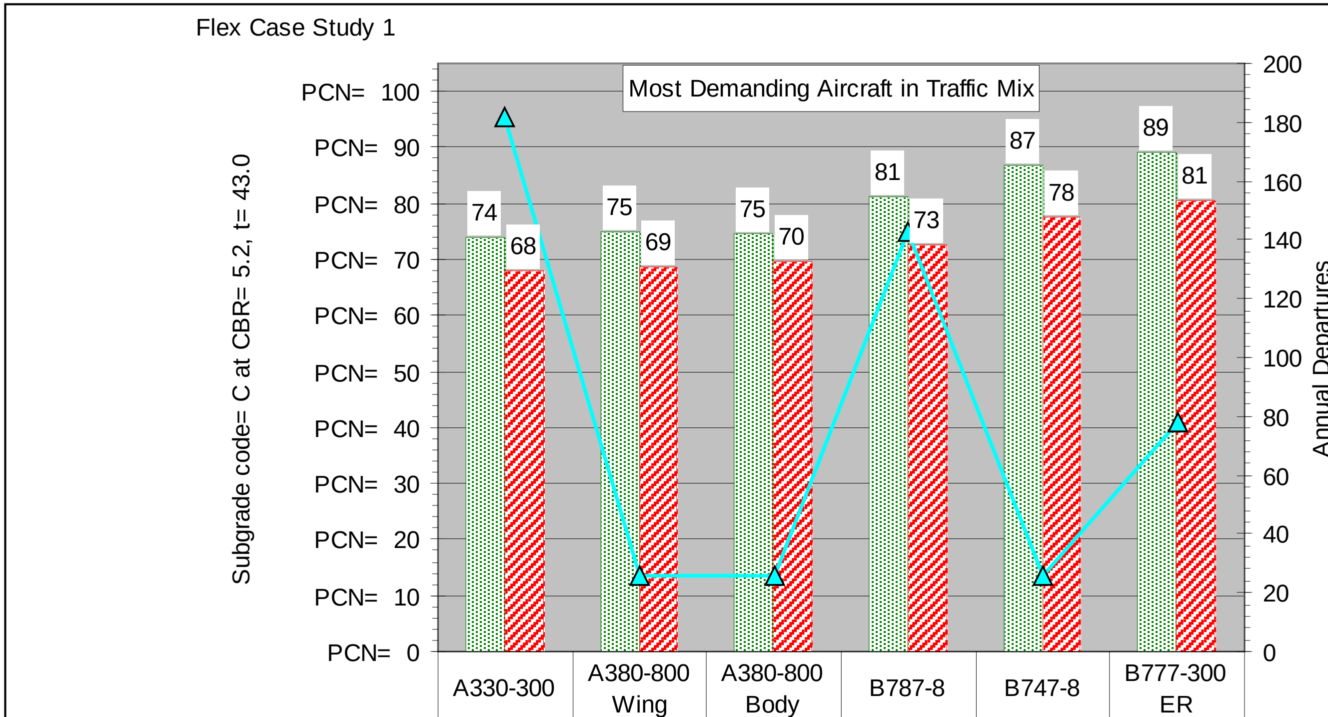
CBR = 5.2



	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	68.1	68.6	69.8	72.7	77.5	80.7
3. Annual Departures from traffic mix	182	26	26	143	26	78

