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RUNWAY PCN DESIGN THROUGH SEVERAL CPT CORRELATION WITH FAARFIELD

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ABSTRACT

Several places need a pioneer airport in several area. However it doesnot close the probability that sometimes the bigger airship needs a bigger quality. For an instance the pioneer airport use only a thin runway layer, when it need to be upgraded some of them destroy an existing layer and create a new one. In order to save more money in airship runway design we need to maximize thickness layer based on potentially next served airship.

Keywords –CBR, ACN, PCN, CPT

INTRODUCTION

Runway is an important part of Airport, almost every critical and important thing while the plane take off and landing is happened on runway. To create a good runway we have to refer to the regulation from Director General of Civil Aviation Number KP 262 2017 [1]. Runway thick calculation was designed by the kinds of airship which will use the runway. The problem will be complicated while the runway was designed for several development. In several pioneer airport which serve a small airship, runway wasn't prepared for a huge development, so when it will be used for a hugher air ship, it need to be changed with a new one.

For a long time it was a common thing and it really costs much money, so the engineer needs to find a new way to reduce the overcost in runway design. It have to be determined how to create a simple runway and it can be easy developed to serve a bigger airship[2].Overload movement should not normally bepermitted on pavements exhibiting signs of distress orfailure[3].

Another problem is a limited soil data in several area, a costly soil mechanic tests will make the engineer use only cpt tests to determine the soil properties and condition[4]. For example here are the CPT value for 11 CPT points.AircraftA380-800 (NLA), Maximum Takeoff Weight (MTOW)(1,239,000 lbs.) and Wheel Load (58,852 lbs.) [5].

