Comparison of Flexible Airfield Pavement Designs Using FAARFIELD v1.42 and APSDS 5.0

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Abstract. A case study has been carried out to compare the design of airfield pavements for a major airport using FAARFIELD v1.32 and APSDS 5.0. For the aircraft departure data used in the study, the pavement analysis shows that the APSDS 5.0 design method yielded pavement structure thicknesses that are nearly the same as FAARFIELD v1.32 for CBR greater than 10%. An adjustment factor k_c is required for APSDS design thickness to produce designs that are consistent with FAARFIELD for CBR less than 10%. In May 2017, FAA developed new subgrade failure models for flexible pavements in FAARFIELD v1.41 using the full-scale traffic test data collected at the NAPTF for Test Sections in Construction Cycles CC3 and CC5. FAARFIELD v1.41 was subsequently updated and evolved to version 1.42 in September 2017. In this paper, a comparison is carried out using the latest version of FAARFIELD v1.42 to examine if the new subgrade deformation models compute the design thicknesses that are compatible with that generated by APSDS5. For the Boeing 737-800 (Code C) and 777-300ER (Code E) aircrafts spectrum and 100,000 movements analyzed in the study, the new subgrade failure models developed for the latest version of FAARFIED generate the flexible pavement thicknesses that are not significantly difference from that of APSDS 5.0 for subgrade CBR ≥ 5%. The new failure model in FAARFIELD v1.42 produces flexible design thicknesses that differ less from APSDS 5.0 than FAARFIELD v1.32. The design thicknesses are more consistent for B737-800 with 2 wheels configuration. However, the differences are observed to be larger for CBR ≤ 5% when modelled with B777-300ER having 6 wheels configuration. The differences in the design thickness are attributed to the different coefficients adopted in the subgrade failure models in the design software.

Keywords: Airfield pavement design, subgrade failure models, APSDS 5.0, FAARFIELD v1.42.

1 Introduction

Road and airfield flexible pavement design methods are similar in that load-induced strains are estimated using layered elastic methods. Mechanistic analysis is used to predict state of stress beneath the wheel load and empirically relate stresses to performance. The empirical aircraft pavement performance data is obtained from full-scale test pavements each of which has been loaded with an actual undercarriage of a particular aircraft. The major differences between airfield and road pavements are the magnitude of load and the number of load repetition on the structures. Airfield pavements are subjected to a much higher magnitude of tyre load than that of road pavements.

The new generation and larger airplanes resulted in higher gross maximum take-off weight (MTOW), tyre load and contact pressure. Boeing 777-9, the latest series of long-range, wide-body twin-engine jet aircraft has two six-wheel main landing gears to support a gross taxi weight of up to 352,442 kg and contact tyre pressure of 1,503 kPa [1]. In Airbus 350 family of aircraft, the gross taxi weight of the A350-900 is 272,900 kg and with the tyre contact pressure of 1,682 kPa. The 575,000 kg Airbus A380 (with tyre contact pressure of 1,503 kPa) has two six-wheel body gears in addition to two four-wheel wing gears, for a total of 20 wheels in the main gear assembly. The complex gear loads applied to airport pavements by these new aircraft types are quite different from the loads applied by the older generation of commercial airplanes. Complex wheel load interactions within pavement structures contribute to premature failure of the pavement structures and must therefore be considered in pavement design analyses [2].

A case study was carried out to compare the design of airfield pavements for a major airport using FAARFIELD v1.32 and APSDS 5.0 [3]. For the aircraft departure data used in the study, the pavement analysis shows that the APSDS5.0 design method yielded pavement structure thicknesses that are nearly the same as FAARFIELD v1.32 for CBR greater than 10%. An adjustment factor k_c is required for APSDS design thickness in order to produce designs that are consistent with FAARFIELD for CBR less than 10%. In May 2017, FAA developed new subgrade failure models for flexible pavements in FAARFIED v1.41 using the full-scale traffic test data collected at the NAPTF for Test Sections in Construction Cycles CC3 and CC5 [4]. FAARFIELD was subsequently updated and evolved to version 1.42 in September 2017. In view of the development of the new subgrade failure models, it is necessary to compare the design thicknesses generated by FAARFIELD v1.42 and to examine if the thicknesses are compatible with that computed by APSDS5. To meet the objective, Boeing 737-800 (Code C) and B777-300ER (Code E) aircrafts and 100,000 movements were analyzed at various subgrade CBR using the two software programs. The same wander characteristics with a standard deviation of 773 mm is used in the pavement analysis.