PCN 81/ F/C/W/T would not allow unrestricted 747-8 and 777-300ER operations

PCN Determination-CBR Sensitivity

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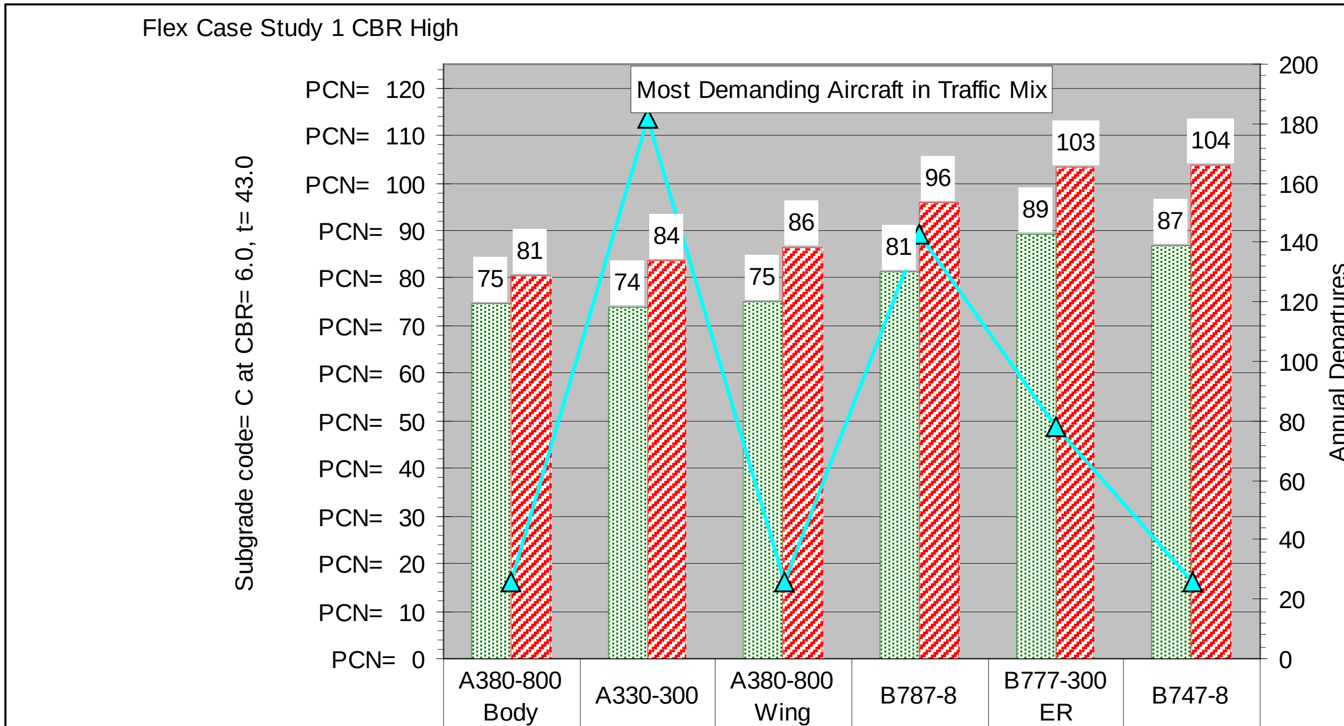
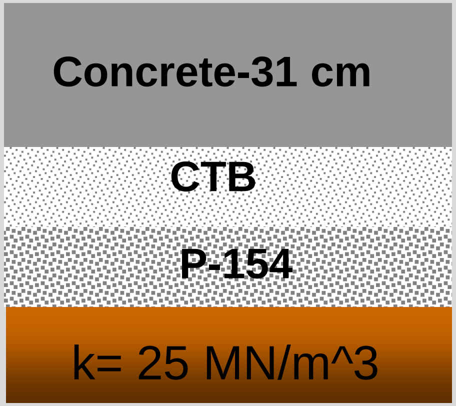
CBR = 6



	A380-800 Body	A330-300	A380-800 Wing	B787-8	B777-300 ER	B747-8
1. Aircraft ACN at traffic mix GW	74.7	74.0	75.1	81.2	89.3	86.8
2. Calculated PCN at CDF max. GW	80.5	83.6	86.3	95.8	103.2	103.6
3. Annual Departures from traffic mix	26	182	26	143	78	26

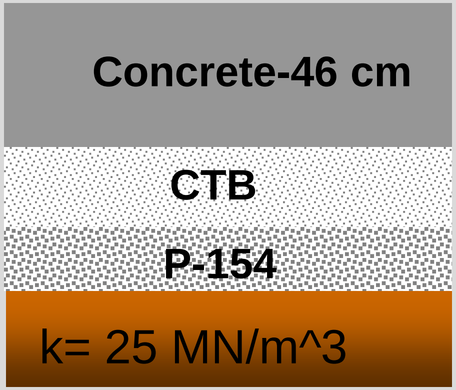
PCN 104/ F/C/W/T allows all aircraft to operate

