



Influence of CBR Variations on Rigid Pavement Structural Design for Airport Service Roads

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ABSTRACT

Keywords:

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Rigid pavement on airport service roads is essential for smooth vehicle operations, with subgrade conditions being the primary factor in determining concrete slab thickness. Variations in the California Bearing Ratio (CBR) of the subgrade commonly affect pavement thickness and construction costs. This study analyzes how changes in subgrade CBR impact rigid pavement thickness for service roads using the empirical method of Pd T-14-2003. It also compares the results with international standards, including FAA AC 150/5320-6G and ICAO Annex 14, to validate findings and assess the relevance of Indonesian standards globally. The research involved collecting traffic data and geotechnical parameters and calculating design thickness variations based on CBR values. Results indicate that each 1% increase in CBR decreases the required concrete slab thickness by 4 mm: 163 mm at 6% CBR, 158 mm at 7%, and 155 mm at 8%. Comparison with international standards shows that Pd T-14-2003 tends to produce conservative designs. However, integrating mechanistic-empirical approaches could improve safety and economic efficiency. These findings demonstrate that enhancing subgrade quality can reduce slab thickness, leading to material savings and lower construction costs. This study advances the traditional CBR approach by incorporating advanced soil mechanics principles and offers a framework for adopting international best practices in Indonesian airport pavement design, supporting the advancement of domestic aviation infrastructure.

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INTRODUCTION

The global aviation industry's rapid expansion has intensified demands on airport infrastructure, particularly pavement systems that must withstand increasingly heavy aircraft loads while maintaining operational safety and economic viability. Modern airport pavement design has evolved from purely empirical approaches to sophisticated mechanistic-empirical methods that integrate advanced soil mechanics principles, structural analysis, and performance prediction models (Sun et al., 2024). This evolution reflects the industry's recognition that traditional design methods, while proven over decades, may not fully capture the complex interactions between subgrade conditions, traffic loading patterns, and environmental factors that govern pavement performance.

International aviation authorities have developed comprehensive design standards that reflect this sophisticated understanding. The Federal Aviation Administration's Advisory Circular AC 150/5320-6G incorporates mechanistic-empirical design principles that consider stress distribution, fatigue analysis, and performance-based criteria (FAA, 2021). Similarly, the International Civil Aviation Organization's Annex 14 provides global standards that emphasize performance-based design approaches capable of handling diverse aircraft configurations and loading scenarios (ICAO, 2018). These international frameworks represent the state of the art in airport pavement design, incorporating decades of research in soil mechanics, structural engineering, and materials science (de Moura, dos Santos Silva, Costa, Neto, & Viana, 2021; Sun et al., 2024).

In contrast, many developing countries, including Indonesia, continue to rely primarily on empirical design methods developed decades ago. While these methods have proven adequate for historical aircraft operations, the emergence of new aircraft types, increased traffic volumes, and evolving operational requirements necessitate a critical evaluation of their continued applicability. The research gap between international best practices and domestic design methodologies represents not merely a technical discrepancy but a potential constraint on airport operational efficiency and long-term infrastructure sustainability.

Rigid pavements on airport service roads play a crucial role in ensuring the smooth operation of airport support vehicles. Pavements are layered structures built on top of the subgrade, constructed with suitable materials and compacted to withstand traffic loads and environmental conditions without deformation or cracking (Al-Qaili et al., 2024; Kwon et al., 2024). Airport pavement design has unique characteristics because it must withstand very high traffic loads, high tire pressures, and dynamic traffic conditions (Sun et al., 2024). The thickness of concrete slabs in rigid pavements is significantly influenced by the bearing capacity of the subgrade, which is generally represented by the California Bearing Ratio (CBR). Variations in the CBR value will directly impact the required slab thickness and the pavement's design life (Putra & Yasruddin, 2021).

From a soil mechanics perspective, the CBR test provides a measure of the shear strength of soil under controlled moisture and density conditions (Hazirbaba, 2018; Matajinimvar, Choobbasti, & Kutanaei, 2025). However, the relationship between CBR and actual soil behavior under complex loading conditions involves multiple factors including stress history, drainage conditions, and load duration effects that simple empirical correlations may not fully capture (Das, 2019). Advanced geotechnical analysis considers soil behavior under repeated loading, the influence of stress state on deformation characteristics, and the interaction between soil properties and pavement structural response (Holtz et al., 2011). Globally, research shows that the choice of rigid pavement design method significantly determines long-term performance and life-cycle costs (White, 2021). Several other studies have confirmed that subgrade weakness can increase the risk of premature cracking and faulting in concrete slabs (Koh et al., 2025; Sun et al., 2024). Subgrade can influence pavement thickness design and road construction costs (Elbosraty et al., 2025).