2 Literature Review

The design philosophy for airport pavements in Australia has been discussed by Emery [5, 6] and Rodway [7], The use of surfacing is inter-related to the pavement design philosophy. The Australian approach is to design lower cost pavements, with lighter surfacing, thinner layers, thinner surfacing, and less capable materials. This is common with South African and New Zealand practice, and differs from USA practice. Seals are used instead asphalt where possible. Thin asphalt is used instead of thick asphalt, if possible. And thin asphalt is used instead of concrete. The design philosophy for lower cost pavements has been successful, and is a reflection of our relative benign climate, a willingness to stretch designs (reduce reliability), a high local capability for inspection and maintenance (to repair failures), and less intense trafficking [5]. The American Federal Aviation Administration (FAA) developed FAARFIELD and the Australian APSDS (Airport Pavement Structural Design System) are the two commonly used for airport pavement designs. FAARFIELD has various default parameters with regard to materials and thicknesses, and some caution is needed in using it in Australia [6].

Following their full-scale tests on stabilized and un-stabilized pavements in 1948, the US Army Corp for Engineers concluded that at elevated temperatures bituminous bound pavement layers were not superior in load distributing capability to excellent quality (CBR 100%) base materials. The Corps specifically stated that their tests indicated that 50mm asphalt surfacing was adequate over a crushed rock basecourse for 90 tonne wheel loads and 1 MPa tyre pressures. That is, high quality crushed rock basecourses had sufficient shear strength to withstand the high stresses produced in the zone directly beneath aircraft wheels and did not require thick asphalt surface layers to protect them. The Corps early preference for heavily-compacted, proof-rolled unbound crushed rock basecourses and relatively thin asphalt surfacings continues. From 1946 Australia adopted the Corps' approach and continues today to build flexible aircraft pavements that consist of 60mm of asphalt supported by heavily compacted, proof-rolled, unbound fine crushed rock basecourse and sub-bases [7].

The development of APSDS in Australia was from a flexible pavement design program, CIRCLY [8]. Based on layered elastic analysis, APSDS has two unique features. The first is that it computes subgrade strains for all points across the pavement to capture all damage contributed by all the aircraft wheels. This approach contrasts with other methods of pavement thickness design that often only compute a single (maximum) strain value. Using the pattern of strains computed allows the development of equations to relate load repetitions to pavement rut-depth by calibrating against full-scale test data. The second unique feature is that, in order to adequately reflect the test data, different calibration parameters are used for each wheel configuration.

APSDS also uses the Barker and Brabston [9] approach to model unbound base and subbase layers, standard granular materials designated by FAA as P209 and P154 respectively. Both APSDS and FAARFIELD v1.42 use sub-layering techniques for these unbound layers to take account of stress-dependence of the materials.

APSDS also considers aircraft wander. Aviation traffic loads differ from road traffic loads as aircraft wheel loads are spread more across the width of the pavement. This is partly due to a lower degree of channelization and partly due to the wide variation in spacing of wheels and groups of aircraft wheels compared with the standardized wheel configuration on road vehicles. Field observations have shown that successive passes of aircraft along a runway or taxiway pavement follow a bell-curve distribution about the pavement center-line and follows a normal distribution, so the degree of aircraft wander can be characterized by the standard deviation. The standard deviation of wander is significantly different for runways, taxiways and aircraft docking bays. This affects the required pavement thickness at each of these locations.

Data collected in the 1970's indicates wander widths of 1,778 mm for taxiways and

3,556 mm for runways. The standard deviation for a taxiway is 775 mm and for a runway is 1,524 mm [10]. The wander width is the zone containing 75 percent of the aircraft center lines (1.15 standard deviations on either side of the mean value with a normal distribution).

In 2001, Wardle et al [11] published a calibration of APSDS 4.0 against S77-1 designs, known as the *Chicago Calibration*. The performance parameters obtained in the calibration is shown in Table 1.

