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Runway Pavement Strength Evaluation of Yogyakarta International Airports with COMFAA 3.0 Software

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Abstract: Yogyakarta International Airport (YIA) is a new airport which serves as an international transit station for Yogyakarta and surrounding areas. The airport was designed to serve large and heavy aircrafts with relatively high frequency. To meet flight safety standards, the runway must be designed to be able withstand the wheel weight of aircrafts to be served by the airport. The study aims to determine the thickness and strength of the runway pavement using the FAA method (Federal Aviation Administration) and COMFAA software. The reference aircraft used was Boeing 747-400ER based on landing wheel configuration. With a subgrade CBR value of 6%, Aircraft Classification Number (ACN) and Pavement Classification Number values of 77.8 and 94.9, respectively, were obtained. PCN value higher than ACN value indicates that the pavement structure condition is able to withstand the weight of all aircraft types that are planned to be served by the runway of YIA.

Keywords: Federal Aviation Administration, aircraft classification number, pavement classification number

1. Introduction

The Special Region of Yogyakarta is one of the biggest tourist destinations in Indonesia with a global reputation. According to Statistics of D.I.Y Province [1], in 2017 the number of domestic or international tourist visits to the Special Region of Yogyakarta that landed at Adisujtipto Airport reached 7.8 million passengers, even though the airport owned by the Indonesian Air Force is ideally only able to accommodate 1.8 million passengers per year. Limited length of runway and number of aircraft parking stands pose an obstacle for queueing aircrafts to land at Adisutjipto Airport. Overcapacity issue on the runway coupled with lack of space for expansion resulted in the decision to build a new airport on the south coast of Java, namely in Temon District, Kulon Progo, Special Region of Yogyakarta (DIY). The new airport is now called New Yogyakarta International Airport (YIA). MoU signing was held on May 11, 2011, focusing on capacity optimization and modernization of Adisutcipto Airport, and feasibility study for the construction of the new airport [2].

Runway is a defined rectangular area on a land aerodrome prepared for the landing and takeoff of aircraft. Designing runway needs to take into account length, width, orientation (direction), configuration, slope, and pavement thickness. Runway pavement thickness is stated in Pavement Classification Number (PCN). The value of PCN must be greater than the value of Aircraft Classification Number (ACN). ACN is the 'weight value' of an aircraft, and every aircraft has a different ACN value depending on the weight and configuration of aircraft axis and wheels.

In the construction project of YIA, the calculation of runway flexible pavement thickness is performed using the FAA (Federal Aviation Administration) 2014 method with one-lane runway type and the analysis of PCN value strength is performed using COMFAA software, where the PCN value cannot be below the ACN value of the reference aircraft. Considering that aircrafts operating in YIA are going to vary, this will affect the ACN value of each aircraft.

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The reference aircraft in this study is Boeing B747-400ER which is one of jumbo jet wide-body aircrafts in the world that lands on YIA.

2. Theoretical Framework

The advent of new generation of modern common aircrafts, rapid growth of air travel demand, consistent and exact traffic laws and regulations for different phases of flight operations have made the airport to be considered as a complex and dynamic system. Runway pavements, which are the passageways of different aircrafts, are flexible, rigid, and composite. Because pavement system is directly subjected to the aircraft loads, pavement behavior and condition have a significant effect on fleet performance; therefore, having an adequate pavement system considering all the designing circumstances is necessary [3]. The previous studies compared rigid pavement planning methods on apron using the FAA, PCA, (Portland Cement Association), and LCN (Load Classification Number) methods at Juanda Airport. Based on the results of the analysis and discussion, it was concluded that the design of rigid pavement structure thickness for the LCN method yielded a result of 44 cm, FAA yielded 33.5 cm, and PCA yielded 32.5 cm. Considering that the planning of airport pavement thickness could be calculated using various methods, the planning of runway flexible pavement thickness at Husein Sastranegara Airport, Bandung, using the International Civil Aviation Organization (ICAO)) method and FAARFIELD software stated that that the runway pavement thickness needs to be improved either graphically or analytically. FAARFIELD gave vastly different pavement calculation results compared to both values of the ACN-PCN method. The ACN-PCN method will provide a higher thickness of the pavement layer when compared to the calculation using the FAARFIELD [4], [5].