Incompatibility between failure models
New Design Software and PCN Software



COMFAA Design

Assumed 1,200 dep/yr of 777-300ER



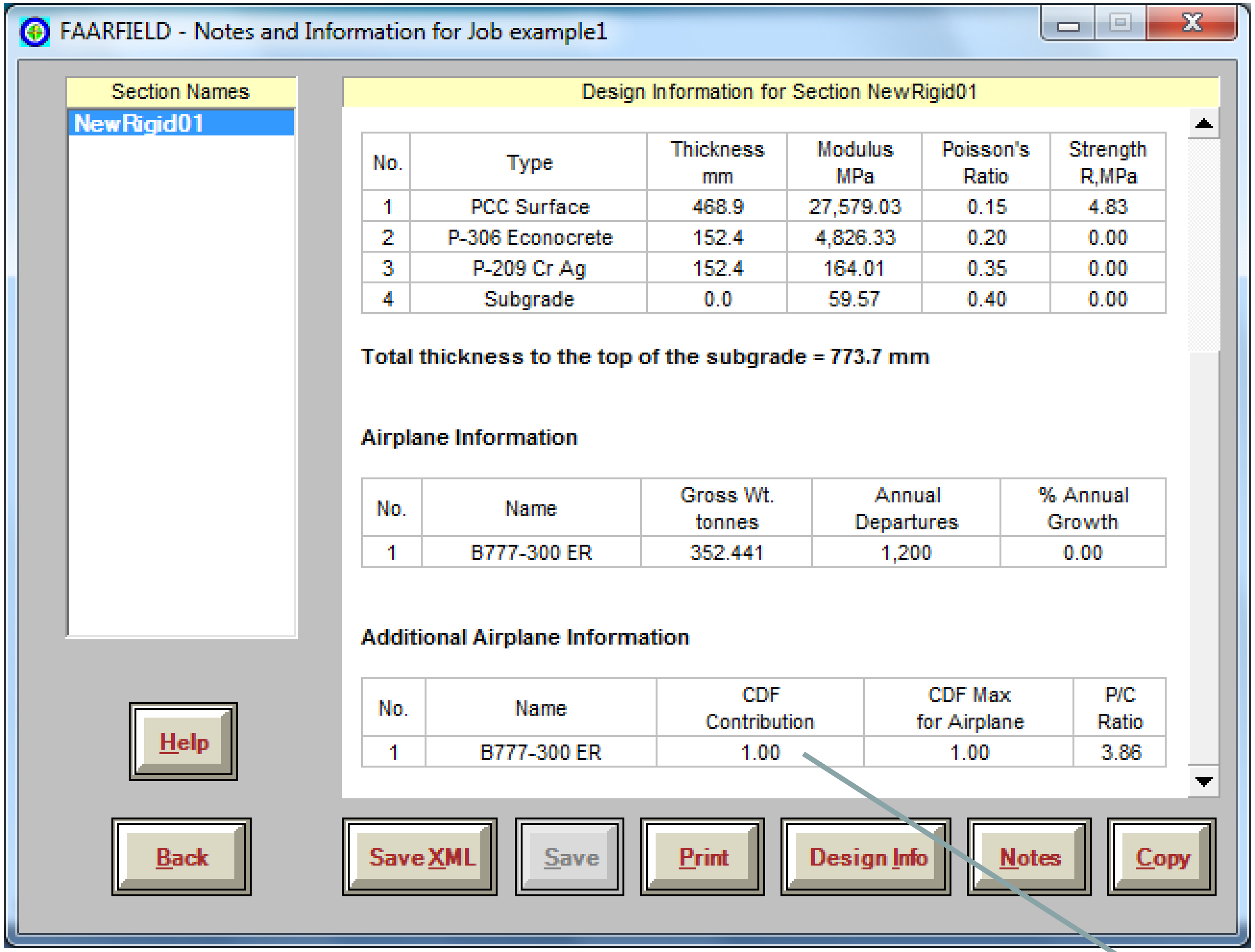
Faarfield Design

- New designs using Faarfield could result in thickness mismatch with COMFAA and exceedingly high PCN due to different failure models

- For new pavement design using Faarfield it is recommended to base the PCN on the highest ACN aircraft in the traffic mix since CDF=1.0

- PCN evaluation of older pavements (i.e. overlays added for strengthening or change in traffic) to be determined using COMFAA.

New Design Thickness Requirement



FAARFIELD - Notes and Information for Job example1

Section Names
NewRigid01

Design Information for Section NewRigid01

No.	Type	Thickness mm	Modulus MPa	Poisson's Ratio	Strength R,MPa
1	PCC Surface	468.9	27,579.03	0.15	4.83
2	P-306 Econocrete	152.4	4,826.33	0.20	0.00
3	P-209 Cr Ag	152.4	164.01	0.35	0.00
4	Subgrade	0.0	59.57	0.40	0.00

Total thickness to the top of the subgrade = 773.7 mm

Airplane Information

No.	Name	Gross Wt. tonnes	Annual Departures	% Annual Growth
1	B777-300 ER	352.441	1,200	0.00

Additional Airplane Information

No.	Name	CDF Contribution	CDF Max for Airplane	P/C Ratio
1	B777-300 ER	1.00	1.00	3.86

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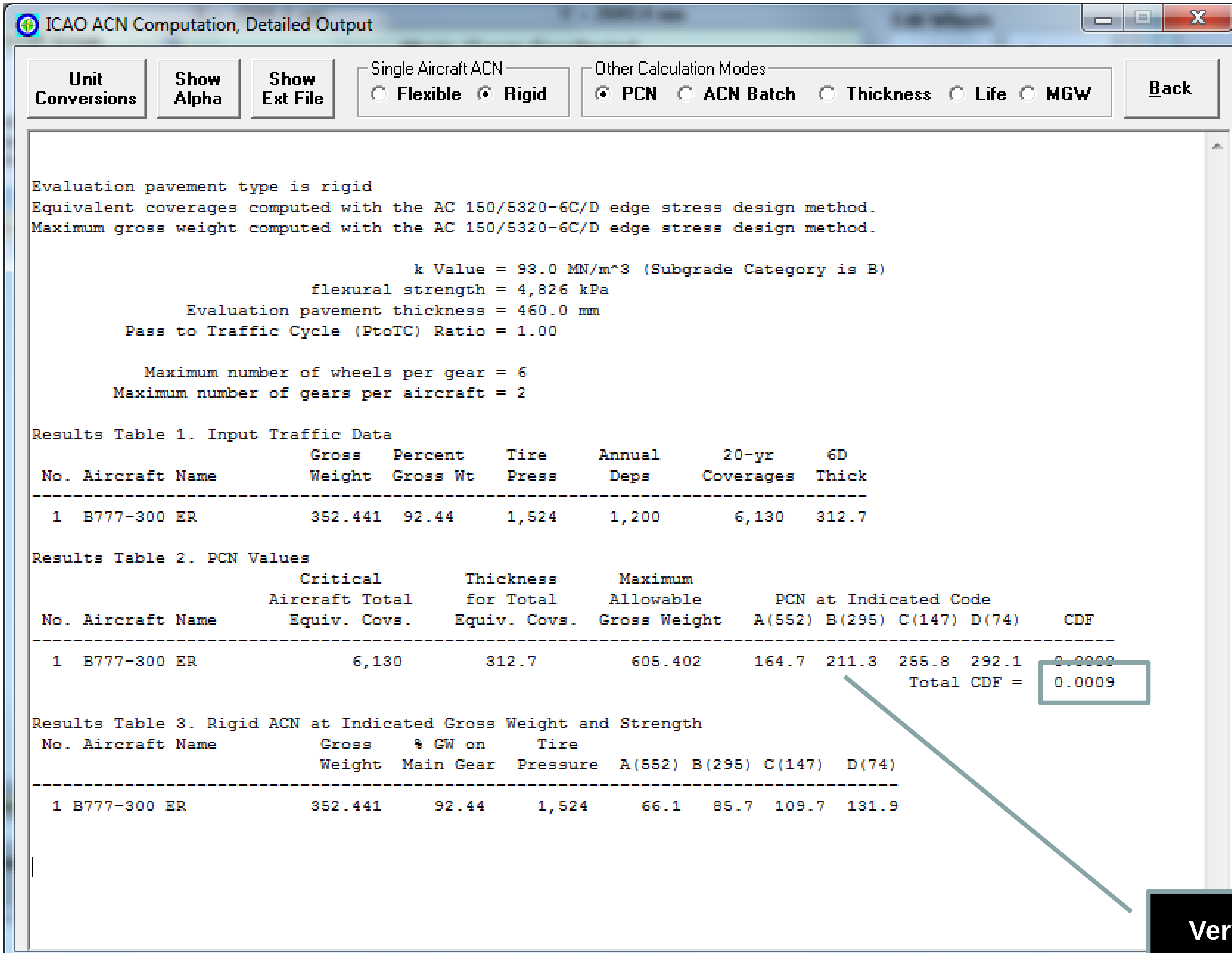
CDF=1.0