Table 1. Performance parameters obtained from *Chicago calibration* [11]

Subgrade CBR (%)	Subgrade Modulus, E (MPa)	k	B
3	30	0.0032	9.5
6	60	0.0030	10.9
10	100	0.0024	15.0
15	150	0.0020	23.6

Validation of APSDS against the FAA methodology was performed by comparing thicknesses calculated from this software to those calculated from the S77-1 empirical design curve. The comparison covered a range of 108 design scenarios, including medium to large passenger jet aircrafts in Australia and a wide range of subgrade moduli. The analysis showed that good general agreement between APSDS and S77-1 with a medium difference of 36 mm (or 6.7% of the S77-1 thickness) [12]. White [13] confirmed that better agreement between APSDS 4.0 and COMFAA pavement thicknesses could be obtained by using different calibration parameters for each wheel configuration. The performance parameters reported in Table 1 were subsequently recalibrated in 2010 and the update performance parameters are referred to *Melbourne calibration* [14].

3 Subgrade Performance Models

3.1 APSDS 5.0

In airport pavement design, layered elastic models are used to compute values of chosen damage indicators, most commonly subgrade strain, which are then related to pavement life (strain repetitions). The strain value can be converted to damage using a performance relationship of the form:

$$N = \left(\frac{k}{\varepsilon} \right)^{b} \tag{1}$$

In this relationship, N is the predicted strain repetitions to cause failure, k is a material constant determined by calibration, b is the damage exponent for the material determined by calibration and ε is the static load-induced strain.

The introduction of new generation aircraft, such as the Boeing 777 and the Airbus A380, both of which have 6-wheel configurations was the major impetus for FAA to conduct new full-scale tests the US National Airport Pavement Test Facility (NAPTF) to improve the accuracy of pavement thickness designs for such aircrafts. Using this calibration data, APSDS 5.0 produced pavement thickness designs that more accurately reflects the performance of the full-scale test pavements than did the 2001 calibration [14]. APSDS 5.0 correlation with the S77-1 designs was improved by using different calibration parameters for each wheel configuration (see Table 2). The recalibration of the APSDS 5.0 was referred to *Melbourne calibration*.

Table 2. Performance parameters obtained from *Melbourne calibration* [14]

Subgrade CBR (%)	Wheel Configuration	Weighted Error (mm)	Weighted Error (%)	k	b
3	1 wheel	17.10	1.7%	0.00382	7.8
	2 wheels	20.14	1.9%	0.00254	12.4
	4 wheels	28.03	2.0%	0.00204	17.8
	6 wheels	35.67	2.3%	0.00200	27.1
	All wheel groups	143.14	11.0%	0.00180	25.3
6	1 wheel	9.66	1.6%	0.00382	9.3
	2 wheels	11.56	1.9%	0.00297	12.5
	4 wheels	31.72	4.2%	0.00216	18.7
	6 wheels	29.96	3.6%	0.00188	27.1
	All wheel groups	50.65	7.0%	0.00204	21.7
10	1 wheel	12.41	3.1%	0.00382	10.4
	2 wheels	7.46	2.0%	0.00300	13.1
	4 wheels	17.30	3.9%	0.00225	19.0
	6 wheels	9.85	2.0%	0.00192	27.1
	All wheel groups	25.14	5.8%	0.00254	16.2
15	1 wheel	8.71	3.2%	0.00382	11.0
	2 wheels	7.04	3.0%	0.00280	15.1
	4 wheels	16.58	6.1%	0.00252	18.3
	6 wheels	10.60	3.5%	0.00217	27.1
	All wheel groups	19.57	7.3%	0.00275	16.3

The Damage Factor for the i-th loading is defined as the number of repetitions (n_i) of a given damage indicator divided by the 'allowable' repetitions (N_i) of the damage indicator that would cause failure. The Cumulative Damage Factor (*CDF*) is given by summing the damage factors for all loadings in the traffic spectrum using Miner's hypothesis:

$$CDF = \sum \frac{n_i}{N_i} \tag{2}$$

where, *CDF* is the cumulative damage factor, n_i is the number of repetitions and N_i is the allowable repetitions.

