

PAVEMENT DESIGN OF MINANGKABAU INTERNATIONAL AIRPORT TAXIWAYS ALPHA AND BRAVO USING BOEING B777-300ER AS DESIGN AIRCRAFT

Prasetyo Muhammad⁽¹⁾, Mayza Febrianty⁽²⁾, Fatmawati Sari⁽³⁾, Djoko Priambodo⁽⁴⁾

^{1,2,3,4}Institut Transportasi dan Logistik Trisakti

e-mail: ¹prasetyomuhammad@gmail.com , ²mayzaafeb@gmail.com , ³fatmaasari@gmail.com ,
⁴djokogendul@gmail.com

corresponding: ¹prasetyomuhammad@gmail.com

Received :
02 August 2026

Revised :
09 September 2026

Accepted :
01 October 2026

Abstract: The increasing demand for wide-body aircraft operations at Minangkabau International Airport, particularly the planned operation of the Boeing B777-300ER at its Maximum Take-Off Weight (MTOW), requires taxiway pavements with adequate functional condition and structural capacity. Therefore, this study was conducted to evaluate the functional condition of Taxiways Alpha and Bravo, determine the appropriate maintenance strategy, and assess the pavement structural capacity using COMFAA software through subgrade California Bearing Ratio (CBR) simulations. A descriptive quantitative approach was employed using secondary data, including pavement condition and structural data, aircraft traffic data, and aircraft characteristics. The results showed that the Pavement Condition Index (PCI) values were 65.42 for Taxiway Alpha and 67.36 for Taxiway Bravo, classifying both taxiways as fair and indicating that a 10 cm overlay is the appropriate maintenance treatment. The COMFAA analysis produced a Pavement Classification Number (PCN) of 95, which exceeded the Aircraft Classification Number (ACN) of the Boeing B777-300ER (89). In addition, subgrade CBR simulations ranging from 6% to 8% generated PCN values between 93.4 and 134.8, all of which were higher than the aircraft ACN. These findings indicate that the pavement structure of Taxiways Alpha and Bravo is capable of supporting Boeing B777-300ER operations at MTOW.

Keywords: Taxiway, Pavement Condition Index (PCI), COMFAA, Pavement Classification Number (PCN), Aircraft Classification Number (ACN)

Introduction

Since 2026, the Boeing 777-300ER (B777-300ER) has been utilized for Hajj pilgrimage transport at Minangkabau International Airport. However, due to limitations in taxiway infrastructure, the aircraft's operational weight is restricted to a Reduced Take-Off Weight (RTOW) of 330 tons, which is below its Maximum Take-Off Weight (MTOW) of 352.4 tons. This 330-ton limitation is officially stipulated in the AIP Supplement and reinforced by Injourney Airports Letter No. API.0963/TK.09/2026/HO-B dated February 6, 2026, regarding "*Permohonan Overload Operation B-777-300 ER Penerbangan Haji Tahun 2026 di Bandara Minangkabau*", addressed to Direktorat Operasi PT Garuda Indonesia (Persero) Tbk. This condition is influenced by the limited load-bearing capacity of the pavement on both Taxiway Alpha and Taxiway Bravo, as evidenced by Pavement Classification Number (PCN) values of 70 F/C/X/U for Taxiway Alpha and 64 F/C/X/U for Taxiway Bravo, according to data from the 2026 Minangkabau International Airport Aeronautical Information Publication (AIP). With the subgrade soil category classified as Category C, the B777-30ER aircraft yields an Aircraft Classification Number (ACN) of 89.

Taxiway Alpha and Taxiway Bravo were also inspected regarding their pavement condition based on the type, severity level, and extent of distress observed along both taxiways.

The Pavement Condition Index (PCI) method was employed as it comprehensively evaluates airport pavement conditions through visual surveys of asphalt-surfaced pavements, including porous friction courses. Field observations revealed surface cracking, rutting, and pavement surface deformation. Based on the PCI data from Minangkabau International Airport, the PCI scores obtained were 65.42 for Taxiway Alpha and 67.36 for Taxiway Bravo. In accordance with the standards in ASTM D5340-24, the PCI ratings for both taxiways fall into the "fair" category. This condition indicates that the pavement surface requires corrective maintenance in the form of an overlay to improve both the PCI score and rating.