The research has been conducted to evaluate the pavement sufficiency of four Iraqi airports (Baghdad International airport, Basrah International airport, Salaymaniyh International airport, and Balad Airfield) by use the ACN-PCN method. The results indicate that the old runway is not adequate to accommodate every type of aircraft except the small body aircraft (B 737-300, A 319-100), because the ACN /PCN ratio of the critical airplane model B 777-200 LR equal to 1.9 which is more than 1, therefore this runway should be reconstructed to increase the pavement strength (PCN) [6]. The pavements of runway, taxiway, apron at Soekarno Hatta Airport were analyzed for strength using the ICAO method and the largest reference plane, the Airbus A-380, was able to withstand loads of up to 80,000 lbs, while the weight of the Airbus A-380 was only 57,000 lbs [7].

Analysis and evaluation of pavement apron using the FAA method at Kalimarau Berau airport give results showed the same thickness of rigid pavement of 15 inches (38.10 cm) with a 10-year design lifespan and 15-inches (38.10 cm) with a 5-year design lifespan, because of the number of Annual Departure Equivalent at 5 years and 10 years on airplanes Airbus A300 plans each opening smaller than 1200 (annual minimum number departure on the pavement thickness planning curve for dual wheel gear) [8]. The existing pavement thickness at Husein Sastranegara International Airport, Bandung was 39.3 inches and the reference aircraft used was Boeing 787-9 that had an ACN value of 87/F/C/X. Using COMFAA software, a PCN value of 50/F/C/X/T was obtained. Since the PCN value was less than the ACN value, recalculation was performed using the CBR method and pavement thickness of 50 inches was obtained, which required an overlay of 10.7 inches [9].

The study conducted a comparison analysis of the calculation of flexible pavement thickness of the runway of Samarinda Baru Airport using 3 methods, namely CBR, LCN, and FAA methods. The result of the CBR Method showed a total runway pavement thickness of 66 cm, consisting of surface thickness of 15 cm, base course thickness of 28 cm, and subbase course thickness of 23 cm. For the LCN Method, a total runway pavement thickness of 45 cm was obtained, consisting of surface thickness of 11 cm, base coarse thickness of 18 cm, subbase coarse thickness of 16 cm. For the FAA Method, a total pavement thickness of 72 cm was obtained, consisting of surface thickness of 11 cm, base coarse thickness of 33 cm, and subbase coarse thickness of 28 cm [10]. The analyzed the total runway pavement of Lombok International Airport (BIL) using the FAA method and reference aircraft of B 739 obtained a surface pavement of 4 inches, a base course of 10.6 inches and a subbase course of 31.4 inches [11].

Based on the evaluation of Sultan Mahmud Badaruddin II Airport Palembang, a runway pavement thickness of 78.04 cm, a taxiway of 76.23 cm, and an apron of 76.48 cm were obtained [12]. An evaluation of runway thickness using COMFAA software with critical aircraft of B737-900 for a pavement thickness of 75.7 inches and a CBR of 5.1% obtained PCN values that are greater than the ACN value, thus, the pavement was in safe condition [13]. The previous study is to evaluate the impact of Large Aircraft on airport flexible pavement versus overloading in ICAO Practice. On the basis of the results of this research, it is concluded that, The statement in ICAO Practice “the annual number of overload movement should not exceed approximately 5 per cent of total annual aircraft movement” must be re-evaluated due to many factors as new large aircraft type, annual departures and soil characteristics which High reduction in pavement life that has an average of 8.2% of 20 years design life due to introduction of A380-800 by 5% of annual departures, occurred at 3% CBR [14]. The evaluated runway pavement using COMFAA 3.0 software with B777-300ER as the reference aircraft and a subgrade CBR of 7% obtained an ACN value of 89.3 and a PCN value of 93.1. Bangladesh airport currently accommodates wide-body aircraft such as the Boeing 777 and it is hoped that wide-body aircraft operations will increase significantly in the future [15].