The limitations of purely empirical design approaches become apparent when considering the mechanistic behavior of pavement systems. Empirical methods, by definition, rely on statistical correlations developed from specific datasets and may not adequately account for variations in material properties, environmental conditions, or loading scenarios outside their original calibration range (Huang, 2004). Mechanistic-empirical approaches, conversely, explicitly model the physical processes governing pavement response and can therefore provide more reliable predictions across diverse conditions (Agunwamba & Tiza, 2023; Otieno, 2024). Traditional pavement design is largely based on empirical methods, procedures developed from large-scale field tests and historical observations of the relationships between soil conditions, traffic loads, layer thickness, and service life. Empirical methods are practical and relatively simple because they require only a few concise parameters (e.g., CBR, ESAL or equivalent vehicle count, and several climatic factors) and proven statistical correlations in the original data population (Hu et al., 2022).

Older guidelines such as AASHTO 1993 and those based on classic field test results are examples of empirical principles widely used in many countries due to their ease and speed of application (Ahmed et al., 2023; Li & Khazanovich, 2022). Sensitivity to CBR and Equivalent Single Axle Loads (ESAL) is crucial in empirical methods based on seasonal moisture conditions, which can alter structural response (Kollaros & Athanasopoulou, 2017; Rahim & George, 2005; Vandenbossche et al., 2011). Empirical methods are simple, fast, and data-efficient, making them practical for initial design or locations with limited data; however, they

are less able to model local sensitivity and variations in subgrade depth (Shallal & Ahmed, 2019).

Although empirical methods such as Pd T-14-2003 are still widely used in rigid pavement design in Indonesia, variations in subgrade conditions in the field create uncertainty regarding slab thickness. The reaction modulus k (k -value) and CBR will influence the design thickness of the road pavement (Tuleubekov & Brill, 2014). Pavement thickness and depth of pavement layer construction can be reduced by increasing the CBR value of the material or stabilizing it using cement and lime (Amakye et al., 2022). Research conducted by (Caecarma et al., 2025) on deflection behavior and cost efficiency in rigid pavements concluded that low CBR values result in high deflections for rigid pavements. Although there have been many studies on the comparison of empirical and mechanistic methods regarding the effect of CBR on pavement design, a gap is still seen in how variations in subgrade CBR are integrated into the analysis of rigid pavements of service roads with the empirical method Pd T-14-2003.

However, the mechanistic-empirical design philosophy recognizes that pavement performance results from fundamental engineering principles governing stress distribution, material response, and failure mechanisms. The Mechanistic-Empirical Pavement Design Guide (MEPDG), developed through the NCHRP 1-37A project, represents a paradigm shift toward performance-based design that explicitly considers environmental effects, traffic variability, and material property variations. This approach enables more accurate prediction of specific distress types and provides a framework for optimizing pavement designs based on life-cycle cost considerations. This mechanical property is very important for the subgrade because it contributes to better load distribution and increased structural stability (Bahurudeen et al., 2015; Ghosh et al., 2024). Empirical methods tend to be more sensitive to changes in subgrade modulus, climatic conditions, and traffic characteristics, so the results often produce different layer thicknesses. Variations in CBR values will affect the thickness of rigid road pavements, so this study is important to conduct to determine the effect of CBR on the design thickness of rigid road pavements.

The novelty of this research lies in the analysis of the effect of CBR on pavement thickness on concrete slabs for rigid pavement of airport service roads based on variations in the bearing capacity of the subgrade using the empirical method Pd T-14-2003. The empirical method used in Indonesia uses the Pd T-14-2003 method. This study provides a real contribution to enriching the literature on rigid pavement design on airport service roads in Indonesia. The purpose of this study is to analyze the effect of variations in the CBR value of the subgrade on the thickness of rigid pavement on airport service roads. The results of this study are expected to provide a quantitative reference regarding the effect of CBR variations on the design of airport rigid pavements and service road design decisions by considering the varying bearing capacity of the subgrade.

