U.S. Department
of Transportation

Federal Aviation Administration

Advisory Circular

Subject: Standardized Method of Reporting Airport Pavement Strength - PCN

Date: 8/26/2011
Initiated by: AAS-100

AC No: 150/5335-5B
Change:

1. PURPOSE OF THIS ADVISORY CIRCULAR.

a. This advisory circular (AC) provides guidance for using the standardized International Civil Aviation Organization (ICAO) method to report airport runway, taxiway, and apron pavement strength. ICAO requires member states to report aerodrome-related aeronautical data, including pavement strength. The standardized method, known as the Aircraft Classification Number – Pavement Classification Number (ACN-PCN) method, has been developed and adopted as an international standard and has facilitated the exchange of pavement strength rating information.

b. The AC provides guidance for reporting changes to airport data that is generally published on Federal Aviation Administration (FAA) Form 5010, Airport Master Record. The data elements associated with Gross Weight (Data Elements 35 through 38) and Pavement Classification Number (Data Element 39) are affected.

2. EFFECTIVE DATE.

Effective **three years** after the issue date of this AC, all public-use paved runways at primary airports serving air carrier aircraft should (will, if mandatory through the Applicability paragraph, below) be assigned gross weight and PCN data using the guidance provided in this AC. Effective **five years** after the issue date of this AC, all public-use paved runways at nonprimary commercial service airports serving air carrier aircraft should (will, if mandatory through the Applicability paragraph, below) be assigned gross weight and PCN data using the guidance provided in this AC.

3. APPLICABILITY.

The FAA recommends the guidelines and specifications in this AC for reporting airport pavement strength using the standardized method. In general, use of this AC is not mandatory. *However*, use of this AC is mandatory for all projects funded with Federal grant monies through the Airport Improvement Program (AIP) and with revenue from the Passenger Facility Charge (PFC) Program. See Grant Assurance No. 34, "Policies, Standards, and Specifications," and PFC Assurance No. 9, "Standards and Specifications."

4. WHAT THIS AC CANCELS.

This AC cancels AC 150/5335-5A, Standardized Method of Reporting Airport Pavement Strength – PCN, dated September 28, 2006.

5. PRINCIPAL CHANGES.

a. Chapter 3 now incorporates the improvements to the COMFAA program.

b. Appendix 1 now introduces a cumulative damage factor method for computing PCN based on equivalent traffic.

c. A new Appendix 2 facilitates converting existing pavement cross-section information to a standard section required for PCN calculations.

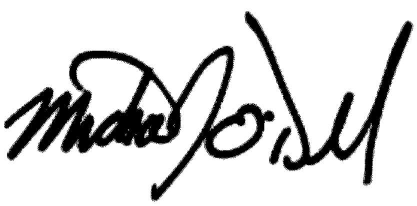
d. Appendix 3 now includes examples using the new method for determining PCN.

e. Appendix 4 now uses the new PCN calculation method to consider pavement overloads.

f. New Appendices 5 and 6 revise the standard for reporting airport data for runway weight bearing capacity.

6. RELATED READING MATERIAL.

The publications listed in Appendix 7 provide further information on the development and use of the ACN-PCN method.



Director, Office of Airport Safety and Standards

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CHAPTER 1. INTRODUCTION

1.0 BACKGROUND.

The United States is a contracting state of the International Civil Aviation Organization (ICAO) and, under 47 USC §40105(b), shall act consistently with the obligations of the United States Government under an international agreement. Annex 14 to the Convention of International Civil Aviation, Aerodromes, contains a standard that requires member states to publish information on the strengths of all public airport pavements in its own Aeronautical Information Publication (AIP). The FAA reports pavement strength information to the National Airspace System Resources (NASR) database and publishes pavement strength information in the Airport Master Record (Form 5010) and the Airport/Facility Directory (AFD).

1.1 DEVELOPMENT OF A STANDARDIZED METHOD.

In 1977, ICAO established a Study Group to develop a single international method of reporting pavement strengths. The study group developed, and ICAO adopted, the Aircraft Classification Number - Pavement Classification Number (ACN-PCN) method. Using this method, it is possible to express the effect of an individual aircraft on different pavements with a single unique number that varies according to aircraft weight and configuration (e.g. tire pressure, gear geometry, etc.), pavement type, and subgrade strength. This number is the Aircraft Classification Number (ACN). Conversely, the load-carrying capacity of a pavement can be expressed by a single unique number, without specifying a particular aircraft or detailed information about the pavement structure. This number is the Pavement Classification Number (PCN).

a. Definition of ACN. ACN is a number that expresses the relative effect of an aircraft at a given configuration on a pavement structure for a specified standard subgrade strength.

b. Definition of PCN. PCN is a number that expresses the load-carrying capacity of a pavement for unrestricted operations.

c. System Methodology. The ACN-PCN system is structured so a pavement with a particular PCN value can support an aircraft that has an ACN value equal to or less than the pavement’s PCN value. This is possible because ACN and PCN values are computed using the same technical basis.

1.2 APPLICATION.

The use of the standardized method of reporting pavement strength applies only to pavements with bearing strengths of 12,500 pounds (5 700 kg) or greater. The method of reporting pavement strength for pavements of less than 12,500 pounds (5 700 kg) bearing strength remains unchanged.

1.3 LIMITATIONS OF THE ACN-PCN SYSTEM.

The ACN-PCN system is only intended as a method of reporting relative pavement strength so airport operators can evaluate acceptable operations of aircraft. It is not intended as a pavement design or pavement evaluation procedure, nor does it restrict the methodology used to design or evaluate a pavement structure.

CHAPTER 2. DETERMINATION OF AIRCRAFT CLASSIFICATION NUMBER

2.0 DETERMINATION OF THE ACN.

The aircraft manufacturer provides the official computation of an ACN value. Computation of the ACN requires detailed information on the operational characteristics of the aircraft, such as maximum aft center of gravity, maximum ramp weight, wheel spacing, tire pressure, and other factors.

2.1 SUBGRADE CATEGORY.

The ACN-PCN method adopts four standard levels of subgrade strength for rigid pavements and four levels of subgrade strength for flexible pavements. These standard support conditions are used to represent a range of subgrade conditions as shown in Tables 2-1 and 2-2.

Table 2-1. Standard Subgrade Support Conditions for Rigid Pavement ACN Calculation

Subgrade Strength Category	Subgrade Support k-Value pci (MN/m3)	Represents pci (MN/m3)	Code Designation
High	552.6 (150)	k > 442 (>120)	A
Medium	294.7 (80)	221<k<442 (60<k<120)	B
Low	147.4 (40)	92<k<221 (25<k<60)	C
Ultra Low	73.7 (20)	k<92 (<25)	D

Table 2-2. Standard Subgrade Support Conditions for Flexible Pavement ACN Calculation

Subgrade Strength Category	Subgrade Support CBR-Value	Represents	Code Designation
High	15	CBR > 13	A
Medium	10	8<CBR<13	B
Low	6	4<CBR<8	C
Ultra Low	3	CBR<4	D

2.2 OPERATIONAL FREQUENCY.

Operational frequency is defined in terms of coverages that represent a full-load application on a point in the pavement. Coverages must not be confused with other common terminology used to reference movement of aircraft. As an aircraft moves along a pavement section it seldom travels in a perfectly straight path or along the exact same path as before.

This movement is known as aircraft wander and is assumed to be modeled by a statistically normal distribution. As the aircraft moves along a taxiway or runway, it may take several trips or passes along the pavement for a specific point on the pavement to receive a full-load application. It is easy to observe the number of passes an aircraft may make on a given pavement, but the number of coverages must be mathematically derived based upon the established pass-to-coverage ratio for each aircraft.

2.3 RIGID PAVEMENT ACN.

For rigid pavements, the aircraft landing gear flotation requirements are determined by the Westergaard solution for a loaded elastic plate on a Winkler foundation (interior load case), assuming a concrete working stress of 399 psi (2.75 MPa).

2.4 FLEXIBLE PAVEMENT ACN.

For flexible pavements, aircraft landing gear flotation requirements are determined by the California Bearing Ratio (CBR) method for each subgrade support category. The CBR method employs a Boussinesq solution for stresses and displacements in a homogeneous, isotropic elastic half-space.

2.5 ACN CALCULATION.

Using the parameters defined for each type of pavement section, a mathematically derived single wheel load is calculated to define the landing gear/pavement interaction. The derived single wheel load implies equal stress to the pavement structure and eliminates the need to specify pavement thickness for comparative purposes. This is achieved by equating the thickness derived for a given aircraft landing gear to the thickness derived for a single wheel load at a standard tire pressure of 181 psi (1.25 MPa). The ACN is defined as two times the derived single wheel load (expressed in thousands of kilograms).

2.6 VARIABLES INVOLVED IN DETERMINATION OF ACN VALUES.

Because aircraft can be operated at various weight and center of gravity combinations, ICAO adopted standard operating conditions for determining ACN values. The ACN is to be determined at the weight and center of gravity combination that creates the maximum ACN value. Tire pressures are assumed to be those recommended by the manufacturer for the noted conditions. Aircraft manufacturers publish maximum weight and center of gravity information in their Aircraft Characteristics for Airport Planning (ACAP) manuals. To standardize the ACN calculation and to remove operational frequency from the relative rating scale, the ACN-PCN method specifies that ACN values be determined at a frequency of 10,000 coverages.

CHAPTER 3. DETERMINATION OF ACN VALUES USING COMFAA

3.0 AVAILABILITY OF COMFAA SOFTWARE APPLICATION.

To facilitate the use of the ACN-PCN system, the FAA developed a software application that calculates ACN values using the procedures and conditions specified by ICAO. The software is called COMFAA and may be downloaded along with its source code and supporting documentation from the FAA website.[1] The program is useful for determining an ACN value under various conditions; however, the user should remember that official ACN values are provided by the aircraft manufacturer.

3.1 ORIGIN OF THE COMFAA PROGRAM.

Appendix 2 of the ICAO Aerodrome Design Manual, Part 3, Pavements, provides procedures for determining the Aircraft Classification Number (ACN). The appendix provides program code for two FORTRAN software applications capable of calculating the ACN for various aircraft on rigid and flexible pavement systems. The computer program listings in Appendix 2 of the ICAO manual were optically scanned and the FORTRAN code translated into Visual Basic 6.0 for incorporation into COMFAA.

3.2 COMFAA PROGRAM.

The COMFAA software is a general purpose program that operates in two computational modes: ACN Computation Mode and Pavement Thickness Mode.

a. ACN Computation Mode.

- Calculates the ACN number for aircraft on flexible pavements.
- Calculates the ACN number for aircraft on rigid pavements.
- Calculates flexible pavement thickness based on the ICAO procedure (CBR method) for default values of CBR (15, 10, 6, and 3).
- Calculates rigid pavement slab thickness based on the ICAO procedures (Portland Cement Association method, interior load case) for default values of k (552.6, 294.7, 147.4, and 73.7 lb/in^3 [150, 80, 40, and 20 MN/m^3]).

Note: Thickness calculation in the ACN mode is for specific conditions identified by ICAO for determination of ACN. For flexible pavements, a standard tire pressure of 181 psi (1.25 MPa) and 10,000 coverages is specified. For rigid pavements, an allowable stress level of 399 psi is identified by ICAO. These parameters seldom represent actual design criteria used for pavement design. The thickness calculated in ACN mode has little meaning to pavement design requirements and should not be used for determining allowable pavement loading.

[1] See http://www.faa.gov/airports/engineering/design_software/. This software is in the public domain.

b. Pavement Thickness Mode (see Note).

- Calculates total flexible pavement thickness based on the FAA CBR method specified in AC 150/5320-6[2], Airport Pavement Design and Evaluation, for CBR values and coverage levels specified by the user.

- Calculates rigid pavement slab thickness based on the FAA Westergaard method (edge load analysis) specified in AC 150/5320-6 for k values and coverage levels specified by the user.

Note: The pavement thickness requirements associated with the ACN-PCN procedures are based upon historical procedures identified in previous versions of AC 150/5320-6. The FAA has replaced these procedures for pavement design with new procedures.

3.3 INTERNAL AIRCRAFT LIBRARY.

COMFAA contains an internal library of aircraft covering most large commercial and U.S. military aircraft currently in operation. The internal library is based on aircraft information provided directly by aircraft manufacturers or obtained from ACAP Manuals. The default characteristics of aircraft in the internal library represent the ICAO standard conditions for calculation of ACN. These characteristics include center of gravity at the maximum aft position for each aircraft in the ACN mode, whereas the pavement thickness mode center of gravity is fixed to distribute 95 percent of the maximum gross load to the main landing gear for all aircraft.

3.4 EXTERNAL AIRCRAFT LIBRARY.

COMFAA allows for an external aircraft library where characteristics of the aircraft can be changed and additional aircraft added as desired. Functions permit users to modify the characteristics of an aircraft and save the modified aircraft in the external library. There are no safeguards in the COMFAA program to assure that aircraft parameters in the external library are feasible or appropriate. The user is responsible for assuring all data is correct.

When saving an aircraft from the internal library to the external library, the COMFAA program will calculate the tire contact area based upon the gross load, maximum aft center of gravity, and tire pressure. This value is recorded in the external library and is used for calculating the pass-to-coverage (P/C) ratio in the pavement thickness mode. Since the tire contact area is constant, the P/C ratio is also constant in the pavement thickness mode. This fixed P/C ratio should be used for converting passes to coverages for pavement thickness determination and equivalent aircraft operations.

[2] New FAA layered elastic and finite element pavement design procedures were adopted in AC 150/5320-6E. The pavement thickness mode uses the FAA CBR method and the FAA Westergaard method, identified in previous versions of AC 150/5320-6. These historical procedures are consistent with the ACN/PCN method, an internationally used standard published by ICAO. Data from the historical procedures relative to the existing ICAO standard are included in this AC.

3.5 USING THE COMFAA PROGRAM.

Using the COMFAA program to calculate ACN values to determine PCN is visually interactive and intuitive.

a. ACN. The user—

- Selects the desired aircraft,
- Confirms the physical properties of the aircraft,
- Clicks on the "MORE" button, and
- Clicks on the ACN Flexible or ACN Rigid button to determine the ACN for the four standard subgrade conditions.

b. PCN. The user—

- Adds the runway traffic mix aircraft to an external file,
- Confirms the physical properties of each individual aircraft in the traffic mix,
- Inputs either annual departures or coverages of the aircraft,
- Inputs the evaluation thickness and the subgrade support strength,
- Inputs the concrete strength if analyzing a rigid pavement,
- Clicks on the "LESS" button to activate the PCN Batch computational mode, and
- Clicks on the PCN Flexible Batch or PCN Rigid Batch button to determine the PCN of the pavement.

The program includes a help file to assist users. Figures 3-1, 3-2, and 3-3 summarize the operation of the COMFAA program.