2.1 Airport and Runway

According to ICAO Annex 14 of 2013 [16], an airport is a defined area on land or water (including any buildings, installations, and equipment) intended to be used either wholly or in part for the arrival, departure, and surface movement of aircraft. According to FAA AC 150/5300-23A of 2014 [17], an airport is a land area used or intended for the landing and takeoff of aircraft, including any buildings and facilities if available. An Aircraft is any machines or devices that are capable of flight in the atmosphere due to air reaction lift force, but not due to air reaction against earth surface used for aviation.

According to the Minister of Transportation Regulation No. PM 56 of 2015 [18], an airport is an area on land and/or water with specified borders that is used as the place for Aircrafts to land and takeoff, receive and discharge passengers or cargo, and a place for intra and intermodal transportation, which is equipped with aviation safety and security facilities, as well as basic facilities and other supporting facilities.

According to the Regulation of the Director General of Civil Aviation of 2005 [19], an airport is an aerodrome used by aircrafts to land and takeoff, receive and discharge passengers and/or cargo and/or post that is equipped with aviation safety facilities and as a place for intermodal transportation transfer. The most essential facility of airport is a runway. It must be designed and planned carefully so that aircrafts can land and takeoff safely. According to ICAO Annex 14 of 2013 [16], a runway is a defined rectangular area on a land aerodrome prepared for the landing and takeoff of aircraft. The minimum distance needed by an airplane to takeoff on maximum takeoff weight condition, on sea level, on atmosphere, on the presence of air, and on 0% runway gradient.

2.2 Characteristics of Reference Airplane

A jumbo jet operating at Yogyakarta International Airport is Boeing 747-400. It is a wide-body jet manufactured by Boeing Commercial Airplanes which has landing wheel type of double dual tandem, can carry up to 410 passengers and has a maximum takeoff load of 877,001.084 lbs [20]. Table 1 showed the Boeing 747-400 Specification.

Table 1 - Boeing 747-400 specification [20]

Seats	410 seats
Overal Length	70.6 m
Wing Span	64.9 m
Height	19 m
Typical Cruise Speed	908 km/h
Maximum Takeoff Weight	877,001.084 lbs
Engines	4 Pratt & Whitney PW4056
Thrust of Engine	163,300 lbs
Maximum Fuel Capacity	216,840 liters

2.3 Aircraft Classification Number (ACN) and Pavement Classification Number (PCN)

ACN is a value indicating the relative effect of reference airplane on a runway in certain category. An ACN value acts as a parameter of strength design and analysis in the planning of airport pavement. ACN is defined as twice the single wheel load drop, aircraft manufacturers have provided official calculations of ACN values, ACN calculations require detailed aircraft information such as maximum center of gravity, maximum ramp weight, wheelbase, tire pressure and other factors. An ACN value cannot exceed the PCN value of the runway itself. PCN is the standard of the international civil aviation organization (ICAO) used to indicate runway strength. PCN is a number indicating the capacity of the pavement layer to support planned aircraft weight. PCN value can help ensure the planning of runway pavement, obtain results in accordance with applicable FAA regulations, and plan runway thickness with set runway lifespan [21]. Flexible pavement for airport is classified into the following: High Strength, CBR 15 (CBR > 13 %), Medium Strength, CBR 10 (CBR 8% -13%), Low Strength, CBR 6 (CBR 4% - 8%), Ultra Low Strength, CBR 3 (CBR < 4%) [22].