Depth	qc1	qc2	qc3	qc4	qc5	qc6	qc7	qc8	qc9	qc10	qc11
0.4	17.58	21.97	13.18	4.39	3.52	8.79	8.79	7.03	26.37	26.37	8.79
0.6	30.6	26.37	14.94	4.39	4.39	13.18	10.55	5.27	30.76	30.76	11.43
0.8	26.37	30.76	17.58	7.03	8.79	11.43	10.55	3.52	21.97	18.46	13.18
1	23.73	29	21.97	8.79	13.18	10.55	12.3	4.39	23.73	13.18	13.18
1.2	21.97	27.25	15.82	10.55	6.15	9.67	13.18	5.27	21.97	12.3	11.43
1.4	20.21	21.97	13.18	12.3	4.39	10.55	13.18	4.39	21.09	11.43	11.43
1.6	17.58	17.58	15.82	13.18	2.64	13.18	15.82	6.15	19.34	8.79	13.18
1.8	17.8	13.18	17.58	14.06	3.52	14.94	16.7	8.79	17.58	8.79	14.94
2	18.46	15.82	13.18	15.82	3.52	13.18	17.58	7.03	15.82	9.67	17.58
2.2	15.82	14.06	11.43	13.18	4.39	14.06	17.58	7.91	13.18	8.79	15.82
2.4	13.18	14.94	13.18	12.3	5.27	11.43	20.21	9.67	14.06	10.55	11.43
2.6	9.67	11.43	12.3	10.55	7.03	8.79	20.21	10.55	12.3	11.43	12.3
2.8	8.79	11.43	13.18	10.55	14.94	7.91	24.61	12.3	10.55	13.18	11.43
3	8.79	8.79	13.18	12.3	21.97	6.15	26.37	15.82	8.79	12.3	13.18
3.2	10.55	9.67	15.82	9.67	43.95	8.79	29	15.82	9.67	11.43	14.06
3.4	9.67	11.43	20.21	9.67	48.34	11.43	30.76	17.58	11.43	13.18	15.82
3.6	7.91	10.55	30.76	8.79	43.95	14.06	30.76	21.97	14.06	13.18	17.58
3.8	11.43	12.3	39.55	8.79	57.13	17.58	32.52	25.49	17.58	15.82	22.85
4	13.18	11.43	65.92	10.55	57.13	20.21	35.16	48.34	26.37	14.06	29
4.2	15.82	13.18	87.89	13.18	70.31	26.37	35.16	43.95	29	14.94	39.55
4.4	20.21	13.18	96.68	14.94	74.71	43.95	39.55	52.73	31.64	14.94	36.04
4.6	26.37	18.46	136.23	17.58	43.95	43.95	43.95	57.13	43.95	17.58	39.55
4.8	23.73	21.97	131.84	20.21	52.73	39.55	43.95	74.71	57.13	23.73	57.13
5	52.73	65.92	109.86	21.97	43.95	43.95	57.13	52.73	83.5	61.52	136.23
5.2	114.26	96.68	105.47	21.09	109.86	35.16	140.63	48.34	145.02	74.71	219.73
5.4	219.73	109.86	114.26	21.97	96.68	39.55	219.73	52.73	219.73	87.89	
5.6		70.31	109.86	21.97	70.31	43.95		43.95		65.92	
5.8		43.95	118.65	30.76	79.1	35.16		52.73		61.52	
6		13.18	79.1	29	61.52	26.37		48.34		30.76	
6.2		12.3	21.97	26.37	65.92	23.73		43.95		8.79	
6.4		14.06	8.79	35.16	52.73	17.58		39.55		9.67	
6.6		15.82	12.3	43.95	43.95	21.97		26.37		11.43	
6.8		17.58	13.18	48.34	43.95	26.37		39.55		13.18	
7		15.82	17.58	43.95	48.34	23.73		26.37		13.18	
7.2		14.94	13.18	52.73	52.73	17.58		25.49		11.43	
7.4		13.18	13.18	52.73	39.55	16.7		21.97		11.43	
7.6		14.94	9.67	74.71	39.55	13.18		26.37		10.55	
7.8		14.94	11.43	61.52	35.16	15.82		21.97		9.67	
8		11.43	13.18	43.95	30.76	14.06		13.18		8.79	
8.2		13.18	13.18	35.16	30.76	13.18		17.58		7.91	
8.4		11.43	17.58	36.91	35.16	12.3		15.82		6.15	
8.6		9.67	16.7	35.16	57.13	13.18		17.58		7.03	
8.8		7.91	20.21	26.37	65.92	11.43		16.7		7.03	
9		17.58	17.58	26.37	70.31	13.18		29		6.15	
9.2		21.97	30.76	29.88	105.47	13.18		39.55		5.27	
9.4		20.21	43.95	30.76	131.84	14.94		35.16		5.27	
9.6		16.7	61.52	24.61	219.73	15.82		48.34		6.15	
9.8		13.18	153.81	21.97		15.82		57.13		5.27	
10		12.3	219.73	21.97		17.58		109.86		6.15	
10.2		13.18		20.21		21.97		127.44		8.79	
10.4		12.3		17.58		21.97		87.89		10.55	
10.6		11.43		21.97		23.73		57.13		13.18	
10.8		12.3		26.37		26.37		83.5		14.94	
11		14.06		30.76		31.64		153.81		14.06	
11.2		15.82		43.95		33.4		197.75		15.82	
11.4		20.21		43.95		30.76		219.73		15.82	
11.6		24.61		61.52		30.76				17.58	
11.8		22.85		65.92		35.16				18.46	
12		21.97		57.13		70.31				17.58	
12.2		30.76		65.92		87.89				15.82	
12.4		26.37		65.92		131.84				16.7	
12.6		30.76		79.1		162.6				19.34	
12.8		30.76		92.29		219.73				21.97	
13		33.4		96.68						30.76	
13.2		30.76		109.86						30.76	
13.4		35.16		219.73						35.16	
13.6		34.28								43.95	
13.8		39.55								52.73	
14		35.16								65.92	
14.2		39.55								79.1	
14.4		48.34								92.29	
14.6		43.95								105.47	
14.8		48.34								123.05	
15		101.07								149.41	
15.2		219.73								219.73	

The CPT data need to be interpreted before used to determined runway characteristic.