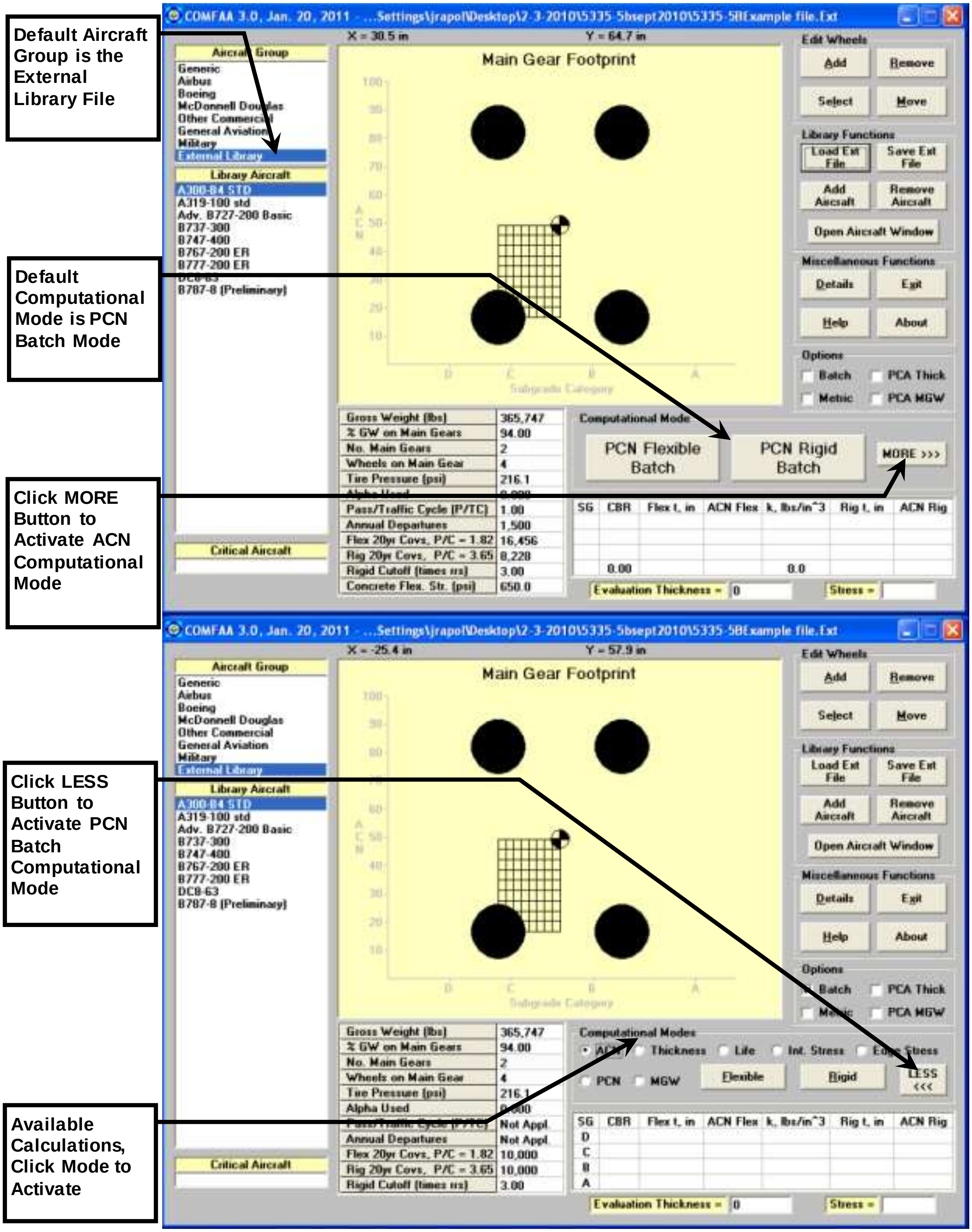

Figure 3-1. Computational Modes of the COMFAA Program

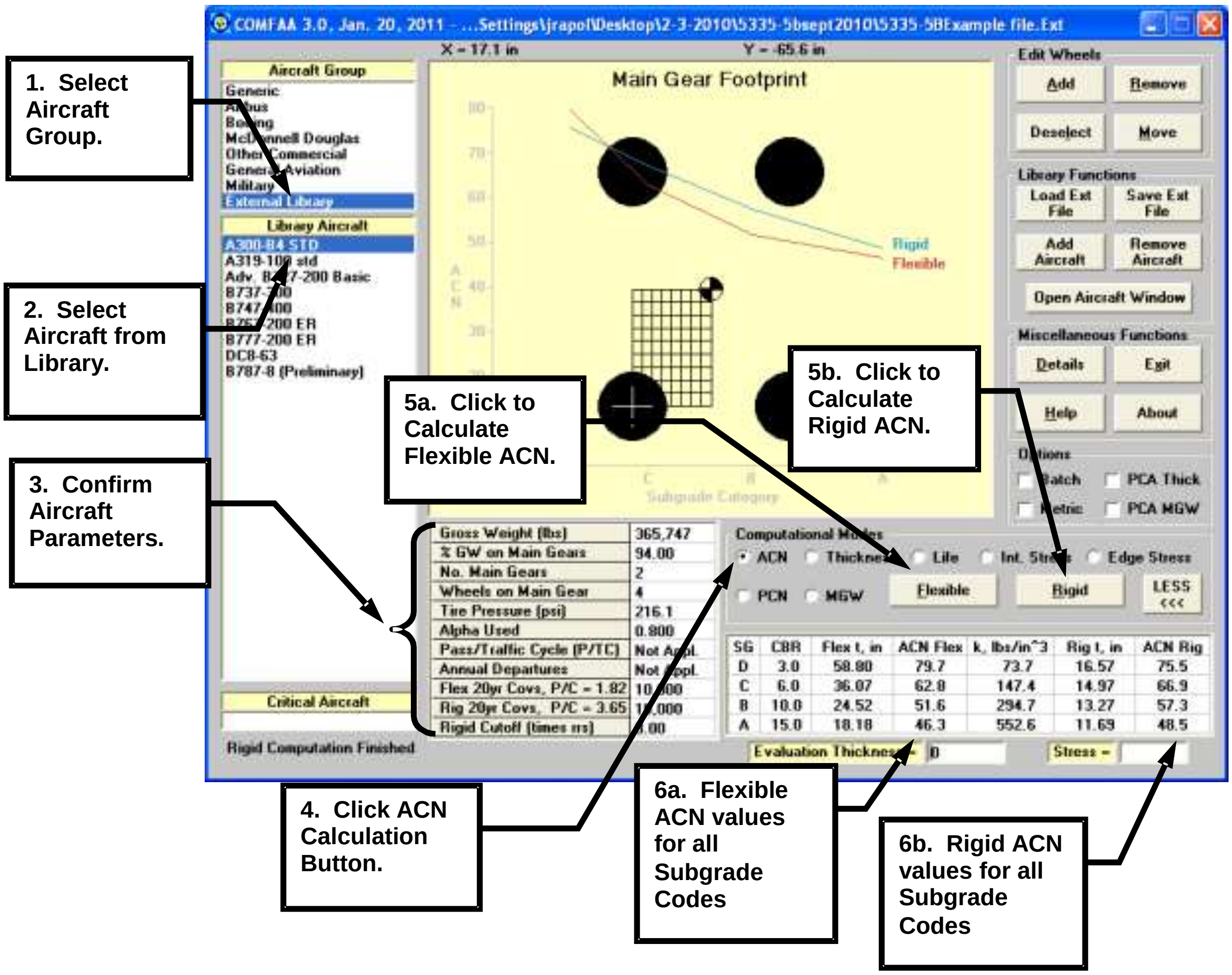

Figure 3-2. Operation of the COMFAA Program in ACN Mode

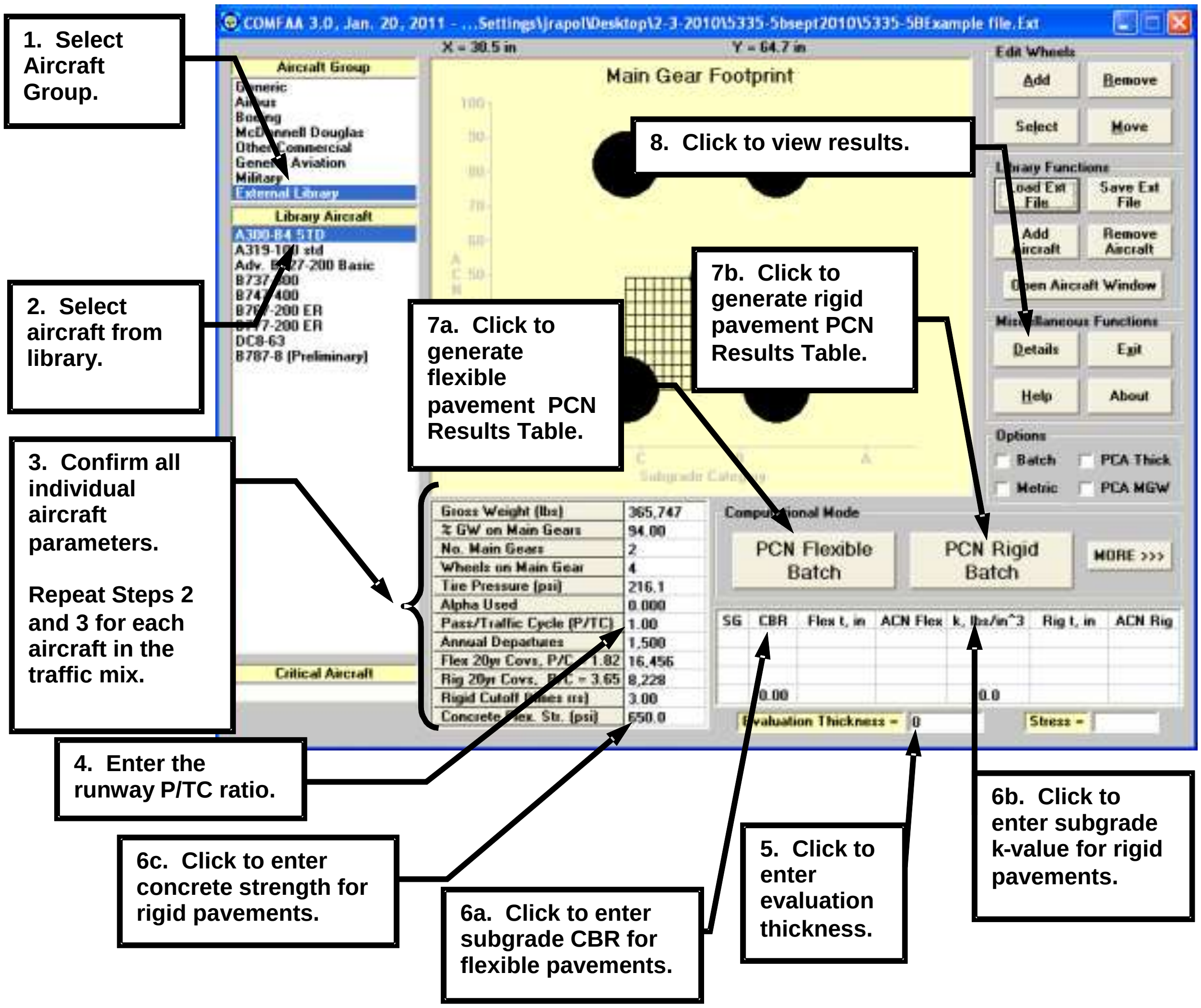

Figure 3-3. Operation of the COMFAA Program in PCN Batch Mode

CHAPTER 4. DETERMINATION OF PCN NUMERICAL VALUE

4.0 PCN CONCEPT.

The determination of a pavement rating in terms of PCN is a process of (1) determining the ACN for each aircraft considered to be significant to the traffic mixture operating of the subject pavement and (2) reporting the ACN value as the PCN for the pavement structure. Under these conditions, any aircraft with an ACN equal to or less than the reported PCN value can safely operate on the pavement subject to any limitations on tire pressure.

Note: PCN values determined in accordance with this AC depend upon the traffic model used to determine the PCN value. Airports should re-evaluate their posted PCN value if significant changes to the original traffic model occur.

4.1 DETERMINATION OF NUMERICAL PCN VALUE.

Determination of the numerical PCN value for a particular pavement can be based upon one of two procedures: the “Using” aircraft method or the “Technical” evaluation method. ICAO procedures permit member states to determine how PCN values will be determined based upon internally developed pavement evaluation procedures. Either procedure may be used to determine a PCN, but the methodology used must be reported as part of the posted rating.

4.2 USING AIRCRAFT METHOD TO DETERMINE PCN

The Using aircraft method is a simple procedure where ACN values for all aircraft currently permitted to use the pavement facility are determined and the largest ACN value is reported as the PCN. This method is easy to apply and does not require detailed knowledge of the pavement structure.

a. Assumptions of the Using Aircraft Method. An underlying assumption with the Using aircraft method is that the pavement structure has the structural capacity to accommodate all aircraft in the traffic mixture and that each aircraft is capable of operating on the pavement structure without restriction.

b. Inaccuracies of the Using Aircraft Method. The accuracy of this method is greatly improved when aircraft traffic information is available. Significant over-estimation of the pavement capacity can result if an excessively damaging aircraft, which uses the pavement on a very infrequent basis, is used to determine the PCN. Likewise, significant under-estimation of the pavement capacity can lead to uneconomic use of the pavement by preventing acceptable traffic from operating. Although there are no minimum limits on frequency of operation before an aircraft is considered part of the normal traffic, the reporting agency must use a rational approach to avoid overstating or understating the pavement capacity. *Use of the Using aircraft method is discouraged on a long-term basis due to the concerns listed above.*

4.3 TECHNICAL EVALUATION METHOD TO DETERMINE PCN.

The strength of a pavement section is difficult to summarize in a precise manner and will vary depending on the unique combination of aircraft loading conditions, frequency of operation, and pavement support conditions. The technical evaluation method attempts to address these and other site-specific variables to determine reasonable pavement strength. *In general terms, for a given pavement structure and given aircraft, the allowable number of operations (traffic) will decrease as the intensity of pavement loading increases (increase in aircraft weight). It is entirely possible that two pavement structures with different cross-sections will report similar strength. However, the permissible aircraft operations will be considerably different. This discrepancy must be acknowledged by the airport operator and may require operational limitations administered outside of the ACN-PCN system.* All of the factors involved in determining a pavement rating are important, and it is for this reason that pavement ratings should not be viewed in absolute terms, but rather as estimations of a representative value. A successful pavement evaluation is one that assigns a pavement strength rating that considers the effects of all variables on the pavement.

The accuracy of a technical evaluation is better than that produced with the Using aircraft procedure but requires a considerable increase in time and resources. Pavement evaluation may require a combination of on-site inspections, load-bearing tests, and engineering judgment. It is common to think of pavement strength rating in terms of ultimate strength or immediate failure criteria. However, pavements are rarely removed from service due to instantaneous structural failure. A decrease in the serviceability of a pavement is commonly attributed to increases in surface roughness or localized distress, such as rutting or cracking. Determination of the adequacy of a pavement structure must not only consider the magnitude of pavement loads but the impact of the accumulated effect of traffic volume over the intended life of the pavement.

a. Determination of the PCN Value. The PCN numerical value is determined from an allowable load rating. While it is important not to confuse the PCN value with a pavement design parameter, the PCN is developed in a similar fashion. An allowable load rating is determined by applying the same principles as those used for pavement design. The process for determining the allowable load rating takes factors such as frequency of operations and permissible stress levels into account. Allowable load ratings are often discussed in terms of aircraft gear type and maximum gross aircraft weight, as these variables are used in the pavement design procedure. Missing from the allowable load rating, but just as important, is frequency of operation. In determining an allowable load rating, the evaluation must address whether the allowable load rating represents the pavement strength over a reasonable frequency of operation. Once the allowable load rating is established, the determination of the PCN value is a simple process of determining the ACN of the aircraft representing the allowable load and reporting the value as the PCN.

b. Concept of Equivalent Traffic. The ACN-PCN method is based on design procedures that evaluate one aircraft against the pavement structure. Calculations necessary to determine the PCN can only be performed for one aircraft at a time. The ACN-PCN method does not directly address how to represent a traffic mixture as a single aircraft. To address this limitation, the FAA uses the equivalent annual departure concept to consolidate entire traffic mixtures into equivalent annual departures of one representative aircraft. The procedure for evaluating equivalent annual departures for a given aircraft from a traffic mixture is based on the cumulative damage factor concept discussed in Appendix 1.

c. Counting Aircraft Operations. When evaluating or designing a pavement section, it is important to account for the number of times the pavement will be stressed. As discussed in paragraph 2.2, an aircraft may have to pass over a given section of pavement numerous times before the portion of pavement considered for evaluation receives one full stress application. While statistical procedures exist to determine the passes required for one full stress application, the evaluation of a pavement section for PCN determination must also consider how aircraft use the pavement in question. The FAA uses a conservative approach for pavement design procedures by assuming that each aircraft using the airport must land and take off once per cycle. Since the arrival or landing weight of the aircraft is usually less than the departure weight, the design procedure only counts one pass at the departure weight for analysis. The one pass at departure weight is considered as one annual departure and the arrival event is ignored. Appendix 1 provides a detailed discussion of traffic analysis.

4.4 LIMITATIONS OF THE PCN.

The PCN value is for reporting relative pavement strength only and should not be used for pavement design or as a substitute for evaluation. Pavement design and evaluation are complex engineering problems that require detailed analyses. They cannot be reduced to a single number. The PCN rating system uses a continuous scale to compare pavement strength where higher values represent pavements with larger load capacity.

4.5 REPORTING THE PCN.

The PCN system uses a coded format to maximize the amount of information contained in a minimum number of characters and to facilitate computerization. The PCN for a pavement is reported as a five-part number where the following codes are ordered and separated by forward slashes.

- Numerical PCN value,
- Pavement type,
- Subgrade category,
- Allowable tire pressure, and
- Method used to determine the PCN.

An example of a PCN code is 80/R/B/W/T, which is further explained in paragraph 4.5.f.

a. Numerical PCN Value. The PCN numerical value indicates the load-carrying capacity of a pavement in terms of a standard single wheel load at a tire pressure of 181 psi (1.25 MPa). The PCN value should be reported in whole numbers, rounding off any fractional parts to the nearest whole number. For pavements of diverse strengths, the controlling PCN numerical value for the weakest segment of the pavement should normally be reported as the strength of the pavement. Engineering judgment may be required in that if the weakest segment is not in the most heavily used part of the runway, then another representative segment may be more appropriate to determine PCN.

b. Pavement Type. For the purpose of reporting PCN values, pavement types are considered to function as either flexible or rigid structures. Table 4-1 lists the pavement codes for the purposes of reporting PCN.

Table 4–1. Pavement Codes for Reporting PCN

Pavement Type	Pavement Code
Flexible	F
Rigid	R

i) Flexible Pavement. Flexible pavements support loads through bearing rather than flexural action. They comprise several layers of selected materials designed to gradually distribute loads from the surface to the layers beneath. The design ensures that load transmitted to each successive layer does not exceed the layer's load-bearing capacity.

ii) Rigid Pavement. Rigid pavements employ a single structural layer, which is very stiff or rigid in nature, to support the pavement loads. The rigidity of the structural layer and resulting beam action enable rigid pavement to distribute loads over a large area of the subgrade. The load-carrying capacity of a rigid structure is highly dependent upon the strength of the structural layer, which relies on uniform support from the layers beneath.

iii) Composite Pavement. Various combinations of pavement types and stabilized layers can result in complex pavements that could be classified as between rigid or flexible. A pavement section may comprise multiple structural elements representative of both rigid and flexible pavements. Composite pavements are most often the result of pavement surface overlays applied at various stages in the life of the pavement structure. If a pavement is of composite construction, the pavement type should be reported as the type that most accurately reflects the structural behavior of the pavement. The method used in computing the PCN is the best guide in determining how to report the pavement type. For example, if a pavement is composed of a rigid pavement with a bituminous overlay, the usual manner of determining the load-carrying capacity is to convert the pavement to an equivalent thickness of rigid pavement. In this instance, the pavement type should be reported as a rigid structure. A general guideline is that when the bituminous overlay reaches 75 to 100 percent of the rigid pavement thickness the pavement can be considered as a flexible pavement. It is permissible to include a note stating that the pavement is of composite construction but only the rating type, "R" or "F", is used in the assessment of the pavement load capacity.

c. Subgrade Strength Category. As discussed in paragraph 2.1, there are four standard subgrade strengths identified for calculating and reporting ACN or PCN values. Tables 2-1 and 2-2 list the values for rigid and flexible pavements.

d. Allowable Tire Pressure. Table 4-2 lists the allowable tire pressure categories identified by the ACN-PCN system. The tire pressure codes apply equally to rigid or flexible pavement sections; however, the application of the allowable tire pressure differs substantially for rigid and flexible pavements.

Table 4–2. Tire Pressure Codes for Reporting PCN

Category	Code	Tire Pressure Range
High	W	No pressure limit
Medium	X	Pressure limited to 218 psi (1.5 MPa)
Low	Y	Pressure limited to 145 psi (1.00 MPa)
Very Low	Z	Pressure limited to 73 psi (0.50 MPa)

i) Tire Pressures on Rigid Pavements. Aircraft tire pressure will have little effect on pavements with Portland cement concrete (concrete) surfaces. Rigid pavements are inherently strong enough to resist tire pressures higher than currently used by commercial aircraft and can usually be rated as code W.

ii) Tire Pressures on Flexible Pavements. Tire pressures may be restricted on asphaltic concrete (asphalt), depending on the quality of the asphalt mixture and climatic conditions. Tire pressure effects on an asphalt layer relate to the stability of the mix in resisting shearing or densification. A poorly constructed asphalt pavement can be subject to rutting due to consolidation under load. The principal concern in resisting tire pressure effects is with stability or shear resistance of lower quality mixtures. A properly prepared and placed mixture that conforms to FAA specification Item P-401 can withstand substantial tire pressure in excess of 218 psi (1.5 Mpa). Item P-401, Plant Mix Bituminous Pavements, is provided in the current version of AC 150/5370-10, Standards for Specifying Construction of Airports. Improperly prepared and placed mixtures can show distress under tire pressures of 100 psi (0.7 MPa) or less. Although these effects are independent of the asphalt layer thickness, pavements with well-placed asphalt of 4 to 5 inches (10.2 to 12.7 cm) in thickness can generally be rated with code X or W, while thinner pavement of poorer quality asphalt should not be rated above code Y.

e. Method Used to Determine PCN. The PCN system recognizes two pavement evaluation methods. If the evaluation represents the results of a technical study, the evaluation method should be coded T. If the evaluation is based on “Using aircraft” experience, the evaluation method should be coded U. Technical evaluation implies that some form of technical study and computation were involved in the determination of the PCN. Using aircraft evaluation means the PCN was determined by selecting the highest ACN among the aircraft currently using the facility and not causing pavement distress. PCN values computed by the technical evaluation method should be reported to the NASR database and shown on the FAA Form 5010, Airport Master Record. Publication of a Using aircraft evaluation in the Airport Master Record, Form 5010, and the NASR database is permitted only by mutual agreement between the airport owner and the FAA.

f. Example PCN Reporting. An example of a PCN code is 80/R/B/W/T—with 80 expressing the PCN numerical value, R for rigid pavement, B for medium strength subgrade, W for high allowable tire pressure, and T for a PCN value obtained by a technical evaluation.

g. Report PCN Values to FAA (See Appendix 5). Once a PCN value and the coded entries are determined, the PCN code should be reported to the appropriate regional FAA Airports Division, either in writing or as part of the annual update to the Airport Master Record, FAA Form 5010-l. The regional office will forward the PCN code to FAA headquarters where it will be disseminated by the National Flight Data Center through aeronautical publications such as the Airport/Facility Directory (AFD) and the Aeronautical Information Publication (AIP). An aircraft's ACN can then be compared with the published PCN to determine if the aircraft is restricted from operating on the airport's pavements, subject to any limitation on tire pressure.

APPENDIX 1. EQUIVALENT TRAFFIC

1.0 EQUIVALENT TRAFFIC.

A detailed method based on the cumulative damage factor (CDF) procedure allows the calculation of the combined effect of multiple aircraft in the traffic mix for an airport. This combined traffic is brought together into the equivalent traffic of a critical aircraft. This is necessary since the procedure used to calculate ACN allows only one aircraft at a time. By combining all of the aircraft in the traffic mix into an equivalent critical aircraft, calculation of a PCN that includes the effects of all traffic becomes possible.

The assessment of equivalent traffic, as described in this section, is needed only in the process of determining PCN using the technical method and may be disregarded when the Using aircraft method is employed.

In order to arrive at a technically derived PCN, it is necessary to determine the maximum allowable gross weight of each aircraft in the traffic mixture, which will generate the known pavement structure. This in turn requires that the pavement cross-section and aircraft loading characteristics be examined in detail. Consequently, the information presented in this appendix appears at first to apply to pavement design rather than a PCN determination. However, with this knowledge in hand, an engineer will be able to arrive at a PCN that will have a solid technical foundation.

1.1 EQUIVALENT TRAFFIC TERMINOLOGY.

In order to determine a PCN, based on the technical evaluation method, it is necessary to define common terms used in aircraft traffic and pavement loading. The terms arrival, departure, pass, coverage, load repetition, operation, and traffic cycle are often used interchangeably by different organizations when determining the effect of aircraft traffic operating on a pavement. It is important to determine which aircraft movements need be counted when considering pavement stress and how the various movement terms apply in relation to the pavement design and evaluation process. In general, and for the purpose of this document, they are differentiated as follows:

a. Arrival (Landing) and Departure (Takeoff). Typically, aircraft arrive at an airport with a lower amount of fuel than is used at takeoff. As a consequence, the stress loading of the wheels on the runway pavement is less when landing than at takeoff due to the lower weight. This is true even at the touchdown impact in that there is still lift on the wings, which alleviates the dynamic vertical force. Because of this, the FAA pavement design procedure only considers departures and ignores the arrival traffic count. However, if the aircraft do not receive additional fuel at the airport, then the landing weight will be substantially the same as the takeoff weight (discounting the changes in passenger count and cargo), and the landing operation should be counted as a takeoff for pavement stress loading cycles. In this latter scenario, there are two equal load stresses on the pavement for each traffic count (departure), rather than just one. Regardless of the method of counting load stresses, a traffic cycle is defined as one takeoff and one landing of the same aircraft, subject to a further refinement of the definition in the following text.

b. Pass. A pass is a one-time movement of the aircraft over the runway pavement. It could be an arrival, a departure, a taxi operation, or all three, depending on the loading magnitude and the location of the taxiways. Figure A1-1 shows typical traffic patterns for runways having either parallel taxiways or central taxiways. A parallel taxiway requires that none or very little of the runway be used as part of the taxi movement. A central taxiway requires that a large portion of the runway be used during the taxi movement.