METHOD

This research specifically focuses on one of the important elements in the airport operational system, namely the taxiway at Ngurah Rai International Airport. The taxiway was chosen as the object of research because of its crucial role in supporting aircraft movement from the apron to the runway and vice versa, so the condition of the pavement structure must be truly able to withstand large and repeated aircraft loads. The airport service road layout can be seen in Figure 1.



Figure 1. I Gusti Ngurah Rai International Airport Service Road Layout

In this study, the data used consists of primary and secondary data. Primary data is collected directly by researchers through field observations and measurements. This type of data includes CBR values obtained through direct testing and traffic data from field surveys. In addition, primary data were also obtained through observations of the situation at the research site, data collection on actual traffic conditions, and measurements of soil bearing capacity, which are important parameters in pavement structure planning. To strengthen the research findings, visual documentation in the form of photographs or field recordings was also conducted as supporting evidence and supplementary material in the preparation of the final report.

Secondary data is data obtained indirectly, namely from other parties related to the research object or from relevant literature sources. Secondary data can include official documents, technical reports, books, journals, or previous research results related to rigid pavement design and traffic analysis. In the context of this study, the secondary data used includes information on traffic growth, which is crucial for projecting traffic loads over the design period, as well as airport layout data, which provides a general overview of geometric conditions, facility layout, and vehicle and aircraft operational routes. This secondary data serves to complement and enrich primary data, so that the analysis carried out is more comprehensive and can be scientifically accounted for.

The calculation of rigid pavement thickness using the Pd T-14-2003 method follows a structured sequence of steps. The process begins with the selection of the pavement type, whether it is plain concrete without dowels, jointed concrete with dowels, or continuously reinforced concrete. A decision is also made regarding the use of concrete shoulders. Subsequently, the type and thickness of the subbase layer are determined based on the design CBR value, after which the effective CBR is calculated to represent the subgrade condition once the subbase has been installed. The design then requires the selection of concrete strength parameters, either flexural tensile strength or compressive strength at 28 days, along with the determination of the traffic load safety factor.

An initial estimate of the concrete slab thickness is made, followed by the calculation of equivalent stress (TE) and the erosion factor (FE) for each axle group. The equivalent stress is compared against the flexural tensile strength of the concrete to obtain the stress ratio factor (FRT). The load per wheel is then calculated and multiplied by the safety factor to derive the design load. Based on the FRT value and the design load, the number of allowable fatigue repetitions is determined, and the percentage of design repetitions is subsequently calculated. In parallel, the allowable number of repetitions for erosion is evaluated using the erosion factor, and its percentage relative to design repetitions is determined. This procedure is repeated for all wheel loads within each axle group until the maximum number of repetitions is reached. Finally, the fatigue percentages are summed to obtain the total fatigue, and the erosion percentages are likewise aggregated to yield the total erosion. By repeating the process for all

axle groups, the appropriate slab thickness is derived in accordance with traffic loads, subgrade conditions, and material properties.

The field traffic survey was conducted over three days with an average observation time of 24 hours per day, so that the data obtained can describe the actual condition of vehicle movement on the research route. From the observation results, this study uses the highest ADT value as a reference for analysis, because the busiest conditions are considered to represent the maximum load that will be received by the pavement. Traffic data is then summarized based on the direction of vehicle movement, namely from east to west (T-B) and from west to east (B-T), and categorized according to the type of vehicle passing. The types of vehicles recorded include operational vehicles (O), buses (B), baggage trailers (BT), forklift trucks (FT), towing tractors (TT), tandem trucks 1 (TTan1), tandem trucks 2 (TTan2), fire engines type 1 (PK1) and type 2 (PK2), motorcycles (M), and bicycles (S) which are tabulated in Table 1. Heavy vehicles such as towing tractors, tandem trucks, and fire engines have a significant contribution to pavement loading, even though their numbers are relatively fewer than operational vehicles or buses.

Table 1. ADT recapitulation

Direction	Type of vehicle										
	O	B	BT	FT	TT	TTan 1	TTan 2	PK1	PK2	M	S
T-B	1463	391	1015	2	138	2	29	1	1	0	208
B-T	1342	365	947	0	150	0	14	0	0	0	176
Total	2805	756	1962	2	288	2	43	1	1	0	284

The CBR value in the planning area was carried out at 11 test points using the DCP method. To recapitulate the CBR value (%) at the DCP test points, it can be seen in Table 2. In this study, the design CBR was determined at 6% and variations will be made by adding 1 and 2 from the design CBR value, so that in this pavement planning, it will be varied with a CBR of 6-8%.