METHODOLOGY

To determine how the runway need to be, we need to determine the maximum airship which will use the runway. In this case we use two kind of airship, such as ATR-72 500 type and B737 800 NG type. Here are the characteristics.

No	Airship	Wheels	Annual Departu-res	Converti-on Factor	R2
1	ATR 72- 500	Dual Wheel	919	1	919
2	B 737- 800NG	Dual Wheel	5214	1	5214

No.	Ship Types	Wheels	MTOW (lb)	MTOW (kg)	P (%)	N	W2	W1
1	ATR 72-500	Dual Wheel	47,466	21,549.56	95%	4	11273.18	41491
2	B 737-800NG	Dual Wheel	174,700	79,313.80	95%	4	41491.25	41491

No	Jenis Pesawat	Log R2	(w2/w1)^0.5	Log R1	R1
1	ATR 72-500	2.9634	0.5212	1.5447	35.05
2	B 737-800NG	3.7172	1.0000	3.7172	5214.30
TOTAL					**5249**

To determine the corelation of each data we need to determine at what elevation the desgin will be built. If the runway will be built at elevation 4 m below the soil surface so we need to determine a various methode to pick a soil design[6].

Average method

This methode just create an average of value in minus 4 m cpt data and it show 30.1 value

Average minus Deviation Standard method

In thies methode we use a formula below :

qc desain = (qc rerata – (90% SDqc))

= (30.1 – (90% x 19.4))

= 12.7

To determine the runway design we need to determine PCN number and it needs CBR value . In case of there is nothing of CBR value we need to determine CBR value based on CPT – CBR corelation value. Here is the corelation based on Jurnal Dinamika Teknik Sipil Vol 11 / No / 1/ Januari 2011 / Fadly Ahmad [6].

No	Corelation	Source
1	CBR = 0.5 qc	Rahardjo
2	CBR = 0.33 qc	Schmertmann
3	CBR = 0.27 qc	Fadly

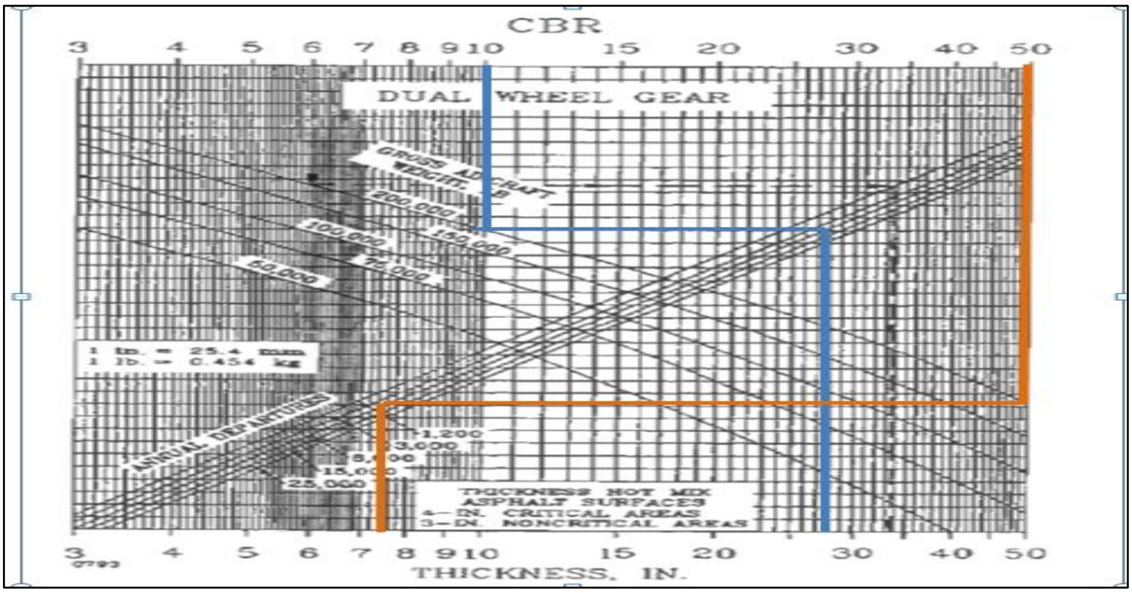
ANALYSIS AND RESULTS

To determine the hardening layer, we need to make a simulation based on choosen correlation and it need to fulfill boundary condition in a table below (Table is in Indonesia in order of original source).