Previous studies indicate that Federal Aviation Administration (FAA) software, such as FAARFIELD and COMFAA, has been widely utilized in airport pavement planning, evaluation, and capacity enhancement. However, existing research still predominantly focuses on runway pavements, general airside planning, as well as pavement design and overlay. Research specifically evaluating the existing condition of taxiways by integrating both functional and structural aspects remains relatively limited.

Discussions regarding the integration of pavement condition assessment using the PCI method with COMFAA software in previous literature tend to focus on differing evaluation objectives. Consequently, the integration between functional pavement condition based on PCI and structural capacity based on COMFAA for taxiways has not been extensively studied. This aspect is crucial because surface deterioration does not always directly reflect the structural capacity of the pavement to sustain aircraft loads.

The next gap pertains to the actual operational conditions of the aircraft. To date, no research has specifically evaluated the structural capacity of Taxiway Alpha and Bravo at Minangkabau International Airport for B777-300ER operations while considering the restriction to Restricted Take-Off Weight (RTOW), nor has it analyzed the feasibility of operations at Maximum Take-Off Weight (MTOW). Furthermore, evaluations incorporating variations in subgrade CBR values are necessary to determine the sensitivity of pavement structural capacity to changes in subgrade bearing capacity.

Therefore, this research is required to integrate functional condition evaluation via PCI, maintenance requirement determination, ACN–PCN relationship analysis, and structural capacity evaluation using COMFAA with subgrade CBR variation simulations to assess the capability of Taxiway Alpha and Bravo in supporting B777-300ER operations from RTOW to MTOW conditions.

The novelty of this research lies in the development of an integrated taxiway pavement evaluation approach that bridges three primary aspects: functional condition, structural capacity, and aircraft operational demands. The functional conditions of Taxiway Alpha and Bravo are evaluated using the Pavement Condition Index (PCI) to determine distress levels and maintenance requirements. Subsequently, structural capacity is evaluated using COMFAA, incorporating variations in CBR values as a representation of subgrade bearing capacity conditions.

Another novelty is the correlation of these structural evaluation results with the actual operational conditions of the B777-300ER, specifically to analyze the pavement's capacity to support an increase in operational load from Restricted Take-Off Weight (RTOW) to Maximum Take-Off Weight (MTOW) through the ACN–PCN approach and COMFAA simulations.

Consequently, this study generates an evaluation framework that not only identifies pavement deterioration levels but also connects surface conditions, maintenance requirements, subgrade bearing capacity characteristics, pavement structural capacity, and the operational feasibility of wide-body aircraft under maximum load conditions.

Method

This research employed a quantitative descriptive approach focusing on the flexible pavements of Taxiway Alpha and Taxiway Bravo at Minangkabau International Airport. Taxiway Alpha has dimensions of 297×30 m, and Taxiway Bravo is 335×30 m. The data utilized were entirely secondary data obtained from PT Angkasa Pura Indonesia as the airport operator, encompassing initial technical planning documents, pavement condition data, PCI data, pavement structural data, flight traffic data, and aircraft characteristics.

The subgrade California Bearing Ratio (CBR) data utilized, sourced from the initial technical documents, was 7.5%. This was due to the unavailability of up-to-date CBR data and the impracticality of conducting subgrade CBR re-testing, which requires substantial cost, time, and effort, particularly given the necessity to close the taxiways during the testing process. However, based on the appendix of the *Keputusan Direktur Jenderal Perhubungan Udara Nomor PR 21 Tahun 2023 Tentang Standar Teknis dan Operasional Peraturan Keselamatan Penerbangan Sipil Bagian 139* (Manual of Standard CASR Part 139) *Volume I Aerodrome Daratan*, for a CBR value range of 4–8% on flexible pavements, a subgrade CBR value of 6% can be used as a representative value. Nevertheless, to determine the effect of variations in subgrade conditions, simulations of subgrade CBR were conducted at 6%, 6.5%, 7%, 7.5% (existing), and 8%, utilizing the existing pavement thickness of 1,000 mm and identical traffic data.