COMFAA PCN- Incompatible with New Design



Evaluation pavement type is rigid
Equivalent coverages computed with the AC 150/5320-6C/D edge stress design method.
Maximum gross weight computed with the AC 150/5320-6C/D edge stress design method.

k Value = 93.0 MN/m^3 (Subgrade Category is B)
flexural strength = 4,826 kPa
Evaluation pavement thickness = 460.0 mm
Pass to Traffic Cycle (PtoTC) Ratio = 1.00

Maximum number of wheels per gear = 6
Maximum number of gears per aircraft = 2

Results Table 1. Input Traffic Data

No.	Aircraft Name	Gross Weight	Percent Gross Wt	Tire Press	Annual Deps	20-yr Coverages	6D Thick
1	B777-300 ER	352.441	92.44	1,524	1,200	6,130	312.7

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(552)	B(295)	C(147)	D(74)	CDF
1	B777-300 ER	6,130	312.7	605.402	164.7	211.3	255.8	292.1	0.0009
								Total CDF =	0.0009

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

No.	Aircraft Name	Gross Weight	% GW on Main Gear	Tire Pressure	A(552)	B(295)	C(147)	D(74)
1	B777-300 ER	352.441	92.44	1,524	66.1	85.7	109.7	131.9

Very high PCN

ICAO Pavement Sub-group Activity- Updates to PCN Guidance in ADM Part 3-Pavements

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- **Current PCN guidance in ICAO Aerodrome Design Manual- Part 3 Pavements states "the airport authority can use any method of his choice to determine the load rating of his pavement." PSG will propose the FAA COMFAA program as initial guidance in calculating PCN rating. An ACN only version of COMFAA is being developed.**

- **PCN definition- A number expressing the bearing strength of a pavement for 'unrestricted operations'. What is meant by 'unrestricted'?**

- **PSG proposal- The term unrestricted operations in the definition of PCN does not mean unlimited operations. Unrestricted refers to the relationship of PCN to the ACN, and it is permissible for an aircraft to operate without weight restriction (subject to tire pressure limitations) when the PCN is greater than or equal to the ACN. The term unlimited operations does not take into account pavement life. The PCN to be reported is such that, the pavement strength is sufficient for the current and future traffic analyzed, and should be re-evaluated if traffic changes significantly.**

ICAO Pavement Sub-group Activity-
Updates to PCN Guidance in ADM Part 3-Pavements

- **Current ICAO overload guidance in Annex 14 is generally a 'rule of thumb' approach. Need to develop a more technically sound method which also takes traffic and pavement life into account.**

- **For pavements of varying cross section and subgrade strength it may be difficult to arrive at a single PCN value to report. A decision must me made whether to report the lowest PCN or a higher PCN which would not restrict traffic. This is at the discretion of the airport authority and may depend on the frequency of operations of heavier aircraft that would be permitted by reporting a higher PCN, where the weaker pavement section is located, or if increased maintenance may be necessary.**

Overload Criteria for Flexible Pavements: Testing Planned for 2013

- **Full-scale tests will consider:**
  - **Percent overload based on PCN. Various overload levels up to 40-50% to be considered. Current ICAO overload guidance for flexible pavements only 10%.**
  - **Percent overload based on CDF-.10, .50, 1.0**
  - **Used pavement life expressed as cumulative damage factor (CDF). Effect of overload on pavement life to be compared against ACN/PCN ratio**