3.2 FAARFIELD v1.42

Prior to introduction of the layered elastic method, flexible aircraft pavements were usually designed using the US Army Corps of Engineers CBR pavement design method detailed in Instruction Report S-77-1 [15]. Aircraft induced deflections at subgrade level were calculated using Boussinesq's single-layer equations which were correlated with the load repetitions observed to cause rutting failure in full-scale tests. The method was adapted from highway design practice in 1942, modified and extrapolated to cater for higher loads, multiple wheel undercarriages and aircraft wander. The FAA computerized its S-77-1 design method in its COMFAA software program.

COMFAA is a general-purpose computer program that operates in two computational modes: Aircraft Classification Number (ACN) Computation Mode and Pavement Design Mode. In ACN Computation Mode, COMFAA calculates the ACN number for aircraft on flexible pavements. In Pavement Design Mode, COMFAA calculates flexible pavement thickness based on the CBR method in AC 150/5320-6D for a CBR value specified by the user [16].

In 1995, the FAA introduced its LEDFAA software design to predict wheel-load interactions and to provide the airport community with a pavement design methodology addressing the needs of the B-777 aircraft [2]. The FAA issued an upgraded version (LEDFAA 1.3) in 2004. It features an expanded aircraft library with design procedures implemented as a computer program. LEDFAA represented a significant departure from earlier FAA design philosophies. Apart from design procedures implemented as a computer program, instead of nomographs, the main change from the user perspective was the replacement of the "design aircraft" concept design for fatigue failure now expressed by a "cumulative damage factor" (CDF) using Miner's Rule. The major material property of the pavement layers was now uniformly expressed as an elastic modulus instead of the previous CBR (California Bearing Ratio) for flexible pavements or k-value for rigid pavements [2].

FAARFIELD has now replaced LEDFAA. FAARFIELD software uses elastic layer theory and finite element methods for flexible and rigid pavement design respectively. The core of the program is a structural response model that consists of two programs (LEAF and NIKE3D). LEAF is a multilayer elastic computational program and NIKE3D is a program based on finite element methods. In May 2017, FAA developed new subgrade failure models for flexible pavements in FAARFIELD v1.41. FAARFIELD v1.41 was subsequently updated and had evolved to version 1.42 in September 2017. The subgrade failure models FAARFIELD v1.42 are shown in Equation 4 and 5.

FAA [4] used a commercial analysis program, CurveExpert© Basic 1.4 to identify the best regression of the lower bound of vertical strain to the common logarithm (base 10) of coverages. From the generated possible models by CurveExpert, the Bleasdale model was selected as showing the best fit. The format of the Bleasdale model is shown in equation (3) and (4). For coverages equal or greater than 1000, the Bleasdale model is used directly. For coverages less than 1000, a straight line model was adopted, tangent to the Bleasdale curve and parallel to the FAARFIELD v1.3 failure model. The failure models used in FAARFIELD v1.42 to find the number of coverages to failure for a given vertical strain at the top of the subgrade are summarized below:

$$\log_{10} Coverages = \left(\frac{1}{a + b * \varepsilon}\right)^{\left(\frac{1}{c}\right)} \quad (3)$$

$$\log_{10} Coverages = \left(\frac{1}{-0.1638+185.19* \varepsilon}\right)^{0.60586} \quad (4)$$

when C > 1000 coverages; and

$$Coverages = \left(\frac{0.00414131}{\varepsilon}\right)^{8.1} \quad (5)$$

when C ≤ 1000 coverages

where:
ε_v = maximum vertical strain at the top of the subgrade

4 Previous Study

A case study has been carried out to compare the design of airfield pavements for a major airport using FAARFIELD v1.32 and APSDS5 [3]. The aircraft spectrum and movements adopted in the study is shown in Table 3. With a growth rate of 2%, the total aircraft movements for wide body aircrafts are 212,640 for a design period of 40 years.