The analysis stages included a review of regulations, previous studies, and research-related literature. This was followed by the collection of primary and secondary data, functional condition evaluation based on PCI data, determination of maintenance recommendations, evaluation of pavement capacity using COMFAA, and a comparison of the simulated PCN values against the ACN of the B777-300ER. The regulatory references applied in this study included *Undang-undang nomor 1 tahun 2009 tentang Penerbangan KP 93 tahun 2015, KP 94 tahun 2015, PR 21 tahun 2023*, FAA AC 150/5335-5C, FAA AC 150/5335-10H, the ICAO Aerodrome Design Manual Part 3 (2018), and ASTM D5340-24 (Standard Test Method for Airport Pavement Condition Index Surveys).

The PCI data were obtained from Minangkabau International Airport. The PCI values were used to depict the level of pavement condition and served as the basis for determining the necessary treatment. In this study, the PCI values were not directly recalculated by the researchers; instead, the pavement condition evaluation results obtained from the airport operator were utilized.

The determination of the critical aircraft was based on the Equivalent Single Wheel Load (ESWL), with the load distribution assumed to be 95% borne by the main landing gear and 5% by the nose gear. The wheel load was calculated using the following equation:

$$W_1 = (1/N) \times 95\% \times \text{MTOW} \quad (1)$$

where W_1 is the aircraft wheel load, N is the number of main landing gear wheels, and MTOW is the maximum take-off weight. For wide-body aircraft with non-standard configurations, a special treatment was applied based on the ICAO Aerodrome Design Manual Part 3, namely a dual tandem approach with a weight of 300,000 lbs, or approximately 136,100 kg, in the wheel load analysis.

The ESWL calculation results indicated that the Airbus A330-300 has the largest wheel load compared to other operating aircraft types. Thus, the Airbus A330-300 should technically be designated as the critical aircraft operating at Minangkabau International Airport. However, the B777-300ER was maintained as the design aircraft because the focus of the research was to design the pavements of Taxiway Alpha and Bravo for the B777-300ER design aircraft under MTOW conditions.

The structural capacity evaluation using COMFAA was conducted by inputting the pavement structure, subgrade CBR, annual departures data, and aircraft characteristics. The resulting PCN values from the analysis were then compared against the ACN. The feasibility criterion employed was $PCN \geq ACN$. Regarding overlay recommendations, the ICAO Aerodrome Design Manual Part 3 (2018) stipulates a minimum thickness for the bituminous layer in critical areas for a dual tandem configuration of 4 inches, or 10.16 cm; therefore, a 10 cm overlay was utilized in this study.

The structural capacity simulations based on CBR value variations were performed using COMFAA while maintaining the existing pavement thickness of 1,000 mm, alongside the same annual departures data and identical aircraft characteristics. The subgrade CBR values were varied at 6%, 6.5%, 7%, 7.5%, and 8% to evaluate the impact of subgrade conditions on the PCN values. The PCN value resulting from each simulation was subsequently compared against the B777-300ER's ACN of 89.3, applying the feasibility criterion of $PCN \geq ACN$. Based on PR 21 (2023), a CBR of 6% was used as the representative value for Category C subgrades in flexible pavements, whereas the 6%–8% CBR variations were utilized to determine the pavement capacity under differing subgrade conditions.

Discussion

Existing Condition and Air Traffic

Minangkabau International Airport currently features a runway, an apron, and three taxiways. Taxiway Alpha and Bravo serve as connectors between the runway and the apron, while Taxiway Charlie connects the apron to the hangar. Facility data indicates that Taxiway Alpha measures 297×30 m with a PCN of 70 F/C/X/U and an RTOW of 330,903 kg, whereas Taxiway Bravo measures 335×30 m with a PCN of 64 F/C/X/U and an RTOW of 312,441 kg. The MTOW of the B777-300ER itself is recorded at 352,441 kg.

