Research on Engineering Structures & Materials
www.jresm.org
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Research Article

Assessment of airport rigid pavement bearing capacity using the ACR–PCR method under tropical conditions: A case study of Tan Son Nhat International Airport, Vietnam

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Article Info

Article History:

Received 30 Jun 2026
Accepted 15 Oct 2026

Keywords:

ACR–PCR;
Airport rigid pavement;
Pavement bearing capacity;
FAARFIELD;
Technical evaluation;
Tan Son Nhat International Airport

Abstract

The implementation of the Aircraft Classification Rating-Pavement Classification Rating (ACR–PCR) system by the International Civil Aviation Organization (ICAO) in November 2024 has introduced a new framework for airport pavement strength evaluation. However, applications of this methodology to existing rigid airport pavements under tropical conditions remain limited. This study evaluates the structural capacity of Runway 25L/07R at Tan Son Nhat International Airport, Vietnam, using the ICAO ACR–PCR methodology based on the Technical Evaluation approach. Pavement layer thicknesses were established from construction records and coring data, while layer and subgrade elastic moduli were obtained from an available deflection-based DAPS back-calculated dataset. These structural parameters, together with the 2023 aircraft traffic mix, annual departures, aircraft gross weights, and a one-year analysis period, were incorporated into FAARFIELD to determine PCR values for representative runway sections. The calculated PCR values ranged from 850 to 1090, indicating spatial variations in structural capacity along the runway. The minimum PCR was 850/R/A/W/T, while the maximum reached 1090/R/A/W/T. The critical aircraft was identified as the Boeing 777-9 with an ACR of 818/R/A. The minimum PCR exceeded the maximum ACR by approximately 3.91%, indicating compliance with the ACR ≤ PCR operational criterion. The results indicate that the runway remains structurally adequate for current aircraft operations. The study demonstrates the applicability of a field-data-based Technical Evaluation within the ACR–PCR framework for aging rigid airport pavements under tropical conditions and provides a practical basis for pavement strength assessment and management.

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1. Introduction

Assessment of airport pavement structural capacity is essential for safe and efficient airport operations and long-term infrastructure management. For decades, the ICAO ACN–PCN system has been used to report pavement strength and aircraft-pavement compatibility. With the mandatory implementation of the ACR–PCR framework commencing in November 2024, pavement strength reporting has become more closely aligned with mechanistic-empirical analysis and can incorporate structural condition and aircraft-specific traffic information [1–5]. This transition increases the importance of reliable Technical Evaluation, particularly for existing pavements whose current properties may differ from their original design condition.

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DOI: http://dx.doi.org/10.17515/resm2026-1807st0630rs

For aging rigid airport pavements, Technical Evaluation is challenging because it requires representative information on pavement configuration, layer properties, foundation support, and aircraft loading. Field deflection testing and back-calculation can provide in-service structural properties, while FAARFIELD can integrate these properties with aircraft fleet composition, gross weights, and annual departures for PCR determination [6,7,9]. However, published evidence remains comparatively limited on the use of field-derived structural properties and airport-specific traffic within a section-specific ACR–PCR Technical Evaluation of aging rigid runways, particularly under tropical conditions and intensive aircraft operations. Runway 25L/07R at Tan Son Nhat International Airport provides a relevant case for such evaluation. The runway was originally constructed in the 1970s and underwent major rehabilitation during 1999–2000. After decades of intensive aircraft loading and environmental exposure, its structural condition may vary along the runway because of differences in pavement configuration, rehabilitation history, supporting-layer properties, and cumulative loading. A section-based evaluation is therefore appropriate for representing variations in current load-carrying capacity that may not be captured by a single set of nominal structural properties.

Accordingly, this study evaluates the current structural capacity of Runway 25L/07R using the ACR–PCR Technical Evaluation approach. The specific objectives are to: (1) characterize the in-service structural properties of representative runway sections using available deflection-based back-calculated structural data; (2) integrate these properties with airport-specific aircraft traffic in FAARFIELD to determine section-specific PCR values; (3) assess pavement-aircraft compatibility by comparing the calculated PCR values with the ACR of the critical aircraft; and (4) examine spatial variations in structural capacity and their implications for pavement evaluation and management. The contribution of the study lies in linking field-derived structural characterization with section-specific ACR–PCR evaluation of an aging operational rigid runway.

2. Literature Review and Research Gap

2.1 Structural Evaluation of Airport Pavements Using HWD and Back-Calculation

Structural evaluation of existing airport pavements requires information that reflects their current in-service mechanical condition rather than relying exclusively on original design parameters. Nondestructive deflection testing using Falling Weight Deflectometer (FWD) and Heavy Weight Deflectometer (HWD) devices has therefore become an important approach for evaluating airport pavement structural response. These devices apply a controlled dynamic load to the pavement surface and record the resulting deflection basin, which can subsequently be used to characterize the structural behavior of the pavement system [7,13].

Recent reviews of airport pavement evaluation methods have highlighted the increasing role of nondestructive testing in structural assessment and mechanistic-empirical pavement analysis. In particular, FWD and HWD measurements provide field-based information that can support estimation of the mechanical properties of pavement layers and the supporting foundation. Compared with evaluations based only on nominal or historical design properties, field-derived parameters can provide a more representative basis for characterizing the in-service condition of an aging pavement subjected to long-term aircraft loading and environmental exposure [13,17,18]. The measured deflection basin is commonly interpreted through back-calculation procedures to estimate the elastic moduli of pavement layers and subgrade materials. The reliability of the resulting moduli depends on several factors, including the applied load level, pavement structural model, assumed material parameters, and the back-calculation procedure and numerical algorithm used to minimize the difference between measured and calculated deflections [13,20,27]. Recent research has demonstrated that HWD-based back-calculation can provide reasonable estimates of the elastic moduli of rigid airport pavement layers and supporting soils. However, the estimated properties may vary with loading level and analytical procedure, indicating that the back-calculation methodology and input assumptions should be reported clearly when the derived moduli are subsequently used for pavement strength evaluation [20,21].

The influence of the back-calculation procedure is particularly important within the ACR–PCR Technical Evaluation framework because pavement layer and subgrade properties constitute key

structural inputs to subsequent mechanistic–empirical analysis. Previous studies have shown that back-calculated elastic modulus values can be influenced by the applied loading level, pavement structural representation, and analytical assumptions [20,21,27]. Therefore, transparent reporting of the back-calculation procedure, input assumptions, and selection of representative structural properties is important for interpreting the reliability of airport pavement structural evaluations. For aging rigid airport pavements, this field-based approach is especially relevant because long-term aircraft loading, rehabilitation history, environmental exposure, and progressive changes in pavement and foundation condition may cause the in-service structural properties to differ from those assumed during original design. Using elastic moduli back-calculated from HWD-measured deflection response can therefore provide a more representative basis for characterizing the existing pavement structure in subsequent Technical Evaluation and PCR determination [13,20,21].

Environmental exposure is also relevant to the long-term response of airport concrete pavements. Field-based research has shown that temperature and moisture variations can influence the strain response of concrete airport pavement slabs [22]. These findings indicate that the in-service response of long-serving airport pavements may differ from that represented by nominal design properties, particularly where environmental exposure acts together with repeated aircraft loading. In the present study, such environmental and deterioration effects are not modeled explicitly; rather, their accumulated effects may be reflected indirectly through the field-derived structural properties adopted in the Technical Evaluation.

2.2 FAARFIELD-Based Airport Pavement Analysis

Mechanistic–empirical analysis provides a systematic framework for evaluating airport pavement structural performance by relating pavement configuration and material properties to aircraft loading and traffic demand. FAARFIELD, developed by the Federal Aviation Administration (FAA), is the analytical software used in FAA guidance for airport pavement design and evaluation and is also applied to pavement strength evaluation under the ACR–PCR framework [5,6,9]. For existing pavements, the analytical model can incorporate field-derived structural properties, including back-calculated modulus values obtained from nondestructive deflection testing [6,7,13].

For rigid airport pavements, structural evaluation requires consideration of the pavement configuration, concrete slab characteristics, supporting layer and subgrade properties, and aircraft traffic. Aircraft-related inputs include fleet composition, aircraft gross weights, annual departures, and loading characteristics, while the analysis period defines the time interval over which the specified traffic is evaluated [5,6]. Consequently, the calculated pavement response and structural capacity reflect the interaction between the pavement system and the applied aircraft traffic rather than a single structural parameter considered independently. Recent FAARFIELD-based studies have demonstrated the importance of these interacting factors. Hansu et al., for example, investigated rigid runway pavement designs under combinations of strong and weak soil conditions and low and high traffic levels using different aircraft types and annual departure frequencies. Their results demonstrate the relevance of both foundation support and traffic demand in rigid airport pavement analysis [23]. Recent ACR–PCR studies on rigid airport pavements have similarly incorporated pavement thickness, subgrade strength, aircraft characteristics, and traffic information in FAARFIELD-based Technical Evaluation, further illustrating the dependence of pavement strength classification on the combined structural and operational inputs [14,15]. For existing airport pavements, reliable characterization of these inputs is particularly important because the current pavement properties may differ from nominal design values. FAA guidance allows back-calculated modulus values obtained from nondestructive testing to be incorporated into FAARFIELD for pavement evaluation [6,7]. This provides a direct methodological link between field structural assessment and mechanistic-empirical analysis: deflection measurements are first interpreted to characterize the in-service pavement structure, and the resulting structural parameters can then be used together with aircraft traffic information to evaluate pavement capacity [13,20,21].

Accordingly, FAARFIELD-based Technical Evaluation should not be interpreted simply as a software calculation based on nominal pavement geometry. Its reliability depends on the

representativeness of the structural and operational inputs used in the analytical model [5,6,28]. For aging rigid pavements with spatially variable structural properties, integrating field-derived layer and subgrade characteristics with airport-specific aircraft traffic provides a field-informed basis for section-specific pavement strength evaluation and interpretation of variations in structural capacity along the evaluated facility [13-15,20,21,23].

2.3 Development and Recent Applications of the ACR–PCR Framework

The transition from the Aircraft Classification Number–Pavement Classification Number (ACN–PCN) system to the ACR–PCR framework represents a major change in international airport pavement strength reporting. The ACR–PCR framework is more closely aligned with contemporary mechanistic-empirical pavement analysis and provides a structured basis for evaluating the compatibility between aircraft loading demand and pavement structural capacity. Under this framework, the ACR represents the relative structural effect of an aircraft, whereas the PCR is a numerical rating representing pavement load-carrying capacity under defined structural and subgrade conditions [1-5].