Table 3. Aircraft Departure Data

Aircraft	Name	Tire Pressure (kPa)	Total Movements
1	B747-400ER	1,572	47,280
2	B777-300 ER	1,524	147,120
3	A380-800	1,338	13,920
4	A340-300	1,420	4,320

For the aircraft departure data, the pavement analysis shows that the APSDS 5.0 design method yielded pavement structure thicknesses that are nearly the same as FAARFIELD v1.32 for CBR greater than 10%. Figure 1 shows the design thicknesses produced by the two design programs. It shows that FAARFIELD produces design thicknesses that are significantly thicker than designs produced by APSDS for subgrade CBR value less than 10%. An adjustment factor k_c is required for APSDS design thickness to produce designs that are consistent with FAARFIELD for CBR less than 10.

The design thicknesses produced by FAARFIELD correlates to the thicknesses generated by APSDS by a polynomial equation:

$$t_{FAARFIELD} = (k_c)(t_{APSDS}) \tag{6}$$

$$k_c = (1.3748 - 0.0399CBR + 0.00123CBR^2) \tag{7}$$

Where, $t_{FAARFIELD}$ is the design thickness produced by FAARFIELD, t_{APSDS} is the design thickness produced by APSDS, k_c is the adjustment factor and CBR is the subgrade California Bearing Ratio (%).

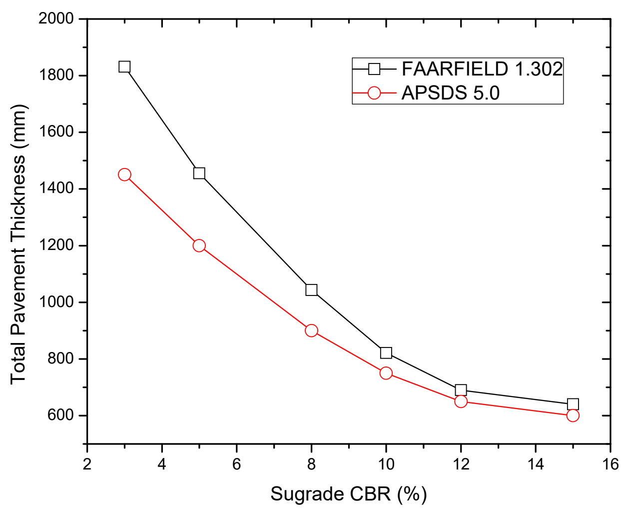

Fig. 1. Pavement thickness produced by APSDS and FAARFIELD v1.32

5 Current Study

5.1 Aircraft Traffic Spectrum

The development of the new subgrade failure models in 2017 prompted the need to compare the design thicknesses generated by FAARFIELD v1.42 and to examine if the thicknesses are compatible with that computed by APSDS 5.0. To meet the objective, Boeing 737-800 (Code C) and Boeing 777-300ER (Code E) aircrafts and with 100,000 aircraft movements (see Table 4) were analyzed at various subgrade CBR values using the two design software.

Table 4. Aircraft Traffic Movements

Aircraft	Name	Tire Pressure (kPa)	Total Movements
1	B737-800	1,407	100,000
2	B777-300 ER	1,524	100,000

5.2 Methodology

Using the traffic spectrum and movements, the pavement models outlined in Table 5 was analysed using subgrade CBR value varying from 3%, 6%, 8%, 12% and 15%. The minimum thickness requirements specified in Table 3.3 of AC 150/5320-6F for the P-401/ P-403 Hot Mix Asphalt Surface and P-401/P-403 St (flexible) are adopted. To model the B737-800 and B777-300ER loadings, the pavement structures consist of 100 mm of P-401/P-403 (HMA) Surface, 125mm of P-401/P-403 St (flex) which is a plant mix bituminous material and variable P-209 Crushed Aggregate base course and P-154 Uncrushed Aggregate subbase layers. Once the models have been developed, the pavement structures are analyzed iteratively with varying thickness of P-209 and P-154 layers until the CDF is close to 1.0.

Table 5. Pavement Models for B737-800 & B777-300ER aircrafts

Layer	Material Type	Thickness (mm)	Modulus (MPa)
1.	P-401/ P-403 HMA Surface	100	1,378.95
2.	P-401/ P-403 St (flexible)	125	2,757.90
3.	P-209 Crushed Aggregate	H_1	variable
4.	P-154 Uncrushed Aggregate	H_2	variable
5.	Subgrade CBR (%)	3, 5, 8, 12 & 15	

6 Results and Discussions

Table 6, 7 and 8 present the pavement thicknesses computed by FAARFIELD v1.42 and APSDS 5.0 respectively for B737-800 at subgrade CBR values of 3%, 5%, 8%, 12% and 15%. Table 9, 10 and 11 are the design thicknesses for B777-300ER at the range of subgrade CBR specified in the design.