Table 1. Airside Pavement Existing Condition

Facility	Dimention	PCN	Maximum Operating Weight
<i>Taxiway Alpha</i>	297×30 m	70 F/C/X/U	RTOW 330.903 kg
<i>Taxiway Bravo</i>	335×30 m	64 F/C/X/U	RTOW 312.441 kg
<i>Runway 33-15</i>	3000×45 m	79 F/C/X/U	MTOW
<i>Taxiway Charlie</i>	305×23 m	53 F/C/X/U	275.520 kg

Aircraft movement data for the 2017–2025 period indicates that the peak traffic for each respective aircraft type was 8,354 movements for the B737-800, 7,753 movements for the B737-900ER, 68 movements for the B777-300ER, 8,660 movements for the A320-200, 1,309 movements for the A320-214, and 312 movements for the A330-300. Flight activity declined during the COVID-19 pandemic and subsequently rebounded, particularly for the A320-200. Although the frequency of the B777-300ER is lower, this aircraft possesses a significantly larger MTOW, making it crucial for the evaluation of taxiway structural capacity.

Aircraft movement data from 2017 to 2025 was utilized to represent the operational loads exerted on airside facilities. The following information constitutes secondary data obtained from Minangkabau International Airport and serves as the basis for selecting the peak traffic volume for each aircraft type.

Table 2. Aircraft Movement Based on Aircraft Type in Minangkabau International Airport 2017–2025

Years	B737-800	B737-900ER	B777-300ER	A320-200	A320-214	A330-300
2017	8.354	7.753	64	5.853	1.298	312
2018	4.690	5.063	63	3.446	844	206

Pavement Design of Minangkabau International Airport Taxiways Alpha and Bravo using Boeing B777-300ER as Design Aircraft

2019	5.924	5.958	67	5.235	1.309	128
2020	2.691	3.163	0	3.521	700	12
2021	2.745	816	0	3.796	1.222	64
2022	2.686	2.642	32	5.038	783	10
2023	1.881	1.768	66	8.180	94	142
2024	2.075	852	68	8.660	300	76
2025	1.976	738	0	7.809	705	116

Critical Aircraft

Variations in landing gear configurations result in different wheel load distributions. The research data indicates that the B737-800 and B737-900ER utilize a dual-wheel configuration, the B777-300ER and A330-300 employ a dual-tandem configuration, whereas the A320 utilizes a dual-wheel setup. Based on the wheel load calculations, the A330-300 generates the highest wheel load. Consequently, if the determination of the critical aircraft were based purely on the Equivalent Single Wheel Load (ESWL), the A330-300 would be designated as the critical aircraft in operation. Nevertheless, this study utilizes the B777-300ER as the design aircraft, as the specific objective of the research is to design and evaluate the capacity of Taxiway Alpha and Bravo in supporting B777-300ER operations under Maximum Take-Off Weight (MTOW) conditions.

Pavement Functional Condition based on PCI

Distress data for Taxiway Alpha and Bravo indicate the presence of block cracking, alligator or fatigue cracking, corrugation and shoving, rutting, and raveling at several stationing (STA) locations. The variation in the types and extent of the distress demonstrates that the pavement condition is not uniform. These data served as the basis for the Pavement Condition Index (PCI) evaluation conducted by the airport operator.

Table 3. Taxiway Pavement Functional Condition Based on PCI Values

Taxiway	PCI Number	PCI Rating Scale	Recomendation
Alpha	65,42	<i>Fair</i>	<i>Overlay 10 cm</i>
Bravo	67,36	<i>Fair</i>	<i>Overlay 10 cm</i>

Taxiway Alpha has an average PCI number of 65.42, and Taxiway Bravo has 67.36. Both fall under the "fair" PCI rating scale. Taxiway Alpha exhibits a notably wide variation in PCI numbers, ranging from 45.29 at STA 0+275–0+286 to 100.00 at STA 0+242–0+253, whereas Taxiway Bravo features PCI numbers ranging from 48.60 at STA 0+130–0+140 to 100.00 across several segments. This distribution indicates that the distress is localized; however, the average values for both taxiways reside within the "fair" PCI rating scale, thereby necessitating maintenance interventions.