- **Full-scale tests will consider:**
  - **Dual, Dual tandem and 6 wheel gears**
  - **Monitoring rutting will give indication of subbase failure due to overload**

Aircraft Classification Number – NEW Method

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- **ICAO-PSG-Item.7**

"The PSG agreed that the introduction of an ACN determination procedure more consistent with modern pavement design methods needs to be addressed quickly knowing that the development of such a procedure would take time. Thoughts toward this new approach will be carried on during the 2012-2015 work cycle"

OBJECTIVES:

- **To align the new ACN procedure with the current recommended practice for pavement design and analysis method, the multi-layered linear elastic analysis (ML²EA).**
- **Take advantage of the latest advanced methodology in pavement thickness design by keeping the current ACN-PCN structure unchanged (number, pavement type, subgrade code…).**
- **To develop a new and unique procedure (based on the ML²EA techniques) for PCN determination and publication which would be derived from the new ACNs of a traffic mix and the pavement characteristics.**

New Proposal Benefits

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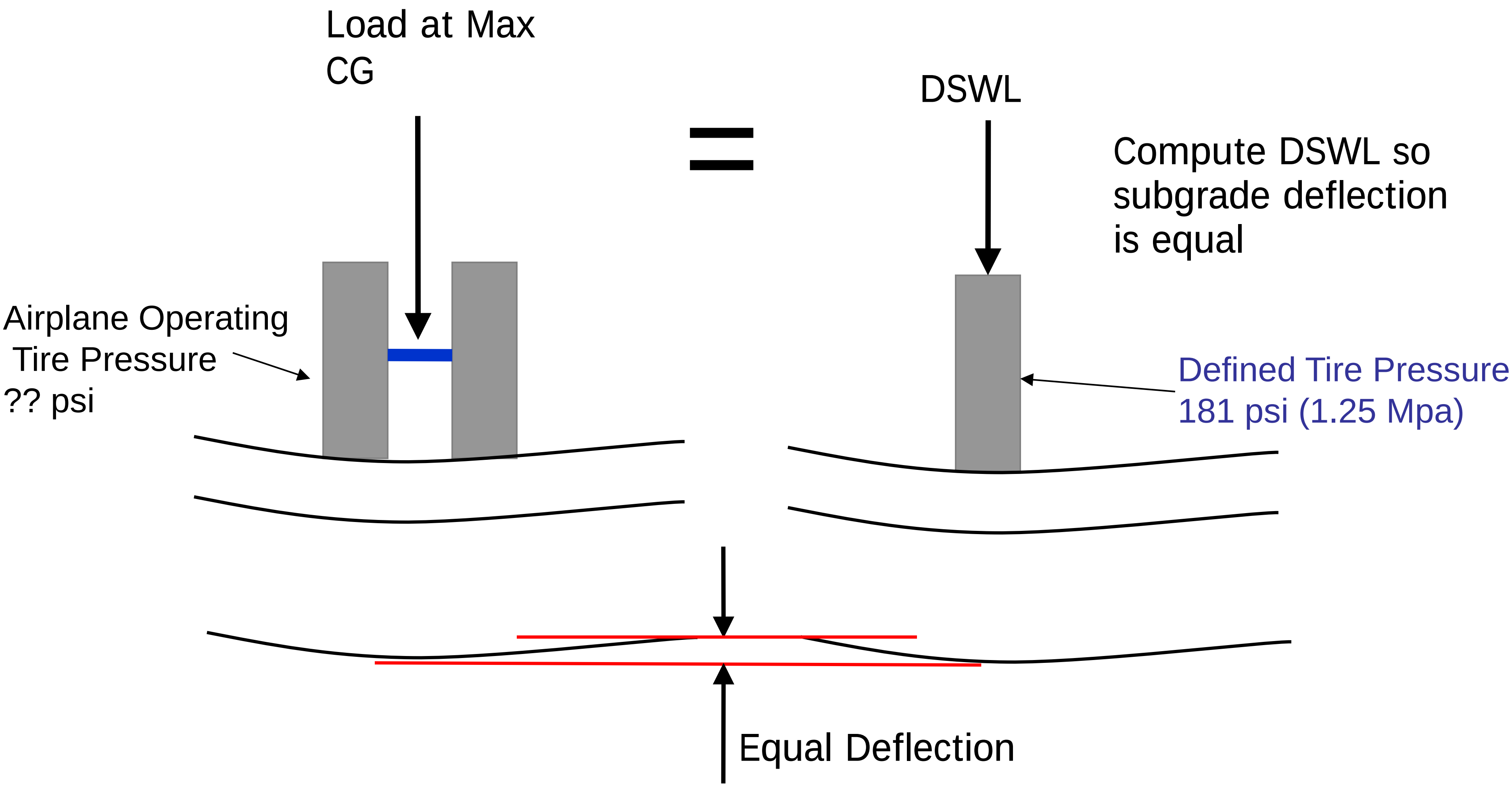
- Primary benefit to the airport owner is lower cost, and improved pavement management with optimal use of their pavement infrastructures and proper management of aircraft operating weights and frequencies.
- The mechanical approach will eliminate de facto the Alpha-factors (introduced to offset the overestimated damage produced by multi-wheel arrangement in the initial CBR equation)
- Current one-leg approach replaced by the full aircraft gear arrangement, allowing to accurately include gear proximity effect within the ACN calculation.
- Eliminate inconsistencies between pavement design and pavement strength reporting requirement.