Figure 2 depicts the design thicknesses produced by the two design programs for B737-800 and Figure 4 shows the design thicknesses for B777-300ER. For the B737-800 and B777-300ER aircrafts spectrum and 100,000 movements analyzed in the study, the new subgrade failure models developed for the latest version of FAARFIED v1.42 generate the flexible pavement thicknesses that are not significantly difference from that of APSDS 5.0 for subgrade CBR ≥ 5%. The differences in the design thickness are observed to be marginal.

For B737-800 loading, APSDS 5.0 produces design thicknesses that are slightly thicker than designs produced by FAARFIELD v1.42 at subgrade CBR value of 3%. The thickness difference is 50 mm in the P-154 Uncrushed Aggregate subbase layer. This indicates that the new subgrade failure model in FAARFIELD generates design thicknesses that is consistent with APSDS for the B737-800 aircraft with 2 wheels configuration.

On the other hand, for B777-300ER aircraft, FAARFIELD v1.42 produces design thicknesses that are significantly thicker than designs produced by APSDS for subgrade CBR value less than 5%. The thickness differences are observed to be significance for CBR ≤ 5% when modelled with B777-300ER having 6 wheels configuration. The P-154 Uncrushed Aggregate layer is 375 mm thicker in the FAARFIELD model than that of APSDS at CBR of 3%. Overall, the thicknesses differences are observed to be less for CBR ≥ 5%. The differences in the design thickness are attributed to the different coefficients adopted in the subgrade failure models in the design software.

Table 6. Pavement Structures for Subgrade CBR of 3% & 5%

No.	Aircraft	Thickness (mm)		Thickness (mm)	
	Boeing 737-800	FAARFIELD	APSDS	FAARFIELD	APSDS
1.	P-401/ P-403 HMA Surface	100	100	100	100
2.	P-401/ P-403 St (flexible)	125	125	125	125
3.	P-209 Crushed Aggregate	300	300	300	300
4.	P-154 Uncrushed Aggregate	615	665	360	335
	Subgrade CBR (%)	3		5	
	Total pavement thickness (mm)	1,140	1,190	885	860

Table 7. Pavement Structures for Subgrade CBR of 8% & 12%

No.	Aircraft	Thickness (mm)		Thickness (mm)	
	Boeing 737-800	FAARFIELD	APSDS	FAARFIELD	APSDS
1.	P-401/ P-403 HMA Surface	100	100	100	100
2.	P-401/ P-403 St (flexible)	125	125	125	125
3.	P-209 Crushed Aggregate	300	270	165	150(1)

4.	P-154 Uncrushed Aggregate	110	100(1)	101	100(1)
	Subgrade CBR (%)	8		12	
	Total pavement thickness (mm)	635	595	491	475

(1) minimum FAA thickness

Table 8. Pavement Structures for Subgrade CBR of 15%

No.	Aircraft	Thickness (mm)	
	Boeing 737-800	FAARFIELD	APSDS
1.	P-401/ P-403 HMA Surface	100	100
2.	P-401/ P-403 St (flexible)	125	125
3.	P-209 Crushed Aggregate	150(1)	150(1)
4.	P-154 Uncrushed Aggregate	100(1)	100(1)
	Subgrade CBR (%)	15	
	Total pavement thickness (mm)	475	475

(1) minimum FAA thickness

Table 9. Pavement Structures for Subgrade CBR of 3% & 5%

No.	Aircraft	Thickness (mm)		Thickness (mm)	
	Boeing 777-300ER	FAARFIELD	APSDS	FAARFIELD	APSDS
1.	P-401/ P-403 HMA Surface	100	100	100	100
2.	P-401/ P-403 St (flexible)	125	125	125	125
3.	P-209 Crushed Aggregate	450	450	450	450
4.	P-154 Uncrushed Aggregate	1,485	1,110	825	615
	Subgrade CBR (%)	3		5	
	Total pavement thickness (mm)	2,160	1,785	1,500	1,290