These results align with the function of the PCI as an indicator of functional pavement condition. A lower PCI number signifies a deterioration in quality and a more significant need for maintenance (Amanah, 2023; Lamtiar et al., 2024; Shesar Agustin et al., 2025). The "fair" condition on both taxiways serves as the foundation for selecting an overlay as the maintenance action to preserve and enhance pavement performance.

Recomendation and Taxiways Pavement Capacity

Based on the ICAO Aerodrome Design Manual Part 3 (2018), for a critical aircraft with a dual-tandem configuration, the minimum thickness of the bituminous layer in critical areas is 4 inches or 10.16 cm. This study rounded this thickness down to 10 cm. The existing structure consists of a 13 cm surface course, a 35 cm base course, and a 52 cm subbase. The existing surface was then converted into an equivalent base course thickness using an equivalency factor of 1.2.

$$13 \text{ cm} \times 1.2 = 15.6 \text{ cm} \quad (2)$$

$$15.6 \text{ cm} + 35 \text{ cm} = 50.6 \text{ cm} \quad (3)$$

Following the addition of the 10 cm overlay, an evaluation using COMFAA yielded a PCN of 95 for the Boeing 777-300ER, alongside an ACN of 89.3 on a Category C subgrade. This relationship satisfies the $PCN \geq ACN$ criterion.

$$PCN = 95 > ACN \text{ B777-300ER} = 89.3 \quad (4)$$

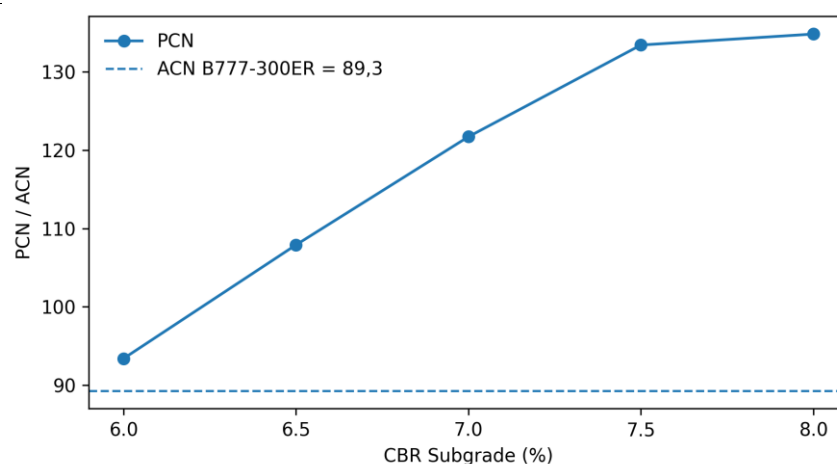
These results indicate that the addition of a 10 cm overlay can enhance the structural capacity calculated through COMFAA without requiring comprehensive reconstruction. These findings align with the research by Sumarda et al. (2022) and Sudika et al. (2021), which demonstrated that an overlay can be effectively utilized as a capacity enhancement measure for airport pavements. The distinction lies in the fact that this study specifically focuses on Taxiway Alpha and Bravo at Minangkabau International Airport while evaluating subgrade CBR variations for the Boeing 777-300ER.

Pavement Structural Capacity Based on Various CBR Values

PR 21 tahun 2023 establishes a CBR of 6% as the representative value for Category C subgrades in flexible pavements, which corresponds to a CBR range of 4%–8%. Consequently, a CBR value of 6% was utilized as the design CBR. The 7.5% CBR value obtained from the initial airport planning documents was not employed as the representative design value, as this study strictly adheres to the subgrade categories stipulated by the regulation. To ascertain the sensitivity of the pavement capacity to varying subgrade conditions, simulations were executed at CBR values of 6%, 6.5%, 7%, 7.5%, and 8%.