Table 2. CBR value

No TP	CBR (%) at 250 mm depth	CBR (%) at 500 mm depth	CBR (%) at 1000 mm depth
1	0.99	1.65	3.63
2	4.04	3.59	11.02
2x	1.77	8.14	8.07
3	1.12	1.77	2.81
5	0.99	1.65	3.63
6	7.93	43.7	54.51
7	1.96	1.09	17.81
8	7.31	7.76	10.57
9	38.28	43.45	51.63
10	1.3	23.92	32.51
11	2.4	7.69	21.5

racapitulation

The subbase layer serves to increase the bearing capacity of the subgrade, provide a stable working floor, and achieve a surface with uniform bearing capacity. The planning will use a cement stabilized foundation type with a friction coefficient (F) of 1.8, as shown in Table 3.

Table 3. Coefficient of friction

No	Type of Foundation Material	Friction Factor (F)
1	Burtu, Lapen, and Construction Layer	2.2

No	Type of Foundation Material	Friction Factor (F)
2	Asphalt Concrete (Laston), Thin Asphalt Concrete (Lataston)	1.8
3	Lime stabilization	1.8
4	Asphalt stabilization	1.8
5	Cement stabilization	1.8
6	Coral	1.5
7	Crushed stone	1.5
8	Sand and Gravel (Sirtu)	1.2
9	Soil	0.9

Adjustment of vehicle type using vehicle type table and its configuration, load distribution table for each axle of vehicle and traffic survey data that has been conducted, then the enumeration of vehicle traffic operating on Service Road results can be seen in Table 4. For example, it can be seen that if the baggage trailer has the same load distribution as passenger vehicles in general, but even so the baggage trailer has a load of 1.4 tons where the weight is different from the standard load of highways for similar vehicles, which is 2 tons. For details of adjustments for each vehicle can be seen in detail in Table 4.

Table 4. Vehicle type adjustment

Vehicle	Weight (ton)	Normal weight (ton)	Load distribution (%)	Load Distribution (ton)	Normal Load Distribution 1 (ton)
O	2	2	50%,50%	1.1	1.1
B	13	9	34%,66%	4.5, 7.5	3.6
BT	1.4	2	50%,50%	0.7, 0.7	1.1
FT	2	2	50%,50%	1, 1	1.1
TT	7.5	5,3	34%,66%	2.55, 4.95	1.8, 3.5
TTan1	24	25	25%,75%	6, 18	6.25, 18.75
TTan2	24	25	25%,75%	6, 18	6.25, 18.75
PK1	7	5,3	34%,66%	3, 4	1.8, 3.5
PK2	34	25	25%,75%	9.5, 24.5	6.25, 18.75

RESULTS AND DISCUSSION

Traffic analysis

Traffic analysis is conducted based on survey data, which is then categorized by vehicle type. This stage will identify the load on each wheel, the number of vehicles, the number of axles per vehicle, and the distribution of vehicle loads based on the axle type of vehicles operating on the service road. The complete list of these figures can be seen in Table 5. These results serve as a crucial input for pavement design, ensuring that the structural thickness is capable of withstanding both the frequency and magnitude of loads over the design period. The summarized values from this traffic categorization and load distribution are presented comprehensively in the recapitulated data table.

Number of axles for commercial vehicles (JSKN) during the design life (20 years)

$$\begin{aligned}
 \text{JSKN} &= 365 \times \text{JSKNH} \times R \\
 &= 365 \times 2273 \times 24.3 \\
 &= 365 \times 2273 \times 24.3
 \end{aligned}$$

$$\begin{aligned}
 \text{JSKN plan} &= 0.7 \times 2.016 \times 10^7 \\
 &= 1.41 \times 10^7
 \end{aligned}$$