Recent research has examined both the theoretical implications and practical implementation of this transition. White (2024) critically reviewed the ACR–PCR framework, discussing its closer connection with modern airport pavement analysis while also identifying aspects requiring further consideration as implementation progresses [24]. Other recent studies have compared the ACN–PCN and ACR–PCR frameworks for airport pavements and reported differences in pavement strength classification, reflecting differences in the analytical formulations and structural assumptions underlying the two systems [8,11,12,14-16,26]. Field condition and structural characterization are particularly relevant when ACR–PCR is applied to existing pavements. Armeni and Loizos (2024) examined pavement strength reporting using PCR and highlighted the importance of pavement structural characteristics and material properties in evaluating existing airfield pavements [12]. Alves and Fontul (2024) also applied the ACR–PCR methodology to existing runway pavements, illustrating the practical role of structural evaluation in the implementation of the new rating system [25]. These studies indicate that application of ACR–PCR to existing facilities involves more than conversion of previously reported PCN values; appropriate representation of the current pavement structure and its mechanical condition is important for the evaluation [12,25,26]. Recent investigations have also specifically addressed rigid airport pavements. Sun et al. compared the ACN–PCN and ACR–PCR systems for rigid airport pavement through a case-study-based analysis [14], while Zhang et al. (2025) evaluated ACR–PCR for rigid pavements using multiple aircraft types and airport cases [15]. These studies illustrated the application of the new rating framework to rigid pavement systems and indicated that pavement structural characteristics, including pavement thickness and foundation conditions, influence the resulting pavement strength assessment [14,15]. Collectively, the findings indicate that ACR–PCR evaluation should be interpreted within the context of the complete pavement structure and aircraft loading environment rather than as a direct numerical replacement for PCN. The reliability of Technical Evaluation also depends on the structural parameters used to represent the existing pavement. Recent work on airport pavement back-calculation has shown that estimated pavement and subgrade moduli can be influenced by loading level, pavement structural representation, analytical assumptions, and back-calculation methodology [13,20,21,27]. This observation reinforces the importance of integrating field measurements, transparent back-calculation procedures, and representative structural parameters when applying the Technical Evaluation approach to existing airport pavements. Despite these advances, much of the recent ACR–PCR literature has concentrated on comparisons between the former and new pavement strength rating systems, methodological evaluations, or implementation case studies [12,14,15,24-27]. Comparatively limited attention in the published literature has been given to Technical Evaluation of aging rigid runways in which spatially distributed field measurements are used to characterize variations in pavement and foundation properties before determining PCR for different homogeneous sections. This issue is particularly relevant for long-serving airport pavements that have undergone rehabilitation and sustained intensive aircraft operations, where a single set of nominal structural properties may not adequately represent the condition of the entire runway.

2.4 Research Gap and Contribution of the Present Study

Recent studies have substantially advanced understanding of the transition from ACN–PCN to ACR–PCR and have illustrated the application of the new rating framework to existing airport pavements, including rigid pavement systems [12,14,15,24-26]. Parallel developments in nondestructive pavement evaluation and back-calculation have also improved the ability to characterize the in-service structural properties of airport pavement systems [13,17,18,20,21,27]. However, these research areas have generally been addressed through separate lines of investigation, particularly through comparisons between the ACN–PCN and ACR–PCR systems or evaluations of selected pavement configurations. Published evidence remains comparatively limited on the integration of field-derived structural properties with airport-specific traffic data within the ACR–PCR Technical Evaluation procedure for aging rigid runways.

This limitation is important for long-serving airport pavements because their current structural properties may vary along the facility as a result of differences in pavement configuration, rehabilitation history, cumulative aircraft loading, foundation support, and environmental exposure. Consequently, representing an entire runway using only nominal design properties or a single structural condition may not adequately characterize its current load-carrying capacity. A field-data-based evaluation that represents variations among pavement sections can therefore provide additional information for PCR determination and pavement management. In Vietnam, Pham et al. (2025) presented a preliminary application of FAARFIELD for ACR–PCR determination using an assumed 4E international airport, assumed pavement structural properties, and assumed aircraft traffic inputs [19]. Their study demonstrated FAARFIELD implementation in the Vietnamese context; however, it did not incorporate field-measured pavement response or section-specific structural characterization of an existing operational runway. The present study addresses this gap through an integrated Technical Evaluation of Runway 25L/07R at Tan Son Nhat International Airport. Pavement configuration and layer thickness information obtained from construction records and coring data are combined with elastic moduli derived from deflection-based back-calculation to characterize the in-service pavement structure. These structural parameters are subsequently integrated with airport-specific aircraft traffic in FAARFIELD to determine PCR values for representative runway sections. The resulting section-specific PCR profile is then compared with the ACR of the critical aircraft to assess current pavement-aircraft compatibility and is further examined through sensitivity analyses of the analysis period and traffic-growth assumption.

The methodological contribution of the present study therefore lies not in the use of FAARFIELD itself, but in linking field-derived structural characterization with section-specific ACR–PCR Technical Evaluation. Unlike much of the recent literature, which has focused on comparisons between the ACN–PCN and ACR–PCR systems, implementation case studies, or selected pavement configurations [12,14,15,24-26], and the preliminary Vietnamese application based on assumed pavement and traffic conditions [19], the present study uses spatially distributed, deflection-based back-calculated properties to characterize representative structural inputs for multiple homogeneous sections along an aging operational runway. This approach enables spatial variations in pavement load-carrying capacity to be evaluated on a consistent basis while also examining the sensitivity of the resulting PCR profile to key analysis assumptions. Accordingly, the contribution of the present study is framed as an integrated field-data-based and section-specific Technical Evaluation of an aging operational rigid runway in Vietnam, rather than as the first use of the ACR–PCR methodology or FAARFIELD in the country.

3. Overview of PCR and ACR Indices and PCR Determination Using the ACR–PCR Methodology

3.1 Pavement Classification Rating (PCR) and Aircraft Classification Rating (ACR)

The PCR is a numerical rating that represents the load-carrying capacity of an airport pavement. Under the ACR–PCR methodology, the PCR is expressed using the pavement classification rating value, pavement type, subgrade strength category, maximum allowable tire pressure category, and the evaluation method [1-3]. Guidance for the implementation and reporting of PCR values has

subsequently been provided by aviation authorities through regional and national pavement evaluation documents [4,5]. The ACR is a numerical rating that expresses the relative effect of an aircraft on an airport pavement for a specified standard subgrade strength category. Within the ACR–PCR framework, the ACR provides a standardized measure of the relative structural effect of an aircraft for pavement-aircraft compatibility assessment [1-3]. ACR values are determined from aircraft characteristics using standardized computational procedures and are used to assess pavement-aircraft compatibility under the ACR–PCR system [4,5]. Under the ACR–PCR system, aircraft with an ACR not exceeding the published PCR may operate without pavement-strength-related restrictions, provided that the applicable tire-pressure limitations are satisfied [1-5]. ACR values are specified separately for rigid and flexible pavement structures. Where the ACR exceeds the published PCR, operation should be subject to evaluation in accordance with the applicable overload criteria and requirements of the competent authority [1-5].

3.2 PCR Determination Using the ACR–PCR Methodology

3.2.1 PCR Determination Using the Aircraft Method

For PCR determination using the Aircraft Method, the ACR values of aircraft satisfactorily and regularly operating on the runway, taxiway, and apron are first identified. The maximum ACR value among these aircraft is then adopted as the published PCR for the corresponding pavement structure. The primary advantages of this method are its simplicity and ease of implementation, as it relies mainly on aircraft operational experience and does not require the comprehensive structural inputs needed for a detailed Technical Evaluation. Accordingly, the Aircraft Method can be useful where sufficient aircraft operational experience is available but detailed structural information for Technical Evaluation is limited.

Despite its practical advantages, the Aircraft Method does not directly evaluate the actual structural capacity of the pavement. The resulting PCR is derived from aircraft operational experience rather than from mechanistic pavement analysis or detailed structural condition assessment. Consequently, the reported PCR may not fully reflect changes in pavement structural condition associated with long-term traffic loading, environmental exposure, and other deterioration processes. For pavement strength assessment requiring a more detailed representation of the existing pavement structure, Technical Evaluation provides an analytical approach based on pavement structural information, aircraft loading, and appropriate analytical procedures [1,3]. Field investigation and nondestructive deflection testing can provide additional information for characterizing the in-service structural properties used in such evaluations [13,20,21].

3.2.2 PCR Determination Using the Technical Evaluation Method

The Technical Evaluation Method determines pavement strength through a comprehensive analysis of pavement structural characteristics and actual operating conditions. Unlike the Aircraft Method, this approach explicitly considers pavement structural characteristics, subgrade support, aircraft traffic, and analytical pavement response, thereby providing a more detailed basis for pavement strength assessment. Accordingly, pavement strength reporting should, whenever practicable, be based on a Technical Evaluation rather than solely on aircraft operational experience [1,3,5]. Nondestructive deflection testing using HWD, FWD, or similar devices can be used to characterize pavement structural response and derive structural parameters for subsequent analysis [7,13]. This study applies the ACR–PCR methodology using the Technical Evaluation approach in accordance with the relevant ICAO framework. The proposed assessment integrates historical pavement information, available HWD/SHWD deflection data and DAPS-based back-calculated pavement structural properties, airport-specific aircraft traffic data, and mechanistic–empirical analysis using FAARFIELD. The resulting PCR values are subsequently compared with the ACR of the critical aircraft to assess pavement–aircraft compatibility and interpret spatial variations in the structural capacity of the runway. The overall research framework is presented in Figure 1.