Table 10. Pavement Structures for Subgrade CBR of 8% & 12%

No.	Type	Thickness (mm)		Thickness (mm)	
	Boeing 777-300ER	FAARFIELD	APSDS	FAARFIELD	APSDS
1.	P-401/ P-403 HMA Surface	100	100	100	100
2.	P-401/ P-403 St (flexible)	125	125	125	125
3.	P-209 Crushed Aggregate	400	400	300	205

4.	P-154 Uncrushed Aggregate	250	145	101	100(1)
	Subgrade CBR (%)	8		12	
	Total pavement thickness (mm)	875	770	626	530

(1) minimum FAA thickness

Table 11. Pavement Structures for Subgrade CBR of 15%

No.	Aircraft	Thickness (mm)	
	Boeing 777-300ER	FAARFIELD	APSDS
1.	P-401/ P-403 HMA Surface	100	100
2.	P-401/ P-403 St (flexible)	125	125
3.	P-209 Crushed Aggregate	220	150(1)
4.	P-154 Uncrushed Aggregate	101	100(1)
	Subgrade CBR (%)	15	
	Total pavement thickness (mm)	546	475

(1) minimum FAA thickness

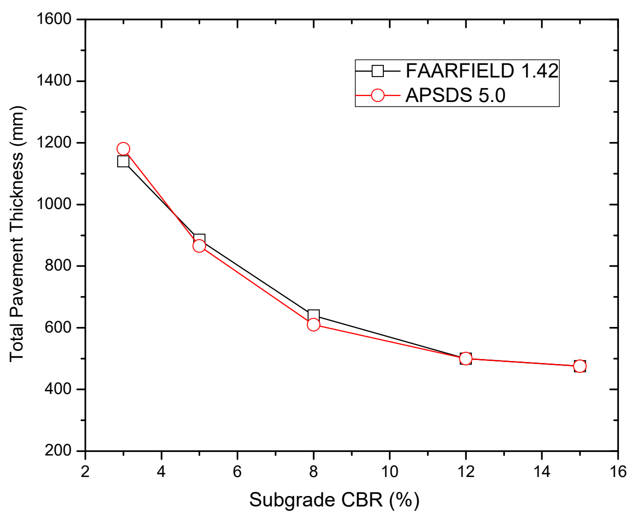

Fig. 2. Design thicknesses produced by APSDS 5.0 and FAARFIELD v1.42 (B737-800 aircraft)

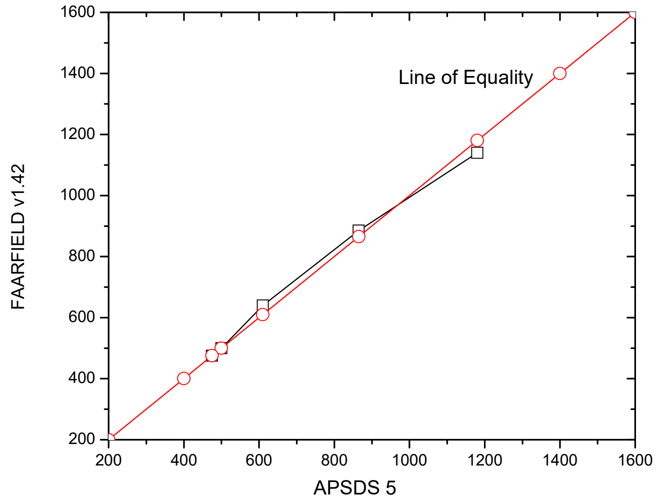

Fig. 3. APSDS 5.0 versus FAARFIELD v1.42 for CBR 3%, 5%, 8%, 12% & 15% (B737-800 aircraft)