2.4 The FAA Method

The FAA method is the most widely used method for planning flexible pavement of aerodrome developed by American Federal. This method was built upon the CBR method. The type and value of subgrade strength greatly affected the calculation analysis using the FAA method. Pavement thickness planning using the FAA method was based on charts designed by the FAA. The steps in determining the thickness of flexible pavement were as follows:

a) Identify aircraft data, growth, and movement of aircraft operating at an airport (Annual Departure).
b) Determine the reference airplane. An aircraft with the heaviest load may be used (Maximum Takeoff Weight/MTOW).
c) Determine the CBR value of subgrade dan subbase course.

d) Determine the type of aircraft landing wheel (aircraft wheel configuration).

2.5 COMFAA Software

COMFAA 3.0 is a software developed by the Federal Aviation Administration (FAA) that is used to analyze the strength of a flexible pavement of an airport with predetermined pavement thickness data. COMFAA 3.0 software could be run by entering the design aircraft traffic data, design pavement thickness, and ACN-PCN values. COMFAA is loaded with internal aircraft data which includes several US commercial and military aircrafts currently in operation. These data are provided directly by the aircraft manufacturer. Airplane standard characteristics on the internal data represent ICAO standard conditions for ACN calculations. The characteristics of external data in COMFAA could be modified, allowing users to modify an airplane [21].

3. Research Method

The initial stage included the collection of secondary data from PT Angkasa Pura I and the FAA. Then, the data was analyzed using the FAA method. The secondary data enabled the calculation of runway flexible pavement using the FAA by determining the type of reference aircraft and the load of main landing gear of the reference aircraft, calculating Equivalent Annual Departure (EAD), and then determining total pavement thickness required.

3.1 The Analysis of Runway Pavement Thickness Using the FAA Method

3.1.1 Determining a Reference Aircraft

In planning airport runways, a reference aircraft has to be determined because of the various types of aircrafts that are going to operate at YIA. The aircrafts have different landing gear configurations and weights. The heaviest aircraft available may be chosen because the ACN value of a heavy aircraft is representative of other aircrafts with smaller ACN values. According to ICAO, the requirement of runway planning using flexible pavement is that the PCN value from the calculation of flexible pavement thickness must be greater than the ACN value of the reference aircraft [16]. Annual Departure Data of YIA can be seen in Table 2.

The determination of a reference aircraft not only depended on the weight and body width (jumbo jet), but also took into account the annual departure. For this planning, the researcher used aircraft movement data at YIA in 2019 and the reference aircraft used was the Boeing B-747 400 Belly because it is a jumbo jet aircraft that has a large MTOW with fewer wheel configurations than Airbuss. The Airbus A380 is a wide-body aircraft with the FAA landing gear configuration as Two Dual Wheels in Tandem Main Gear/Three Dual Wheels in Tandem Body Gear with Dual wheel Nose. Whereas, B-747 400 Belly is a wide-body aircraft with the FAA landing gear configuration as Two Dual Wheels in Tandem Main Gear/Two Dual Wheels in Tandem Body Gear with Dual Wheel Nose Gear.

Table 2 - Annual departure data of YIA [23]

No.	Aircraft Name	Gross Wt (tons)	MTOW (kg)	Annual Departures
1	A321-200 std	89.40	89,400	10
2	A320-100	68.40	68,400	10,047
3	B737-800	79.24	79,243	7,409
4	B737-900 ER	85.37	85,366	6,019
5	D-200	88.31	88,314	5,567
6	A330-300 std	230.90	230,900	119
7	B787-9 (Preliminary)	251.74	251,744	41
8	A350-900	272.90	272,904	1
9	B777-300 ER	352.44	352,441	400
10	B747-400	397.80	397,801	22
11	B747-400 Belly	397.80	397,801	22
12	A380	562.00	562,000	52
13	A380 Belly	562.00	562,000	52