Tipe roda pendaratan	Berat kotor (lb)	Kedalaman pemadatan Tanah Noh-Kohesif (in)				Kedalaman pemadatan Tanah-Kohesif (in)			
		100%	95%	90%	85%	100%	95%	90%	85%
S	30.000	8	8-18	18-32	32-44	6	6-9	9-12	12-17
	50.000	10	10-24	24-36	36-48	6	6-9	9-16	16-20
	75.000	12	12-30	30-40	40-52	6	6-12	12-19	19-25
D (termasuk 2S)	50.000	12	12-28	28-38	38-50	6	6-10	10-17	17-22
	100.000	17	17-30	30-42	42-55	6	6-12	12-19	19-25
	150.000	19	19-32	32-46	46-60	7	7-14	14-21	21-28
	200.000	21	21-37	37-53	53-69	9	9-16	16-24	24-32
2D (termasuk B757, B767, A-300, DC-10-10, L1011)	100.000	14	14-26	26-38	38-49	5	6-10	10-17	17-22
	200.000	17	17-30	30-43	43-56	5	6-12	12-18	18-26
	300.000	20	20-34	34-48	48-63	7	7-14	14-22	22-29
	400.000-600.000	23	23-41	41-59	59-76	9	9-18	18-27	27-36
2D/D1, 2D/2D1 (termasuk MD11, A340, DC10-30/40)	500.000-800.000	23	23-41	41-59	59-76	9	9-18	18-27	27-36
2D/2D2 (termasuk B47 series)	800.000	23	23-41	41-59	59-76	9	9-18	18-27	27-36
	975.000	24	24-44	44-62	62-78	10	10-20	20-28	28-37
3D (termasuk B777series)	550.000	20	20-36	36-52	52-78	6	6-14	14-21	21-29
	650.000	22	22-39	39-56	52-67	7	7-16	16-22	22-30
	750.000	24	24-42	42-57	57-70	8	8-17	17-23	23-30
2D/3D2 (termasuk A380 series)	1250.000	24	24-42	42-61	61-78	9	9-18	18-27	27-36
	1350.000	25	25-44	44-64	64-81	10	10-20	20-29	29-38

Based on table above we know that maximum airship use a dual wheel and the soil is non cohesif with CBR target is in 95%. So the depth of compaction layer is around 21-37 inch.

Based on three correlation above we know that Schmertmeenn is a middle one between three of them, so we use it to determine how deep the base is. Based on it we know that CBR is 1/3 qc so we know that CBR is 10%.



a. Total Thickness
From table above the blue one (28 inch) is for a total hardening layer, for the thickness design we use around 30 inch. It for an annual departure 5249

b. Subbase Thickness
Through the same graphics we use a Class C Base Course such as 65%. Based on plotting we get the minimum thickness around 7.5 inch. It mean the thickness of surface and base above sub base is more than 7.5 inch, for design it used 12 in. It mean the subbase thickness is 30 in – 12 in = 18 in.

c. Surface Thickness
Based on KP 93 2015 the minimum layer for critical area is 4 in.