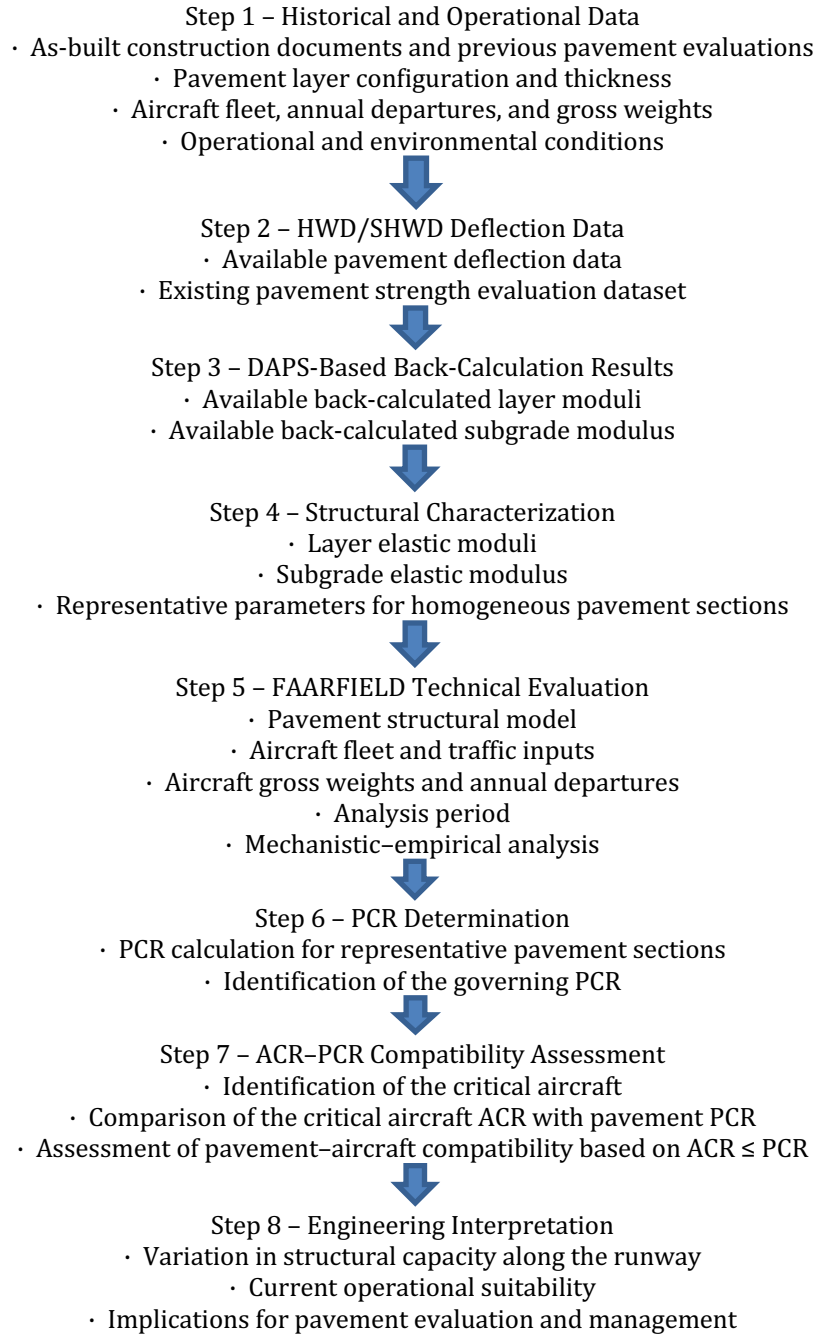


Fig. 1. Research framework for structural capacity assessment of rigid airport pavements using the ACR–PCR Technical Evaluation approach

The Technical Evaluation Method incorporates pavement structural characterization, aircraft traffic information, and analytical pavement evaluation to determine PCR. For in-service pavements, structural parameters may be established from available pavement records, field investigation, and nondestructive deflection testing. Elastic moduli derived through back-calculation can then be used to characterize representative pavement sections for subsequent analysis. For each representative pavement section, the structural model and aircraft traffic are incorporated into FAARFIELD. Input parameters include pavement layer thicknesses, elastic moduli of the structural layers and supporting foundation, aircraft fleet composition, aircraft gross weights, annual departures, and the analysis period. FAARFIELD uses a CDF-based Technical Evaluation procedure to determine the critical aircraft and the corresponding PCR for the evaluated pavement structure. Within this procedure, a CDF of 1.0 represents the limiting damage criterion defined by the adopted pavement analysis model; a CDF greater than 1.0 does not necessarily indicate that the pavement can no longer support aircraft traffic.

3.3 FAARFIELD-Based PCR Evaluation Procedure

FAARFIELD, developed by the Federal Aviation Administration (FAA), was used in this study to determine the PCR of Runway 25L/07R. The analysis incorporated pavement structural parameters, including layer thicknesses and elastic moduli, together with airport-specific aircraft traffic data. Field-derived elastic modulus values obtained from the existing pavement strength evaluation dataset were used to characterize the in-service pavement structure for the subsequent PCR evaluation [6,7,9]. FAARFIELD includes an internal aircraft database containing the aircraft characteristics required for pavement analysis *(*Figure 2*)*. In the present study, the relevant aircraft types were selected from this database and combined with airport-specific aircraft gross weights and annual departure data to represent the aircraft traffic at Runway 25L/07R.

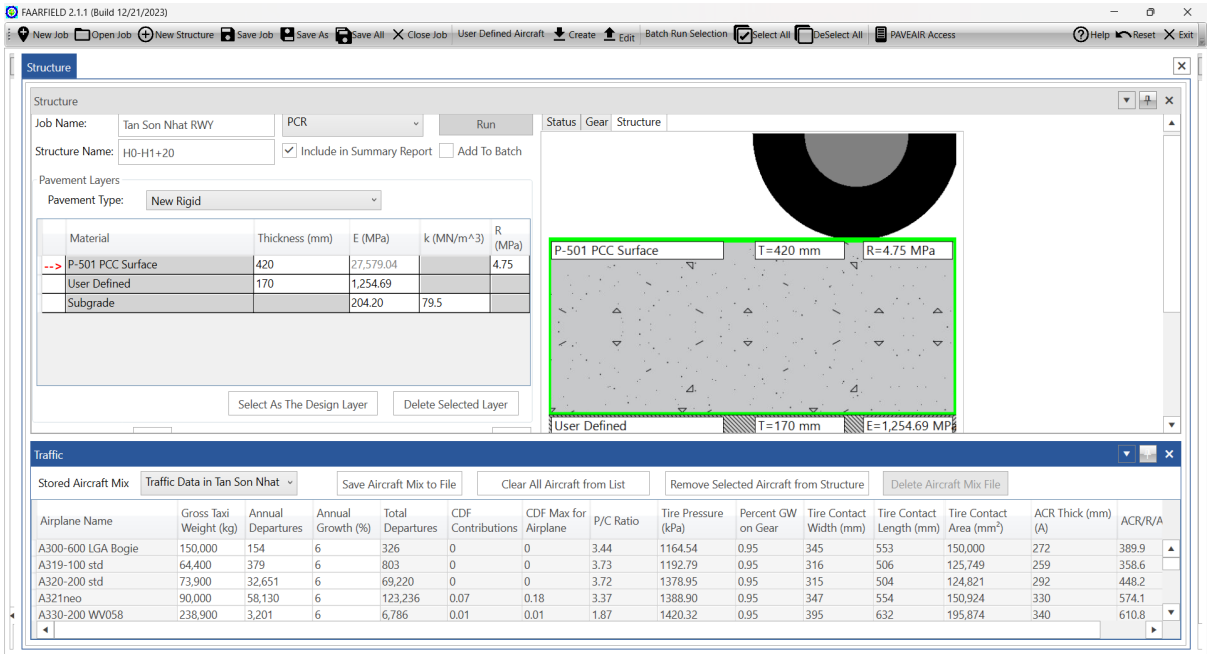


Fig. 2. FAARFIELD software interface for PCR determination

For the pavement structural model, the layer configuration, thicknesses, and elastic moduli corresponding to the evaluated sections of Runway 25L/07R were defined in FAARFIELD using the available pavement strength evaluation dataset. These section-specific structural parameters were used to represent the existing rigid pavement conditions in the subsequent PCR analysis. In addition to the pavement structural parameters, aircraft traffic data were incorporated into the FAARFIELD analysis, including aircraft fleet composition, aircraft gross weights, and annual departures. The 2023 aircraft traffic dataset was adopted to represent the current operating conditions of Runway 25L/07R. Together with the section-specific pavement layer thicknesses and elastic moduli, these traffic inputs were used in the FAARFIELD analysis to determine the PCR of the evaluated runway sections. A one-year analysis period was adopted to represent the current evaluation condition rather than to predict long-term pavement performance. In the FAARFIELD pavement models, Poisson's ratios of 0.15, 0.35, and 0.40 were assigned to the P-501 PCC surface, user-defined supporting layers, and subgrade, respectively. These FAARFIELD input values are distinct from the Poisson's ratios adopted in the original DAPS back-calculation, which could not be recovered from the available source records.

4. Assessment of the Bearing Capacity of Runway 25L/07R at Tan Son Nhat International Airport Using the ACR–PCR Method

4.1 Collection and Determination of Input Parameters

4.1.1 Determination of Pavement Structural Parameters

The classification and description of the pavement structure were performed with reference to the terminology and rigid pavement categories specified in TCVN 10907:2015 [10]. The thicknesses of

the pavement structural layers were determined using information obtained from as-built construction documentation and, where required, supplemented by pavement coring investigations. Based on the structural configuration of Runway 25L/07R, the pavement was classified into two homogeneous structural sections, referred to as Zone 1 and Zone 2 (*Figure 3*).

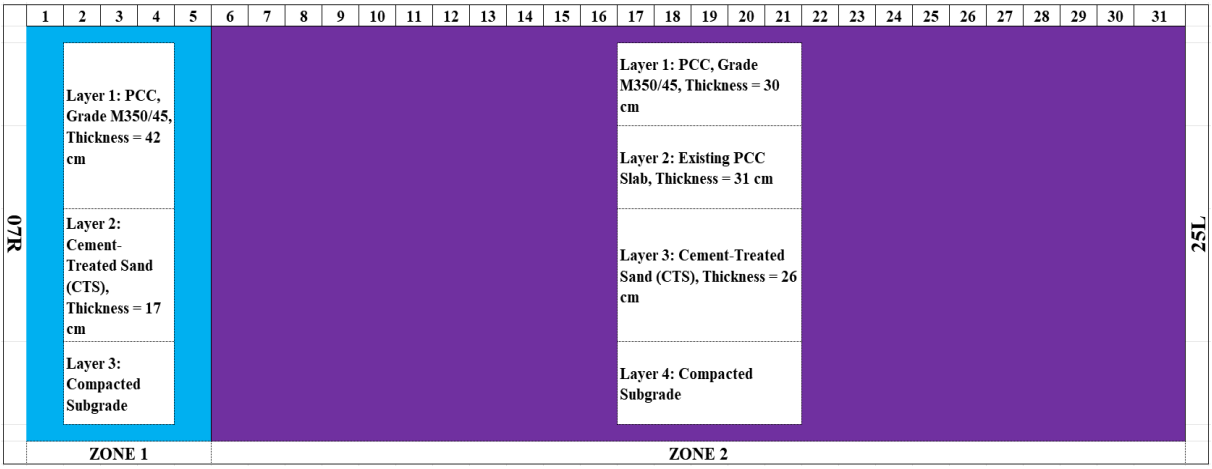
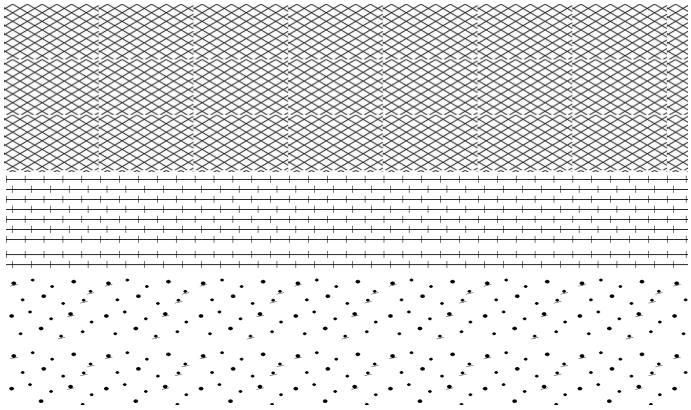


Fig. 3. Pavement structures of Zone 1 and Zone 2 on Runway 25L/07R

Zone 1 consists of a 42-cm PCC slab over a 17-cm cement-treated sand (CTS) base and the underlying subgrade, as illustrated in Figure 4. Zone 2 comprises a 30-cm new PCC overlay, a 31-cm existing PCC slab, a 26-cm CTS base, and the underlying subgrade (Figure 5).