HOW TO ACHIEVE A NEW ACN?

- Keep the same procedure as today by replacing the CBR design procedure by the ML²EA procedure. By retaining the same appearance and simplicity of the current system, the changes would not be as substantial as they might otherwise appear to those who are unfamiliar with airfield pavement.

- The new procedure would require the following set parameters:
  i. Define typical flexible structures (Surface and base AC layer thicknesses and moduli have to be fixed),
  ii. Define the new DSWL standard condition (1.5MPa suggested),
  iii. Define standard number of coverages of an aircraft landing gear (10,000?, 100,000?, other?),
  iv. Compute the DSWL (in kg) at standard conditions which gives the same pavement thickness (for the given design criteria) as required by the considered aircraft for the standard number of coverages
  v. Pavement thickness is computed by adjusting (subbase) thickness so that CDF is equal to one (1)

Historical Definition of ACN- 1980's



1^{st} Computation Batch

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- **Compute Aircraft Classification Numbers (ACN) with new calculation method based on ML²EA computer programs Alizé-LCPC and FAARFIELD V1.4 (Adapted for the purpose)**
- **Compare computed values with current ACN**
- **Compare results derived from Alizé-LCPC and FAARFIELD**
- **The new ACN calculation method is based on the following steps:**
  1. **Compute the pavement thickness required by the aircraft**
  2. **Compute the new Derived Single Wheel Load (DSWL), at a standard tire pressure inflation of 1.5 MPa, that would require the same pavement thickness (SAC and BAC being fixed)**
  3. **Compute the ACN as two times the new DSWL (in Kgs)**

Standard Parameters for the ACN Calculation

Pavement structure

- Surface layer and base layer are fixed, only the subbase layer is adjusted to reach a CDF of 1 (for a fixed number of passes)
- Pavement structures are different for Alizé-LCPC and FAARFIELD:

May consider other standard surface and base layer thicknesses

Alizé-LCPC

Thickness	Layer	Modulus
6 .00 cm (2.36 in)	SAC	E = 1300.00 MPa
12.00 cm (4.72 in)	BAC	E = 2700.00 MPa
Variable thickness	UGA (<u>Design layer</u>)	E = variable
	Subgrade	

FAARFIELD

Thickness	Layer	Modulus
10.16 cm (4.00 in)	P-401 / P-403 HMA Surface	E = 1378.95 MPa
12.70 cm (5.00 in)	P-401 / P-403 St (flex)	E = 2757.90 MPa
Variable thickness	P-209 CrAg (<u>Design layer</u>)	E = variable
	Subgrade	

- The subgrade is defined by its Young modulus E through the equivalency

  E = 10 x CBR ~1500 x CBR (E in PSI)

  Other equivalencies could be explored
- The design criterion is the subgrade failure

Standard Parameters cont.

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■ Aircraft traffic

- **Pavement structures are designed for 36,500 aircraft passes (equivalent to 10 passes per day over 10 years)**