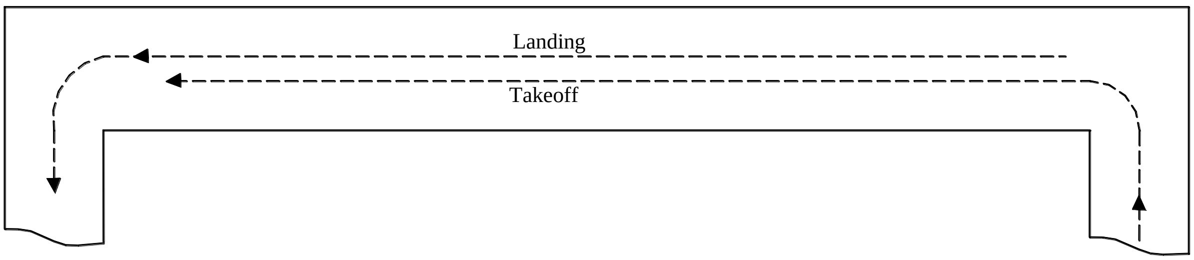

Figure A1-1a. Runway with Parallel Taxiway

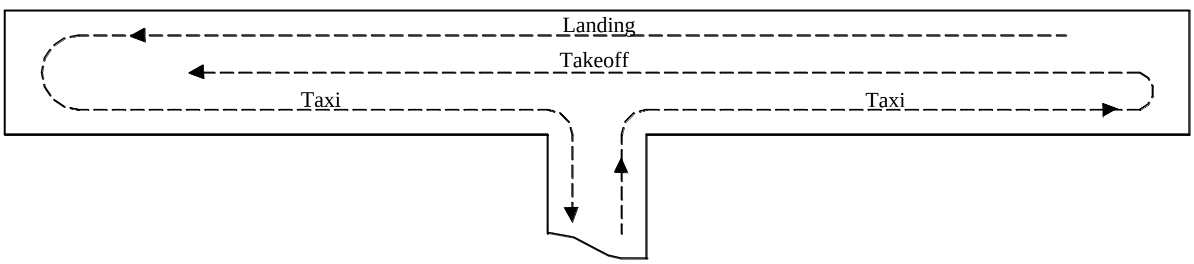

Figure A1-1b. Runway with Central Taxiway

Figure A1-1. Traffic Load Distribution Patterns

i) Parallel Taxiway Scenario. In the case of the parallel taxiway, as shown in Figure A1-1a, two possible loading situations can occur. Both of these situations assume that the passenger count and cargo payload are approximately the same for the entire landing and takeoff cycle:

1) If the aircraft obtains fuel at the airport, then a traffic cycle consists of only one pass since the landing stress loading is considered at a reduced level, which is a fractional equivalence. For this condition only the takeoff pass is counted, and the ratio of passes to traffic cycles (P/TC) is 1.

2) If the aircraft does not obtain fuel at the airport, then both landing and takeoff passes should be counted, and a traffic cycle consists of two passes of equal load stress. In this case, the P/TC ratio is 2.

ii) Central Taxiway Scenario. For a central taxiway configuration, as shown in Figure A1-1b, there are also two possible loading situations that can occur. As was done for the parallel taxiway condition, both of these situations assume that the payload is approximately the same for the entire landing and takeoff cycle:

1) If the aircraft obtains fuel at the airport, then both the takeoff and taxi to takeoff passes should be counted since they result in a traffic cycle consisting of two passes at the maximum load stress. The landing pass can be ignored in this case. It is recognized that only part of the runway is used during some of these operations, but it is conservative to assume that the entire runway is covered each time a pass occurs. For this situation, the P/TC ratio is 2.

2) If the aircraft does not obtain fuel at the airport, then both the landing and takeoff passes should be counted, along with the taxi pass, and a traffic cycle consists of three passes at loads of equal magnitude. In this case, the P/TC ratio is 3.

iii) A simplified, but less conservative, approach would be use a P/TC ratio of 1 for all situations. Since a landing and a takeoff only apply full load to perhaps the end third of the runway (opposite ends for no shift in wind direction), this less conservative approach could be used to count one pass for both landing and takeoff. However, the FAA recommends conducting airport evaluations on the conservative side, which is to assume any one of the passes covers the entire runway.

Table A1-1 summarizes the P/TC ratio discussion.

Figure A3-1. P/TC Ratio Summary

Taxiway Serving the Runway	P/TC Fuel Obtained at the Airport (i.e. departure gross weight more than arrival gross weight.)	P/TC No Fuel Obtained at the Airport (i.e. departure gross weight same as arrival gross weight.)
Parallel	1	2
Central	2	3

c. Coverage. When an aircraft moves along a runway, it seldom travels in a perfectly straight line or over the exact same wheel path as before. It will wander on the runway with a statistically normal distribution. One coverage occurs when a unit area of the runway has been traversed by a wheel of the aircraft main gear. Due to wander, this unit area may not be covered by the wheel every time the aircraft is on the runway. The number of passes required to statistically cover the unit area one time on the pavement is expressed by the pass to coverage (P/C) ratio.

Although the terms coverage and P/C ratio have commonly been applied to both flexible and rigid pavements, the P/C ratio has a slightly different meaning when applied to flexible pavements as opposed to rigid pavements. This is due to the manner in which flexible and rigid pavements are considered to react to various types of gear configurations. For gear configurations with wheels in tandem, such as dual tandem (2D) and triple dual tandem (3D), the ratios are different for flexible and rigid pavements, and using the same term for both types of pavements may become confusing. It is incumbent upon the user to select the proper value for flexible and rigid pavements.

Aircraft passes can be determined (counted) by observation but coverages are used by the COMFAA program. The P/C ratio is necessary to convert passes to coverages for use in the program. This ratio is different for each aircraft because of the different number of wheels, main gear configurations, tire contact areas, and load on the gear. Fortunately, the P/C ratio for any aircraft is automatically determined by the COMFAA program and the user only need be concerned with passes.

d. Operation. The meaning of this term is unclear when used in pavement design or evaluation. It could mean a departure at full load or a landing at minimal load. It is often used interchangeably with pass or traffic cycle. When this description of an aircraft activity is used, additional information should be supplied. It is usually preferable to use the more precise terms described in this section.

e. Annual Departure and Traffic Cycle Ratio. The FAA standard for counting traffic cycles at an airport for pavement design purposes is to count one landing, one taxi, and one take-off as a single event called a departure. For pavement evaluation related to determination of PCN, it may be necessary to adjust the number of traffic cycles (departures) based upon the scenarios discussed in paragraph 1.1b of this appendix. Similar to the discussion above regarding P/C ratio, the traffic cycle to coverage (TC/C) ratio is needed to finalize the equivalent traffic determination. The TC/C ratio differs when applied to flexible pavements as opposed to rigid pavements. The ratio in flexible pavement, rather than passes to coverages, is required since there could be one or more passes per traffic cycle. When only one pass on the operating surface is assumed for each traffic count, then the P/C ratio is sufficient. However, when situations are encountered where more than one pass is considered to occur during the landing to takeoff cycle, then the TC/C ratio is necessary in order to properly account for the effects of all of the traffic. These situations occur most often when there are central taxiways or fuel is not obtained at the airport.

Equation A1-1 translates the P/C ratio to the TC/C ratio for flexible and rigid pavements by including the previously described ratio of passes to traffic cycles (P/TC):

$$TC/C = P/C \div P/TC \qquad \text{(Equation A1-1)}$$

Where:

TC = Traffic Cycles
C = Coverages
P = Passes

Since the COMFAA program will automatically determine passes to coverages and convert annual departures to coverages, the conditions described in paragraph 1.1b can be addressed by simply multiplying annual departures by the pass to traffic cycle (P/TC) ratio. COMFAA requires the P/TC ratio parameter and will automatically perform this multiplication.

1.2 EQUIVALENT TRAFFIC CALCULATIONS.

In order to complete the equivalent traffic calculations for converting one of the aircraft in the mix to another, a procedure based on cumulative damage factor (CDF) is used. The CDF method is similar to the one used in the design procedures embodied in the design program FAARFIELD, required by AC 150/5320-6, and provides more consistent results than the wheel load method (as in FAA's CBR and Westergaard methods) when the traffic mix contains a wide range of gear geometries and strut loads. The primary difference between the CDF procedure used here and the one in FAARFIELD is that in FAARFIELD, the CDF is summed over all aircraft to produce the criterion for design whereas in the procedure used here the CDF methodology is used to convert the traffic for the complete mix into an equivalent number of coverages of one of the aircraft in the mix. That aircraft is designated the "critical" aircraft or "most demanding" aircraft for PCN determination or the "design" aircraft for thickness design (FAA's CBR and Westergaard methods). The wheel load method is briefly described before describing the CDF method.

In the wheel load method, select one of the aircraft in the mix to be the critical aircraft and then convert the traffic of the remaining aircraft into equivalent traffic of the critical aircraft. First, with equation A1-1, convert the traffic for the gear type of each of the conversion aircraft into equivalent traffic for the same gear type as the critical aircraft.

$$TC_{CRTGE} = TC_{CNV} \times 0.8^{(M-N)} \qquad \text{(Equation A1-2)}$$

Where:

TC_{CNV} = the number of traffic cycles of the conversion aircraft.
TC_{CRTGE} = the number of traffic cycles of the critical aircraft equivalent to the number of traffic cycles of the conversion aircraft due to gear type equivalency.
N = the number of wheels on the main gear of the conversion aircraft.
M = the number of wheels on the main gear of the critical aircraft.

Second, with equation A1-3, convert the gear equivalency traffic cycles into equivalent traffic based on load magnitude.

$$\text{Log}\left(TC_{CRTE}\right) = \text{Log}\left(TC_{CRTGE}\right) \times \sqrt{\frac{W_{CRT}}{W_{CNV}}}$$

Or (Equation A1-3)

$$TC_{CRTE} = \left(TC_{CRTGE}\right)^{\sqrt{W_{CRT}/W_{CNV}}}$$

Where:

TC_{CRTE} = the number of traffic cycles of the critical aircraft equivalent to the number of traffic cycles of the conversion aircraft due to gear type and load magnitude equivalencies.
W_{CNV} = the wheel load of the conversion aircraft.
W_{CRT} = the wheel load of the critical aircraft.

Alternatively, both operations can be combined into a single equation:

$$TC_{CRTE} = \left(TC_{CNV} \times 0.8^{(M-N)}\right)^{\sqrt{W_{CRT}/W_{CNV}}} \qquad \text{(Equation A1-4)}$$

Finally, the equivalent traffic cycles of all of the conversion aircraft are added to the original traffic cycles of the critical aircraft to give the total equivalent traffic cycles of the critical aircraft.

In the CDF method, the number of equivalent traffic cycles of the critical aircraft is defined as the number of traffic cycles of the critical aircraft that will cause the same amount of damage to the pavement as the number of traffic cycles of the conversion aircraft, where damage is defined by CDF.

CDF is derived from Miner's Rule, which states the damage induced in a structural element is proportional to the number of load applications divided by the number of load applications required to fail the structural element. In airport pavement design, load applications are counted in coverages, so the relationship for calculating equivalent traffic is first derived in terms of coverages.

$$CDF_{CNV} = \frac{C_{CNV}}{C_{CNVF}} = \frac{\text{coverages of the conversion aircraft}}{\text{coverages to fail the pavement when loaded by the conversion aircraft}}$$

$$= \text{cumulative damage factor resulting from the coverages of the conversion aircraft}$$

$$CDF_{CRTE} = \frac{C_{CRTE}}{C_{CRTF}} = \frac{\text{equivalent coverages of the critical aircraft}}{\text{coverages to fail the pavement when loaded by the critical aircraft}}$$

$$= \text{cumulative damage factor resulting from the equivalent coverages of the critical aircraft}$$

CDF is the fraction of the total pavement life used up by operating the indicated aircraft on the pavement. It therefore follows that the CDF for the equivalent critical aircraft is equal to the CDF for the conversion aircraft. Or:

$$\frac{C_{CRTE}}{C_{CRTF}} = \frac{C_{CNV}}{C_{CNVF}}, \text{ and}$$

$$C_{CRTE} = \frac{C_{CRTF}}{C_{CNVF}} C_{CNV} \qquad \text{(Equation A1-5)}$$

But:

$$TC_{CNV} = PC_{CNV} \times C_{CNV}, \text{ and}$$
$$TC_{CRTE} = PC_{CRT} \times C_{CRTE}$$

Where:

TC_{CNV} = the number of traffic cycles of the conversion aircraft.
TC_{CRTE} = the number of traffic cycles of the critical aircraft equivalent to the number of traffic cycles of the conversion aircraft.
PC_{CNV} = pass-to-coverage ratio for the conversion aircraft.
PC_{CRT} = pass-to-coverage ratio for the critical aircraft.

Therefore, the equivalent traffic cycles of the critical aircraft by the CDF method is given by:

$$TC_{CRTE} = \frac{PC_{CRT}}{PC_{CNV}} \frac{C_{CRTF}}{C_{CNVF}} TC_{CNV} \qquad \text{(Equation A1-6)}$$

Equation A1-6 can be rewritten as:

$$C_{CRTEI} = C_{CRTF} \times CDF_{CNVI}$$

Where:

C_{CRTEI} = the number of equivalent coverages of the Ith aircraft in the list, including the critical aircraft.

CDF_{CNVI} = the CDF of the Ith aircraft in the list, including the critical aircraft.

Summing over all aircraft in the list gives the total number of equivalent coverages of the critical aircraft, $C_{CRTETotal}$, as:

$$C_{CRTETotal} = \sum_{I=1}^{N} C_{CRTEI} = \sum_{I=1}^{N} C_{CRTF} \times CDF_{CNVI} = C_{CRTF} \sum_{I=1}^{N} CDF_{CNVI}$$

Where N = the total number of aircraft in the list, including the critical aircraft.

Defining the total CDF for the traffic mix, CDF_T, as the total number of equivalent coverages of the critical aircraft divided by the number of coverages to failure of the critical aircraft, gives the equation:

$$CDF_T = \frac{C_{CRTETotal}}{C_{CRTF}} = \sum_{I=1}^{N} CDF_{CNVI} \qquad \text{(Equation A1-7)}$$

The total CDF for the traffic mix is therefore, by this definition, the sum of the CDFs of all of the aircraft in the traffic mix, including that of the critical aircraft.

Table A1-2 shows how the above calculations are combined, using the COMFAA Life calculation with the Batch option checked, to determine the equivalent traffic cycles of the critical aircraft. The pavement is assumed to be a flexible structure 33.80 inches thick on a CBR 8 subgrade. For this example, assume that the B747-400 is the critical aircraft. Also assume that the P/TC ratio is 1.0 so Traffic Cycles equals Annual Departures. Referring to the Top table, the CDF contribution of each aircraft on the pavement is calculated by dividing 20-year Coverages (Column 7) by Life (Column 9), with results shown in the Bottom portion of the table. The B747-400 is the assumed critical aircraft, so the operations of all other aircraft are equated to the B747-400. The results are shown in Column 11 of the Bottom portion of the table. Column 11 results use equation A1-6, i.e., (3000/0.6543)*Col. 10. The sum of the equivalent annual departures (Equation A1-7) indicates that all other aircraft are equivalent to 468 departures of the B747-400.

Figure A3-2. Example of COMFAA Batch Life Calculations

Top

CBR = 8.00
Evaluation pavement thickness = 33.80 in

Results Table: Life Computations

No.	Aircraft Name	Gross Weight	Percent Gross Wt	Tire Press	Annual Deps	6D Thick	20-yr Coverages	Life Thick	Coverages to Failure (Life)
1	A300-B4 STD	365,747	94.00	216.1	1,500	29.86	16,456	33.80	310,137
2	A319-100 std	141,978	92.60	172.6	1,200	22.08	6,443	33.80	1,602,794.6E+003
3	Adv. B727-200 Basic	185,200	96.00	148.0	400	25.09	2,754	33.80	385,343
4	B737-300	140,000	90.86	201.0	6,000	25.19	31,003	33.80	2,730,009.4E+002
5	B747-400	877,000	93.32	200.0	3,000	33.15	34,410	33.80	52,590
6	B767-200 ER	396,000	90.82	190.0	2,000	29.44	21,813	33.80	815,894
7	B777-200 ER	657,000	91.80	205.0	300	28.87	4,375	33.80	675,096
8	DC8-63	330,000	96.12	194.0	800	28.10	9,269	33.80	1,080,551

Bottom

Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6	Col. 7	Col. 8	Col. 9	Col. 10	Col. 11
									CDF	Equivalent Coverages
A300-B4 STD						16,456		310,137	0.0531	243
A319-100 std						6,443		1.60E+09	0.0000	0
Adv. B727-200 Basic						2,754		385,343	0.0071	33
B737-300						31,003		2.73E+08	0.0001	1
B747-400				**3,000**		**34,410**		**52,590**	**0.6543**	**3,000**
B767-200 ER						21,813		815,894	0.0267	123
B777-200 ER						4,375		675,096	0.0065	30
DC8-63						9,269		1,080,551	0.0086	39
								Totals	**0.7564**	**3,468**

The Top portion of the table can be viewed in the Details window in the program after executing the Life function for Flexible pavement with the program in the "MORE" mode. Pavement thickness and subgrade strength must be entered in the program for this function to work correctly. Results for all aircraft in the list will be computed and displayed if the Batch box is checked. Otherwise, results for only one aircraft are displayed. Detailed instructions are given later for operating the program.

Coverages to failure for each individual aircraft is computed in the program by changing the number of coverages for that aircraft until the design thickness by the CBR method (for flexible pavements) is the same as the evaluation pavement thickness, in this case 33.8 inches. As explained above, CDF is the ratio of applied coverages to coverages to failure, and is a measure of the amount of damage done to the pavement by that aircraft over a period of 20 years (under the assumptions implicit in the design procedure). If the CDF for any aircraft is equal to one, then the pavement is predicted to fail in 20 years if it is the only aircraft in operation. If the sum of the CDFs for all aircraft in the list is equal to one, then the pavement is predicted to fail in 20 years with all of the aircraft operating at their assumed operating weights and annual departures. The sum of the CDFs in this example is 0.7564, indicating that the pavement is being operated under a set of conservative assumptions.

It should be noted that the sum of the CDFs as calculated in COMFAA do not strictly provide a prediction of pavement damage caused by the accumulation of damage from all of the aircraft because not all of the aircraft landing gears pass down the same longitudinal path. The summation given here would therefore provide a somewhat conservative result than expected. In comparison with the FAARFIELD computer program, the COMFAA values correspond to the “CDF Max for Aircraft” values from FAARFIELD. The “CDF Contribution” values from FAARFIELD are summed along defined longitudinal paths and do not correspond to the values from COMFAA, except when the Contribution and Max for Aircraft values coincide. This discussion indicates how, all other things being equal, the equivalent critical aircraft concept used in FAA’s CBR and Westergaard methods and in COMFAA, produces more conservative designs than the procedure used in FAARFIELD, and why the two methodologies can never be made to produce the same predictions of pavement life for different traffic mixes.

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APPENDIX 2. TECHNICAL EVALUATION METHOD—EVALUATION PAVEMENT PROPERTIES DETERMINATION

1.0. TECHNICAL EVALUATION METHOD.

The Technical Evaluation method for determining a PCN requires pavement thickness and cross-sectional properties as well as traffic mix details.

1.1 FLEXIBLE PAVEMENT CROSS-SECTION PROPERTIES—EQUIVALENT THICKNESS DETERMINATION.

The thickness of the flexible pavement section under consideration must be referenced to standard flexible pavement sections for evaluation purposes. The standard section is the total thickness requirement calculated by the COMFAA program assuming minimum layer thickness for the asphalt surface, minimum base layer thickness of material with a CBR 80 or higher, and a variable thickness subbase layer with a CBR 20 or greater. Two reference pavement sections are used.

When no aircraft in the traffic mix have four or more wheels on a main gear, the minimum asphalt surface course thickness requirement is 3 inches and the minimum high quality crushed aggregate base course thickness requirement is 6 inches.

When one or more aircraft in the traffic mix have four or more wheels on a main gear, the minimum asphalt surface course thickness requirement is 5 inches and the minimum high quality crushed aggregate base course thickness requirement is 8 inches.

Structural Layer Thickness (inches)	Less than Four Wheels on Main Gear	Four or More Wheels on Main Gear
Asphaltic Concrete (FAA Item P-401)	3	5
High Quality Granular Base (FAA Item P-209)	6	8

If the pavement has excess material or improved materials, the total pavement thickness may be increased according to the FAA CBR method summarized herein as Figures A2-1 and A2-2 and Table A2-1. The pavement is considered to have excess asphalt, which can be converted to extra equivalent thickness, when the asphalt thickness is greater than the minimum thickness of asphalt surfacing of the referenced pavement section. The pavement may also be considered to have excess aggregate base thickness when the cross-section has a high quality crushed aggregate base thickness greater than the minimum thickness of high quality crushed aggregate base of the referenced pavement section or when other improved materials, such as asphalt stabilization or cement treated materials, are present. Likewise, additional improved base materials may also be converted to additional subbase material to add to the total pavement thickness.

If the evaluation pavement section is deficient for asphalt pavement surface course (i.e. less than 3 inches) and/or high quality crushed aggregate base course (i.e. less than 6 inches), the subbase thickness is reduced using a slightly more conservative inverse layer equivalency factor for surface course material and/or the subbase thickness is reduced using a slightly more conservative inverse layer equivalency factor for high quality crushed aggregate base material. This is shown in Table A2-1.

Table A2-1. FAA Flexible Pavement Layer Equivalency Factor Range

Structural Item	Description	Range Convert to P-209	Recommended Convert to P-209	Range Convert to P-154	Recommended Convert to P-154
P-501	Portland Cement Concrete (PCC)	--	--	--	--
P-401	Plant Mix Bituminous Pavements (HMA)	1.2 to 1.6	1.6	1.7 to 2.3	2.3
P-403	Plant Mix Bituminous Pavements (HMA)	1.2 to 1.6	1.6	1.7 to 2.3	2.3
P-306	Econocrete Subbase Course (ESC)	1.2 to 1.6	1.2	1.6 to 2.3	1.6
P-304	Cement Treated Base Course (CTB)	1.2 to 1.6	1.2	1.6 to 2.3	1.6
P-212	Shell Base Course	--	--	--	--
P-213	Sand-Clay Base Course	--	--	--	--
P-220	Caliche Base Course	--	--	--	--
P-209	Crushed Aggregate Base Course	1.0	1.0	1.2 to 1.6	1.4
P-208	Aggregate Base Course	1.0	1.0	1.0 to 1.5	1.2
P-211	Lime Rock Base Course	1.0	1.0	1.0 to 1.5	1.2
P-301	Soil-Cement Base Course	n/a	--	1.0 to 1.5	1.2
P-154	Subbase Course	n/a	--	1.0	1.0
P-501	Portland Cement Concrete (PCC)	Range Convert to P-401 2.2 to 2.5, 2.5 Recommended			

When there is not sufficient material to obtain a standard reference surface and/or crushed aggregate base course thickness, the subbase thickness is reduced using a conservative inverse of the layer equivalency factor for the material.