Tabel 4. Simulation Result of PCN vs ACN Based on Various Subgrade CBR Values ($PCN \geq ACN$)

CBR (%)	Existing Pavement Thickness (mm)	PCN	ACN B777-300ER	Status
6,0	1.000	93,4	89,3	OK
6,5	1.000	107,9	89,3	OK
7,0	1.000	121,7	89,3	OK
7,5	1.000	133,4	89,3	OK
8,0	1.000	134,8	89,3	OK



Picture 1 Correlation between Subgrade CBR Values and COMFAA-Derived PCN

The simulation results indicate a positive correlation between the increase in CBR and the PCN values. At a CBR of 6%, a PCN of 93.4 was obtained; this value increased to 107.9 at a CBR of 6.5%, 121.7 at 7%, 133.4 at 7.5%, and 134.8 at 8%. All derived PCN values exceed the B777-300ER's ACN of 89.3. Consequently, within the simulated CBR range, the analytical

Pavement Design of Minangkabau International Airport Taxiways Alpha and Bravo using Boeing B777-300ER as Design Aircraft

results demonstrate that the existing pavement structure is capable of supporting B777-300ER operations at MTOW.

These findings also reveal that a CBR of 6%, acting as the representative value for a Category C subgrade, yields a PCN of 93.4, which is greater than the ACN of 89.3. This implies that the necessity to increase the CBR value does not emerge as a minimum prerequisite to accommodate the design aircraft based on these simulation results. However, this study emphasizes that enhancing the CBR cannot be achieved directly, as it necessitates subgrade improvement measures, such as recompaction or alternative bearing capacity enhancement methods.

Comparison of PCN Values Between AIP Data and CBR Variation Simulation Results

Table 5. Comparison of PCN Values Between AIP Data and Subgrade CBR Variation Simulation Results

Parameter	Taxiway Alpha (AIP)	Taxiway Bravo (AIP)	Various CBR Values				
	7,5%	7,5%	6%	6,5%	7%	7,5%	8%
Pavement thickness (mm)	1.000	1.000	1.000	1.000	1.000	1.000	1.000
PCN	70	64	93,4	107,9	121,7	133,4	134,8
ACN B777- 300ER	89	89	89,3	89,3	89,3	89,3	89,3

The comparison indicates that the PCN published in the AIP—namely 70 for Taxiway Alpha and 64 for Taxiway Bravo—is lower than the PCN value derived from the COMFAA simulation. However, this study does not imply that the AIP values are invalid. This discrepancy may be influenced by differences in evaluation bases, methods, establishment periods, or operational considerations. The AIP values remain the figures utilized in airport operational information and serve as an international reference, whereas the research findings represent an evaluation based on the structural parameters available in this study.

Given these conditions, the RTOW restriction for the B777-300ER can be reviewed through further technical evaluation. The research results demonstrate that, based on the analyzed parameters, the simulated PCN values are greater than the B777-300ER's ACN across all CBR variations. This supports the conclusion that the pavements of Taxiway Alpha and Bravo possess adequate structural capacity to support B777-300ER operations at MTOW.

Integrative Discussion

The research results demonstrate that pavement condition and structural bearing capacity aspects provide distinct yet complementary information. The PCI values of 65.42 for Taxiway Alpha and 67.36 for Taxiway Bravo indicate that the surface condition of both taxiways falls under the "fair" category and requires maintenance. Concurrently, the COMFAA results for the existing structural condition yield a PCN of 93.4 at a design CBR of 6%, which exceeds the ACN of 89.3. Consequently, the maintenance requirements are primarily related to the pavement surface condition and calculated capacity enhancement, rather than indicating that the existing structure is inherently failing to support the design aircraft load.