- **Aircraft lateral wandering is not addressed (i.e. σ=0)**

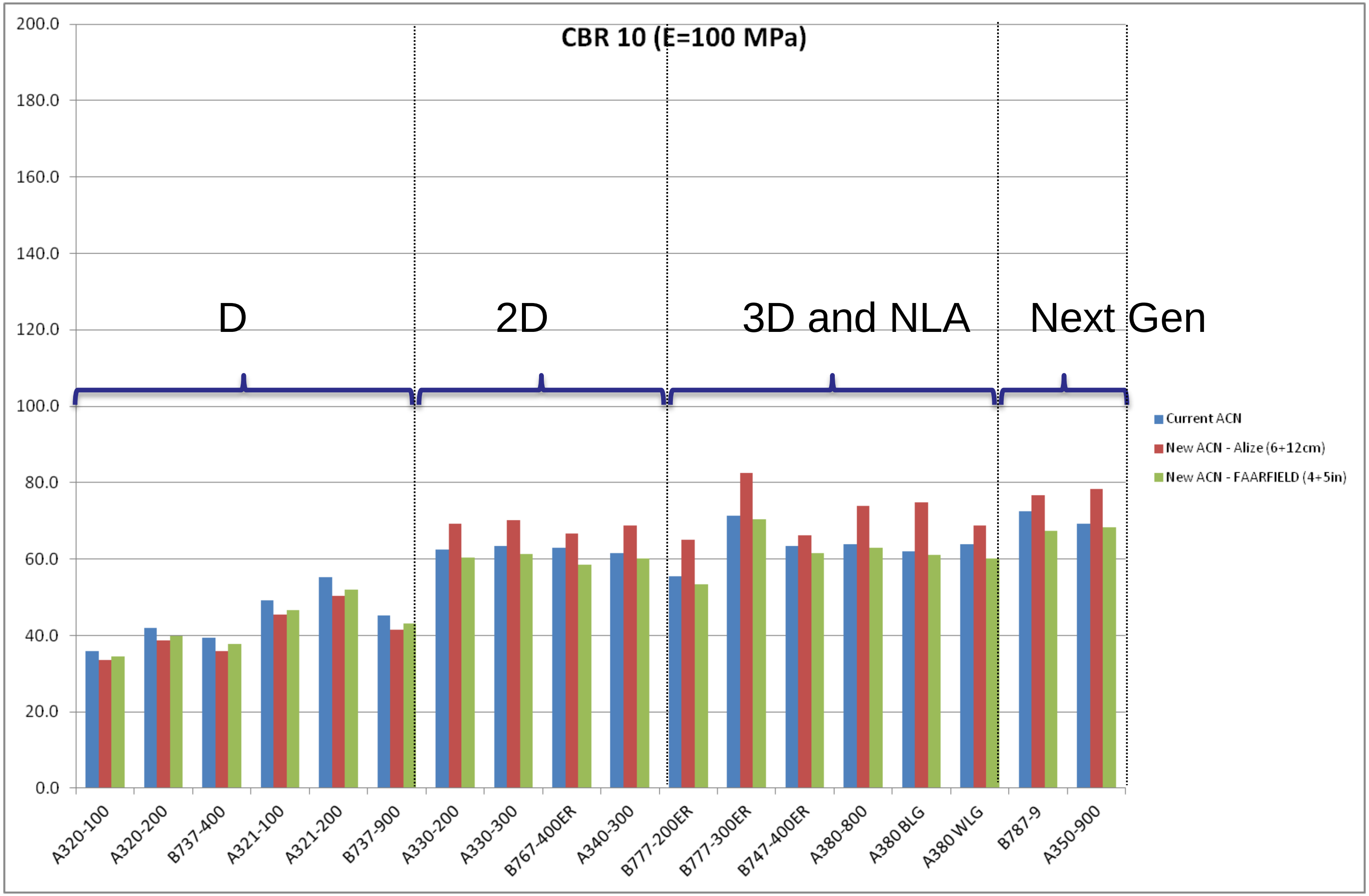
■ DSWL

  – **The new DSWL would be the single wheel load inflated at 1.5 MPa that produces the same strain at subgrade level in a multi-layer linear elastic system as the design gear,**

- **The new DSWL is computed for the same traffic level as the aircraft i.e. at 36,500 passes**

- **Lateral wandering is not addressed (fixed at σ=0)**

ACN comparison – CBR 10 (E=100 MPa)



ACN comparison – CBR 3 (E=30 MPa)

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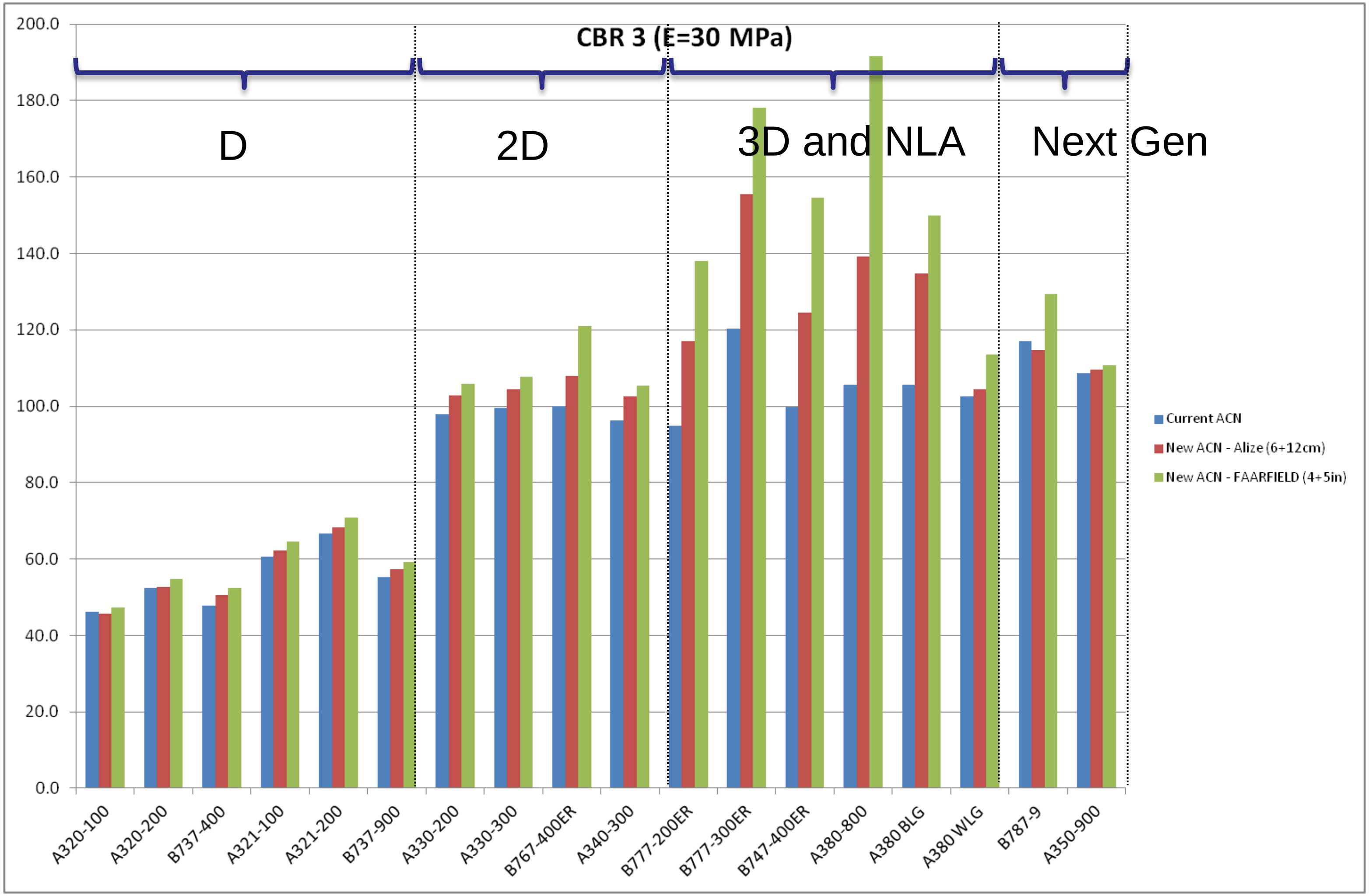