	P-154 thickness reduction to meet P-401 requirement.	P-154 thickness reduction to meet P-209 requirement.
P-154 is reduced by	Thickness deficiency * 1/(P-401 layer equivalency factor used for P-154 +0.1) e.g. if 2.3 is the factor to convert P-401 to P-154, then (1/2.4) is the factor to convert P-154 to P-401.	Thickness deficiency * 1/(P-209 layer equivalency factor used for P-154 +0.1) e.g. if 1.4 is the factor to convert P-209 to P-154, then (1/1.5) is the factor 130 to convert P-154 to P-209

1.2 RIGID PAVEMENT CROSS-SECTION PROPERTIES—IMPROVED SUBGRADE SUPPORT DETERMINATION. The rigid pavement characteristics—including subgrade soil modulus, k, the concrete thickness, and flexural strength—are needed for PCN determination. The foundation modulus (k value) is assigned to the material directly beneath the concrete pavement layer. However, the k value for the subgrade is determined and then corrected to account for improved layers (subbases) between the subgrade and the concrete layer. There are k value corrections available for uncrushed aggregate subbases, crushed aggregate subbases, and subbases stabilized with asphalt cement or Portland cement. The k value may be increased according to the methods described in the FAA Westergaard method, summarized herein as Figures A2-3 through A2-6. The thickness of the concrete in a rigid pavement may be increased if an asphalt overlay has been placed on the surface. The thickness may be increased using the factor described in the FAA Westergaard method, summarized herein as Figure A2-7. Each 2.5 inches of asphalt may be converted to 1.0 inch of concrete. The references for both improvement subgrade support guidance and additional thickness conversion guidance is summarized in Table A2-2.

Table A2-2. FAA Rigid Pavement Subbase Effect on Foundation k Value

FAA Pavement Layer	Effect When Uncrushed Aggregate (Bank Run Sand and Gravel) is Used as the Subbase	Effect When Well-Graded Crushed Aggregate is Used as the Subbase	Effect When Asphalt Cement or Portland Cement Stabilized Materials are Used as the Subbase
P-401 and/or P-403			Ref. Figure A2-6
P-306			Ref. Figure A2-6
P-304			Ref. Figure A2-6
P-209		Ref. Figure A2-5, Upper Graph	
P-208 and/or P-211	Ref. Figure A2-5, Lower Graph		
P-301	Ref. Figure A2-5, Lower Graph		
P-154	Ref. Figure A2-5, Lower Graph		
	Effect on Rigid Pavement Thickness		
P-401 Overlay	Ref. Figure A2-7		

2.0 AVAILABILITY OF SUPPORT PROGRAM TO DETERMINE PAVEMENT CHARACTERiSTICS.

To facilitate the use of the ACN-PCN system, FAA developed a software application that incorporates the guidance in this appendix and determines the evaluation thickness for both flexible and rigid pavements and the foundation k value for rigid pavements. The software may be downloaded from the FAA website.

2.1 USING THE SUPPORT PROGRAM.

The support program is visually interactive and intuitive, as shown in Figures A2-8 and A2-9.

320. **STABILIZED BASE AND SUBBASE.** Stabilized base and subbase courses are necessary for new pavements designed to accommodate jet aircraft weighing 100,000 pounds (45 350 kg) or more. These stabilized courses may be substituted for granular courses using the equivalency factors discussed in paragraph 322. These equivalency factors are based on research studies which measured pavement performance. See FAA Report No. FAA-RD-73-198, Volumes I, II, and III. Comparative Performance of Structural Layers in Pavement Systems. See Appendix 3. A range of equivalency factors is given because the factor is sensitive to a number of variables such as layer thickness, stabilizing agent type and quantity, location of stabilized layer in the pavement structure, etc. Exceptions to the policy requiring stabilized base and subbase may be made on the basis of superior materials being available, such as 100 percent crushed, hard, closely graded stone. These materials should exhibit a remolded soaked CBR minimum of 100 for base and 35 for subbase. In areas subject to frost penetration, the materials should meet permeability and nonfrost susceptibility tests in addition to the CBR requirements. Other exceptions to the policy requiring stabilized base and subbase should be based on proven performance of a granular material such as lime rock in the State of Florida. Proven performance in this instance means a history of satisfactory airport pavements using the materials. This history of satisfactory performance should be under aircraft loadings and climatic conditions comparable to those anticipated.

321. **SUBBASE AND BASE EQUIVALENCY FACTORS.** It is sometimes advantageous to substitute higher quality materials for subbase and base course than the standard FAA subbase and base material. The structural benefits of using a higher quality material is expressed in the form of equivalency factors. Equivalency factors indicate the substitution thickness ratios applicable to various higher quality layers. Stabilized subbase and base courses are designed in this way. Note that substitution of lesser quality materials for higher quality materials, regardless of thickness, is not permitted. The designer is reminded that even though structural considerations for flexible pavements with high quality subbase and base may result in thinner flexible pavements; frost effects must still be considered and could require thicknesses greater than the thickness for structural considerations.

a. **Minimum Total Pavement Thickness.** The minimum total pavement thickness calculated, after all substitutions and equivalencies have been made, should not be less than the total pavement thickness required by a 20 CBR subgrade on the appropriate design curve.

b. **Granular Subbase.** The FAA standard for granular subbase is Item P-154, Subbase Course. In some instances it may be advantageous to utilize nonstabilized granular material of higher quality than P-154 as subbase course. Since these materials possess higher strength than P-154, equivalency factor ranges are established whereby a lesser thickness of high quality granular may be used in lieu of the required thickness of P-154. In developing the equivalency factors the standard granular subbase course, P-154, was used as the basis. Thicknesses computed from the design curves assume P-154 will be used as the subbase. If a granular material of higher quality is substituted for Item P-154, the thickness of the higher quality layer should be less than P-154. The lesser thickness is computed by dividing the required thickness of granular subbase, P-154, by the appropriate equivalency factor. In establishing the equivalency factors the CBR of the standard granular subbase, P-154, was assumed to be 20. The equivalency factor ranges are given below in Table 3-6:

TABLE 3-6. RECOMMENDED EQUIVALENCY FACTOR RANGES FOR HIGH QUALITY GRANULAR SUBBASE

Material	Equivalency Factor Range
P-208, Aggregate Base Course	1.0 - 1.5
P-209, Crushed Aggregate Base Course	1.2 - 1.8
P-2 I1, Lime Rock Base Course	1.0 - 1.5

Figure A2-1. Flexible Pavement Stabilized Base Layer(s) Equivalency Discussion. (FAA CBR method)

c. **Stabilized Subbase.** Stabilized subbases also offer considerably higher strength to the pavement than P-154. Recommended equivalency factors associated with stabilized subbase are presented in Table 3-7.

TABLE 3-7. RECOMMENDED EQUWALENCY FACTOR RANGES FOR STABILIZED SUBBASE

Material	Equivalency Factor Range
P-301, Soil Cement Base Course	1.0 - 1.5
P-304, Cement Treated Base Course	1.6 - 2.3
P-306, Econocrete Subbase Course	1.6 - 2.3
P-401, Plant Mix Bituminous Pavements	1.7 - 2.3

d. **Granular Base.** The FAA standard for granular base is Item P-209, Crushed Aggregate Base Course. In some instances it may be advantageous to utilize other nonstabilized granular material as base course. Other materials acceptable for use as granular base course are as follows:

TABLE 3-8. RECOMMENDED EQUIVALENCY FACTOR RANGES FOR GRANULAR BASE

Material	Equivalency Factor Range
P-208, Aggregate Base Course	1.0'
P-21 1, Lime Rock Base Course	1.0

'Substitution of P-208 for P-209 is permissible only if the gross weight of the design aircraft is 60,000 lbs (27 000 kg) or less. In addition, if P-208 is substituted for P-209, the required thickness of hot mix asphalt surfacing shown on the design curves should be increased 1 inch (25 mm).

e. **Stabilized Base.** Stabilized base courses offer structural benefits to a flexible pavement in much the same manner as stabilized subbase. The benefits are expressed as equivalency factors similar to those shown for stabilized subbase. In developing the equivalency factors Item P-209, Crushed Aggregate Base Course, with an assumed CBR of 80 was used as the basis for comparison. The thickness of stabilized base is computed by dividing the granular base course thickness requirement by the appropriate equivalency factor. The equivalency factor ranges are given below in Table 3-9. Ranges of equivalency factors are shown rather than single values since variations in the quality of materials, construction techniques, and control can influence the equivalency factor. In the selection of equivalency factors, consideration should be given to the traffic using the pavement, total pavement thickness, and the thickness of the individual layer. For example, a thin layer in a pavement structure subjected to heavy loads spread over large areas will result in an equivalency factor near the low end of the range. Conversely, light loads on thick layers will call for equivalency factors near the upper end of the ranges.

TABLE 3-9. RECOMMENDED EQUIVALENCY FACTOR RANGES FOR STABILIZED BASE

Material	Eauivalencv Factor Range
P-304, Cement Treated Base Course	1.2 - 1.6
P-306, Econocrete Subbase Course	1.2 - 1.6
P-401, Plant Mix Bituminous Pavements	1.2 - 1.6

Note: Reflection cracking may be encountered when P-304 or P-306 is used as base for a flexible pavement. The thickness of the hot mix asphalt surfacing course should be at least 4 inches (100 mm) to minimize reflection cracking in these instances.

f. **Example.** As an example of the use of equivalency factors, assume a flexible pavement is required to serve a design aircraft weighing 300,000 pounds (91 000 kg) with a dual tandem gear. The equivalent annual departures are 15,000. The design CBR for the subgrade is 7. Item P-401 will be used for the base course and the subbase course.

Figure A2-2. Flexible Pavement Stabilized Base Layer(s) Equivalency Discussion (Continued). (FAA CBR method)

324. GENERAL. Rigid pavements for airports are composed of Portland cement concrete placed on a granular or treated subbase course that is supported on a compacted subgrade. Under certain conditions, a subbase is not required (see paragraph 326).

325. CONCRETE PAVEMENT. The concrete surface must provide a nonskid surface, prevent the infiltration of surface water into the subgrade, and provide structural support to the aircraft. The quality of the concrete, acceptance and control tests, methods of construction and handling, and quality of workmanship are covered in Item P-501, Portland Cement Concrete Pavement.

326. SUBBASE. The purpose of a subbase under a rigid pavement is to provide uniform stable support for the pavement slabs. A minimum thickness of 4 inches (100 mm) of subbase is required under all rigid pavements, except as shown in Table 3-10 below:

TABLE 3-10. CONDITIONS WHERE NO SUBBASE IS REQUIRED

Soil Classification	Good Drainage		Poor Drainage	
	No Frost	Frost	No Frost	Frost
GW	X	X	X	X
GP	X	X	X	
GM	X			
GC	X			
SW	X			

Note: X indicates conditions where no subbase is required.

327. SUBBASE QUALITY. The standard FAA subbase for rigid pavements is 4 inches (100 mm) of Item P-154, Subbase Course. In some instances, it may be desirable to use higher-quality materials or thicknesses of P-154 greater than 4 inches (100 mm). The following materials are acceptable for use as subbase under rigid pavements:

Item P-154 – Subbase Course
Item P-208 – Aggregate Base Course
Item P-209 – Crushed Aggregate Base Course
Item P-211 – Lime Rock Base Course
Item P-304 – Cement Treated Base Course
Item P-306 – Econocrete Subbase Course
Item P-401 – Plant Mix Bituminous Pavements

Materials of higher quality than P-154 and/or greater thicknesses of subbase are considered in the design process through the foundation modulus (k value). The costs of providing the additional thickness or higher-quality subbase should be weighed against the savings in concrete thickness.

328. STABILIZED SUBBASE. Stabilized subbase is required for all new rigid pavements designed to accommodate aircraft weighing 100,000 pounds (45 400 kg) or more. Stabilized subbases are as follows:

Item P-304 – Cement Treated Base Course
Item P-306 – Econocrete Subbase Course
Item P-401 – Plant Mix Bituminous Pavements

The structural benefit imparted to a pavement section by a stabilized subbase is reflected in the modulus of subgrade reaction assigned to the foundation. Exceptions to the policy of using stabilized subbase are the same as those given in paragraph 320.

329. SUBGRADE. As with a flexible pavement, the subgrade materials under a rigid pavement should be compacted to provide adequate stability and uniform support; however, the compaction requirements for rigid pavements are not as stringent as for flexible pavement because of the relatively lower subgrade stress. For cohesive soils used in fill sections, the top 6 inches (150 mm) must be compacted to 90 percent maximum density. Fill depths

Figure A2-3. Rigid Pavement Stabilized Subbase Layer(s) Discussion. (FAA Westergaard method)

greater than 6 inches (150 mm) must be compacted to 90 percent maximum density or meet the requirements of Table 3-2. For cohesive soils in cut sections, the top 6 inches (150 mm) of the subgrade must be compacted to 90 percent maximum density. For noncohesive soils used in fill sections, the top 6 inches (150 mm) of fill must be compacted to 100 percent maximum density, and the remainder of the fill must be compacted to 95 percent maximum density or meet the requirements of Table 3-2. For cut sections in noncohesive soils, the top 6 inches (150 mm) of subgrade must be compacted to 100 percent maximum density and the next 18 inches (460 mm) of subgrade must be compacted to 95 percent maximum density. Swelling soils require special considerations. Paragraph 314 contains guidance on the identification and treatment of swelling soils.

a. Contamination. In rigid pavement systems, repeated loading might cause intermixing of soft subgrade soils and aggregate base or subbase. This mixing can create voids below the pavement in which moisture can accumulate, causing pumping to occur. Chemical and mechanical stabilization of the subbase or subgrade can effectively reduce aggregate contamination (see paragraph 207). Geotextiles have been found to be effective at providing separation between fine-grained subgrade soils and pavement aggregates (FHWA-HI-90-001 Geotextile Design and Construction Guidelines). Geotextiles should be considered for separation between fine-grained soils and overlying pavement aggregates. In this application, the geotextile is not considered to act as a structural element within the pavement. Therefore, the modulus of the base or subbase is not increased when a geotextile is used for stabilization. For separation applications, the geotextile is designed based on survivability properties. FHWA-HI-90-001 contains additional information about design and construction using separation geotextiles.

330. DETERMINATION OF FOUNDATION MODULUS (k VALUE) FOR RIGID PAVEMENT. In addition to the soils survey and analysis and classification of subgrade conditions, rigid pavement design also requires the determination of the foundation modulus. The k value should be assigned to the material directly beneath the concrete pavement. However, the FAA recommends that a k value be established for the subgrade and then corrected to account for the effects of the subbase.

a. Determination of k Value for Subgrade. The preferred method of determining the subgrade modulus is by testing a limited section of embankment that has been constructed to the required specifications. The plate bearing test procedures are given in AASHTO T 222, Nonrepetitive Static Plate Load Test of Soils and Flexible Pavement Components for Use in Evaluation and Design of Airport and Highway Pavements. If the construction and testing of a test section of embankment is impractical, the values listed in Table 2-3 may be used. The values in Table 2-3, however, are approximate, and engineering judgment should be used when selecting a design value. Fortunately, rigid pavement is not overly sensitive to k value, and an error in estimating k will not have a large impact on rigid pavement thickness.

b. Determination of k Value for Granular Subbase. It is usually not practical to determine a foundation modulus on top of a subbase by testing, at least in the design phase. Usually, the embankment and subbase will not be in place in time to perform any field tests, so the k value will have to be assigned without the benefit of testing. The probable increase in k value associated with various thicknesses of different subbase materials is shown in Figure 2-4. The upper graph in Figure 2-4 should be used when the subbase is composed of well-graded crushed aggregate, such as P-209. The lower graph in Figure 2-4 applies to bank-run sand and gravel, such as P-154. Both curves in Figure 2-4 apply to unstabilized granular materials. Values shown in Figure 2-4 are guides and can be tempered by local experience.

c. Determination of k Value for Stabilized Subbase. As with granular subbase, the effect of stabilized subbase is reflected in the foundation modulus. Figure 3-16 shows the probable increase in k value with various thicknesses of stabilized subbase located on subgrades of varying moduli. Figure 3-16 is applicable to cement stabilized (P-304), Econocrete (P-306), and bituminous stabilized (P-401) layers. Figure 3-16 assumes a stabilized layer is twice as effective as well-graded crushed aggregate in increasing the subgrade modulus. Stabilized layers of lesser quality than P-304, P-306, or P-401 should be assigned somewhat lower k values. After a k value is assigned to the stabilized subbase, the concrete slab thickness design procedure is the same as that described in paragraph 331.

Figure A2-4. Rigid Pavement Stabilized Subbase Layer(s) Discussion (Continued). (FAA Westergaard method)

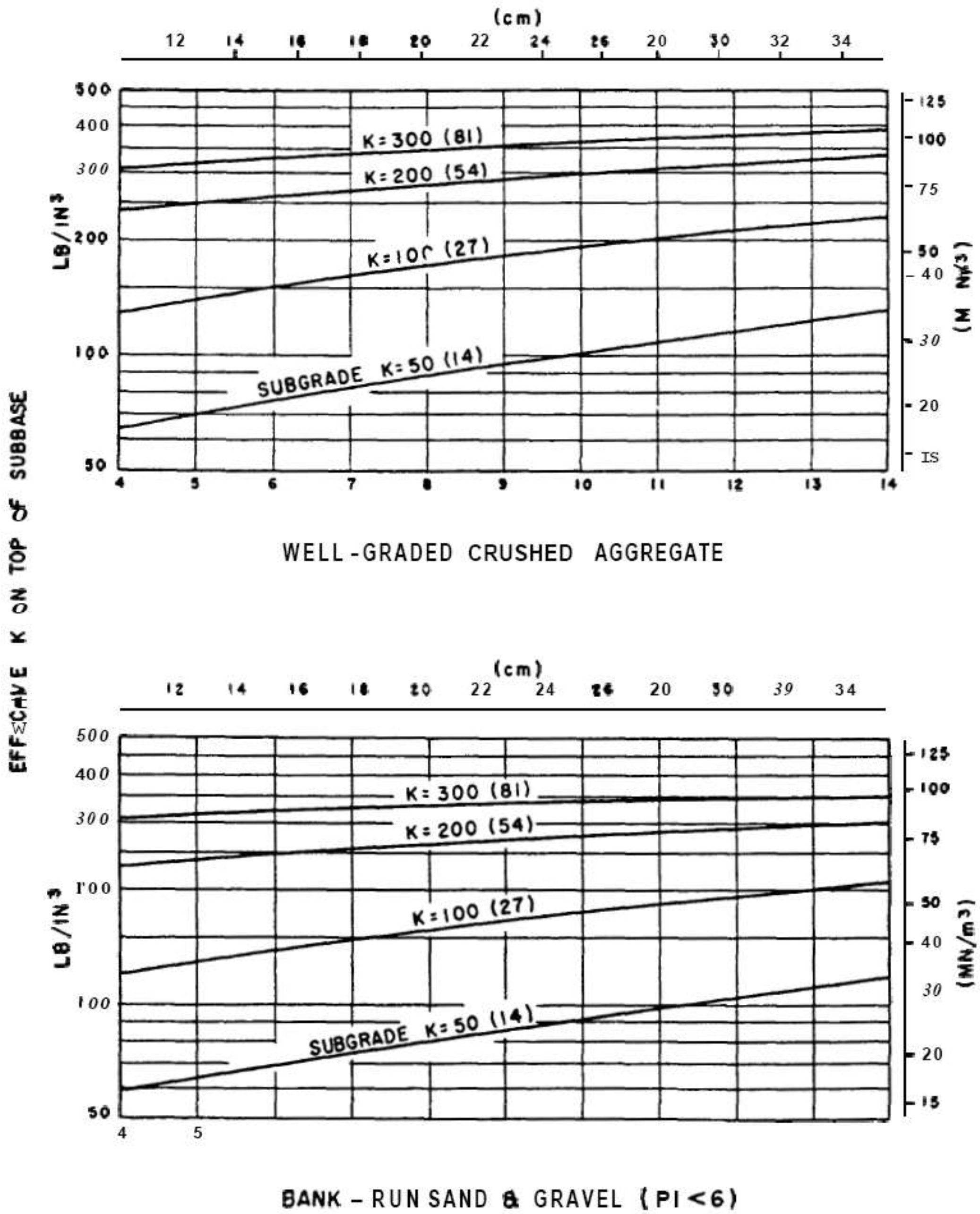

Figure A2-5. Subbase Layer Effect on Subgrade Support, k, for Rigid Pavement. (FAA Westergaard method)