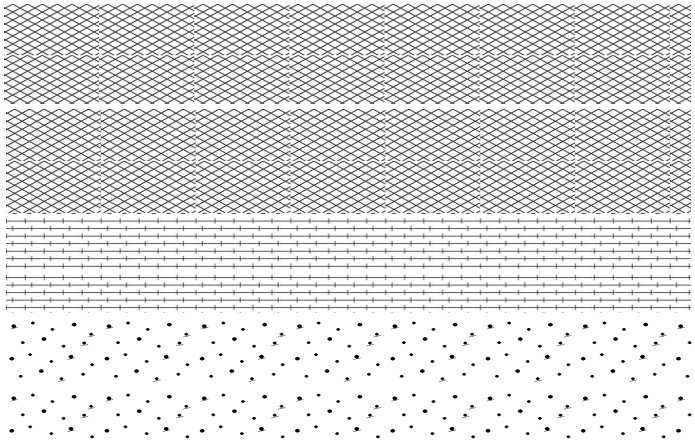


Layer 1: PCC, Grade M350/45, Thickness = 42 cm (E_{21})

Layer 2: Cement-Treated Sand (CTS), Thickness = 17 cm (E_{11})

Layer 3: Compacted Subgrade ($E_{Subgrade1}$)

Fig. 4. Typical rigid pavement structure of Zone 1 on Runway 25L/07R



Layer 1: PCC, Grade M350/45, Thickness = 30 cm (E_{32})

Layer 2: Existing PCC Slab, Thickness = 31 cm (E_{22})

Layer 3: Cement-Treated Sand (CTS), Thickness = 26 cm (E_{12})

Layer 4: Compacted Subgrade ($E_{Subgrade2}$)

Fig. 5. Typical rigid pavement structure of Zone 2 on Runway 25L/07R

Zone 2, covering the remaining sections of Runway 25L/07R from location H6+00–H7+20 to location H36+00–H38+00, is characterized by a composite rigid pavement structure. The pavement consists of a PCC overlay constructed over a PCC slab, underlain by a CTS layer and a compacted subgrade foundation (Figure 5).

A total of 548 measurement points were included in the available pavement strength evaluation dataset along Runway 25L/07R, covering the section from H0 to H38+00. The measurement locations were spaced at approximately 12 m intervals according to the original pavement strength evaluation survey. For each homogeneous pavement section, the available back-calculated elastic modulus values at the measurement locations were summarized using the arithmetic mean, following the procedure adopted in the existing pavement strength evaluation report. These mean values were used to characterize the representative average in-service structural condition of each homogeneous pavement section for the subsequent ACR–PCR Technical Evaluation. No formal inferential statistical analysis was performed in the present study. Minimum or lower-percentile modulus values were not adopted because their use would require a separately defined statistical criterion for conservative section characterization, which was beyond the scope of the present evaluation. These mean values were therefore not intended to represent conservative lower-bound or characteristic design moduli. Table 1 presents the elastic modulus values of the pavement structural layers and subgrade at the measurement points between H0 and H1+20 on Runway 25L/07R.

Table 1. Elastic modulus values of pavement structural layers and subgrade at measurement points along Runway 25L/07R between locations H0 and H1+20

No.	E_{21} (MPa)	PCC Thickness (cm)	E_{11} (MPa)	CTS Thickness (cm)	$E_{Subgrade1}$ (MPa)
1	33,282.47	42	1,278.12	17	195.81
2	29,000.00	42	1,035.89	17	222.38
3	31,149.05	42	1,257.83	17	205.42
4	30,852.63	42	1,256.76	17	207.87
5	33,350.55	42	1,282.33	17	205.02
6	32,211.31	42	1,267.95	17	165.70
7	30,967.46	42	1,285.63	17	221.65
8	33,460.78	42	1,283.73	17	188.22
9	29,000.00	42	1,245.11	17	162.04
10	32,984.10	42	1,264.49	17	205.16
11	29,857.36	42	1,235.75	17	218.64
12	32,435.33	42	1,251.94	17	212.76
13	33,602.06	42	1,275.68	17	207.97
14	33,602.06	42	1,275.68	17	203.33
15	31,149.05	42	1,257.83	17	202.80
16	29,000.00	42	1,295.26	17	217.81
17	32,153.67	42	1,247.96	17	212.71
18	29,857.36	42	1,235.75	17	218.34
19	32,839.79	42	1,278.65	17	213.12
20	33,313.33	42	1,281.49	17	197.19
Average	31,703.42	42	1,254.69	17	204.20

The elastic modulus data used in this study were obtained from the existing pavement strength evaluation dataset for Runway 25L/07R. In the original evaluation, pavement deflection measurements were processed using DAPS back-calculation to determine the elastic moduli of the pavement structural layers and subgrade at the measurement locations. The back-calculation process yielded the elastic moduli of the pavement structural layers in Zone 1 (E_{21} and E_{11}) and the corresponding subgrade modulus ($E_{Subgrade1}$), as well as the elastic moduli of the pavement layers in Zone 2 (E_{32}, E_{22}, and E_{12}) and the corresponding subgrade modulus ($E_{Subgrade2}$) at all measurement locations along the runway. The original raw HWD/SHWD deflection records and the complete DAPS back-calculation configuration files were not available for the present study. Consequently, the individual applied load levels, detailed computational settings of the back-calculation procedure, and the specific Poisson's ratios adopted in the original DAPS analysis could not be reliably recovered. To avoid introducing unsupported assumptions, these parameters were not retrospectively inferred or replaced by typical values from the literature. Accordingly, the present study uses the available field-derived back-calculated modulus dataset as the basis for structural

characterization rather than attempting to reproduce the original DAPS back-calculation process. Based on the available back-calculated results, representative structural parameters were established for each homogeneous pavement section and subsequently used to develop the corresponding pavement structures for the FAARFIELD-based PCR analysis. The surface PCC layer was modeled using the FAARFIELD P-501 PCC material definition, with its associated material properties. For the underlying existing PCC, cement-treated supporting layer, and subgrade, the representative field-derived structural properties were incorporated into the FAARFIELD model as applicable. In Zone 2, the existing PCC and cement-treated supporting layer were modeled as user-defined layers, while the subgrade was represented using the corresponding field-derived subgrade modulus. The resulting representative structural parameters for Zone 1 are presented in Table 2, while the variations in the average elastic moduli of the pavement layers and subgrade within Zone 2 are illustrated in Figures 6 and 7.

Table 2. Average elastic modulus values of pavement structural layers and subgrade at representative locations within Zone 1

No.	E_{21} (MPa)	PCC Thickness (cm)	E_{11} (MPa)	CTS Thickness (cm)	$E_{Subgrade1}$ (MPa)
1. Location H0–H1+20	31,703.42	42	1,254.69	17	204.20
2. Location H1+20–H2+40	31,482.41	42	1,260.38	17	200.66
3. Location H2+40–H3+60	32,012.20	42	1,251.00	17	199.59
4. Location H3+60–H4+80	32,076.86	42	1,262.16	17	196.85
5. Location H4+80–H6+00	31,513.64	42	1,241.37	17	196.54

4.1.2 Determination of Aircraft Traffic Parameters

Aircraft operational data at Tan Son Nhat International Airport (TIA) were collected, including aircraft fleet composition, aircraft gross weights, and annual departures. To provide broader operational context, available airport statistics for the period 2019–2023 were also reviewed in terms of annual passenger traffic, cargo and mail throughput, and commercial aircraft movements. As shown in Figure 8, passenger traffic decreased substantially from 41.24 million passengers in 2019 to 10.29 million in 2021, before recovering to 40.74 million in 2023. Commercial aircraft movements exhibited a similar pattern, decreasing from 260.86 thousand movements in 2019 to 106.87 thousand in 2021 and subsequently recovering to 250.62 thousand in 2023. In contrast, cargo and mail throughput showed a different temporal pattern, ranging from 516.26 to 693.24 thousand tons over the same period.

The pronounced reductions in passenger traffic and aircraft movements during 2020–2021 coincide with the COVID-19 pandemic period. Accordingly, traffic data from these years were not considered representative of the operational conditions adopted for the structural evaluation. Based on the recovery of airport activity and the availability of detailed aircraft-specific operational records, aircraft traffic data for 2023 were adopted as the reference dataset for Runway 25L/07R.

Although passenger and cargo volumes provide useful indicators of overall airport activity, they were not used as direct structural loading inputs in the Technical Evaluation performed in this study. Accordingly, pavement traffic demand was represented by aircraft fleet composition, aircraft gross weights, and annual departures based on the available 2023 aircraft traffic dataset. The aircraft types, corresponding gross weights, and annual departures used in the FAARFIELD analysis are presented in Table 3.

For the baseline PCR evaluation, an annual traffic growth rate of 6% was applied consistently to all pavement sections. The same aircraft fleet composition, aircraft gross weights, annual departures,

traffic-growth assumption, and one-year analysis period were used throughout the runway so that the calculated PCR values could be compared on a consistent basis.