These findings reinforce the importance of airport evaluations that do not rely on a single indicator alone. The PCI depicts functional condition through distress types, severity levels, and extents, whereas ACN–PCN provides the basis for assessing structural capacity compatibility with aircraft loads. Research by Amanah (2023), Lamtiar et al. (2024), and Shesar Agustin et al.

(2025) highlights the significance of PCI in determining maintenance requirements, whereas Silvani Desy Palino & Budi Hartanto Susilo (2021), Sumarda et al. (2022), and Sudika et al. (2021) demonstrate the application of FAA software for capacity and overlay evaluations.

The novelty of this research lies in the implementation of this comprehensive evaluation sequence on Taxiway Alpha and Bravo at Minangkabau International Airport, focusing on B777-300ER operations that remain restricted by RTOW limits. The CBR simulation results (6%–8%) indicate that all PCN values exceed the ACN, while the 10 cm overlay recommendation yields a PCN of 95. These results provide a technical basis derived from the data available in this study to assess the capability of the pavement structure to support planned MTOW operations.

Furthermore, regarding the methodology applied, it should be acknowledged that this study still utilizes the ACN-PCN calculation method. The International Civil Aviation Organization (ICAO) has indeed issued a new regulation to report airport pavement strength using the Aircraft Classification Rating–Pavement Classification Rating (ACR-PCR) system. However, because its implementation at the national level is still being carried out in phases, the ACN-PCN framework remains the applicable and valid standard for current operational assessments in Indonesia.

Results

Based on the evaluation results, Taxiway Alpha has an average PCI number of 65.42 and Taxiway Bravo 67.36, placing both in the "fair" PCI rating scale. This condition indicates the necessity for maintenance, with a recommended overlay thickness of 10 cm in accordance with the provisions of the ICAO Aerodrome Design Manual Part 3 for a dual-tandem configuration. The COMFAA evaluation following the overlay yields a PCN of 95, whereas the Boeing B777-300ER ACN is 89.3, thereby satisfying the $PCN \geq ACN$ criterion. Subgrade condition simulations utilizing CBR values ranging from 6% to 8% yield corresponding PCN values of 93.4, 107.9, 121.7, 133.4, and 134.8, respectively, against the Boeing B777-300ER ACN of 89.3. All variations indicate an "OK" status, with PCN values exceeding the ACN. Consequently, based on the parameters and data utilized, the pavement structures of Taxiway Alpha and Bravo are assessed as capable of supporting Boeing B777-300ER operations under Maximum Take-Off Weight (MTOW) conditions. The novelty of this research lies in the integrated evaluation of the functional condition and structural capacity of Taxiway Alpha and Bravo under actual operational conditions that still enforce RTOW limits, followed by testing the structural capacity through CBR variations. The practical implication is that these findings can serve as a reference for airport operators regarding overlay maintenance and technical reviews of pavement capacity. Re-evaluating the PCN values listed in the AIP remains necessary through further technical evaluation and up-to-date field data.

Bibliography

- Airport Engineering Division AAS-, F. (2020). *AC 150/5370-10H, Standard Specifications for Construction of Airports, 21 December 2018 (updated by errata 19 August 2020)*. <http://www.faa.gov/airports/aip/procurement/>.
- Amanah, T. (2023). The Pavement Condition Index Functional Evaluation of Runway Pavement Used Pavement Condition Index (PCI) Method (Case Study : Fatmawati Soekarno Airport Provinsi Bengkulu). *Journal of Civil Engineering and Planning*, 4(1), 14–25. <https://doi.org/10.37253/jcep.v4i1.7660>
- Direktorat Jenderal Perhubungan Udara. (2023). *Peraturan Direktur Jenderal Perhubungan Udara Nomor PR 21 Tahun 2023 tentang Standar Teknis dan Operasional Peraturan*