Table 5. Calculation of the number of axles based on their type and load

Vehicle type	Axle load configuration (ton)				Number of vehicles	Number of Axles per vehicle	Total number of Axles	STRT		STRG		STdRG	
	RD	RB	RGD	RGB				BS (ton)	JS	BS (ton)	JS	BS (ton)	JS
1	2				3	4	5	6	7	8	9	10	11
Operational Vehicle	1	1			2805								
Bus	4.5	7.5			756	2	1512	4.5	75 6	7.5	75 6		
Baggage Trailer	0.7	0.7			1962								
Forklift Truck	1	1			2								
Trowing Tractor	2.55	4.95			288	2	576	2.55	28 8	4.95	28 8		
Tandem Truck 1	6	18			2	2	4	6	2			18	2
Tandem Truck 2	6	18			43	4	172	6	43			18	43
PKP-PK1	3	4			1	2	2	3 4	1 1				
PKP-PK2	9.25	24.5			1	2	2	9.25	1			24.5	1
Total							2273		109 9		105 3		56

Calculation of the resulting axle repetitions

The calculation of the axle repetitions is based on Table 5. At this stage, the calculation is carried out using the previously obtained load proportions, axle proportions, and planned traffic values. This will then produce the resulting axle repetition values. For details, see Table 6.

Table 6. Calculation of the designed axis repetitions

Axle type	Axle load (ton)	Number of Axles	Load proportion	Axle proportion	Design traffic (repetitions)	Actual repetition (N)
1	2	3	4	5	6	7=4x5x6x7
STRT	6	45	0.041246563	0.66	1.41×10^7	0.3×10^6
	4.5	756	0.692942255	0.66	1.41×10^7	6.44×10^6
	2.55	288	0.263978002	0.66	1.41×10^7	2.45×10^6
	9.25	1	0.00091659	0.66	1.41×10^7	0.0085×10^6
	3	1	0.00091659	0.66	1.41×10^7	0.0085×10^6
Total		1091	1			
STRG	7.5	756	0.724137931	0.26	1.41×10^7	13.8×10^6
	4.95	288	0.275862069	0.26	1.41×10^7	5.25×10^6
Total		1044	1			
SRdRG	18	45	0.97826087	0.08	1.41×10^7	5.86×10^6
	24.5	1	0.02173913	0.08	1.41×10^7	$0,024 \times 10^6$
Total		46	1			
Cumulative						14.1×10^6

Calculation of pavement concrete thickness at CBR 6%

Pavement design for subgrade conditions with a CBR value of 6% was conducted using traffic survey data and several established technical assumptions. The design loads used were derived from actual field survey results, thus reflecting operational conditions. The planned

pavement type is a reinforced concrete pavement without longitudinal reinforcement, with dowels used to transfer the load between the slabs. To strengthen the pavement edges, a concrete shoulder type was used, which serves to maintain structural stability and reduce the potential for damage to the pavement edges. The pavement's design life was set at 20 years with a JSKN of 1.41×10^7 , indicating the magnitude of aircraft and supporting vehicle traffic loads that the structure must withstand. A safety factor of 1.1 was chosen to provide additional margin for variations in field conditions. The flexural tensile strength of the concrete used in the design was set at 4.0 MPa at 28 days, in accordance with concrete quality standards for rigid pavements with good crack resistance.

In the foundation layer, a 15 cm thick cement stabilization sub-base is used, which aims to increase the bearing capacity of the subgrade and reduce differential deformation. The subgrade with an original CBR value of 6% is increased to an effective CBR of 41% through a process of improvement and compaction, thus providing a better bearing capacity. From the results of design calculations based on these data, an estimated concrete slab thickness of 163 mm is obtained. This thickness is considered sufficient to withstand operational loads on the taxiway during the specified design life, taking into account traffic loads, subgrade characteristics, and safety factors.

Table 7. Fatigue and erosion analysis at 6% CBR variation

Axle type	Axle load (ton) [kN]	Design load per wheel (kN)	Actual repetition	Stress & erosion factor	Fatigue analysis		Erosion analysis	
					Allowable repetition	Fatigue damage (%)	Allowable repetition	Erosion damage (%)
1	2	3	4	5	6	7=4x100/6	8	9=4x100/8
STRT	9.25 (92.5)	50.875	0.0085x10 ⁶	TE=1.11	7x10 ³	12.14	6x10 ⁴	14.17
	6 (60)	33	0.3x10 ⁶	FRT=0.275	TT	0.00	TT	0.00
	4.5 (45)	25	6.44x10 ⁶	FE=1.97	TT	0.00	TT	0.00
	3 (30)	16.5	0.0085x10 ⁶		TT	0.00	TT	0.00
	2.55 (25.5)	14.5	2.45x10 ⁶		TT	0.00	TT	0.00
STRG	7.5 (75)	20.625	13.8x10 ⁶	TE=1.6	TT	0.00	TT	0.00
	4.95 (49.5)	13.6125	5.25x10 ⁶	FRT=0.4	TT	0.00	TT	0.00
				FE=2.57				
STdRG	24.5 (245)	33.7	0.024x10 ⁶	TE=1.34	0.5x10 ⁵	48	4.5x10 ⁵	5.33
	18 (180)	24.75	5.86x10 ⁶	FRT=0.335	TT	0.00	7.5x10 ⁶	78.13
				FE=2.53				
					60% < 100%		97.6% < 100%	