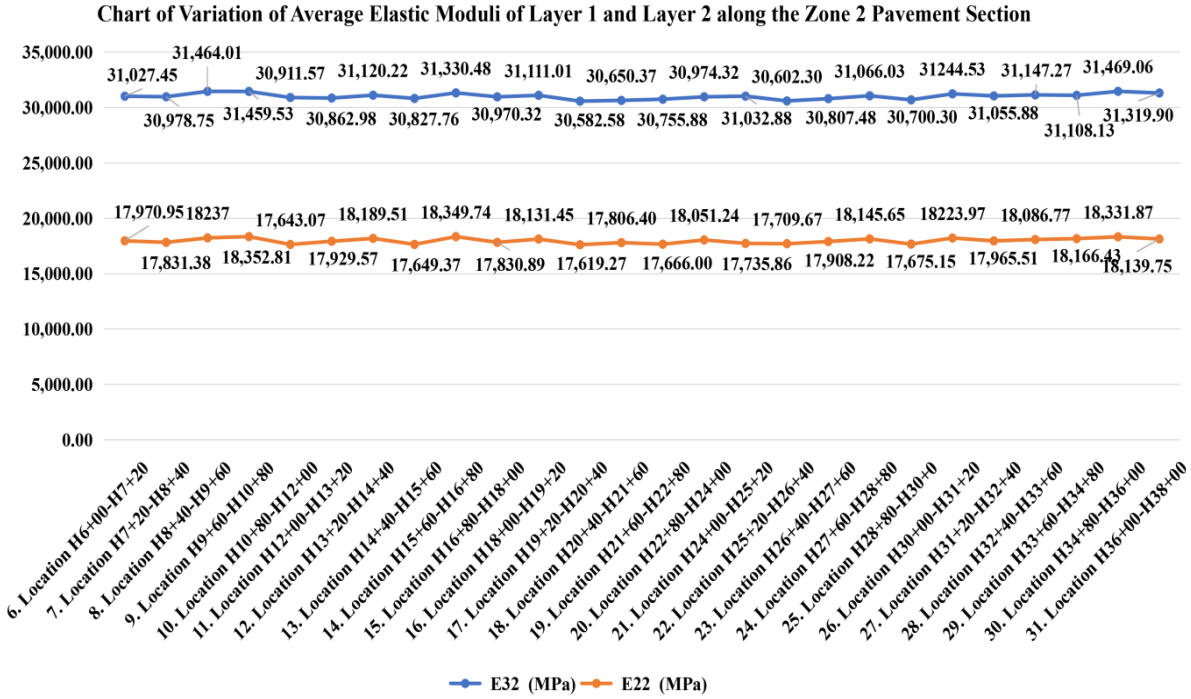


Fig. 6. Variation of average elastic moduli of layers 1 and 2 within Zone 2 of Runway 25L/07R

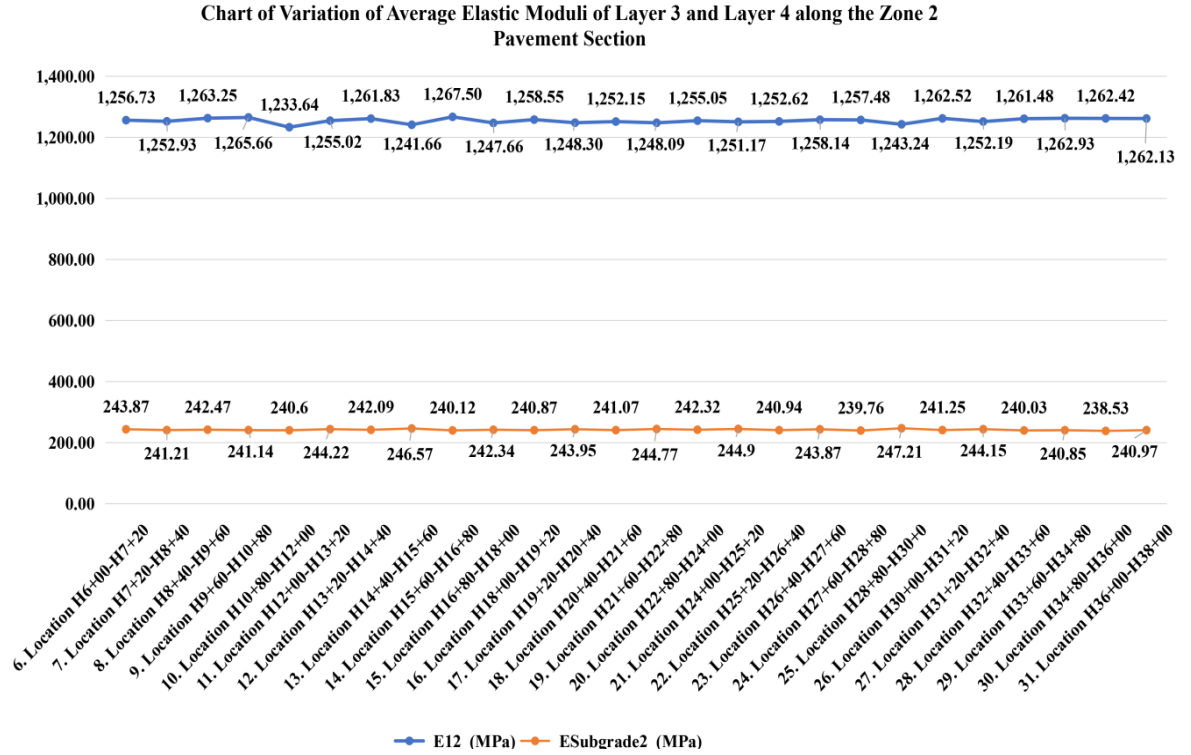


Fig. 7. Variation of average elastic moduli of layers 3 and 4 within Zone 2 of Runway 25L/07R

4.1.3 Determination of Aircraft Operational Configuration

Considering the parallel taxiway system and on-airport aircraft refueling facilities at Tan Son Nhat International Airport, a P/TC ratio of 1.0 was adopted as the operational assumption for the pavement evaluation.

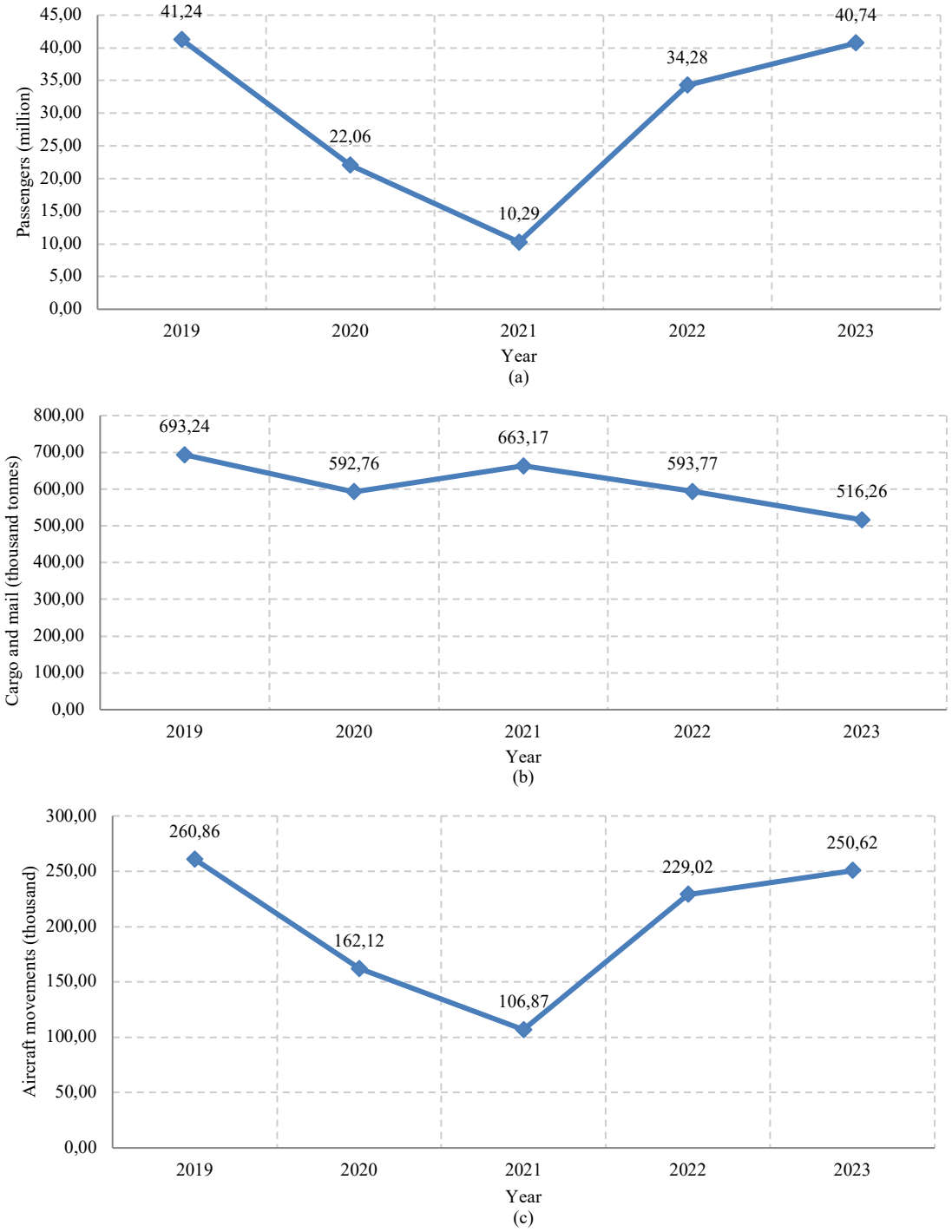


Fig. 8. Operational traffic trends at Tan Son Nhat International Airport during 2019–2023: (a) annual passenger traffic; (b) annual cargo and mail throughput; and (c) annual commercial aircraft movements

4.1.4 Determination of the Analysis Period

The rigid pavement structure of Runway 25L/07R was constructed several decades ago, with the most extensive rehabilitation works carried out during 1999–2000. Considering the long service history of the pavement, a one-year analysis period was adopted as the baseline condition for the FAARFIELD evaluation. This relatively short analysis period reflects the objective of assessing the current structural capacity of the runway rather than predicting its long-term performance. A longer analysis period would incorporate greater cumulative aircraft traffic and could therefore affect the calculated PCR. To examine the robustness of the baseline evaluation, additional sensitivity analyses were performed using alternative analysis periods of 2 and 5 years and annual

traffic growth rates of 0% and 6%. These scenarios were used to assess the influence of the analysis period and traffic-growth assumption on the calculated PCR values.