3.1.2 Calculating EAD

The equations used to calculate EAD can be referred to in Eq. (1) to Eq. (4) as follows:

$$LogR1 = LogR2 \times \left(\frac{W2}{W1}\right)^{1/2} \quad (1)$$

$$R2 = \text{annual departures} \times \text{multiplier factor} \quad (2)$$

$$W2 = 0{,}95 \times MTOW \times \left(\frac{1}{n}\right) \tag{3}$$

$$W1 = 0{,}95 \times MTOW \text{ reference aircraft} \times \left(\frac{1}{n}\right) \tag{4}$$

where R1 is Equivalent Annual Departure Plan, R2 is Equivalent Annual Departure (the sum of annual departure of all aircrafts converted into the reference aircraft in accordance with the landing gear type), W1 is the wheel load of the reference aircraft and W2 is the wheel load of the aircraft in question. MTOW is the Maximum Takeoff Weight, and 1/n is the conversion factor according to the aircraft wheel type. The conversion of aircraft wheel type can be seen in Table 3.

Table 3 - The conversion of aircraft wheel type [24]

Converted from	To	Multiplier Factor
Single Wheel	Dual Wheel	0.8
Single Wheel	Dual Tandem	0.5
Dual Wheel	Dual Tandem	0.6
Dual Tandem	Dual Tandem	1.0
Dual Tandem	Single Wheel	2.0
Dual Tandem	Dual Wheel	1.7
Dual Tandem	Single Wheel	1.3
Double Dual Tandem	Dual Tandem	1.7

3.1.3 Calculating Total Pavement Thickness

The total pavement thickness was calculated by plotting CBR subgrade data obtained from the FAA, Advisory Circular 150/5335-5C, MTOW (Maximum Takeoff Weight) of the reference aircraft, and the Equivalent Annual Departure value into a Graph in accordance with the type of aircraft being referred to, which was Boeing B747-400 Belly. After the data are plotted to the graph, pavement thickness will be obtained.

3.2 Analysis of the Strength of Runway Pavement with COMFAA Software

COMFAA program was used to determine the PCN and ACN values of the runway pavement thickness that indicated the capability of the runway to withstand aircraft loads. Following were the steps to determine ACN and PCN values using COMFAA program. In determining the PCN value with COMFAA, all planes are inputted into the software based on annual departure and expense. This is based on the fact that the damaging effect of the aircraft on the pavement differs depending on the characteristics of aircraft loads and movements, while other PCN methods identify annual On departure all operational aircraft are converted to critical aircraft.

a) Convert the pavement thickness obtained from the FAA method analysis to the reference pavement thickness.
b) Input traffic data such as: aircraft type, aircraft weight, annual departure amount.
c) Input the reference thickness to COMFAA.
d) Input subgrade CBR value.
e) ACN and PCN values were obtained.

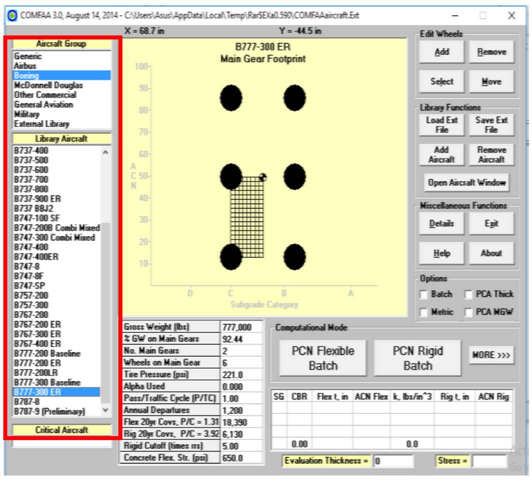

Fig. 1 - COMFAA software main screen.

4. Results and Discussion

4.1 Gear Departure (R2)

Aircrafts operating at YIA had different landing gear shape, thus, it was necessary to calculate the R2 value for every aircraft by multiplying aircraft movement with the conversion factor in accordance with the landing gear type, then, the total overall pavement load was obtained. Therefore, the gear departure of every plan aircraft could be calculated using Eq. (2). The results of the R2 value calculation were presented in Table 4.