The calculation in Table 7 is done based on data from Table 6. In this table, the values that have been obtained previously will be calculated which will then produce the fatigue percentage value and erosion percentage value, at this stage if the analysis results from one of the controls exceed 100% then it is certain that the road will be easily damaged, and if the results from one of the controls are far below 100%, then the road is not effective from an economic point of view, then the best solution to the problem is to look at one of the controls to approach the value of 100%, thus a safe and effective pavement plan will be obtained from an economic point of view, as in Table 7.

Calculation of pavement concrete thickness at CBR 7%

Pavement planning was carried out using load data from field surveys. The type of pavement used was reinforced without longitudinal reinforcement with concrete spokes and shoulders, with a design life of 20 years and a JSKN of 1.41×10^7 . The load safety factor was set at 1.1, while the flexural tensile strength of the concrete at 28 days was 4.0 MPa. The foundation layer used was a 15 cm thick cement stabilizer. The subgrade had a CBR value of 7% which was increased to an effective CBR of 48%, resulting in an estimated concrete slab thickness of 158 mm. Based on Table 8, the percentage of fatigue damage and the percentage of erosion were smaller (closer to) 100%, so the slab thickness taken for soil with a CBR of 7% was 158 mm.

Table 8. Fatigue and erosion analysis at 7% CBR variation

Axle type	Axle load (ton) [kN]	Design load per wheel (kN)	Actual repetition	Stress & erosion factor	Fatigue analysis		Erosion analysis	
					Allowable repetition	Fatigue damage (%)	Allowable repetition	Erosion damage (%)
1	2	3	4	5	6	7=4x100/6	8	9=4x100/8
STRT	9.25 (92.5)	50.875	0.0085×10^6	TE=1.46	2×10^3	42.50	6.2×10^4	13.71
	6 (60)	33	0.3×10^6	FRT=0.286	9×10^6	3.33	TT	0.00
	4.5 (45)	25	6.44×10^6	FE=2	TT	0.00	TT	0.00
	3 (30)	16.5	0.0085×10^6		TT	0.00	TT	0.00
	2.55 (25.5)	14.5	2.45×10^6		TT	0.00	TT	0.00
STRG	7.5 (75)	20.625	13.8×10^6	TE=1.638	TT	0.00	TT	0.00
	4.95 (49.5)	13.6125	5.25×10^6	FRT=0.41	TT	0.00	TT	0.00
				FE=2.608				
STdRG	24.5 (245)	33.7	0.024×10^6	TE=1.392	7.2×10^4	33.33	5.5×10^5	4.36
	18 (180)	24.75	5.86×10^6	FRT=0.348	TT	0.00	107	58.60
				FE=2.5				
					79.17% < 100%		96.38% < 100%	

Calculation of pavement concrete thickness at CBR 8%

Pavement planning was carried out using load data from field surveys. The type of pavement used was reinforced without longitudinal reinforcement with concrete spokes and shoulders, with a design life of 20 years and a JSKN of 1.41×10^7 . The load safety factor was set at 1.1, while the flexural tensile strength of the concrete at 28 days was 4.0 MPa. The foundation layer used was a 15 cm thick cement stabilizer. The subgrade had a CBR value of 8% which was increased to an effective CBR of 56%, resulting in an estimated concrete slab thickness of 155 mm. Based on Table 9, the percentage of fatigue damage and the percentage of erosion were smaller (closer to) 100%, so the slab thickness taken for soil with a CBR of 8% was 155 mm.