Table 3. Aircraft traffic inputs used in the FAARFIELD analysis for Tan Son Nhat International Airport

Ordinal number	Aircraft Type	Gross Weight (kg)	Annual Departures (flights)
1	A300-600 LGA Bogie	150,000	154
2	A319-100 Std	64,400	379
3	A320-200 Std	73,900	32,651
4	A321 Neo	90,000	58,130
5	A330-200 WV058	238,900	3,201
6	A330-200F WV000	233,900	856
7	A350-1000	308,900	4,597
8	A350-900	272,900	1,159
9	B737-900 ER	85,366	3,568
10	B747-8	449,056	281
11	B767-300	163,747	712
12	B777-9	352,442	2,720
13	B787-10	254,692	8,433
14	A220-100	60,781	8,457

Source: Tan Son Nhat International Airport operational statistics (2023)

4.2 PCR Calculation for Runway 25L/07R at Tan Son Nhat International Airport

4.2.1 PCR Calculation Results

Using the input parameters established for each PCR evaluation location, the corresponding data were entered into the FAARFIELD software. For example, for the section between H0 and H1+20, the field-derived structural characterization comprised a 42-cm PCC slab with an average back-calculated modulus of 31,703.42 MPa, a 17-cm cement-treated sand layer with an average modulus of 1,254.69 MPa, and a subgrade with an average modulus of 204.20 MPa. In the subsequent FAARFIELD model, the surface PCC layer was represented using the P-501 PCC material definition, while the supporting layer and subgrade were represented using the corresponding field-derived structural properties as applicable.

Aircraft traffic and operational data were entered through the traffic module of FAARFIELD. A P/TC ratio of 1.0 was adopted as described in Section 4.1.3. The analysis period was set to one year to provide a consistent current-condition evaluation basis for all pavement sections.

After all pavement structural and operational parameters had been defined, PCR calculations were performed using FAARFIELD. The software performed the pavement evaluation and generated the corresponding PCR. For the section between H0 and H1+20, the calculated PCR was 850/R/A/W/T (Figure *9*).

FAARFIELD also provides the calculated ACR values corresponding to the aircraft gross weights adopted in the analysis. For each aircraft type, the software reports the ACR value for the pavement category and subgrade condition under evaluation. In the present case, for the runway section between H0 and H1+20, the calculated ACR of the critical aircraft, Boeing 777-9, was 818/R/A. This value did not exceed the calculated PCR of 850/R/A/W/T, indicating compliance with the ACR ≤ PCR operational criterion under the evaluated conditions.

Federal Aviation Administration FAARFIELD 2.1 Airport Master Record

FAARFIELD 2.1.1 (Build 12/21/2023)

RUNWAY DATA

Job Name: Tan Son Nhat RWY

Structure: H0-H1+20

Gross Weight (In THSDS)

35 S	120
36 D	250
37 2D	550
38 2D/2D2	1,097
39 PCR	850/R/A/W/T

Fig. 9. Screenshot of FAARFIELD-calculated PCR for the runway section between locations H0 and H1+20

Figure 10 presents the FAARFIELD aircraft traffic output, including the CDF Contribution and Maximum Aircraft CDF values associated with the evaluated aircraft entries.

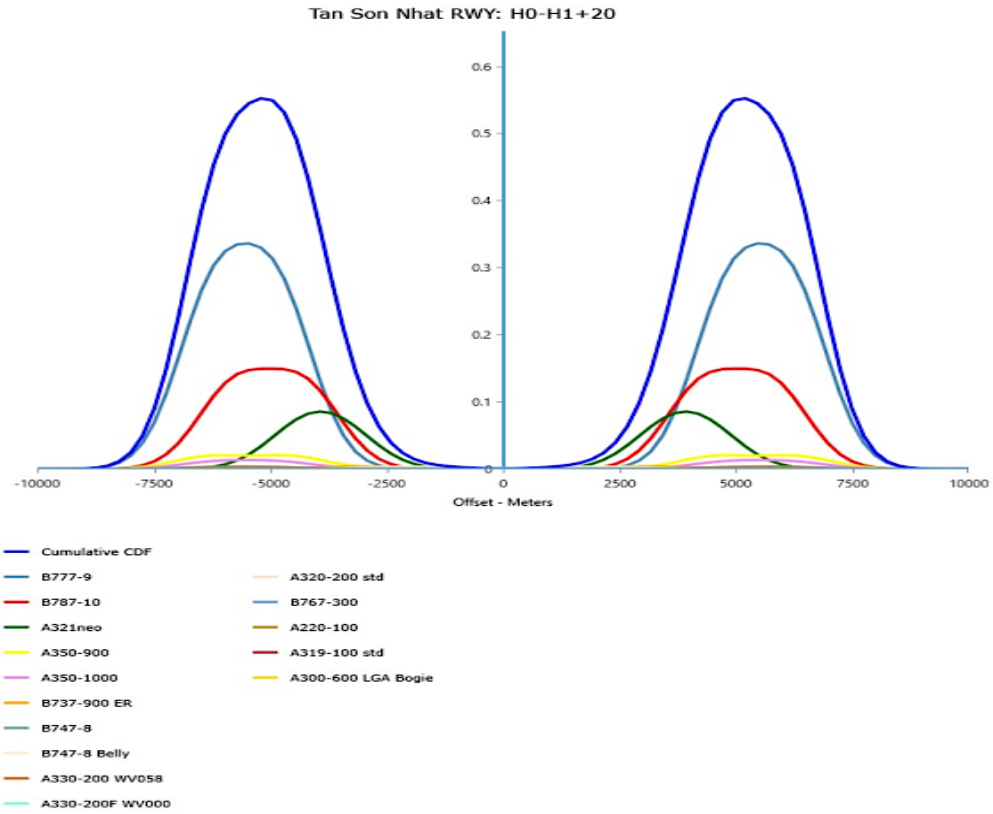


Fig. 10. Screenshot of FAARFIELD-calculated CDFs for individual aircraft types at location H0–H1+20

FAARFIELD also provides a PCR graph that visually compares the ACR values of the most demanding aircraft in the traffic mix with the calculated PCR (*Figure 11*). In the graph, the horizontal black line represents the calculated PCR value, while the bars correspond to the ACR values of individual aircraft types. The graph shows that the ACR values of the aircraft included in the evaluated traffic mix remain below the calculated PCR. For Runway 25L/07R, the Boeing 777-9 was identified as the critical aircraft governing the PCR calculation.

FAARFIELD provides a detailed PCR report summarizing the calculation results. The report is organized into three main tables: the first presents the aircraft traffic input data, the second

summarizes the characteristics of the critical aircraft controlling the PCR, and the third lists the calculated ACR values for all aircraft included in the traffic mix.

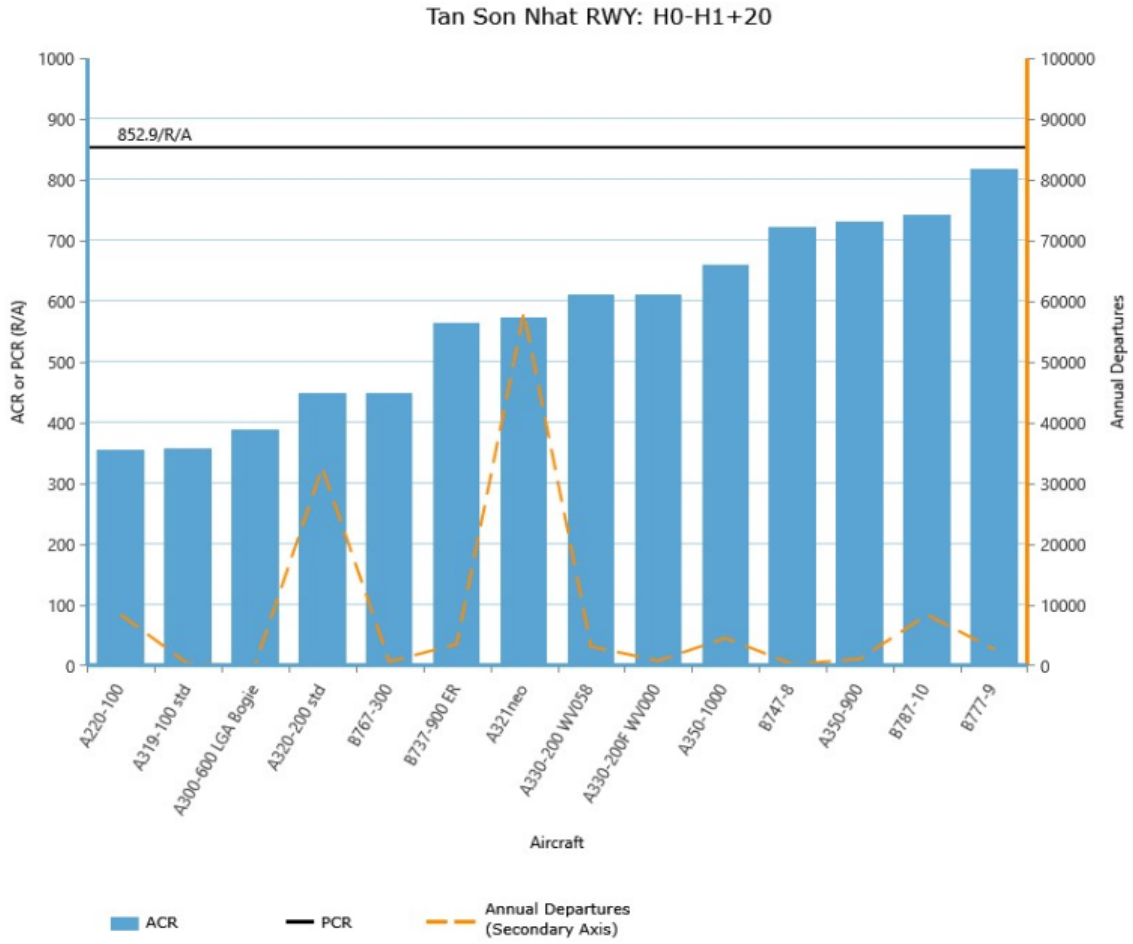


Fig. 11. Screenshot of comparison of ACR values and the PCR

The Cumulative Damage Factor (CDF) represents the cumulative structural damage associated with the complete aircraft traffic mix over the specified analysis period. In FAARFIELD, the contributions of the aircraft traffic mix are combined within the cumulative damage analysis used to identify the critical aircraft for PCR determination. A CDF greater than 1.0 indicates that the cumulative traffic demand exceeds the pavement damage criterion under the assumed structural, traffic, and analysis-period conditions. The PCR is subsequently determined by adjusting the gross weight of the critical aircraft until a CDF of 1.0 is obtained, after which the ACR corresponding to this maximum allowable gross weight (MAGW) under the evaluation procedure is reported as the PCR. For the baseline one-year, 6% traffic-growth scenario adopted in this study, the calculated PCR values of all evaluated runway sections remained above the ACR of the critical Boeing 777-9 (818/R/A), indicating pavement–aircraft compatibility under the evaluated conditions, as summarized in *Table 4*.