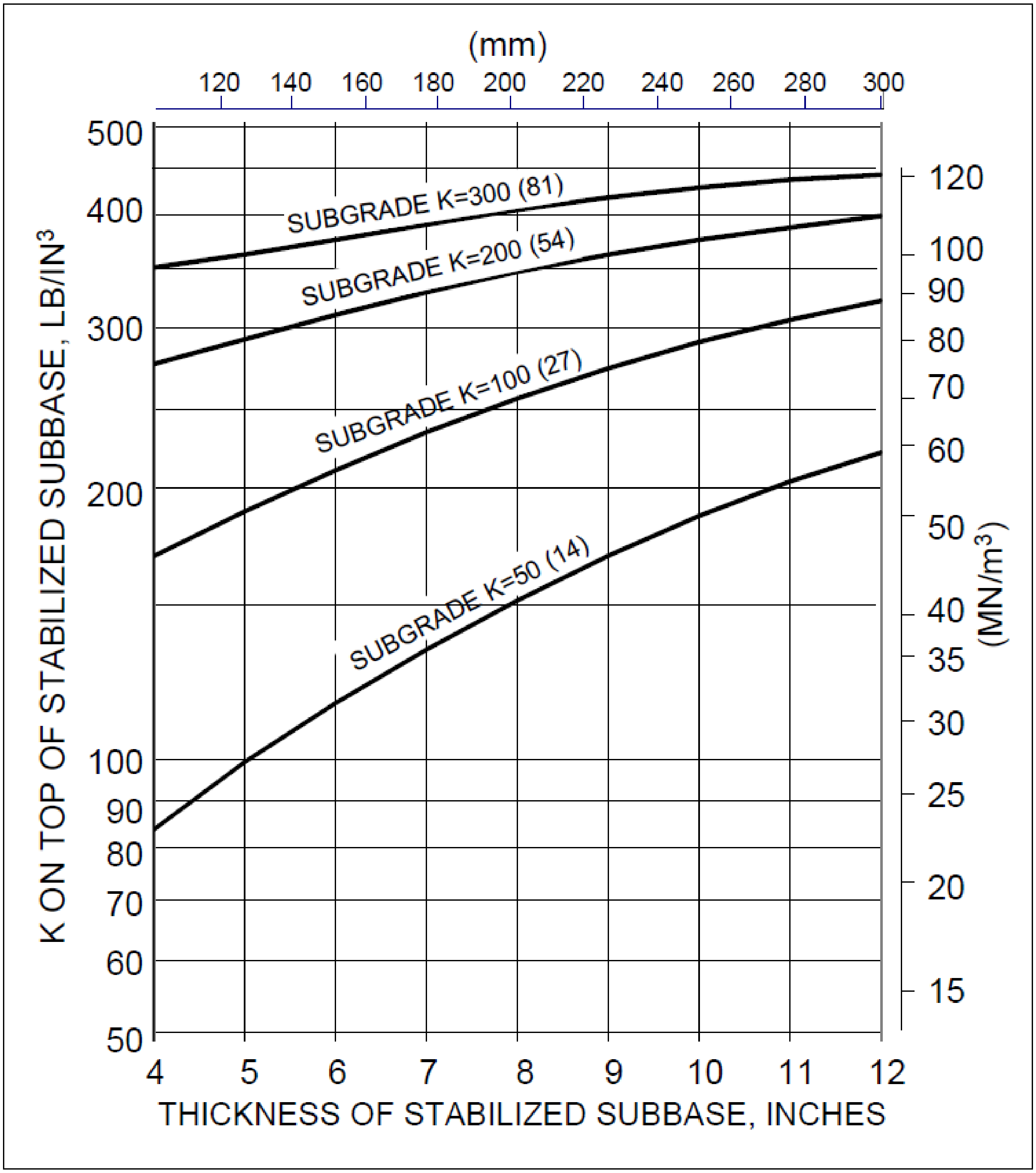

Figure A2-6. Stabilized Subbase Layer Effect on Subgrade Support, k, for Rigid Pavement. (FAA Westergaard method)

subbase must be at the equilibrium moisture content when field CBR tests are conducted. Normally, a pavement that has been in place for at least 3 years will be in equilibrium. Procedures for calculating CBR values from NDT tests are also available. Layer conversions (i.e., converting base to subbase, etc.) are largely a matter of engineering judgment. When performing the conversions, it is recommended that any converted thicknesses not be rounded off.

406. HOT MIX ASPHALT OVERLAY ON EXISTING RIGID PAVEMENT. The design of a hot mix asphalt overlay on an existing rigid pavement is also based on a thickness deficiency approach. However, new pavement thickness requirements for rigid pavements are used to compare with the existing rigid pavement. The formula for computing overlay thickness is as follows:

$$t = 2.5(Fh_d - C_b h_e)$$

Where:

t = thickness of hot mix asphalt overlay, inches (mm).
F = a factor which controls the degree of cracking in the base rigid pavement.
h_d = thickness of new rigid pavement required for design conditions, inches (mm). Use the exact value for h_d; do not round off. In calculating h_d use the k value of the existing foundation and the flexural strength of the existing concrete as design parameters.
C_b = a condition factor that indicates the structural integrity of the existing rigid pavement. Values range from 1.0 to 0.75.
h_e = thickness of existing rigid pavement, inches (mm).

a. F Factor. The "F" factor is an empirical method of controlling the amount of cracking that will occur in the rigid pavement beneath the hot mix asphalt overlay. It is a function of the amount of traffic and the foundation strength. The assumed failure mode for a hot mix asphalt overlay on a existing rigid pavement is that the underlying rigid pavement cracks progressively under traffic until the average size of the slab pieces reaches a critical value. Further traffic beyond this point results in shear failures within the foundation, producing a drastic increase in deflections. Since high strength foundations can better resist deflection and shear failure, the F factor is a function of subgrade strength as well as traffic volume. Photographs of various overlay and base pavements shown in Figure 4-2 illustrate the meaning of the F factor. Figures 4-2a, b, and c show how the overlay and base pavements fail as more traffic is applied to a hot mix asphalt overlay on an existing rigid pavement. Normally an F factor of 1.0 is recommended unless the existing pavement is in quite good condition, see paragraph 406b(1) below. Figure 4-3 should be used to determine the appropriate F factor for pavements in good condition.

b. C_b Factor. The condition factor "C_b" applies to the existing rigid pavement. The C_b factor is an assessment of the structural integrity of the existing pavement.

(1) Selection of C_b Factor. The overlay formula is rather sensitive to the C_b value. A great deal of care and judgement are necessary to establish the appropriate C_b. NDT can be a valuable tool in determining a proper value. A C_b value of 1.0 should be used when the existing slabs contain nominal structural cracking and 0.75 when the slabs contain structural cracking. The designer is cautioned that the range of C_b values used in hot mix asphalt overlay designs is different from the "C_r" values used in rigid overlay pavement design. A comparison of C_b and C_r and the recommended F factor to be used for design is shown below:

C_r	C_b	Recommended F factor
0.35 to 0.50	0.75 to 0.80	1.00
0.51 to 0.75	0.81 to 0.90	1.00
0.76 to 0.85	0.91 to 0.95	1.00
0.86 to 1.00	0.96 to 1.00	Use Figure 4.3

The minimum C_b value is 0.75. A single C_b should be established for an entire area. The C_b value should not be varied along a pavement feature. Figures 4-4 and 4-5 illustrate C_b values of 1.0 and 0.75, respectively.

Figure A2-7. Flexible Pavement quivalency to Rigid Pavement. (FAA Westergaard method)

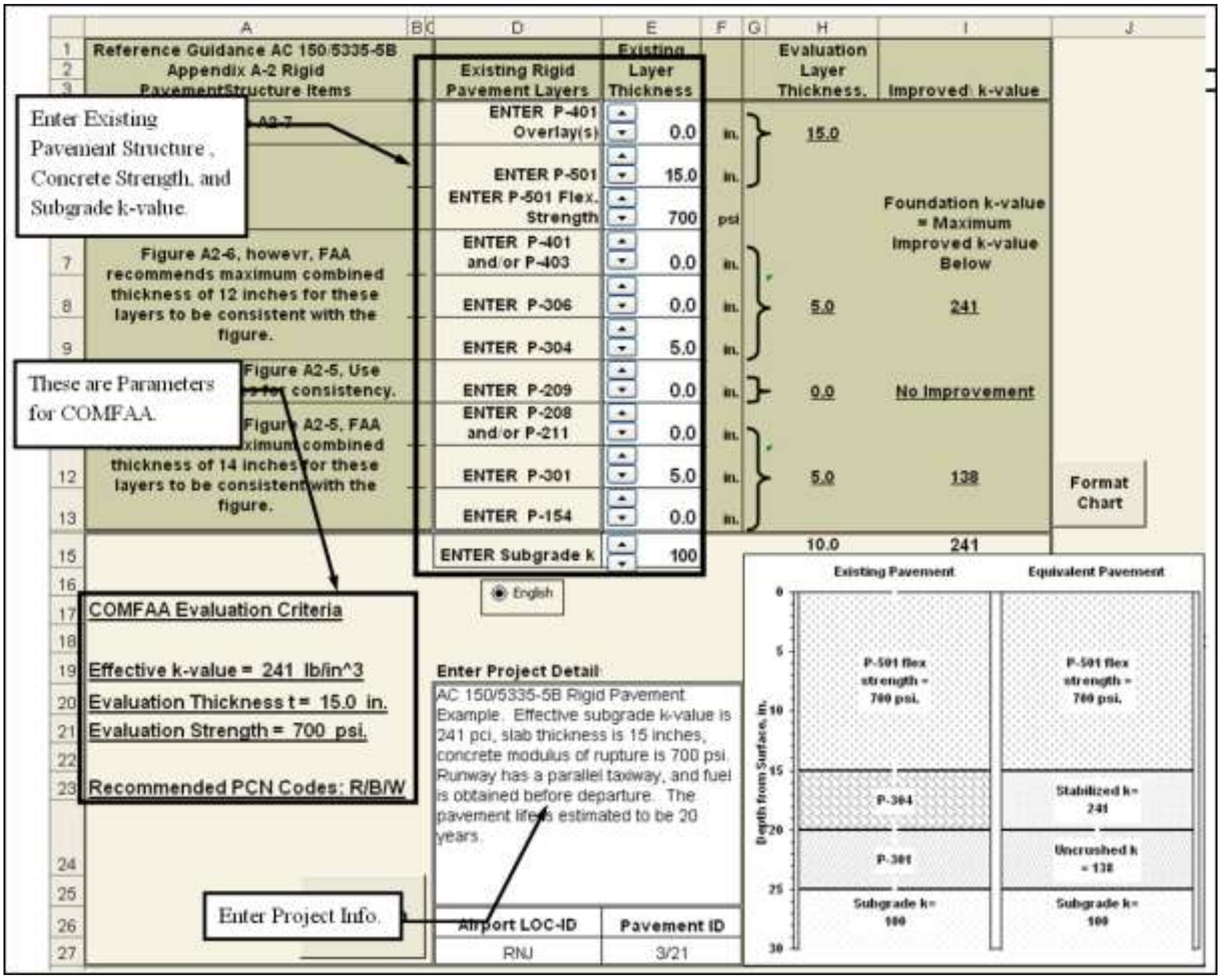

Figure A2-8. Rigid Pavement k Value. (FAA Westergaard method)

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APPENDIX 3. PCN DETERMINATION EXAMPLES

1.0. The Using Aircraft Method.

The Using aircraft method of determining PCN is presented in the following steps. This procedure can be used when there is limited knowledge of the existing traffic and runway characteristics. It is also useful when engineering analysis is neither possible nor desired. Airport authorities should be more careful in the application of a Using aircraft PCN in that the rating has not been rigorously determined.

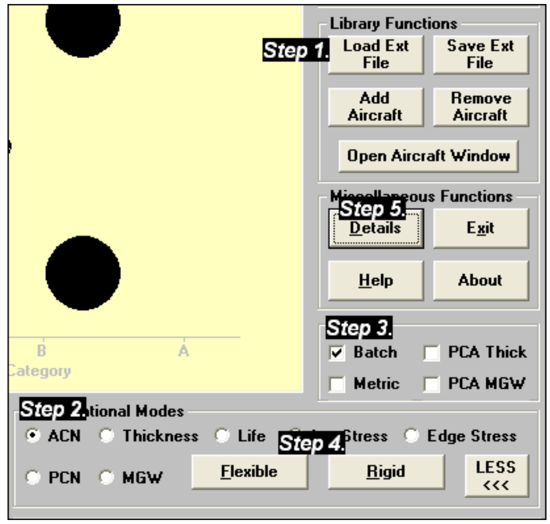
There are two basic steps required to arrive at a Using aircraft PCN:

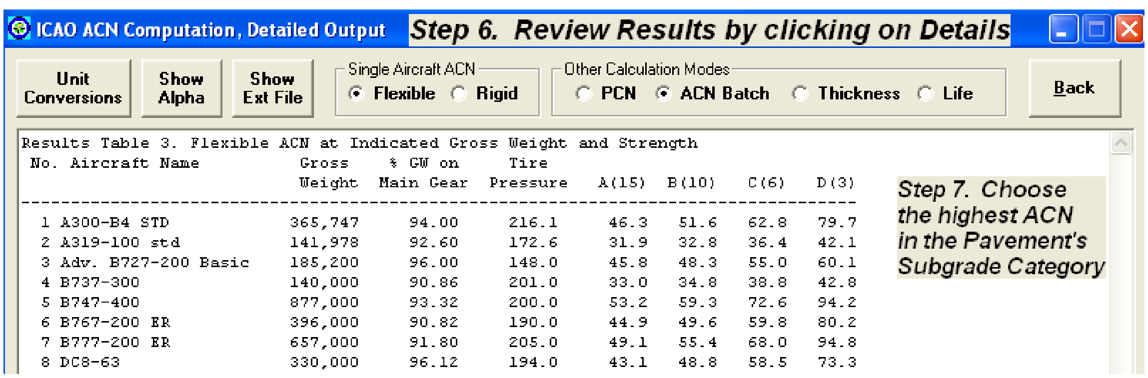
- Determine the ACN for each aircraft in the traffic mix currently using the pavement**.**

- Assign the highest ACN value as the PCN.

These steps are explained below in greater detail. Figure A3-1 shows the steps needed to automatically perform the ACN calculations using COMFAA along with the results.

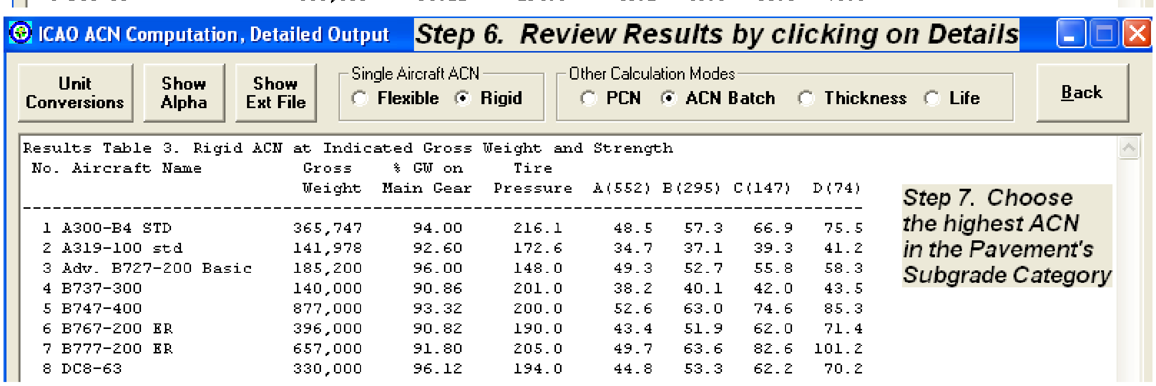
1. Load Ext file.
2. Click More to access ACN Computational Mode.
3. Check Batch.
4. Click Flexible Button or Rigid Button.
5. When calculations finish, click Details Button.
6. View results.
7. Select highest ACN for the pavement's subgrade category.





Results Table 3. Flexible ACN at Indicated Gross Weight and Strength

No.	Aircraft Name	Gross Weight	% GW on Main Gear	Tire Pressure	A(15)	B(10)	C(6)	D(3)
1	A300-B4 STD	365,747	94.00	216.1	46.3	51.6	62.8	79.7
2	A319-100 std	141,978	92.60	172.6	31.9	32.8	36.4	42.1
3	Adv. B727-200 Basic	185,200	96.00	148.0	45.8	48.3	55.0	60.1
4	B737-300	140,000	90.86	201.0	33.0	34.8	38.8	42.8
5	B747-400	877,000	93.32	200.0	53.2	59.3	72.6	94.2
6	B767-200 ER	396,000	90.82	190.0	44.9	49.6	59.8	80.2
7	B777-200 ER	657,000	91.80	205.0	49.1	55.4	68.0	94.8
8	DC8-63	330,000	96.12	194.0	43.1	48.8	58.5	73.3



Results Table 3. Rigid ACN at Indicated Gross Weight and Strength

No.	Aircraft Name	Gross Weight	% GW on Main Gear	Tire Pressure	A(552)	B(295)	C(147)	D(74)
1	A300-B4 STD	365,747	94.00	216.1	48.5	57.3	66.9	75.5
2	A319-100 std	141,978	92.60	172.6	34.7	37.1	39.3	41.2
3	Adv. B727-200 Basic	185,200	96.00	148.0	49.3	52.7	55.8	58.3
4	B737-300	140,000	90.86	201.0	38.2	40.1	42.0	43.5
5	B747-400	877,000	93.32	200.0	52.6	63.0	74.6	85.3
6	B767-200 ER	396,000	90.82	190.0	43.4	51.9	62.0	71.4
7	B777-200 ER	657,000	91.80	205.0	49.7	63.6	82.6	101.2
8	DC8-63	330,000	96.12	194.0	44.8	53.3	62.2	70.2

Figure A3-1. Example of COMFAA ACN Batch Results for Flexible and Rigid Pavements.

1. Assign the pavement surface type as code F or R.

2. From available records, determine the average strength of the pavement subgrade. If the subgrade strength is not known, make a judgment of High, Medium, Low, or Ultra Low.

3. Determine which aircraft has the highest ACN from a list of aircraft that are presently using the pavement, based on the surface type code assigned in Step 1 and the subgrade code in Step 2. ACN values may be determined from the COMFAA program or from ACN graphs found in the manufacturer's published ACAP manuals. Use the same subgrade code for each of the aircraft when determining the maximum ACN. Base ACNs on the highest operating weight of the aircraft at the airport if the data is available; otherwise, use an estimate or the published maximum allowable gross weight of the aircraft in question. Report the ACN from the aircraft with the highest ACN that ***regularly uses the pavement*** as the PCN for the pavement.

4. The PCN is simply the highest ACN with appropriate tire pressure and evaluation codes added. The numerical value of the PCN may be adjusted up or down at the preference of the airport authority. Reasons for adjustment include local restrictions, allowances for certain aircraft, or pavement conditions.

5. The tire pressure code (W, X, Y, or Z) should represent the highest tire pressure of the aircraft fleet currently using the pavement. For flexible pavements, code X should be used if no higher tire pressure is evident from among the existing traffic. It is commonly understood that concrete can tolerate substantially higher tire pressures, so the rigid pavement rating should normally be given as W.

6. The evaluation method for the Using aircraft method is reported as U.

1.1 USING AIRCRAFT EXAMPLE FOR FLEXIBLE PAVEMENTS.

The following example illustrates the Using aircraft PCN process for flexible pavements:

An airport has a runway with the following traffic mix: (from COMFAA Open Aircraft Window)

No.	Aircraft Name	Gross Weight (lbs)	Percent GW on Gears	Tire Press. (psi)	Annual Departures	No. of Tires on Gear	Number of Gears
1	A300-B4 STD	365,747	94.00	216.1	1,500	4	2
2	A319-100 std	141,978	92.60	172.6	1,200	2	2
3	Adv. B727-200 Basic	185,200	96.00	148.0	400	2	2
4	B737-300	140,000	90.86	201.0	6,000	2	2
5	B747-400	877,000	93.32	200.0	3,000	4	4
6	B767-200 ER	396,000	90.82	190.0	2,000	4	2
7	B777-200 ER	657,000	91.80	205.0	300	6	2
8	DC8-63	330,000	96.12	194.0	800	4	2

The runway has a flexible (asphalt-surfaced) pavement with a subgrade strength of CBR 9 and flexible pavement ACNs shown in Table A3-1.

Table A3-1. Using Aircraft and Traffic for a Flexible Pavement

ICAO ACN Computation, Detailed Output

Unit Conversions | Show Alpha | Show Ext File | Single Aircraft ACN: (•) Flexible ( ) Rigid | Other Calculation Modes: ( ) PCN (•) ACN Batch ( ) Thickness

Results Table 3. Flexible ACN at Indicated Gross Weight and Strength

No.	Aircraft Name	Gross Weight	% GW on Main Gear	Tire Pressure	A(15)	B(10)	C(6)	D(3)
1	A300-B4 STD	365,747	94.00	216.1	46.3	51.6	62.8	79.7
2	A319-100 std	141,978	92.60	172.6	31.9	32.8	36.4	42.1
3	Adv. B727-200 Basic	185,200	96.00	148.0	45.8	48.3	55.0	60.1
4	B737-300	140,000	90.86	201.0	33.0	34.8	38.8	42.8
5	B747-400	877,000	93.32	200.0	53.2	59.3	<-- Max. ACN	.2
6	B767-200 ER	396,000	90.82	190.0	44.9	49.6	59.8	80.2
7	B777-200 ER	657,000	91.80	205.0	49.1	55.4	68.0	94.8
8	DC8-63	330,000	96.12	194.0	43.1	48.8	58.5	73.3

- Since this is a flexible pavement, the pavement type code is F, (Table 4-1).
- The subgrade strength under the pavement is CBR 9, or Medium category, so the appropriate code is B (Table 2-2).
- The highest tire pressure of any aircraft in the traffic mix is 216.1 psi, so the tire pressure code is X (Table 4-2).
- From the above list, the critical aircraft is the B747-400, because it has the highest ACN of the group at the operational weights shown (59.3/F/B). Additionally, it has regular service.
- Since there was no engineering analysis done in this example, and the rating was determined simply by examination of the current aircraft using the runway, the evaluation code from Paragraph 4.5e is U.
- Based on the results of the previous steps, the runway pavement should tentatively be rated as PCN 59/F/B/X/U, assuming that the pavement is performing satisfactorily under the current traffic.
- If this pavement was a taxiway, the airport could rate this taxiway as the same PCN.