Table 4 - The results of R2 calculation

No	Aircraft Type	Annual Departures (a)	Landing Gear Configuration	Multiplier Factor (b)	R2 (a × b)
1	A321-200 std	10	Dual Wheel	0.6	6.0
2	A320-100	10,047	Dual Wheel	0.6	6,028.2
3	B737-800	7,409	Single Wheel	0.5	3,704.5
4	B737-900 ER	6,019	Single Wheel	0.5	3,009.5
5	D-200	5,567	Single Wheel	0.5	2,783.5
6	A330-300 std	119	Single Wheel	0.5	59.5
7	B787-9 (Preliminary)	41	Double Dual Tandem	1.7	69.7
8	A350-900	1	Single Wheel	0.5	0.5
9	B777-300 ER	400	Dual Tandem	1.0	400
10	B747-400	22	Double Dual Tandem	1.7	37.4
11	B747-400 Belly	22	Double Dual Tandem	1.7	37.4
12	A380	52	Double Dual Tandem	1.7	88.4
13	A380 Belly	52	Double Dual Tandem	1.7	88.4

4.2 Wheel Load of Each Aircraft (W2)

Aircraft landing or takeoff is supported by rear landing gear so that rear wheels could support aircraft weight during operation. Therefore, wheel load gear of every plan aircraft type could be calculated using Eq. (3). The results of the W2 calculation were presented in Table 5.

4.3 Plan Aircraft Wheel Load (W1)

Plan aircraft wheel load (W1) with reference aircraft Boeing B747-400ER could be calculated using Eq. (4). W1 = 0.95 × 877,001.084 × 1/8 = 104,143.88 lbs.

Table 5 - The results of W2

No	Aircraft Type	MTOW (lbs) (a)	Multiplier Factor (b)	W2 (0.95 × a × b)
1	A321-200 std	197,093	0.25	46,809.65
2	A320-100	150,796	0.25	35,814.10
3	B737-800	174,701	0.25	41,491.47
4	B737-900 ER	188,200	0.25	44,697.46
5	D-200	199,699	0.5	94,857.04
6	A330-300 std	509,047	0.5	241,797.50
7	B787-9 (Preliminary)	555,001	0.125	65,906.31
8	A350-900	601,650	0.5	285,783.91
9	B777-300 ER	776,999	0.25	184,537.36
10	B747-400	877,001	0.125	104,143.88
11	B747-400 Belly	877,001	0.125	104,143.88
12	A380	1,238,998	0.25	294,262.00
13	A380 Belly	1,238,998	0.25	294,262.00

4.4 Equivalent Annual Departure of Reference Aircraft (R1)

After the R2 and W2 values of every aircraft type, and the W1 value of the reference aircraft were obtained, then the equivalent annual departure (R1) value could be calculated using Eq. (1) of the determined reference aircraft, Boeing B747-400 Belly. The calculation results were presented in Table 6. Based on the calculation using the reference aircraft

Boeing B747-400 Belly, an equivalent annual departure (R1) value of 9,734.31 was obtained. The total R1 value was used to determine pavement thickness.

Table 6 – The results of R1

No	Aircraft Type	R2	W2	W1	Log R1	R1
1	A321-200 std	6	46,809.65	104,143.88	0.52	3.32
2	A320-100	6,028.2	35,814.10	104,143.88	2.22	164.73
3	B737-800	3,704.5	41,491.47	104,143.88	2.25	178.88
4	B737-900 ER	3,009.5	44,697.46	104,143.88	2.28	190.04
5	D-200	2,783.5	94,857.04	104,143.88	3.29	1,938.31
6	A330-300 std	59.5	241,797.50	104,143.88	2.70	505.70
7	B787-9 (Preliminary)	69.7	65,906.31	104,143.88	1.47	29.26
8	A350-900	0.5	285,783.91	104,143.88	-0.50	0.32
9	B777-300 ER	400	184,537.36	104,143.88	3.46	2,908.83
10	B747-400	37.4	104,143.88	104,143.88	1.57	37.40
11	B747-400 Belly	37.4	104,143.88	104,143.88	1.57	37.40
12	A380	88.4	294,262.00	104,143.88	3.27	1,870.06
13	A380 Belly	88.4	294,262.00	104,143.88	3.27	1,870.06
					TOTAL R1	**9,734.31**