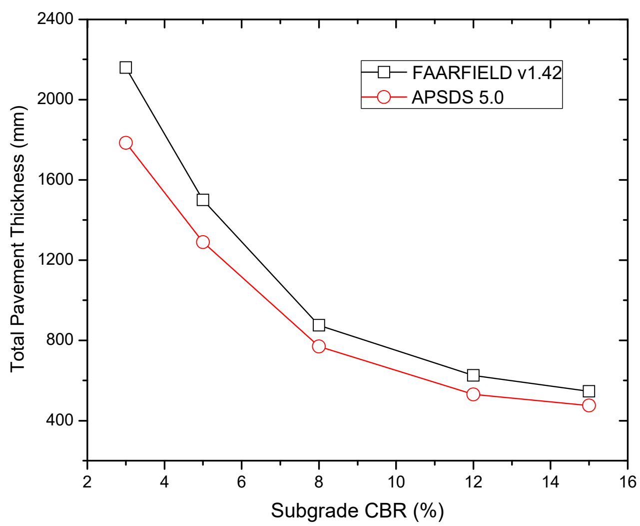

Fig. 4. Design thicknesses produced by APSDS 5.0 and FAARFIELD v1.42 (B777-300ER aircraft)

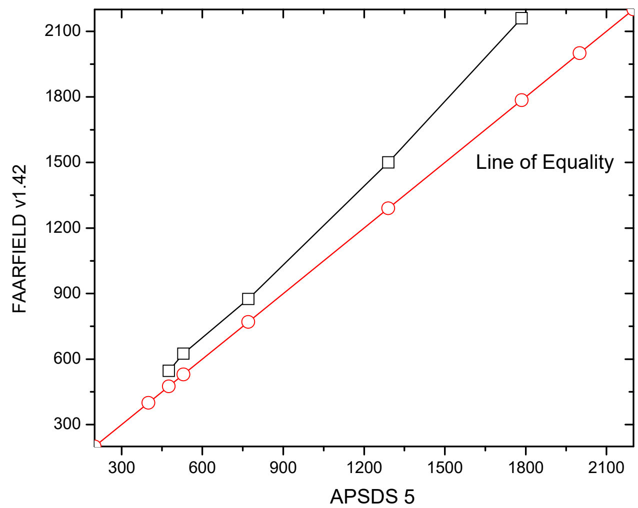

Fig. 5. APSDS 5.0 versus FAARFIELD v1.42 for CBR 3%, 5%, 8%, 12% & 15% (B777-300ER)

7 Conclusions

A brief literature review of the subgrade failure models used in APSDS 5.0 and FAARFIELD v1.42 has been conducted. The key differences are that in APSDS 5.0 different calibration parameters for the subgrade failure model are adopted for each wheel configuration, whereas in FAARFIELD v1.42 different failure models are used for coverages equal or greater than 1,000 and for coverages less than 1,000.

The development of the new subgrade failure models in FAARFIELD in 2017 prompted the need to compare to the design thicknesses generated by FAARFIELD v1.42 and to examine if the thicknesses are compatible with that computed by APSDS5.0. To make an assessment, Boeing 737-800 (Code C) and B777-300ER (Code E) aircrafts and 100,000 aircraft movements were analyzed at various subgrade CBR values using the two software programs. The conclusions of the study are as follows:

- For the aircraft spectrum and movements analyzed in the study, the new subgrade failure models developed for the FAARFIELD v1.42 generate the flexible pavement thicknesses that are not significantly difference from that of APSDS 5.0 for subgrade CBR ≥ 5%.
- For CBR ≤ 3% and with B737-800 aircraft loading, APSDS5 produces design thickness that are marginally thicker than that generated from FAARFIELD v1.42. On the contrary, FAARFIELD v1.42 generates

thicker pavement than APSDS 5.0 for B777-300ER aircraft on subgrade CBR ≤ 3%.

- Overall, it is observed that the new subgrade failure model in FAARFIELD v1.42 produces flexible design thicknesses that differ less from APSDS 5.0 than FAARFIELD v1.32. The design thicknesses are more consistent for B737-800 aircraft with 2 wheels configuration. However, the differences are observed to be larger for CBR ≤ 5% when modelled with B777-300ER having 6 wheels configuration on the main landing gear. The differences in the design thickness are attributed to the different coefficients adopted in the subgrade failure models in the design software.

At the time of writing this paper, FAARFIELD 2.0 [1] was still in the development phase. It is recommended that a similar comparison be carried using a wide spectrum of aircrafts using the latest version of FAARFIELD in next stage of the study. This will include the 4 wheels configuration on the main landing gear such as the A350-900 and B787-9 aircrafts.

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