If the pavement shows obvious signs of distress, this rating may need to be adjusted downward at the discretion of the airport authority. If the rating is lowered, then one or more of the aircraft will have ACNs that exceed the assigned rating. This may require the airport to restrict the allowable gross weight for those aircraft or consider pavement strengthening. The rating could also be adjusted upward, depending on the performance of the pavement under the current traffic.

1.2 USING AIRCRAFT EXAMPLE FOR RIGID PAVEMENTS.

The following example illustrates the Using aircraft PCN process for rigid pavements:

An airport has a runway with the following traffic mix: (from COMFAA Open Aircraft Window)

No.	Aircraft Name	Gross Weight (lbs)	Percent GW on Gears	Tire Press. (psi)	Annual Departures	No. of Tires on Gear	Number of Gears
1	A300-B4 STD	365,747	94.00	216.1	1,500	4	2
2	A319-100 std	141,978	92.60	172.6	1,200	2	2
3	Adv. B727-200 Basic	185,200	96.00	148.0	400	2	2
4	B737-300	140,000	90.86	201.0	6,000	2	2
5	B747-400	877,000	93.32	200.0	3,000	4	4
6	B767-200 ER	396,000	90.82	190.0	2,000	4	2
7	B777-200 ER	657,000	91.80	205.0	300	6	2
8	DC8-63	330,000	96.12	194.0	800	4	2

The runway has a rigid (concrete-surfaced) pavement with a subgrade strength of k=200 pci and rigid pavement ACNs shown in Table A3-2.

Table A3-2. Using Aircraft and Traffic for a Rigid Pavement from COMFAA (Details Window)

ICAO ACN Computation, Detailed Output

Unit Conversions | Show Alpha | Show Ext File | Single Aircraft ACN: Flexible, Rigid | Other Calculation Modes: PCN, ACN Batch, Thickness

Results Table 3. Rigid ACN at Indicated Gross Weight and Strength

No.	Aircraft Name	Gross Weight	% GW on Main Gear	Tire Pressure	A(552)	B(295)	C(147)	D(74)
1	A300-B4 STD	365,747	94.00	216.1	48.5	57.3	66.9	75.5
2	A319-100 std	141,978	92.60	172.6	34.7	37.1	39.3	41.2
3	Adv. B727-200 Basic	185,200	96.00	148.0	49.3	52.7	55.8	58.3
4	B737-300	140,000	90.86	201.0	38.2	40.1	42.0	43.5
5	B747-400	877,000	93.32	200.0	52.6	63.0	74.6	85.3
6	B767-200 ER	396,000	90.82	190.0	43.4	51.9	62.0	71.4
7	B777-200 ER	657,000	91.80	205.0	49.7	63.6	82.6 <-- *Max. ACN*	
8	DC8-63	330,000	96.12	194.0	44.8	53.3	62.2	70.2

- Since this is a rigid pavement, the pavement type code is *R*, (Table 4-1).
- The subgrade strength under the pavement is k=200 pci, which is Low category, so the appropriate code is C (Table 2-1).
- The highest tire pressure of any aircraft in the traffic mix is 216.1 psi, so the tire pressure code is X, as found in Table 4-2. However, since concrete can normally tolerate substantially higher tire pressures, the code W should be assigned.
- The B777-200 has the highest ACN of the group at the operational weights shown (82.6/R/C). However, the A300-B4 (ACN 66.9/R/C) or the B747-400 (ACN 74.6/R/C) also provide reasonable values since these aircraft have higher frequencies than the B777-200.

- Since there was no engineering analysis done in this example, and the rating was determined simply by examination of the current aircraft using the runway, the evaluation code from Paragraph 4.5e is U.

- Based on these steps, the pavement should tentatively be rated as PCN 83/R/C/W/U in order to accommodate all of the current traffic.

- If the pavement shows obvious signs of distress, this rating may need to be adjusted downward at the discretion of the airport authority. If the rating is lowered, then one or more of the aircraft will have ACNs that exceed the assigned rating. This may require the airport to restrict the allowable gross weight for those aircraft or consideration of pavement strengthening. The rating could also be adjusted upward, depending on the performance of the pavement under the current traffic.

2.0 THE TECHNICAL EVALUATION METHOD.

Use the technical evaluation method of determining PCN when there is reliable knowledge of the existing traffic and pavement characteristics. Although the technical evaluation provides a good representation of existing conditions, the airport authority should still be somewhat flexible in its application since there are many variables in the pavement structure as well as the method of analysis itself. The objective of the technical method is to consolidate all traffic into equivalent annual departures, determine allowable gross weight, and assess the ACN for each aircraft in the traffic mixture so that a realistic PCN is selected.

2.1 TECHNICAL EVALUATION FOR FLEXIBLE PAVEMENTS.

The following list summarizes the steps for using the technical evaluation method for flexible pavements:

- Determine the traffic volume in terms of type of aircraft and number of annual departures/traffic cycles of each aircraft that the pavement will experience over its life.

- Determine the appropriate reference section to use based on the number of wheels on main gears.

- Determine pavement characteristics, including the subgrade CBR and equivalent pavement thickness.

- Calculate the maximum allowable gross weight for each aircraft on that pavement at the equivalent annual departure level.

- Calculate the ACN of each aircraft at its maximum allowable gross weight.

- Select the PCN from the ACN data provided by all aircraft.

These steps are explained in greater detail below. The steps are automated in the COMFAA software, with a results file presented in three tables: a table with input traffic data, a table with a table with the results of the PCN using the CDF analysis at the evaluation pavement thickness and subgrade CBR, and a table with ACN values for each aircraft in the traffic mix. Figure A3-2 shows an excerpt from a results file. Several examples using the same traffic mix with different pavement structures at the end of this section further illustrate the process.

Table A3-3. Excerpt From COMFAA PCN Batch Results File for Flexible Pavement

```
                                 CBR = 7.00 (Subgrade Category is C)
           Evaluation pavement thickness = 33.90 in
        Pass to Traffic Cycle (PtoTC) Ratio = 1.00
          Maximum number of wheels per gear = 6
        Maximum number of gears per aircraft = 4

At least one aircraft has 4 or more wheels per gear.  The FAA recommends a reference section assuming
5 inches of HMA and 8 inches of crushed aggregate for equivalent thickness calculations.
```

Top

Table 1. Input Traffic Data

No.	Aircraft Name	Gross Weight	Percent Gross Wt	Tire Press	Annual Deps	20-yr Coverages	6D Thick
1	A300-B4 STD	365,747	94.00	216.1	1,500	16,456	33.06
2	A319-100 std	141,978	92.60	172.6	1,200	6,443	24.09
3	Adv. B727-200 Basic	185,200	96.00	148.0	400	2,754	27.62
4	B737-300	140,000	90.86	201.0	6,000	31,003	27.51
5	B747-400	877,000	93.32	200.0	3,000	34,410	36.87
6	B767-200 ER	396,000	90.82	190.0	2,000	21,813	32.63
7	B777-200 ER	657,000	91.80	205.0	300	4,375	31.97
8	DC8-63	330,000	96.12	194.0	800	9,269	31.03

Middle

Table 2. PCN Values

No.	Aircraft Name	Critical Aircraft Total Equiv. Covs.	Thickness for Total Equiv. Covs.	Maximum Allowable Gross Weight	PCN at Indicated Code A(15)	B(10)	C(6)	D(3)	CDF
1	A300-B4 STD	156,937	36.54	330,524	40.5	44.7	54.0	69.9	0.6174
2	A319-100 std	>5,000,000	35.23	133,520	29.7	30.5	33.7	39.1	0.0004
3	Adv. B727-200 Basic	339,956	36.68	162,662	38.8	41.0	46.8	52.1	0.0477
4	B737-300	>5,000,000	35.34	130,515	30.4	31.9	35.5	39.6	0.0054
5	B747-400	47,121	37.42	772,687	45.2	49.7	59.7	79.8	4.2993
6	B767-200 ER	275,106	36.40	361,883	40.1	43.9	52.0	71.0	0.4668
7	B777-200 ER	90,959	35.95	608,938	44.4	49.8	60.4	<--- Max PCN	32
8	DC8-63	326,269	36.10	302,294	38.5	43.0	51.7	65.4	0.1673

Bottom

Table 3. Flexible ACN at Indicated Gross Weight and Strength

No.	Aircraft Name	Gross Weight	% GW on Main Gear	Tire Pressure	A(15)	B(10)	C(6)	D(3)
1	A300-B4 STD	365,747	94.00	216.1	46.3	51.6	62.8	79.7
2	A319-100 std	141,978	92.60	172.6	31.9	32.8	36.4	42.1
3	Adv. B727-200 Basic	185,200	96.00	148.0	45.8	48.3	55.0	60.1
4	B737-300	140,000	90.86	201.0	33.0	34.8	38.8	42.8
5	B747-400	877,000	93.32	200.0	Max ACN --->		72.6	94.2
6	B767-200 ER	396,000	90.82	190.0	44.9	49.6	59.8	80.2
7	B777-200 ER	657,000	91.80	205.0	49.1	55.4	68.0	94.8
8	DC8-63	330,000	96.12	194.0	43.1	48.8	58.5	73.3

1. Determine the traffic volume in terms of annual departures for each aircraft that has used or is planned to use the airport during the pavement life period. Record all significant traffic, including non-scheduled, charter, and military, as accurately as possible. This includes traffic that has occurred since the original construction or last overlay and traffic that will occur before the next planned overlay or reconstruction. If the pavement life is unknown or undetermined, assume that it will include a reasonable period of time. The normal design life for pavement is 20 years. However, the expected life can vary depending on the existing pavement conditions, climatic conditions, and maintenance practices.

The information necessary for the traffic volume process is—

- Past, current, and forecasted traffic cycles of each significant aircraft.
- Aircraft operational or maximum gross weights.
- Typical aircraft weight distribution on the main and nose gear. If unknown, AC 150/5320-6 assumes 95 percent weight on the main gear.
- Main gear type (dual, dual tandem, etc.).
- Main gear tire pressure.
- Fuel-loading practices of aircraft at the airport (P/TC ratio).
- Type of taxiway system – parallel or central (P/TC ratio).

2. From field data or construction drawings, document the CBR of the subgrade soil. Alternatively, conduct field or laboratory tests of the subgrade soil in order to determine the CBR. Accurate portrayal of the subgrade CBR value is vital to the technical method because a small variation in CBR could result in a disproportionately large variation in the aircraft allowable gross weight and the corresponding PCN.

3. The COMFAA program calculates pavement thickness requirements based on annual departures. COMFAA allows the user to directly input either coverages or annual departures. Since the pass-to-coverage ratio for flexible pavement may be different than rigid pavement, the user must enter coverages in the appropriate location for each pavement type.

4. Determine the total pavement thickness and cross-sectional properties. The thickness of the pavement section under consideration must be converted to an equivalent pavement thickness based on a standard reference pavement section for evaluation purposes. The equivalent pavement thickness is the total thickness requirement calculated by the COMFAA program assuming minimum layer thickness for the asphalt surface, minimum base layer thickness of material with a CBR 80 or higher, and a variable subbase layer with a CBR 20 or greater. If the pavement has excess material or improved materials, the total pavement thickness may be increased according to the FAA CBR method as detailed in Appendix 2. The pavement is considered to have excess asphalt, which can be converted to extra equivalent thickness, when the asphalt thickness is greater than the minimum thickness of asphalt surfaced. The recommended reference section for this traffic mix is an asphalt surface course thickness of 5 inches. The pavement may also be considered to have excess aggregate base thickness when the cross-section has a high quality crushed aggregate base thickness greater than 8 inches or when other improved materials such as asphalt stabilization or cement treated materials, are present. Likewise, additional subbase thickness or improved subbase materials may also be converted to additional total pavement thickness. Using the support program to facilitates converting existing pavement structures to the requisite standard equivalent structure used in COMFAA.

5. Using the annual departures and P/TC ratio for the runway, the equivalent pavement thickness, and the appropriate CBR of the subgrade, compute the maximum allowable

gross weight for each aircraft using the COMFAA program in the pavement design mode.

6. Assign the subgrade CBR strength found in Step 2 to the appropriate standard ACN-PCN subgrade code as given in Table 2-2.

7. The ACN of each aircraft at the maximum allowable gross weight is may now be determined from the COMFAA program using the ACN mode. Enter the allowable gross weight of the aircraft, and calculate the ACN based on the standard subgrade code corresponding to the CBR found in Step 2. Alternatively, consult an "ACN versus Gross Weight" chart as published in the manufacturer's ACAP manuals.

8. Assign the tire pressure code based on the highest tire pressure in the traffic mix from Table 4-2. Keep in mind the quality of the asphalt surface layer, as discussed in Section 2.1, when assigning this code.

9. As the evaluation method is technical, assign the code of *T*, as described in paragraph 4.5e.

10. The numerical value of the PCN is selected from the list of ACN values from all aircraft. COMFAA lists these values as PCN values. If all aircraft regularly use the airport, then select the highest ACN value and report it as the PCN. If some of the aircraft in the traffic mix use the airport infrequently, then further consideration must be given to the selection of the PCN. If an aircraft that operates infrequently at the airport generates a PCN value considerably higher than the rest of the traffic mix, then using this aircraft to determine the PCN will require a new PCN determination if this aircraft's operations increase.

11. If the calculated maximum allowable gross weight is equal to or greater than the critical aircraft operational gross weight required for the desired pavement life, then the pavement is capable of handling the predicted traffic for the time period established in the traffic forecast. Accordingly, the assigned PCN determined in Step 10 is sufficient. If the **allowable gross weight from is less than the critical** aircraft gross weight required for the desired pavement life, then the pavement may be assigned a PCN equal to the ACN of the critical aircraft at that gross weight, but with a lower expected pavement life. Additionally, it may then be necessary to develop a relationship of allowable gross weight based on the assigned PCN versus pavement life. Any overload should be treated in terms of ACN and equivalent critical aircraft operations per individual operation. Allowance for the overload should be negotiated with the airport authority since pre-approval cannot be assumed. Specific procedures on how to relate pavement life and gross weight for flexible pavements are found in Appendix 4 of this document.

2.2 TECHNICAL EVALUATION EXAMPLES FOR FLEXIBLE PAVEMENTS.

The following four examples help demonstrate the technical evaluation method of determining a PCN for flexible pavements. The first example pavement has more than adequate strength to handle the forecasted traffic. The second example is for an under-strength pavement with a traffic volume that has increased to such a level that pavement life is reduced from the original design. The third example pavement is the same as the first, except that the runway has a central rather than a parallel taxiway. Example 4 discusses the effect on pavement life when aircraft with a higher ACN the PCN uses the pavement without implementing allowable gross weight restrictions.

a. Flexible Pavement Example 1. An airport has a flexible (asphalt-surfaced) runway pavement with a subgrade CBR of 9 and a total thickness of 32.0 inches, as shown in the left graph of Figure A3-1 (5 inch asphalt surface layer, 4 inches of stabilized base, 6 inch base layer and 17 inches subbase layer). Additional fuel is generally obtained at the airport before departure, and the runway has a parallel taxiway. The pavement was designed for a life of 20 years. It is assumed for the purposes of this example that the traffic level is constant over the 20-year time period. The ACN for each aircraft in the traffic is shown in Table A3-3, which is similar to Table A3-1 but with the ACN for all subgrade categories shown. The thickness of the P-304 and P-209 exceeds the minimum standard for the CDF analysis method and is converted to additional P-154 as shown in Figure A3-2 for an equivalent pavement thickness of 33.9 inches.

<u>Existing pavement:</u>
5 inch asphalt surface layer (P-401)
4 inch base layer (P-304)
6 inch base layer (P-209)
17 inches subbase layer (P-154)
Subgrade CBR 9

P-304 plus P-209 exceed P-209 requirements.
Portion of P-304 is converted to P-209 and excess P-304 converted to P-154.
This conversion results in 1.9 inches added to equivalent pavement thickness.

<u>Equivalent Pavement:</u>
5 inch asphalt surface layer (P-401)
8 inch base layer (P-209)
20.9 inch subbase layer (P-154)
33.9 inch total thickness
Subgrade CBR 9

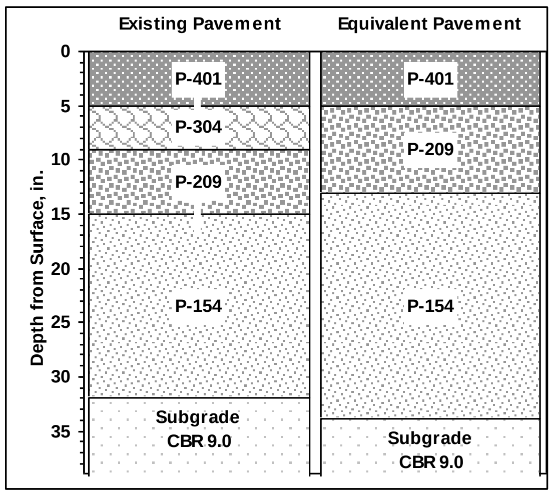


Figure A3-2. Flexible Pavement Example 1 Cross-Section

Table A3-4 shows the results of the COMFAA Batch PCN Flexible calculations. The Bottom portion of Table A3-4 shows traffic parameters and the ACN of the traffic aircraft for all subgrade categories. All traffic aircraft were added using the aircraft library embedded in COMFAA.

Table A3-4. Flexible Pavement Example 1

CBR = 9.00 (Subgrade Category is B)
Evaluation pavement thickness = 33.90 in
Pass to Traffic Cycle (PtoTC) Ratio = 1.00
Maximum number of wheels per gear = 6
Maximum number of gears per aircraft = 4

At least one aircraft has 4 or more wheels per gear. The FAA recommends a reference section assuming 5 inches of HMA and 8 inches of crushed aggregate for equivalent thickness calculations.

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R... s Table 1. Input Traffic Data

No.	Aircraft Name	Gross Weight	Percent Gross Wt	Tire Press	Annual Deps	20-yr Coverages	6D Thick
1	A300-B4 STD	365,747	94.00	216.1	1,500	16,456	27.26
2	A319-100 std	141,978	92.60	172.6	1,200	6,443	20.31
3	Adv. B727-200 Basic	185,200	96.00	148.0	400	2,754	23.13
4	B737-300	140,000	90.86	201.0	6,000	31,003	23.28
5	B747-400	877,000	93.32	200.0	3,000	34,410	30.26
6	B767-200 ER	396,000	90.82	190.0	2,000	21,813	27.01
7	B777-200 ER	657,000	91.80	205.0	300	4,375	26.47
8	DC8-63	330,000	96.12	194.0	800	9,269	25.71

Middle

R... le 2. PCN Values

No.	Aircraft Name	Critical Aircraft Total Equiv. Covs.	Thickness for Total Equiv. Covs.	Maximum Allowable Gross Weight	PCN at Indicated Code A(15)	B(10)	C(6)	D(3)	CDF
1	A300-B4 STD	912,994	31.86	397,499	51.6	58.1	70.9	88.6	0.0008
2	A319-100 std	>5,000,000	33.37	145,549	32.9	33.8	37.5	43.3	0.0000
3	Adv. B727-200 Basic	234,034	30.50	219,865	56.9	60.3	67.6	72.6	0.0005
4	B737-300	>5,000,000	33.01	146,340	34.9	36.8	41.0	45.0	0.0000
5	B747-400	35,566	30.31	1,016,201	64.9	73.0	<--- Max PCN		0.0432
6	B767-200 ER	>5,000,000	32.52	418,275	48.1	53.4	65.2	86.2	0.0001
7	B777-200 ER	>5,000,000	33.30	672,617	50.8	57.3	70.6	98.0	0.0000
8	DC8-63	>5,000,000	32.70	347,152	46.2	52.5	62.9	78.2	0.0000

Bottom

R... le 3. Flexible ACN at Indicated Gross Weight and Strength

	...ft Name	Gross Weight	% GW on Main Gear	Tire Pressure	A(15)	B(10)	C(6)	D(3)
1	A300-B4 STD	365,747	94.00	216.1	46.3	51.6	62.8	79.7
2	A319-100 std	141,978	92.60	172.6	31.9	32.8	36.4	42.1
3	Adv. B727-200 Basic	185,200	96.00	148.0	45.8	48.3	55.0	60.1
4	B737-300	140,000	90.86	201.0	33.0	34.8	38.8	42.8
5	B747-400	877,000	93.32	200.0	53.2	59.3	72.6	94.2
6	B767-200 ER	396,000	90.82	190.0	44.9	49.6	59.8	80.2
7	B777-200 ER	657,000	91.80	205.0	49.1	55.4	68.0	94.8
8	DC8-63	330,000	96.12	194.0	43.1	48.8	58.5	73.3

The last four columns of the Bottom portion of Table A3-4 show the ACN for each aircraft at each subgrade strength category. The existing pavement has a CBR of 9, which is Category B subgrade strength, so the values in the column labeled B(10) are used for this analysis. The Top portion of Table A3-4 shows the required thickness using the CBR thickness design in accordance with the FAA CBR method for a flexible pavement with a CBR 9 subgrade. The B747-400 aircraft has the greatest individual pavement thickness requirement (30.26 inches) for its total traffic over 20 years. Note the thickness requirements for each individual aircraft are several inches less than the evaluation pavement thickness of 33.9 inches. This indicates that the pavement has sufficient thickness for existing traffic.