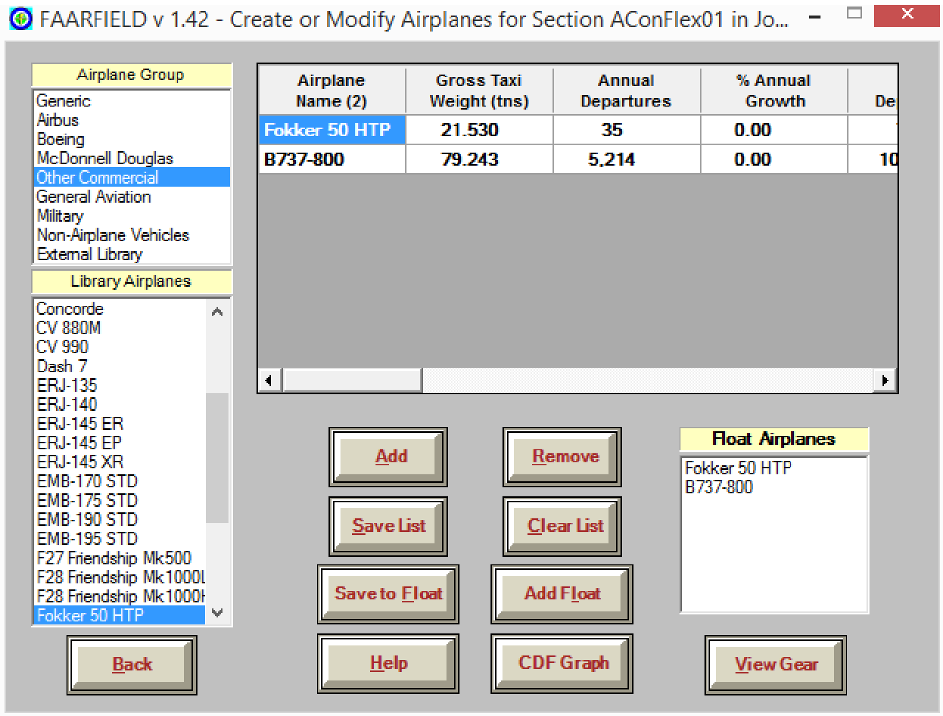
d. Base Thickness
Base course that used is base course for A class with CBR 95%. The thickness is 12 in – 4 in = 8 in.
Based on points above the flexible pavement with 10% CBR can be seen below :

Layer	Tebal (in)	Tebal (cm)
Surface Course	4	10
Base Course	8	20
Subbase Course	18	45
Total	30	75

From data above we try to check our design through FAARFIELD.

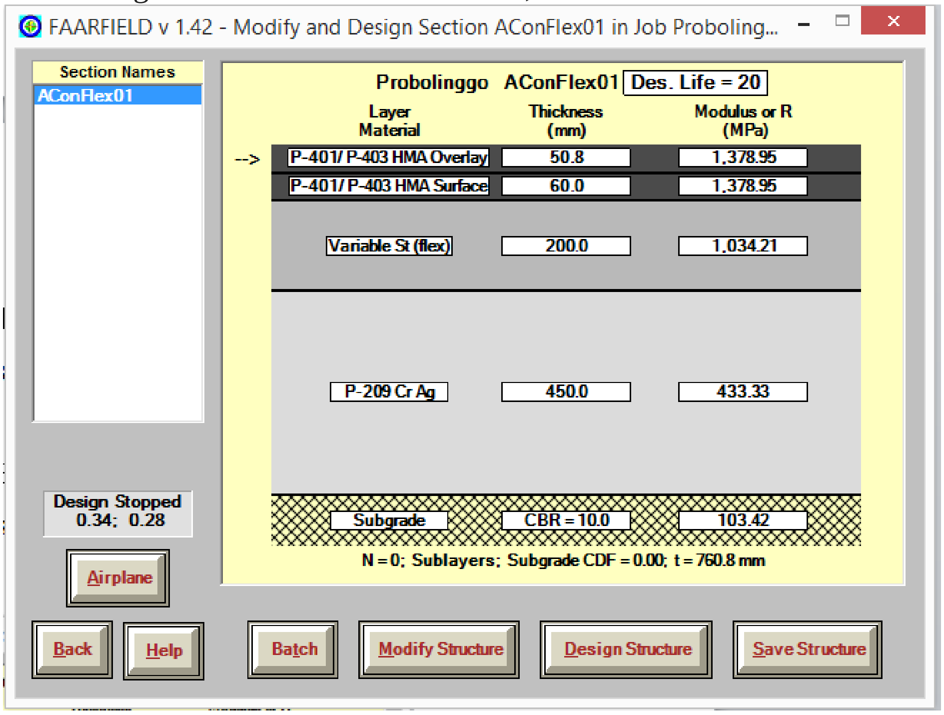
a. Airship determining

In FAARFIELD we simulate two kinds of airship, such as ATR-72 and Boeing 737-800.