Comments

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- For D type aircraft the results derived from Alizé-LCPC and FAARFIELD correlate quite well across all subgrade strengths

- For 2D and 3D aircraft, the difference between Alizé-LCPC and FAARFIELD become quite significant
  - For high subgrade strengths, FAARFIELD is close to current aircraft ACN’s (typically lower) while Alizé-LCPC leads to higher ACNs;
  - For low subgrade strengths, the gap between Alizé-LCPC and FAARFIELD is of less importance, both being higher than current ACNs

- For 3D aircraft, both Alizé-LCPC and FAARFIELD values exceed significantly current ACN values on medium and low subgrade strengths

	Average difference between ACNs from Alizé-LCPC and FAARFIELD (as % of lowest value)			
	E=150 MPa	**E=100 MPa**	**E=60 MPa**	**E=30 MPa**
2-wheels	2.3 %	3.3 %	5.1 %	3.5 %
4-wheels	14.8 %	13.4 %	7.1 %	8.4 %
6-wheels	27.3 %	20.5 %	5.5 %	14.6 %

Preliminary Findings

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- **Very marginal surface and base AC thickness effect: The AC thickness variations are compensated by UGA layer, giving similar equivalent pavement thicknesses and DSWLs when computations are based on the subgrade failure criteria,**
- **2-wheels and 4-wheels aircraft give coherent results compared to current ACN values.**
- **6-wheel gear assembly gives higher DSWLs (thus ACNs), in particular on low subgrade strength,**
- **Comparison between the 787-9 and A350-900 illustrate pretty well the combined effect of individual wheel-loads, which prevails on high subgrade strength, and the gear geometry effect which prevails on low subgrade strength,**
- **The gear proximity effect is revealed when comparing results on A380 full MLG and either its BLG or WLG treated independently. NAPTF test findings on gear interaction could shed more light on this issue.**

Future work

- **Significant discrepancies in current ACNs and ALIZE/FAARFIELD or between ALIZE and FAARFIELD should trigger deeper investigation on:**
  1. **The fundamental differences between ALIZE-lcpc and FAARFIELD (Fatigue law, P-to-C ratio etc...). This should help explaining the 3D gear type results,**
  2. **The gear interaction effect for complex aircraft LG arrangement,**
  3. **The equivalency factors between US material and others**
  4. **Make the method valid for the largest aircraft types from ~ 6t to 600t+**

- **Think about a future integrated computer programme (part of a PMS) which would be based on ML²EA. Pavement design, ACN, PCN and overload operations would be handle by this single tool.**
- **Test other soil fatigue laws (Shell, APSDS...)**

What is the Impact on PCNs?

- The new FAA-AC 150/5335-5C gives clear and complete guidance for PCN determination and publication which remains “ICAO compliant”
- The FAA guidance is based on the CBR method for flexible pavements, and the CDF concept is introduced in the methodology.
- Similar procedure can be implemented on any other program using the CDF concept and the MLEA (e.g. FAARFIELD, ALIZE...),
- Any new procedure would be based on aircraft ACNs, thus a change in ACN number could have a direct impact on pavement PCN which would have been determined with former ACN method.
- As a consequence, new PCN guidance will have to be addressed further to handle the change in ACN <u>so that the entire ACN/PCN system could work under MLEA method</u>.

Closing Comments

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- If the PCN is less than the ACN required, then consideration needs to be taken for the following:

- How confident is the traffic projection and will traffic change in the future, especially for the six most demanding aircraft?

- Were the pavement properties, such as CBR and equivalency factors, accurately derived or just estimated? Small differences in some factors can have significant effect on the final PCN calculation.

- Is an overlay scheduled in the near future? If so, the PCN in this case should be acceptable until the refurbishment is accomplished.

- How much overload is acceptable? FAA tests scheduled for late 2013 should provide some guidance in this area.

- ICAO PCN guidance in Part 3-Pavements is outdated and not very clear. Updates proposed by the PSG should help in determining and reporting more accurate PCN's.

- New ACN/PCN system being considered which will be more in line with current linear elastic design methods.

Questions?

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