Following the procedure described above, the input data corresponding to each evaluated pavement section were entered into FAARFIELD to determine the PCR along the entire length of Runway 25L/07R. The calculated PCR values for the evaluated pavement sections are summarized in Table 5 and presented graphically in Figure 12.

5. Results and Discussion

5.1 Variation of PCR along Runway 25L/07R

The calculated PCR values varied along Runway 25L/07R, indicating spatial differences in pavement structural capacity. Zone 1 (H0–H6+00) exhibited the lower PCR values of 850–860, whereas Zone 2 (H6+00–H38+00) generally showed higher values of 1030–1090. The observed

variation is associated primarily with differences in pavement structural configuration, layer thicknesses, and the field-derived mechanical properties of the pavement layers and supporting foundation. For long-serving rigid pavements, deterioration mechanisms such as cracking and moisture-related weakening may further affect structural performance; however, these effects were not quantified separately in the present study.

Table 4. Calculated ACRs used for comparison with the PCR

No.	Aircraft Name	Gross Weight (kg)	Percent Gross Weight on Main Gear	Tire Pressure (kPa)	Annual Departures	ACR Thickness (mm) (Subgrade Category A)	ACR/R/A
1	A300-600 LGA Bogie	150,000	95.00	1,164.54	154	272	389.9
2	A319-100 Std	64,400	92.60	1,192.79	379	259	358.6
3	A320-200 Std	73,900	93.80	1,378.95	32,651	292	448.2
4	A321 Neo	90,000	94.60	1,388.90	58,130	330	574.1
5	A330-200 WV058	238,900	92.60	1,420.32	3,201	340	610.8
6	A330-200F WV000	233,900	94.60	1,420.32	856	340	610.9
7	A350-1000	308,900	94.80	1,516.85	4,597	358	676.1
8	A350-900	272,900	94.80	1,661.64	1,159	373	730.1
9	B737-900 ER	85,366	94.60	1,516.85	3,568	328	565.3
10	B747-8	449,056	47.40	1,523.74	281	371	721.9
11	B747-8 Belly	449,056	47.40	1,523.74	281	371	721.9
12	B767-300	163,747	95.00	1,378.95	712	292	449.1
13	B777-9	352,442	94.40	1,544.43	2,720	394	818
14	B787-10	254,692	93.20	1,544.43	8,433	376	742.3
15	A220-100	60,781	93.80	1,303.11	8,457	259	354.6

Note: "B747-8 Belly" is a software-generated loading component associated with the B747-8 in FAARFIELD and does not represent an independent aircraft traffic entry.

The results demonstrate that PCR varies with local pavement conditions and highlight the importance of section-by-section structural evaluation rather than relying on a single representative value for the entire runway. Such an approach provides a more spatially representative assessment of pavement load-carrying capacity and supports more informed maintenance and rehabilitation planning.

The calculated PCR values were further examined for consistency with the current operating conditions of Runway 25L/07R. The minimum PCR obtained for the runway was 850/R/A/W/T, while the maximum ACR of the evaluated aircraft fleet was 818/R/A for the Boeing 777-9. The resulting ACR ≤ PCR relationship is consistent with the current operation of the runway under the evaluated aircraft loading conditions. This comparison provides an operational consistency check on the calculated results; however, it should not be interpreted as an independent validation of the numerical PCR values.

5.2 Effect of Pavement Structural Configuration on PCR

A clear difference in PCR values was observed between the two primary pavement structures identified along Runway 25L/07R. The first section, extending from H0 to H6+00, consists of a 42-cm PCC slab supported by a 17-cm cement-treated sand layer and a compacted subgrade. Despite the relatively thick PCC layer, Zone 1 exhibited lower PCR values, as identified in Section 5.1. In contrast, the remaining runway sections are characterized by a composite rigid pavement structure

comprising a 30-cm PCC overlay over an existing 31-cm PCC slab, underlain by a 26-cm cement-treated sand layer and a compacted subgrade. This rehabilitated configuration exhibited higher PCR values than Zone 1.

Table 5. PCR values at representative locations along Runway 25L/07R

Ordinal number	PCR Calculation Results
1. Location H0–H1+20	PCR = 850/R/A/W/T
2. Location H1+20–H2+40	PCR = 850/R/A/W/T
3. Location H2+40–H3+60	PCR = 860/R/A/W/T
4. Location H3+60–H4+80	PCR = 860/R/A/W/T
5. Location H4+80–H6+00	PCR = 850/R/A/W/T
6. Location H6+00–H7+20	PCR = 1060/R/A/W/T
7. Location H7+20–H8+40	PCR = 1050/R/A/W/T
8. Location H8+40–H9+60	PCR = 1080/R/A/W/T
9. Location H9+60–H10+80	PCR = 1080/R/A/W/T
10. Location H10+80–H12+00	PCR = 1040/R/A/W/T
11. Location H12+00–H13+20	PCR = 1050/R/A/W/T
12. Location H13+20–H14+40	PCR = 1070/R/A/W/T
13. Location H14+40–H15+60	PCR = 1030/R/A/W/T
14. Location H15+60–H16+80	PCR = 1080/R/A/W/T
15. Location H16+80–H18+00	PCR = 1050/R/A/W/T
16. Location H18+00–H19+20	PCR = 1070/R/A/W/T
17. Location H19+20–H20+40	PCR = 1030/R/A/W/T
18. Location H20+40–H21+60	PCR = 1050/R/A/W/T
19. Location H21+60–H22+80	PCR = 1040/R/A/W/T
20. Location H22+80–H24+00	PCR = 1060/R/A/W/T
21. Location H24+00–H25+20	PCR = 1040/R/A/W/T
22. Location H25+20–H26+40	PCR = 1040/R/A/W/T
23. Location H26+40–H27+60	PCR = 1050/R/A/W/T
24. Location H27+60–H28+80	PCR = 1070/R/A/W/T
25. Location H28+80–H30+00	PCR = 1030/R/A/W/T
26. Location H30+00–H31+20	PCR = 1070/R/A/W/T
27. Location H31+20–H32+40	PCR = 1050/R/A/W/T
28. Location H32+40–H33+60	PCR = 1070/R/A/W/T
29. Location H33+60–H34+80	PCR = 1070/R/A/W/T
30. Location H34+80–H36+00	PCR = 1090/R/A/W/T
31. Location H36+00–H38+00	PCR = 1070/R/A/W/T

Zone 2 exhibited PCR values approximately 18–21% higher than those of Zone 1. This difference should be interpreted as the combined effect of the overall pavement system rather than being attributed to PCC thickness alone. In the FAARFIELD-based Technical Evaluation, the calculated pavement capacity reflects the interaction among pavement configuration, layer thicknesses, the mechanical properties of the pavement layers and supporting foundation, and the applied aircraft traffic. In Zone 2, the 30-cm PCC overlay constructed over the existing 31-cm PCC slab provides a different structural configuration from the single 42-cm PCC slab in Zone 1. At the same time, the field-derived elastic properties of the supporting layers and subgrade are incorporated into the section-specific evaluation. Therefore, the higher PCR values observed in Zone 2 reflect the combined structural response of the rehabilitated pavement system and its supporting foundation.

From an engineering perspective, these results highlight the importance of evaluating aging rigid airport pavements using section-specific in-service structural properties. Pavement thickness

alone may not adequately represent load-carrying capacity where foundation conditions and rehabilitation history vary along the runway. Accordingly, field-derived structural characterization can provide a more defensible basis for identifying relatively weaker sections and supporting maintenance and rehabilitation planning.

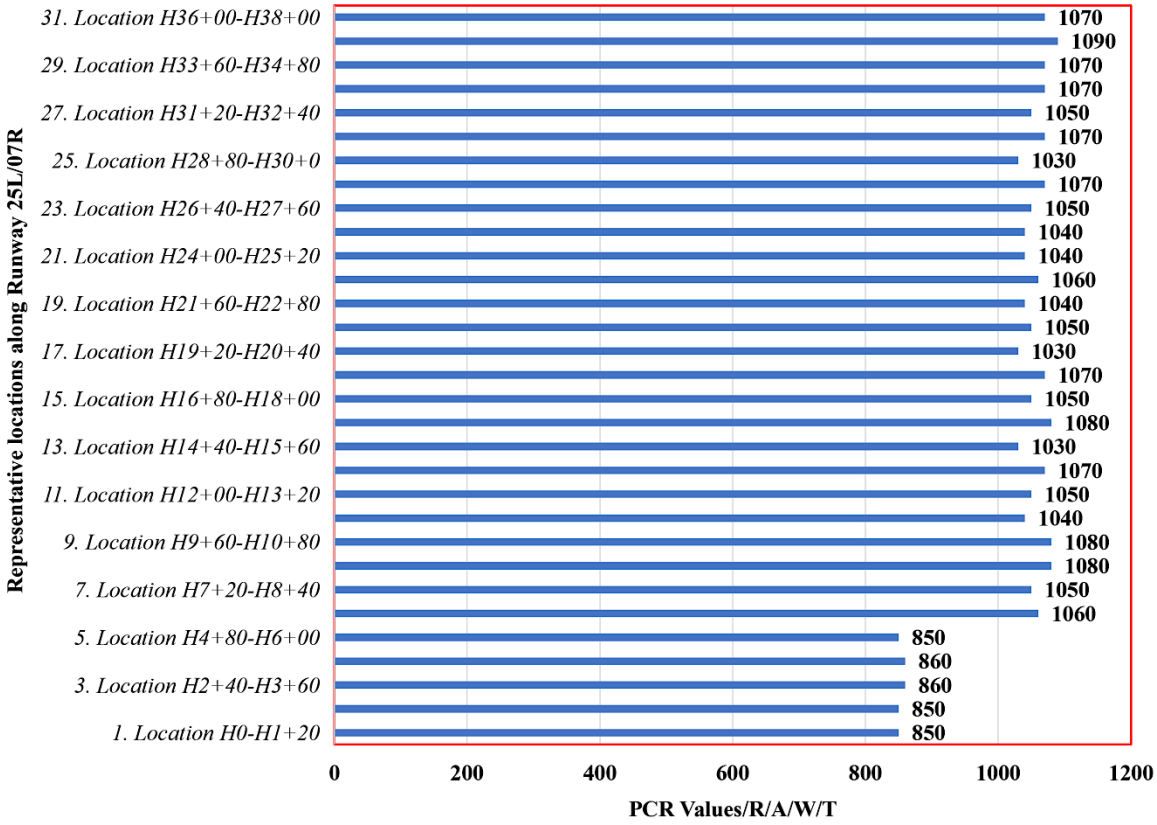


Fig. 12. Distribution of PCR values calculated along Runway 25L/07R

5.3 Sensitivity Analysis of Analysis Period and Traffic Growth

To examine the robustness of the baseline PCR assessment, a sensitivity analysis was conducted by varying the analysis period and annual traffic growth rate while maintaining the same pavement structural parameters, aircraft fleet composition, and aircraft gross weights. The baseline scenario adopted a one-year analysis period and an annual traffic growth rate of 6%, whereas additional scenarios considered 2- and 5-year analysis periods and annual traffic growth rates of 0% and 6%, as summarized in *Table 6*.