b. Simulate through CBR design

CBR Design based on simulation is 10%, the result can be seen below :



Based on simulation we can see there are several changes above, especially in layer thickness where the total of surface is 110.8 m not 100 mm like the design.

PCN ANALYSIS

In PCN-ACN Analysis the CBR clasification is an important part. We can see CBR clasification below.

No	CBR Value	Class
1	>= 15	A
2	>=10	B
3	>=6	C
4	>=3	D

Based on correlation we knew that CBR Design is:

CBR = 0.33 x qc
CBR = 0.33 x 30.1
CBR = 10

It shows that used CBR is in B Class. In first step the airship which served is ATR72 an d BOEING 737-800, ACN that used can be seen as below :

Jenis Pesawat Udara	Massa All - Up (Massa Apron Maksimum) (Massa Operasional Kosong)		Beban pada satu roda gigi utama *(Main gear leg)* (%)	Standar tekanan ban pesawat			ACNrelatif terhadap Subgrade perkerasan Rigid (Kaku)				ACNrelatif terhadap Subgrade perkerasan Flexible			
							High K=150 MN/m³	Medium K=80 MN/m³	Low K= 40 MN/m³	Ultralow K=20 MN/m³	High CBR= 15%	Medium CBR= 10%	Low CBR= 6%	Verylow CBR= 3%
	lbs	kgs		psi	kg/cm²	mPa	A	B	C	D	A	B	C	D
ATR 72 Basic Tires	47466 26896	21530 12200	47.8	114	8.01	0.79	13 6	13 7	14 7	15 8	11 5	12 6	14 7	15 8
B737-800	174700 100000	79243 43459	46.79	204	14.34	1.41	49 25	52 27	54 28	56 30	43 22	45 23	50 25	55 29

Sumber : Peraturan Direktur Jenderal Perhubungan Udara Nomor: KP 262 Tahun 2017 halaman 9-5

Based on table above we know that :

- ACN Maks = 12
- CAN Min = 6
- P Maks = 47.466 lbs
- P Min = 26.896 lbs

For flexibility runway use 1.1 P, so :

$$PCN = 6 + (12 - 6)\frac{(200.000x1.1) - 26.896}{47.466 - 26.896}$$

PCN = 63

Because max ACN is 12, so PCN > ACN

Meanwhile for PCN Boeing 737 :

- ACN Maks = 45
- CAN Min = 23
- P Maks = 174.700 lbs
- P Min = 100.000 lbs

For flexibility runway use 1.1 P, so:

$$PCN = 23 + (45 - 23)\frac{(200.000x1.1) - 100.000}{174.700 - 100.000}$$

PCN = 59

CONCLUSIONS

PCN is a standard used in combination with the Aircraft Classification Number (ACN) to specify the strength of a runway, taxiway or apron of International Civil Aviation Organization (ICAO). This usuallyused to ensure that they are not subjected to unreasonable wear and tear, thus extend their operational life.

The PCN is the ACN of the most harmful aircraft that usually use the pavement on a regular basis. The PCN values are published in the Aeronautical Information Publications (AIPs), part AD (aerodromes).

The PCN is actually indicated as a five-part code, separated by forward-slashes, describing the piece of pavement concerned.

From analyses data above it can be concluded that:

1. Based on simulation we can see there are several changes above, especially in layer thickness where the total of surface is 110.8 m not 100 mm like the design.

2. Based on data above PCN Value is :PCN 59 / R / B / X / U

3. PCN-ACN design need a real CBR value, next every soil investigation need representative CBR value.

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