4.5 Runway Thickness

The pavement thickness calculation using the FAA Method was performed by plotting the data that had been previously identified, including the value of CBR Subgrade of 6%, CBR Subbase of 20%, R1 of 9,734.31 and MTOW of B747-400 Belly of 877,001 lbs. According to the data obtained, it could be determined which pavement thickness was used in the FAA AC 150 / 5320-6D regulation. Because Boeing B747-400 Belly was a jumbo jet with MTOW of 877,001 lbs. In Fig. 2, based on the CBR subgrade value of 6%, a total plan flexible pavement runway value of 46.5 inches = 118.11 cm was obtained.

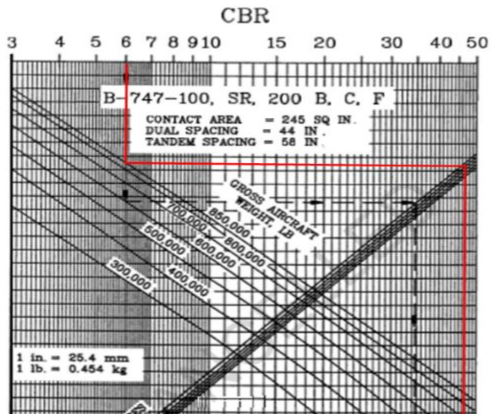

Fig. 2 - Curves of total plan flexible pavement, for Dual Double Tandem Gear critical area for the reference aircraft Boeing B747-400 Belly [26]

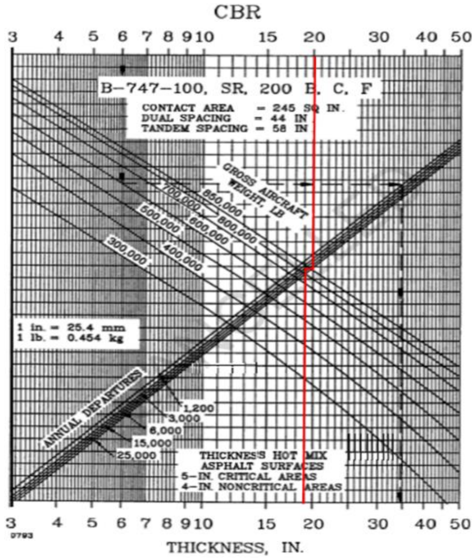

Fig. 3 - Curves of plan flexible pavement of the subbase, for Dual Double Tandem Gear critical are for the reference aircraft Boeing B747-400 Belly [26]

To calculate the flexible pavement thickness of the subbase runway, the FAA AC 150/5320-6D graph was also used [25]. Based on the CBR subbase value of 20%, flexible pavement thickness value of the subbase runway of 19 inches was obtained. The plotting of the graph could be seen in Fig. (3).