Table 6. Sensitivity of calculated PCR values to analysis period and annual traffic growth rate

Annual traffic growth	Analysis period	PCR range	Mean PCR	Mean PCR Zone 1	Mean PCR Zone 2	Sections with PCR < 818
0%	1 year	850–1090	1027.4	854	1060.8	0
0%	2 years	810–1030	974.8	814	1005.8	3
0%	5 years	760–960	911.3	764	939.6	5
6%	1 year	850–1090	1024.5	854	1057.3	0
6%	2 years	810–1030	971.0	812	1001.5	4
6%	5 years	750–950	901.9	756	930.0	5

The results indicate that the analysis period had a substantially greater influence on the calculated PCR than the assumed traffic growth rate. For a 6% annual growth rate, the mean PCR decreased from 1024.5 for the one-year analysis to 971.0 for the two-year analysis and 901.9 for the five-year

analysis. A similar trend was observed for the 0% growth scenario, for which the corresponding mean PCR values were 1027.4, 974.8, and 911.3. In contrast, changing the annual growth rate from 0% to 6% reduced the mean PCR by only approximately 2.9, 3.8, and 9.4 points for the 1-, 2-, and 5-year analysis periods, respectively.

Despite these changes in absolute PCR magnitude, the spatial pattern of pavement capacity remained consistent across all scenarios. Zone 1 consistently exhibited substantially lower PCR values than Zone 2, indicating that the observed spatial variation was primarily associated with differences in pavement configuration and field-derived structural properties rather than with the selected traffic-growth assumption. Under the baseline one-year, 6% growth scenario, all evaluated sections maintained PCR values above the ACR of the critical Boeing 777-9 (818/R/A). With longer analysis periods, however, several Zone 1 sections fell below this value, reflecting the increased cumulative traffic demand incorporated into the evaluation. Accordingly, the one-year, 6% growth scenario was retained as the baseline for the present current-condition assessment, while the longer analysis periods were used only to characterize the sensitivity of PCR to cumulative traffic exposure rather than to predict the remaining structural life of the pavement.

5.4 Comparison with Previous Airport Pavement Studies

The present results are generally consistent with recent FAARFIELD-based studies demonstrating the relevance of pavement structure, foundation support, and aircraft traffic in rigid airport pavement evaluation. Hansu et al. (2024) [23] evaluated rigid runway pavements under combinations of different subgrade and traffic conditions, demonstrating the relevance of foundation condition and aircraft traffic in mechanistic–empirical pavement analysis. Similarly, Zhang et al. (2025) [15] applied the ACR–PCR framework to two rigid-pavement airport cases incorporating different pavement structures, subgrade properties, and aircraft traffic volumes, illustrating how ACR–PCR evaluation is performed under different structural and operational conditions.

For Runway 25L/07R, the calculated PCR varies among the evaluated sections despite the relatively substantial PCC thicknesses. This variation is associated with differences in pavement configuration and the field-derived mechanical properties of the supporting layers and subgrade incorporated into the Technical Evaluation. The results therefore reinforce the importance of using in-service structural properties, rather than slab thickness alone, when evaluating an aging rigid runway. This interpretation is also consistent with recent comparisons of the ACR–PCR and ACN–PCN systems for rigid pavements, which have shown that the two rating frameworks may respond differently to changes in pavement structural characteristics. Sun et al. (2025) [14] further reported, based on a rigid-pavement case study at an airport in Southeast Asia, that the ACR–PCR structural evaluation produced results consistent with those obtained from the pavement thickness design (PTD) method. Taken together, these comparisons support the present finding that PCR variation should be interpreted from the combined pavement–foundation–traffic system, while the use of field-derived structural properties provides additional section-specific information for an aging operational runway.

Direct numerical comparison of PCR values among different airports should nevertheless be made with caution because the reported values are site-specific and depend on pavement configuration, foundation properties, aircraft fleet composition, aircraft gross weights, annual departures, and analytical assumptions. Accordingly, the comparison with previous studies is used here primarily to evaluate consistency in the observed structural trends rather than to establish a universal numerical relationship among PCR values.

5.5 Implications for Airport Pavement Evaluation and Management in Vietnam

The findings of this study have important implications for airport pavement management in Vietnam following the transition from the conventional ACN–PCN system to the ACR–PCR framework. For Tan Son Nhat International Airport, the minimum calculated PCR value of 850/R/A/W/T remained higher than the maximum ACR value of 818/R/A associated with the critical aircraft in the evaluated traffic mix on Runway 25L/07R. This result indicates pavement–aircraft compatibility under the current evaluated loading conditions. However, the relatively small

margin between PCR and the critical-aircraft ACR indicates limited structural reserve under the evaluated conditions, highlighting the importance of continued pavement monitoring and periodic reassessment as cumulative traffic exposure increases.

For Long Thanh International Airport, which is designed to accommodate wide-body aircraft, the ACR–PCR framework may provide a useful basis for future pavement structural evaluation and maintenance planning as field and operational data become available during airport operation. Periodic Technical Evaluation using updated structural and aircraft traffic data could support pavement management decisions throughout the airport's operational life cycle. For Noi Bai International Airport and other major airports in Vietnam, the methodology presented in this study may serve as a practical reference for section-specific PCR evaluation using field-derived structural data and FAARFIELD-based Technical Evaluation. Such section-specific evaluations can support airport operators in identifying relatively weaker pavement sections, prioritizing further investigation, and informing maintenance and rehabilitation planning under the ACR–PCR framework.

5.6 Limitations and Future Research

Despite the practical significance of the findings, several limitations of this study should be acknowledged.

- First, the analysis was conducted exclusively for Runway 25L/07R at Tan Son Nhat International Airport. Consequently, the findings should not be directly generalized to other runways, taxiways, or aprons at airports throughout Vietnam.
- Second, the traffic data used for PCR calculations were primarily based on aircraft operations recorded in 2023. Future changes in fleet composition, traffic growth, and operational patterns may affect the traffic inputs used in PCR evaluation and therefore influence the resulting pavement structural assessment.
- Third, environmental factors such as long-term moisture variations, groundwater fluctuations, and temperature gradients were not explicitly incorporated into the structural evaluation. These factors may influence pavement deterioration and the evolution of structural condition over time.
- Fourth, the calculated PCR values were not independently validated using a separate pavement strength evaluation dataset or an alternative structural evaluation method. Although the calculated ACR–PCR relationship was examined for consistency with the current operating conditions of the runway, this comparison should be regarded as an operational consistency check rather than an independent validation of the numerical PCR values. Future studies incorporating repeated field measurements or alternative evaluation approaches would provide a stronger basis for independent validation of the calculated PCR values.

Future studies should investigate broader traffic scenarios, environmental effects, and time-dependent pavement deterioration to better understand their influence on PCR values. In addition, comparative evaluations of the ACN–PCN and ACR–PCR systems across different airport pavement structures could provide further insight into the implications of the transition to the ICAO ACR–PCR framework. Furthermore, extending the application of the ACR–PCR approach to other major airports in Vietnam with different pavement and operational conditions could contribute to a more comprehensive framework for airport pavement evaluation and management under local conditions.

6. Conclusions

This study applied the ACR–PCR methodology through the Technical Evaluation Method using FAARFIELD software to assess the load-carrying capacity of the rigid pavement of Runway 25L/07R at Tan Son Nhat International Airport in Vietnam. Based on the section-specific ACR–PCR Technical Evaluation, the results demonstrate clear spatial variation in the structural capacity of Runway 25L/07R. The lower-capacity sections were concentrated in Zone 1, whereas the rehabilitated sections in Zone 2 generally exhibited higher structural capacity. These differences

should be interpreted as the combined response of the pavement system, including pavement configuration, layer thicknesses, and the field-derived mechanical properties of the pavement layers and supporting foundation, rather than as the effect of slab thickness alone.

The governing pavement condition was represented by a minimum PCR of 850/R/A/W/T, while the Boeing 777-9 was identified as the critical aircraft with an ACR of 818/R/A. The resulting margin of approximately 3.91% indicates that the evaluated runway remains compatible with the current aircraft loading conditions. However, the relatively limited structural reserve emphasizes the importance of continued structural monitoring and section-specific pavement management as traffic demand, aircraft loading, and pavement conditions change over time. An important finding of the study is that the structural capacity of an aging rigid runway may vary substantially along its length. Consequently, a single reported PCR value, while useful for pavement strength reporting and operational compatibility assessment, may not fully represent the spatial variability of pavement structural condition across the entire runway. Section-based evaluation using field-derived structural properties can therefore provide additional engineering information for identifying relatively weaker areas and prioritizing maintenance, rehabilitation, and further structural investigation. From a pavement-management perspective, the section-specific results also demonstrate the value of combining field-derived structural characterization with aircraft traffic information when evaluating an aging operational runway. Identifying spatial differences in structural capacity can support more targeted follow-up investigation and help prioritize maintenance or rehabilitation activities in relatively weaker sections, while periodic reassessment can account for changes in pavement condition and cumulative aircraft traffic exposure over time.

Overall, the study demonstrates the practical application of the ACR–PCR Technical Evaluation framework to an existing rigid runway using field-derived structural properties, pavement configuration, and airport-specific aircraft traffic. The findings highlight the value of integrating in-service structural characterization with FAARFIELD-based evaluation to support both pavement strength reporting and engineering decision-making for aging rigid airport pavements. Future research should investigate broader traffic scenarios, environmental effects, and time-dependent pavement deterioration to better understand their influence on PCR values. In addition, comparative studies of the ACN–PCN and ACR–PCR systems across different airport pavement structures could provide further insight into the implications of the transition to the ICAO ACR–PCR framework.

Acknowledgments

The authors would like to thank Tan Son Nhat International Airport and its technical staff for providing the technical data and operational information used in this study.

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