- Keselamatan Penerbangan Sipil Bagian 139 (Manual of Standard CASR Part 139) Volume I Aerodrome (Daratan)*. Kementerian Perhubungan Republik Indonesia.
- FAA AC/5335-5C. (n.d.). *Advisory Circular (A C) 150/5335-5C, Standardized Method of Reporting Airport Pavement Strength - PCN, 14 August 2014*.
- ICAO AERODROME DESIGN MANUAL PART 3. (2018). *AERODROME DESIGN MANUAL PART 3 PAVEMENTS SECOND EDITION-1983 INTERNATIONAL CIVIL AVIATION ORGANIZATION*. www.icao.int.
- Ishak, Juniawan, M., Yusman, A. S., & Herista, F. (2025). EVALUASI PERKERASAN AIR SIDE BANDARA INTERNATIONAL MINANGKABAU (BIM). *BEGIBUNG: Jurnal Penelitian Multidisiplin*, 3(3), 53–57. <https://doi.org/10.62667/begibung.v3i3.208>
- Kementerian Perhubungan. (2015). *Keputusan Menteri Perhubungan Nomor KP 93 Tahun 2015 tentang Penetapan Bandar Udara Internasional Minangkabau di Padang, Sumatera Barat*. Kementerian Perhubungan Republik Indonesia.
- Kementerian Perhubungan. (2015). *Keputusan Menteri Perhubungan Nomor KP 94 Tahun 2015 tentang Master Plan / Rencana Induk Bandar Udara Internasional Minangkabau*. Kementerian Perhubungan Republik Indonesia.
- Lamtiar, S., Zhabri Gaffari Darmawan, M., Endrawijaya, I., Kurniawan, A., & Hidayat, Z. (2024). Evaluasi Pavement Condition Index (PCI) Runway 12-30 Bandar Udara Budiarto. *Airman: Jurnal Teknik Dan Keselamatan Transportasi*, 7(1), 49–60. <https://doi.org/10.46509/ajtk.v7i1.452>
- Nur Ulya, F., & Darma, Y. (2022). Kopelma Darussalam Banda Aceh 23111, Indonesia 2,3 Dosen, Jurusan Teknik Sipil. *Universitas Syiah Kuala Jalan Syech Abdurrauf*, (7).
- Republik Indonesia. (2009). *Undang-Undang Nomor 1 Tahun 2009 tentang Penerbangan*. Lembaran Negara Republik Indonesia Tahun 2009 Nomor 1, Tambahan Lembaran Negara Republik Indonesia Nomor 4956. Sekretariat Negara.
- Shahin, M. Y. (2005). *Pavement Management for Airports, Roads, and Parking Lots*. Scholars Portal.
- Shesar Agustin, W., Winiasri, L., Triyono, A., & Penerbangan Surabaya, P. (2025). *Perencanaan Pemeliharaan Dan Perbaikan Landas Pacu Bandar Udara Toraja Berdasarkan Hasil Analisis Kerusakan Perkerasan Lentur Dengan Metode Pavement Condition Index (Pci) Astm D5340-98 Repair Planning For The Runway Of Toraja Airport Based On The Results Of Flexible Pavement Damage Analysis With The Pavement Condition Index (Pci) Method Astm D5340-98*. 16(1), 2548–4168. <https://doi.org/10.34001/Jdpt>
- Silvani Desy Palino, & Budi Hartanto Susilo. (2021). *Analisis Tebal Perkerasan Dan Biaya Dengan Software Faarfield Pada Landas Pacu Bijb Kertajati*.
- Sudika, G. M., Ngurah, G., Partama, E., & Ramadiansyah, A. A. (2021). Perencanaan Peningkatan Daya Dukung Perkerasan Runway Bandara Internasional I Gusti Ngurah Rai-Bali. In *Jurnal Teknik Gradien* (Vol. 13, Number 01). <http://Www.Ojs.Unr.Ac.Id/Index.Php/Teknikgradien>
- Sumarda, G., Made Kariyana, I., & Subekti, I. S. (2022). *Perencanaan Tebal Lapis Tambah (Overlay) Runway Eksisting Bandara Internasional Lombok*. 5(1).