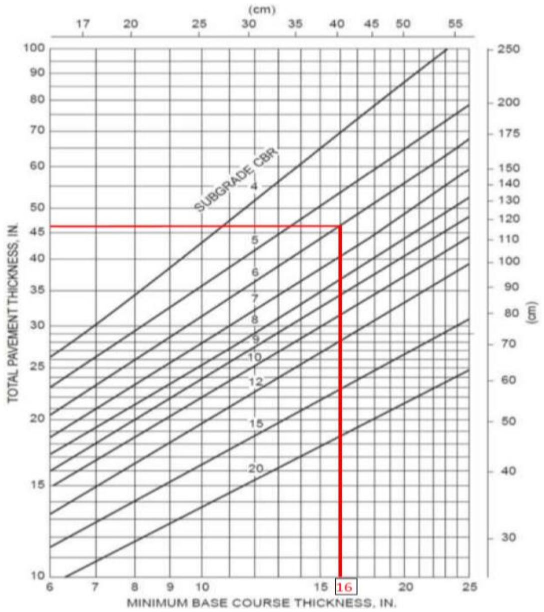

Fig. 4 - Required minimum base course runway thickness according to the FAA

After total flexible pavement and subbase runway values were obtained, the surface runway pavement thickness could be determined using the AC 150/5320-6D by assuming the planned runway area as critical areas, and thus, a runway surface pavement thickness value of 5 inches was obtained [25]. To determine base course runway pavement thickness, simply deduct from the other known layer pavement thickness, so that the base course thickness equals to total pavement thickness deducted with total subbase pavement and surface pavement thickness, and a base course runway value of 22.5 inches was obtained. However, after base course runway flexible pavement thickness was obtained in such fashion, it must be rechecked using the graph from the FAA to determine whether it met the requirements. In Fig. 4, total flexible pavement thickness value of the runway was plotted by connecting the vertical lines of CBR subgrade value of 6% and minimum base course runway thickness value of 16 inches was obtained. Since the value of base course runway calculation was greater than (22,5 inch) the minimum base course runway thickness required, then the above pavement thickness plan met the requirements and could be used. In Fig. 5, we could see the structure of pavement thickness above 6% subgrade for each layer.

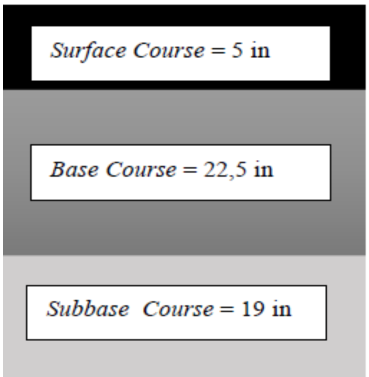

Fig. 5 - The structure of pavement thickness layer

5. Strength Analysis of Flexible Pavement Thickness with COMFAA 3.0 Software

Based on the strength analysis of pavement thickness with the COMFAA software with critical aircraft type B747-400 Belly and using pavement thickness of 46.5 inches, in accordance with the calculation results using the FAA method and subgrade CBR value of 6%. The Strength analysis results of flexible pavement thickness of ACN-PCN presented on Table 7. It was known that all ACN values of reference aircrafts were smaller than the PCN values of reference aircrafts. This was in line with the requirements, thus, the pavement thickness was safe for the airport. For /B747-400 Belly, the ACN value of 77.8 is smaller than the PCN value of 94.9, therefore, the design was safe to use.

Table 7 - Strength analysis results of flexible pavement thickness

Airplane Types	Pavement Thickness According to Airplane	
	B747-400 Belly	
	ACN (F/L/M)	PCN (F/L/M/U)
A380 Belly	75.1	78.9
A380	75.5	91.3
B747-400 Belly	77.8	94.9
B747-400	72.6	85.3
B777-300	89.3	107.0
A350-900	84.4	105.7
B787-9 (Preliminary)	87.5	117.3
A330-300 std	72.6	84.5
D-200	60.4	69.5
B737-900 ER	56.0	62.9
B737-800	50.3	54.6
A320-100	40.3	41.0
A321-200 std	57.6	65.6

6. Conclusion

The results of the planning of runway flexible pavement thickness of Yogyakarta International Airport (YIA) using the FAA method are as follows:

a) The analysis of the design of runway flexible pavement thickness at YIA using the FAA method with a CBR value of 6 % obtains a total runway flexible pavement value of 46.5 inches with a surface course thickness of 5 inches, a base course of 22.5 inches, and a subbase course of 19 inches.

b) The evaluation of runway flexible pavement thickness strength at YIA against aircraft traffic load using the COMFAA software shows that all PCN > ACN. This indicates that the condition of the pavement structure is able to take the load of all types of aircrafts that are planned to be served by the runway.

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