Table 9. Fatigue and erosion analysis at 8% CBR variation

Axle type	Axle load (ton) [kN]	Design load per wheel (kN)	Actual repetition	Stress & erosion factor	Fatigue analysis		Erosion analysis	
					Allowable repetition	Fatigue damage (%)	Repetisi Izin	Persentase Rusak (%)
1	2	3	4	5	6	7=4x100/6	8	9=4x100/8
STRT	9.25 (92.5)	50.875	0.0085×10^6	TE=1.174	2.5×10^3	34.00	6×10^4	14.17
	6 (60)	33	0.3×10^6	FRT=0.2935	4×10^6	7.50	TT	0.00
	4.5 (45)	25	6.44×10^6	FE=2.02	TT	0.00	TT	0.00
	3 (30)	16.5	0.0085×10^6		TT	0.00	TT	0.00
	2.55 (25.5)	14.5	2.45×10^6		TT	0.00	TT	0.00
STRG	7.5 (75)	20.625	13.8×10^6	TE=1.656	TT	0.00	TT	0.00

Axle type	Axle load (ton) [kN]	Design load per wheel (kN)	Actual repetition	Stress & erosion factor	Fatigue analysis		Erosion analysis	
					Allowable repetition	Fatigue damage (%)	Repetisi Izin	Persentase Rusak (%)
	4.95 (49.5)	13.6125	5.25x10 ⁶	FRT=0.414 FE=2.445	TT	0.00	TT	0.00
STdRG	24.5 (245)	33.7	0.024x10 ⁶	TE=1.415	5x10 ⁴	48.00	4.1x10 ⁵	5.85
	18 (180)	24.75	5.86x10 ⁶	FRT=0.354 FE=2.56	TT	0.00	7.6x10 ⁵	77.11
					89.5% < 100%		97.12% < 100%	

Comparison of cement concrete thickness results on CBR variations

Based on the calculation results using the empirical method Pd T-14-2003, which varied the CBR value, it was found that the thickness of rigid road pavement showed quite significant variations. Every 1% increase in CBR value can reduce the average concrete slab thickness requirement by about 4 mm. This shows that the higher the CBR value of the subgrade, the better the bearing capacity of the soil, so that the concrete slab thickness requirement becomes smaller. At a CBR condition of 8%, the pavement thickness was obtained at 155 mm, while at a CBR of 7% the pavement thickness increased to 158 mm, and at a CBR of 6% the thickness reached 163 mm. Visualization of the pavement layer can be seen in Figure 2. Thus, the CBR value has a direct influence on design efficiency, where improving the quality of the subgrade can reduce the need for concrete thickness and have an impact on material savings and construction costs. The perception of the influence of CBR on road pavement thickness is the same as the statement (Caecarna et al., 2025; Koh et al., 2025).

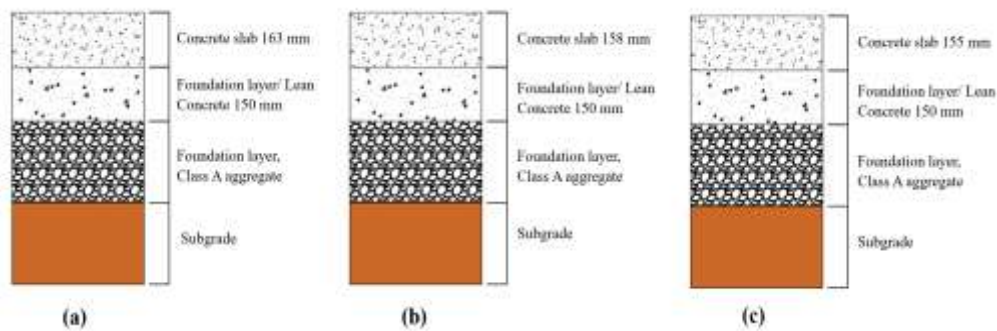


Figure 2. Rigid road pavement layers in CBR variations: (a) CBR 6%, (b) CBR 7%, (c) CBR 8%

CONCLUSION

This study demonstrated that variations in the subgrade *CBR* value directly influence the required thickness of rigid pavement on airport service roads, showing that higher *CBR* values correspond to thinner pavement requirements. This highlights the critical role of subgrade evaluation in pavement planning, affecting technical performance, material efficiency, and construction costs, thereby achieving the research objective effectively. For future research, it is recommended to incorporate additional factors such as actual airport traffic loads, environmental conditions, and local material variations to improve design accuracy. Employing mechanistic-empirical approaches or numerical modeling could also enhance analysis robustness, leading to more adaptive and sustainable pavement designs. Practically, improving subgrade quality through stabilization techniques should be prioritized as it can reduce concrete thickness requirements and support cost-efficient airport infrastructure development.

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