The Middle portion of Table A3-4 shows the results of the detailed method based on the cumulative damage factor (CDF) procedure that allows the calculation of the combined effect of multiple aircraft in the traffic mix. This combined traffic is brought together into equivalent traffic considering each aircraft as the critical aircraft.

The CDF analysis calculates a maximum allowable gross weight, equivalent coverage level, and corresponding thickness for each aircraft in the traffic mix at the evaluation thickness (33.9 in.) and support conditions (9 CBR).

Referring to the CDF calculation results shown in The Middle portion of Table A3-4, there are five aircraft that can load the pavement over 5,000,000 times before the pavement fails. These aircraft have little impact on this pavement's structural performance. All aircraft can operate at gross weights higher than current levels. **Note:** the thickness requirement values in the third column are less than the evaluation thickness. This pavement has sufficient strength to accommodate existing traffic.

The last four columns of The Middle portion of Table A3-4 show ACN of each aircraft at its maximum allowable gross weight and 10,000 coverages. These values are labeled as PCN values and determine the load carrying capacity of the pavement. The values in the column labeled B(10) are used for this analysis since the existing CBR of 9 is within the standard range for Category B subgrade support. The PCN for this pavement can be reported as the highest PCN in the Category B column. The airport may report a PCN of 73/F/B/W/T or 73/F/B/X/T.

b. Flexible Pavement Example 2. This second example has the same input traffic parameters and pavement cross-section as Example 1, but with a CBR of 7.

Existing pavement:
5 inch asphalt surface layer (P-401)
4 inch base layer (P-304)
6 inch base layer (P-209)
17 inches subbase layer (P-154)
Subgrade CBR 7

P-304 plus P-209 exceed P-209 requirements.
Portion of P-304 is converted to P-209 and excess P-304 converted to P-154. This conversion results in 1.9 inches added to equivalent pavement thickness.

Equivalent Pavement:
5 inch asphalt surface layer (P-401)
8 inch base layer (P-209)
20.9 inch subbase layer (P-154)
33.9 inch total thickness
Subgrade CBR 7

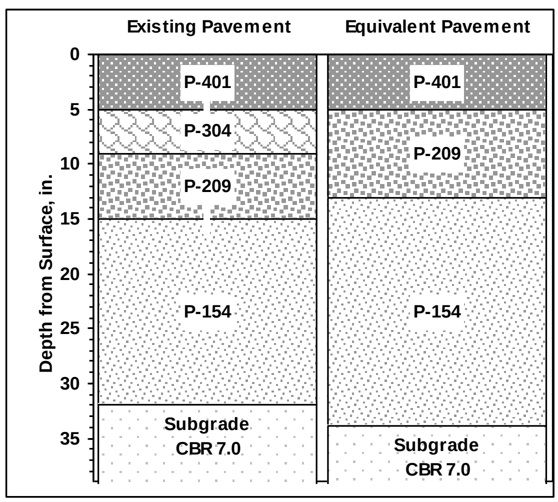

Figure A3-3. Flexible Pavement Example 2 Cross-Section

Table A3-5 shows the results of the COMFAA Batch PCN Flexible calculations. The Bottom portion of Table A3-5 shows traffic parameters and the ACN of the traffic aircraft for all subgrade categories.

Table A3-5. Flexible Pavement Example 2

```
                                   CBR = 7.00 (Subgrade Category is C)
              Evaluation pavement thickness = 33.90 in
        Pass to Traffic Cycle (PtoTC) Ratio = 1.00
          Maximum number of wheels per gear = 6
       Maximum number of gears per aircraft = 4

At least one aircraft has 4 or more wheels per gear.  The FAA recommends a reference section assuming
5 inches of HMA and 8 inches of crushed aggregate for equivalent thickness calculations.
```

Top

Table 1. Input Traffic Data

No.	Aircraft Name	Gross Weight	Percent Gross Wt	Tire Press	Annual Deps	20-yr Coverages	6D Thick
1	A300-B4 STD	365,747	94.00	216.1	1,500	16,456	33.06
2	A319-100 std	141,978	92.60	172.6	1,200	6,443	24.09
3	Adv. B727-200 Basic	185,200	96.00	148.0	400	2,754	27.62
4	B737-300	140,000	90.86	201.0	6,000	31,003	27.51
5	B747-400	877,000	93.32	200.0	3,000	34,410	36.87
6	B767-200 ER	396,000	90.82	190.0	2,000	21,813	32.63
7	B777-200 ER	657,000	91.80	205.0	300	4,375	31.97
8	DC8-63	330,000	96.12	194.0	800	9,269	31.03

Middle

[illegible]e 2. PCN Values

No.	Aircraft Name	Critical Aircraft Total Equiv. Covs.	Thickness for Total Equiv. Covs.	Maximum Allowable Gross Weight	PCN at Indicated Code A(15)	B(10)	C(6)	D(3)	CDF
1	A300-B4 STD	156,937	36.54	330,524	40.5	44.7	54.0	69.9	0.6174
2	A319-100 std	>5,000,000	35.23	133,520	29.7	30.5	33.7	39.1	0.0004
3	Adv. B727-200 Basic	339,956	36.68	162,662	38.8	41.0	46.8	52.1	0.0477
4	B737-300	>5,000,000	35.34	130,515	30.4	31.9	35.5	39.6	0.0054
5	B747-400	47,121	37.42	772,687	45.2	49.7	59.7	79.8	4.2993
6	B767-200 ER	275,106	36.40	361,883	40.1	43.9	52.0	71.0	0.4668
7	B777-200 ER	90,959	35.95	608,938	44.4	49.8	60.4	<--- Max PCN	[illegible]32
8	DC8-63	326,269	36.10	302,294	38.5	43.0	51.7	65.4	0.1673

Bottom

[illegible]e 3. Flexible ACN at Indicated Gross Weight and Strength

[illegible]t Name		Gross Weight	% GW on Main Gear	Tire Pressure	A(15)	B(10)	C(6)	D(3)
1	A300-B4 STD	365,747	94.00	216.1	46.3	51.6	62.8	79.7
2	A319-100 std	141,978	92.60	172.6	31.9	32.8	36.4	42.1
3	Adv. B727-200 Basic	185,200	96.00	148.0	45.8	48.3	55.0	60.1
4	B737-300	140,000	90.86	201.0	33.0	34.8	38.8	42.8
5	B747-400	877,000	93.32	200.0	53.2	59.3	72.6	94.2
6	B767-200 ER	396,000	90.82	190.0	44.9	49.6	59.8	80.2
7	B777-200 ER	657,000	91.80	205.0	49.1	55.4	68.0	94.8
8	DC8-63	330,000	96.12	194.0	43.1	48.8	58.5	73.3

The existing pavement has a CBR of 7, which is Category C subgrade strength, so the values in the column labeled C(6) are used for this analysis.

The Top portion of Table A3-5 shows the required thickness using the CBR thickness design in accordance with the FAA CBR method for a flexible pavement with a CBR 7 subgrade. The B747-400 aircraft has the greatest individual pavement thickness requirement (36.87 inches) for its total traffic over 20 years. Note the thickness requirements for the B747-400 is greater than the evaluation pavement thickness and the thickness required for the A300-B4 (33.06 inches) is only slightly less than the evaluation thickness (33.9 inches). Since the thickness requirement exceeds the evaluation thickness for some of the traffic, the PCN will be less than the ACN values shown in the bottom table.

The Middle portion of Table A3-5 shows the results of the detailed method based on the cumulative damage factor (CDF) procedure that allows the calculation of the combined effect of multiple aircraft in the traffic mix. This combined traffic is brought together into equivalent traffic considering each aircraft as the critical aircraft.

The CDF analysis calculates a maximum allowable gross weight, equivalent coverage level, and corresponding thickness for each aircraft in the traffic mix at the evaluation thickness (33.9 in.) and support conditions (7 CBR).

Referring to the CDF calculation results shown in The Middle portion of Table A3-5, the B737-300 and the A319-100 have little impact on this pavement's performance, However, the B767-200 ER, the B777-200 ER, and the DC 8/63 contribute to the cumulative damage on this pavement's performance. The reduced CBR from 9 to 7 has a substantial impact on the load carrying capacity of the pavement. The thickness requirement values calculated in the CDF analysis exceed the evaluation thickness. The pavement does not have sufficient strength to accommodate all existing traffic. The last four columns of the Bottom portion of Table A3-5 show ACN of each aircraft at its maximum allowable gross weight and 10,000 coverages. These values are labeled as PCN values and determine the load carrying capacity of the pavement. The values in the column labeled C(6) are used for this analysis since the existing CBR of 7 is within the standard range for Category C subgrade support. The PCN for this pavement can be reported as the highest PCN in the Category C column of the Middle portion of Table A3-5. The airport may report a PCN of 60/F/C/W/T or 60/F/C/X/T. The ACN of three aircraft exceed the pavement PCN and the airport should plan for a pavement strengthening project or consider placing restrictions on those aircraft.

c. Flexible Pavement Example 3. The only change in this example from the second example is that the taxiway is a central configuration rather than parallel, such as that shown in Figure A1-1b. Table A3-6 shows the effect when the P/TC ratio changes from 1 to 2, which results in double the number of coverages for each aircraft in the traffic mix. As expected, the required total pavement thickness for each aircraft in the traffic mix has increased. The B747-400 aircraft has the greatest individual pavement thickness requirement (38.06 inches) for its total traffic over 20 years. Note the thickness requirements for the A300-B4 STD now exceeds the evaluation thickness (33.9 in.) and the thickness requirements for two additional aircraft in the traffic approach the evaluation thickness.

Table A3-6. Flexible Pavement Example 3

```
                             CBR = 7.00 (Subgrade Category is C)
         Evaluation pavement thickness = 33.90 in
      Pass to Traffic Cycle (PtoTC) Ratio = 2.00
        Maximum number of wheels per gear = 6
       Maximum number of gears per aircraft = 4

At least one aircraft has 4 or more wheels per gear.  The FAA recommends a reference section assuming
5 inches of HMA and 8 inches of crushed aggregate for equivalent thickness calculations.
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Top

R[illegible] Table 1. Input Traffic Data

No.	Aircraft Name	Gross Weight	Percent Gross Wt	Tire Press	Annual Deps	20-yr Coverages	6D Thick
1	A300-B4 STD	365,747	94.00	216.1	1,500	32,913	34.25
2	A319-100 std	141,978	92.60	172.6	1,200	12,885	25.26
3	Adv. B727-200 Basic	185,200	96.00	148.0	400	5,507	29.24
4	B737-300	140,000	90.86	201.0	6,000	62,007	28.59
5	B747-400	877,000	93.32	200.0	3,000	68,820	38.06
6	B767-200 ER	396,000	90.82	190.0	2,000	43,627	33.79
7	B777-200 ER	657,000	91.80	205.0	300	8,750	33.09
8	DC8-63	330,000	96.12	194.0	800	18,537	32.24

Middle

Re[illegible]e 2. PCN Values

No.	Aircraft Name	Critical Aircraft Total Equiv. Covs.	Thickness for Total Equiv. Covs.	Maximum Allowable Gross Weight	PCN at Indicated Code A(15)	B(10)	C(6)	D(3)	CDF
1	A300-B4 STD	313,878	37.37	320,380	38.9	42.8	51.6	67.1	1.2347
2	A319-100 std	>5,000,000	35.69	130,800	29.0	29.8	32.8	38.2	0.0008
3	Adv. B727-200 Basic	679,913	37.63	155,907	36.9	38.8	44.3	49.6	0.0954
4	B737-300	>5,000,000	35.83	127,496	29.5	31.0	34.4	38.5	0.0109
5	B747-400	94,242	38.57	743,275	42.9	47.1	56.2	75.7	8.5987
6	B767-200 ER	550,218	37.22	351,897	38.7	42.2	49.9	68.3	0.9336
7	B777-200 ER	181,918	36.60	595,613	Max PCN --->		58.4	82.3	0.5664
8	DC8-63	652,541	36.81	293,909	37.1	41.3	49.7	63.0	0.3345

Bottom

R[illegible]le 3. Flexible ACN at Indicated Gross Weight and Strength

[illegible]ft Name	Gross Weight	% GW on Main Gear	Tire Pressure	A(15)	B(10)	C(6)	D(3)
1 A300-B4 STD	365,747	94.00	216.1	46.3	51.6	62.8	79.7
2 A319-100 std	141,978	92.60	172.6	31.9	32.8	36.4	42.1
3 Adv. B727-200 Basic	185,200	96.00	148.0	45.8	48.3	55.0	60.1
4 B737-300	140,000	90.86	201.0	33.0	34.8	38.8	42.8
5 B747-400	877,000	93.32	200.0	53.2	59.3	72.6	94.2
6 B767-200 ER	396,000	90.82	190.0	44.9	49.6	59.8	80.2
7 B777-200 ER	657,000	91.80	205.0	49.1	55.4	68.0	94.8
8 DC8-63	330,000	96.12	194.0	43.1	48.8	58.5	73.3

Referring to the Middle portion of the table, only the B737-300 and the A319-100 std have little impact on this pavement's performance. It is more apparent the pavement is not adequate to accommodate the existing traffic. As expected, changing the taxiway system from parallel to central has lowered the PCN of the pavement by effectively doubling traffic volume. The airport may report 58/F/C/W/T or 58/F/C/X/T. The ACN of four aircraft, the B747-400, the A300-B4 STD, and the B777-200 ER exceed the pavement PCN and the airport should plan for a pavement strengthening project or consider placing restrictions on those aircraft. The net effect of the change in taxiway configuration from that of Example 2 is the reduction in PCN by 2.

d. Flexible Pavement Example 4. As an alternate way of looking at the effect of a parallel versus central taxiway effects, consider how the pavement life would change instead of the PCN. If the reported PCN from Example 2 were to remain at 60/F/C/W/T or 60/F/C/X/T, then the pavement life would be reduced by one-half. This is due to the change in the P/TC ratio. A similar effect would be noticed if fuel was not obtained at the airport, (it was obtained in the second flexible pavement example case). With a P/TC ratio of 3, the

PCN is reduced to 57.With a P/TC ratio of 3, the pavement life would be one-third the pavement life of the same pavement with a P/TC ratio of 1.

2.3 TECHNICAL EVALUATION FOR RIGID PAVEMENTS. The following list summarizes the steps for using the technical evaluation method for rigid pavements:

- Determine the traffic volume in terms of type of aircraft and number of annual departures of each aircraft.
- Determine the pavement characteristics, including subgrade soil modulus, k, and the concrete thickness and flexural strength.
- Perform the CDF calculations to determine the maximum allowable gross weight for each aircraft on that pavement at the equivalent annual departure level.
- Calculate the ACN of each aircraft at its maximum allowable gross weight. Select the PCN from the ACN data provided by all aircraft.

The above steps are explained in greater detail:

1. Determine the traffic volume in the same fashion as noted in paragraph A3-2.1 for flexible pavements.
2. From field data or construction drawings, document the k value of the subgrade soil. Alternatively, conduct field or laboratory tests of the subgrade soil in order to determine the k value. Accurate portrayal of the subgrade k value is vital to the technical method because a small variation in k could result in a disproportionately large variation in the aircraft allowable gross weight and the corresponding PCN.
3. Using COMFAA, input annual departure level for each aircraft, input the Pass/Traffic cycle ratio (P/TC) for the runway.
4. The rigid design procedure implemented in the COMFAA program calculates pavement thickness requirements based on the concrete edge stress, which is in turn dependent on load repetitions of the total traffic mix. It is therefore a requirement to convert traffic cycles or passes to load repetitions by using a pass-to-load repetition ratio. P/C ratios for any aircraft on rigid pavement are calculated in the COMFAA program. COMFAA allows the user to directly input annual departures or coverages and will use aircraft-specific pass-to-coverage ratios to automatically convert to coverages for calculation purposes. Since the pass-to-coverage ratio for rigid pavement may be different than flexible pavement, the user must enter coverages in the appropriate location for each pavement type.
5. Obtain the pavement characteristics including the concrete slab thickness, the concrete modulus of rupture, and average modulus, k, of the subgrade. Concrete elastic modulus is set at 4,000,000 psi and Poisson’s ratio is set at 0.15 in the COMFAA program. Accurate subgrade modulus determination is important to the technical method, but small variations in the modulus will not affect the PCN results

in a disproportionate manner. This is in contrast to flexible pavement subgrade modulus in which strength variations have a significant effect on PCN. If the pavement has a subbase course and/or stabilized subbase layers, then the subgrade modulus is adjusted upwards in the rigid design procedure to an equivalent value in order to account for the improvement in support. Subgrade modulus adjustments are made based on the FAA CBR method guidance included herein as Figures A2-4 through A2-7 and summarized in Table A2-2.

6. Using the known slab thickness modified based on overlays (see Figure A2-7), subgrade modulus modified based on improvements gained from subbase course(s) (see Figures A2-4 and A2-6), P/TC ratio for the runway, each individual aircraft's annual departure level, and each aircraft's parameters, compute the maximum allowable gross weight of each aircraft using the COMFAA program in the pavement design mode.

7. Assign the subgrade modulus (k-value) to the nearest standard ACN-PCN subgrade code. The k-value to be reported for PCN purposes is the improved k-value seen at the top of all improved layers (k-value directly beneath the concrete layer). Subgrade codes for k-value ranges are found in Table 2-1.

8. The ACN of each aircraft may now be determined from the COMFAA program. Enter the allowable gross weight of each aircraft from Step 6, and calculate the ACN for the standard subgrade codes. Alternatively, consult an "ACN versus Gross Weight" chart as published in the manufacturer's ACAP manual.

9. Assign the tire pressure code based on the highest tire pressure in the traffic mix from Table 4-2. As discussed previously, rigid pavements are typically able to handle high tire pressures, so code W can usually be assigned.

10. The evaluation method is technical, so the code T will be used as discussed in paragraph 4.5e.

11. The numerical value of the PCN is selected from the list of ACN values resulting from Step 6 from all aircraft. If all aircraft regularly use the airport, then select the highest ACN value and report it as the PCN. If some of the aircraft in the traffic mix use the airport infrequently, then further consideration must be given to the selection of the PCN. If an aircraft that operates infrequently at the airport generates a PCN value considerably higher than the rest of the traffic mix, then reporting the ACN of this aircraft as the PCN will require a change to the PCN if the aircraft's usage changes.

12. The numerical value of the PCN is the same as the numerical value of the ACN of the critical aircraft just calculated in Step 11.

13. If the allowable gross weight of Step 11 is equal to or greater than the critical aircraft operational gross weight required for the desired pavement life, then the pavement is capable of handling the predicted traffic for the time period established in the traffic forecast. Accordingly, the assigned PCN determined in Step 12 is sufficient. If the

allowable gross weight from Step 11 is less than the critical aircraft gross weight required for the desired pavement life, then the pavement may be assigned a PCN equal to the ACN of the critical aircraft at that gross weight, but with a reduced pavement life. Additionally, it may then be necessary to develop a relationship of allowable gross weight based on the assigned PCN versus pavement life. Appendix 4 provides procedures on how to relate pavement life and gross weight for rigid pavements in terms of PCN. Any overload should be treated in terms of ACN and equivalent critical aircraft operations per individual operation. Allowance for the overload should be negotiated with the airport authority, since pre-approval cannot be assumed. Appendix 4 provides specific procedures on how to relate pavement life and gross weight for rigid pavements.

2.4 TECHNICAL EVALUATION EXAMPLES FOR RIGID PAVEMENTS.

The following three examples help explain the technical evaluation method of determining a PCN for rigid pavements. The first example pavement is under-designed and the traffic volume has increased to such a level that pavement life is reduced from the original design. The second pavement has more than adequate strength to handle the forecasted traffic. The third example pavement is the same as number two, except that the aircraft generally do not obtain fuel at the airport.

a. Rigid Pavement Example 1. An airport has a rigid (concrete-surfaced) runway pavement with a subgrade k-value of 100 pci and a slab thickness of 14 inches, with an existing cross section as shown in Figure A3-4. The concrete has a modulus of rupture of 700 psi, an elastic modulus of 4,000,000 psi, and a Poisson's ratio of 0.15. The runway has a parallel taxiway, and additional fuel is generally obtained at the airport before departure. The pavement life is estimated to be 20 years from the original construction. The traffic shown in Table A3-7 is the same as in Table A3-6.

Existing pavement:
14 inch concrete layer (P-501)
5 inch stabilized subbase layer (P-304)
5 inch soil-cement subbase layer (P-301)
Subgrade k-value 100

k-value improvement.
5 inch P-304 improves k-value to 241
5 inch P-301 improves k-value to 138

Equivalent Pavement:
14 inch concrete layer (P-501)
k-value 241 pci.
Concrete strength 700 psi.

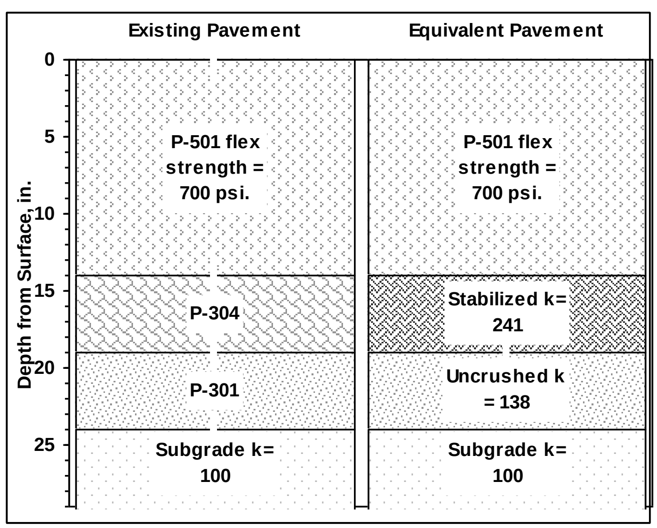

Figure A3-4. Rigid Pavement Example 1 Cross-Section

The critical aircraft will be the one with the highest required thickness for its load magnitude and frequency. The thickness required for each aircraft is determined with the COMFAA program in the pavement design mode. The load repetitions must first be calculated for each aircraft by using Equation A1-1 and then converted to coverages for use in the COMFAA program. Since additional fuel is generally obtained at the airport, and there is a parallel taxiway, so—

P/TC = 1

Tables A3-7 shows the results from COMFAA. The Bottom portion of Table A3-7 shows traffic parameters and the ACN of the traffic aircraft for all subgrade categories. Columns 5 through 8 of the Bottom table show the ACN for each aircraft at each subgrade strength category. The equivalent pavement has a k-value of 241 pci., which is Category B subgrade strength, so the values in the column labeled B(295) are used for this analysis.

Table A3-7. Rigid Pavement Example 1

k Value = 241.0 lbs/in^3 (Subgrade Category is B)
flexural strength = 700.0 psi
Evaluation pavement thickness = 14.00 in
Pass to Traffic Cycle (PtoTC) Ratio = 1.00

Maximum number of wheels per gear = 6
Maximum number of gears per aircraft = 4

Top

R[illegible] Table 1. Input Traffic Data

No.	Aircraft Name	Gross Weight	Percent Gross Wt	Tire Press	Annual Deps	20-yr Coverages	6D Thick
1	A300-B4 STD	365,747	94.00	216.1	1,500	8,228	13.01
2	A319-100 std	141,978	92.60	172.6	1,200	6,443	11.51
3	Adv. B727-200 Basic	185,200	96.00	148.0	400	2,754	12.82
4	B737-300	140,000	90.86	201.0	6,000	31,003	13.19
5	B747-400	877,000	93.32	200.0	3,000	17,205	14.13
6	B767-200 ER	396,000	90.82	190.0	2,000	10,907	12.55
7	B777-200 ER	657,000	91.80	205.0	300	1,458	11.29
8	DC8-63	330,000	96.12	194.0	800	4,634	12.22

Middle

R[illegible]e 2. PCN Values

Column 3

No.	Aircraft Name	Critical Aircraft Total Equiv. Covs.	Thickness for Total Equiv. Covs.	Maximum Allowable Gross Weight	PCN at Indicated Code A(552)	B(295)	C(147)	D(74)	CDF
1	A300-B4 STD	62,088	14.73	339,336	43.7	51.6	60.3	68.3	0.3117
2	A319-100 std	387,982	14.66	130,198	31.3	33.5	35.5	37.3	0.0391
3	Adv. B727-200 Basic	34,074	14.76	166,822	43.4	46.5	49.3	51.7	0.1901
4	B737-300	201,407	14.68	127,775	34.2	36.0	37.7	39.1	0.3621
5	B747-400	35,052	14.76	807,515	47.0	56.0	66.5	76.3	1.1547
6	B767-200 ER	154,821	14.69	367,816	39.4	46.8	55.9	64.6	0.1657
7	B777-200 ER	203,128	14.68	608,1[illegible]	Max PCN --->	56.2	73.1	90.2	0.0169
8	DC8-63	97,256	14.71	305,558	40.2	47.7	55.9	63.3	0.1121

Bottom

R[illegible]le 3. Rigid ACN at Indicated Gross Weight and Strength

No.	Aircraft Name	Gross Weight	% GW on Main Gear	Tire Pressure	A(552)	B(295)	C(147)	D(74)
1	A300-B4 STD	365,747	94.00	216.1	48.5	57.3	66.9	75.5
2	A319-100 std	141,978	92.60	172.6	34.7	37.1	39.3	41.2
3	Adv. B727-200 Basic	185,200	96.00	148.0	49.3	52.7	55.8	58.3
4	B737-300	140,000	90.86	201.0	38.2	40.1	42.0	43.5
5	B747-400	877,000	93.32	200.0	52.6	63.0	74.6	85.3
6	B767-200 ER	396,000	90.82	190.0	43.4	51.9	62.0	71.4
7	B777-200 ER	657,000	91.80	20[illegible]	Max ACN --->	63.6	82.6	101.2
8	DC8-63	330,000	96.12	194.0	44.8	53.3	62.2	70.2

The Top portion of Table A3-7 shows the required thickness using the thickness design in accordance with the FAA Westergaard method for a concrete pavement with subgrade k-value of 241 pci. The B747-400 aircraft has the greatest individual pavement thickness requirement (14.13 inches) for its total traffic over 20 years. Note the thickness requirements for the B747-400 exceeds the evaluation pavement thickness (14.0 in). This indicates the PCN values for the existing traffic will be less than the values shown in the Bottom portion of Table A3-7.

The Middle portion of Table A3-7 shows the results of the detailed method based on the cumulative damage factor (CDF) procedure that allows the calculation of the combined effect of multiple aircraft in the traffic mix. This combined traffic is brought together into equivalent traffic considering each aircraft as the critical aircraft.

The CDF analysis calculates a maximum allowable gross weight, equivalent coverage level, and corresponding thickness for each aircraft in the traffic mix at the evaluation thickness (14.0 in.) and support conditions (241 pci).

Referring to the CDF calculation results shown in the Middle portion of Table A3-7, the B737-300, the A319-100 std, the B767-200 ER, and the B777-200 contribute the least to the cumulative damage on this pavement. However, the required thickness in Column 3 is consistently greater than the evaluation thickness. The pavement does not have sufficient strength to accommodate all existing traffic. The values in the column labeled B(295) of the Middle portion of Table A3-7 are used for this analysis since the existing k-value of 241 pci. is within the standard range for Category B subgrade support. The PCN for this pavement can be reported as the highest PCN in the B(295) column. The airport may report a PCN of 56/R/B/W/T. The ACN (Bottom portion of Table A3-7) of the aircraft the pavement PCN and the airport should plan for a pavement strengthening project or consider placing restrictions on those aircraft.

b. Rigid Pavement Example 2. This second example has the same input parameters as the first, except the slab thickness is increased to 15 inches, as shown in Figure A3-5.

Existing pavement:
15 inch concrete layer (P-501)
5 inch stabilized subbase layer (P-304)
5 inch soil-cement subbase layer (P-301)
Subgrade k-value 100

k-value improvement.
5 inch P-304 improves k-value to 241
5 inch P-301 improves k-value to 138

Equivalent Pavement:
15 inch concrete layer (P-501)
k-value 241 pci.
Concrete strength 700 psi.

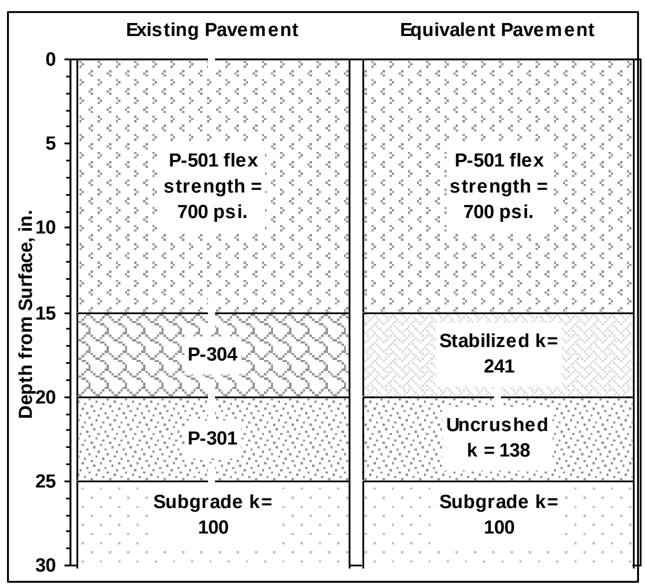

Figure A3-5. Rigid Pavement Example 2 Cross-Section

Table A3-8 shows the results from COMFAA.

Table A3-8. Rigid Pavement Example 2

k Value = 241.0 lbs/in^3 (Subgrade Category is B)
flexural strength = 700.0 psi
Evaluation pavement thickness = 15.00 in
Pass to Traffic Cycle (PtoTC) Ratio = 1.00

Maximum number of wheels per gear = 6
Maximum number of gears per aircraft = 4

R... Table 1. Input Traffic Data

Top

No.	Aircraft Name	Gross Weight	Percent Gross Wt	Tire Press	Annual Deps	20-yr Coverages	6D Thick
1	A300-B4 STD	365,747	94.00	216.1	1,500	8,228	13.01
2	A319-100 std	141,978	92.60	172.6	1,200	6,443	11.51
3	Adv. B727-200 Basic	185,200	96.00	148.0	400	2,754	12.82
4	B737-300	140,000	90.86	201.0	6,000	31,003	13.19
5	B747-400	877,000	93.32	200.0	3,000	17,205	14.13
6	B767-200 ER	396,000	90.82	190.0	2,000	10,907	12.55
7	B777-200 ER	657,000	91.80	205.0	300	1,458	11.29
8	DC8-63	330,000	96.12	194.0	800	4,634	12.22

R... e 2. PCN Values

Middle

No.	Aircraft Name	Critical Aircraft Total Equiv. Covs.	Thickness for Total Equiv. Covs.	Maximum Allowable Gross Weight	PCN at Indicated Code A(552)	B(295)	C(147)	D(74)	CDF
1	A300-B4 STD	62,275	14.73	374,690	50.2	59.3	69.2	78.0	0.0965
2	A319-100 std	443,570	14.76	146,322	35.9	38.4	40.7	42.7	0.0106
3	Adv. B727-200 Basic	32,743	14.72	192,182	51.6	55.1	58.3	60.9	0.0614
4	B737-300	219,728	14.75	144,426	39.6	41.6	43.5	45.1	0.1030
5	B747-400	33,750	14.72	903,532	54.9	65.7	77.8	88.8	0.3722
6	B767-200 ER	165,760	14.75	406,183	45.0	53.8	64.2	73.9	0.0480
7	B777-200 ER	221,741	14.75	676,0	Max PCN --->	66.6	86.5	105.7	0.0048
8	DC8-63	100,727	14.74	338,943	46.5	55.4	64.6	72.7	0.0336

R... e 3. Rigid ACN at Indicated Gross Weight and Strength

Bottom

No.	Name	Gross Weight	% GW on Main Gear	Tire Pressure	A(552)	B(295)	C(147)	D(74)
1	A300-B4 STD	365,747	94.00	216.1	48.5	57.3	66.9	75.5
2	A319-100 std	141,978	92.60	172.6	34.7	37.1	39.3	41.2
3	Adv. B727-200 Basic	185,200	96.00	148.0	49.3	52.7	55.8	58.3
4	B737-300	140,000	90.86	201.0	38.2	40.1	42.0	43.5
5	B747-400	877,000	93.32	200.0	52.6	63.0	74.6	85.3
6	B767-200 ER	396,000	90.82	190.0	43.4	51.9	62.0	71.4
7	B777-200 ER	657,000	91.80	205.0	49.7	63.6	82.6	101.2
8	DC8-63	330,000	96.12	194.0	44.8	53.3	62.2	70.2

The Top portion of Table A3-8 shows the required thickness using the thickness design in accordance with the FAA Westergaard method for a concrete pavement with subgrade k-value of 241 pci. The B747-400 aircraft has the greatest individual pavement thickness requirement (14.13 inches) for its total traffic over 20 years. Note the thickness requirements for each individual aircraft are less than the evaluation pavement thickness of 15.0 inches. This indicates that the pavement may have sufficient thickness for existing traffic, however, the results from the cumulative damage factor (CDF) procedure are needed for confirmation.

The Middle portion of Table A3-8 shows the results of the detailed method based on the CDF procedure that allows the calculation of the combined effect of multiple aircraft in the traffic mix. This combined traffic is brought together into equivalent traffic considering each aircraft as the critical aircraft.

The CDF analysis calculates a maximum allowable gross weight, equivalent coverage level, and corresponding thickness for each aircraft in the traffic mix at the evaluation thickness (15.0 in.) and support conditions (241 pci).

Referring to the calculation results shown in the Middle portion of the table, all aircraft can operate at gross weights higher than current levels. This pavement has more than sufficient strength to accommodate existing traffic. The values in the Column labeled B(295) in the Middle portion of the table are used for this analysis since the existing k-value is within the standard range for Category B subgrade support. The PCN for this pavement can be reported as the highest PCN in the B(295) column. The airport may report a PCN of 67R/B/W/T. The pavement will adequately accommodate the existing traffic within its design life, and no adjustments to the pavement cross-section or life will have to be made.

c. Rigid Pavement Example 3. The only change in this example from the second example is that the aircraft generally do not obtain fuel at the airport. Referring to Table A3-9, the P/TC ratio changes from 1 to 2.

The change results in double the number of coverages for each aircraft in the traffic mix as shown in The Top portion of Table A3-9. As expected, the required total pavement thickness for each aircraft in the traffic mix has increased. The B747-400 aircraft has the greatest individual pavement thickness requirement (14.74) inches) for its total traffic over 20 years.

Table A3-9. Rigid Pavement Example 3

```
                k Value = 241.0 lbs/in^3 (Subgrade Category is B)
      flexural strength = 700.0 psi
Evaluation pavement thickness = 15.00 in
Pass to Traffic Cycle (PtoTC) Ratio = 2.00   <--- Changed from 1.0 to 2.0

  Maximum number of wheels per gear = 6
Maximum number of gears per aircraft = 4
```

Top s Table 1. Input Traffic Data

No.	Aircraft Name	Gross Weight	Percent Gross Wt	Tire Press	Annual Deps	20-yr Coverages	6D Thick
1	A300-B4 STD	365,747	94.00	216.1	1,500	16,456	13.60
2	A319-100 std	141,978	92.60	172.6	1,200	12,885	12.04
3	Adv. B727-200 Basic	185,200	96.00	148.0	400	5,507	13.14
4	B737-300	140,000	90.86	201.0	6,000	62,007	13.74
5	B747-400	877,000	93.32	200.0	3,000	34,410	14.74
6	B767-200 ER	396,000	90.82	190.0	2,000	21,813	13.11
7	B777-200 ER	657,000	91.80	205.0	300	2,917	11.54
8	DC8-63	330,000	96.12	194.0	800	9,269	12.76

Middle e 2. PCN Values — **Column 3**

No.	Aircraft Name	Critical Aircraft Total Equiv. Covs.	Thickness for Total Equiv. Covs.	Maximum Allowable Gross Weight	PCN at Indicated Code A(552)	B(295)	C(147)	D(74)	CDF
1	A300-B4 STD	124,550	15.32	354,757	46.4	54.9	64.2	72.5	0.1929
2	A319-100 std	887,140	15.29	136,973	33.2	35.5	37.7	39.5	0.0212
3	Adv. B727-200 Basic	65,485	15.34	177,246	46.7	50.0	53.0	55.4	0.1228
4	B737-300	439,456	15.30	134,862	36.5	38.4	40.2	41.6	0.2061
5	B747-400	67,501	15.33	846,813	50.1	59.9	71.1	81.4	0.7444
6	B767-200 ER	331,521	15.31	384,177	41.7	49.8	59.4	68.6	0.0961
7	B777-200 ER	443,483	15.30	635,51	**Max PCN --->**	60.3	78.4	96.3	0.0096
8	DC8-63	201,455	15.31	319,688	42.8	50.9	59.6	67.3	0.0672

Bottom le 3. Rigid ACN at Indicated Gross Weight and Strength

No.	Aircraft Name	Gross Weight	% GW on Main Gear	Tire Pressure	A(552)	B(295)	C(147)	D(74)
1	A300-B4 STD	365,747	94.00	216.1	48.5	57.3	66.9	75.5
2	A319-100 std	141,978	92.60	172.6	34.7	37.1	39.3	41.2
3	Adv. B727-200 Basic	185,200	96.00	148.0	49.3	52.7	55.8	58.3
4	B737-300	140,000	90.86	201.0	38.2	40.1	42.0	43.5
5	B747-400	877,000	93.32	200.0	52.6	63.0	74.6	85.3
6	B767-200 ER	396,000	90.82	190.0	43.4	51.9	62.0	71.4
7	B777-200 ER	657,000	91.80	205.0	49.7	63.6	82.6	101.2
8	DC8-63	330,000	96.12	194.0	44.8	53.3	62.2	70.2

Referring to the CDF calculation results shown in the Middle table, the A319-100 std and the B777-200ER have the least impact on this pavement's performance. However, Column 3 of the Middle portion of the table shows that each aircraft requires more than the evaluation thickness when using the CDF method. It is apparent the pavement is not adequate to accommodate double the coverages of the existing traffic. As expected, changing the taxiway system from parallel to central has lowered the PCN of the pavement. The airport may report 60/R/B/W/T. The ACN of two aircraft exceed the pavement PCN and the airport should plan for a pavement strengthening project or consider placing restrictions on those aircraft. The net effect of the change in taxiway configuration from that of Example 2 is the reduction in PCN by 7.

As an alternate way of looking at the effect of a parallel versus central taxiway effects, consider how the pavement life would change instead of the PCN. If the reported PCN from this example were to remain at 60/R/B/W/T then the pavement life would be reduced by 1/2. This is due to the change in the P/TC ratio, which doubled the number of loadings. A similar effect would be noticed if fuel was not obtained at the airport, (it was obtained in the second flexible pavement example case). With a P/TC ratio of 3, the PCN is reduced further and the pavement life would be one-third the pavement life of the pavement with traffic assumptions given for example 2.

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APPENDIX 4. PAVEMENT OVERLOAD EVALUATION BY THE ACN-PCN SYSTEM

1.0 ICAO PAVEMENT OVERLOAD EVALUATION GUIDANCE.

In the life of a pavement, it is possible that either the current or the future traffic will load the pavement in such a manner that the assigned pavement rating is exceeded. ICAO provides a simplified method to account for minor pavement overloading in which the overloading may be adjusted by applying a fixed percentage to the existing PCN.

The ICAO procedure for overload operations is based on minor or limited traffic having ACNs that exceed the reported PCN. Loads that are larger than the defined PCN will shorten the pavement design life, while smaller loads will use up the life at a reduced rate. With the exception of massive overloading, pavements in their structural behavior do not suddenly or catastrophically fail. As a result, occasional minor aircraft overloading is acceptable with only limited loss of pavement life expectancy and relatively small acceleration of pavement deterioration. For those operations in which the magnitude of overload and/or frequency does not justify a detailed (technical) analysis, the following criteria are suggested.

- For flexible pavements, occasional traffic cycles by aircraft with an ACN not exceeding 10 percent above the reported PCN should not adversely affect the pavement.
- For rigid or composite pavements, occasional traffic cycles by aircraft with an ACN not exceeding 5 percent above the reported PCN should not adversely affect the pavement.
- The annual number of overload traffic cycles should not exceed approximately 5 percent of the total annual aircraft traffic cycles.
- Overloads should not normally be permitted on pavements exhibiting signs of distress, during periods of thaw following frost penetration, or when the strength of the pavement or its subgrade could be weakened by water.
- Where overload operations are conducted, the airport authority should review the relevant pavement condition on a regular basis and should also review the criteria for overload operations periodically, since excessive repetition of overloads can cause severe shortening of pavement life or require major rehabilitation of the pavement.

However, these criteria give little guidance to the airport authority as to the impact of these overload operations on the pavement in terms of pavement life reduction or increased maintenance requirements. This appendix discusses methods for making overload allowances for both flexible and rigid pavements that will clearly indicate these effects and will give the authority the ability to determine the impact both economically and in terms of pavement life.

1.1 OVERLOAD GUIDANCE.

The overload evaluation guidance in this appendix applies primarily to flexible and rigid pavements that have PCN values that were established by the technical method. Pavements that have ratings determined by the using aircraft method can use the overload guidelines provided by ICAO. The procedures presented here rely on the COMFAA program.

The adjustments for pavement overloads start with the assumption that some of the aircraft in the traffic mix have ACNs that exceed the PCN. If the steps outlined in Appendix 2 have been followed for the technical method, then most of the necessary data already exists to perform an examination of overloading.

For flexible pavement, it was found in the second example of Appendix 3 that the B747-400, the B777-200ER, and A300-B4 STD aircraft have ACNs that exceed the recommended runway PCN rating. Likewise, for the first rigid pavement example, the ACNs of the B747-400, A300B4 STD, and B777-200 ER exceed the recommended runway rating.

Table A4-1. Flexible Pavement Example 2 (from COMFAA Details Window)

CBR = 7.00 (Subgrade Category is C)
Evaluation pavement thickness = 33.90 in
Pass to Traffic Cycle (PtoTC) Ratio = 1.00
Maximum number of wheels per gear = 6
Maximum number of gears per aircraft = 4

At least one aircraft has 4 or more wheels per gear. The FAA recommends a reference section assuming 5 inches of HMA and 8 inches of crushed aggregate for equivalent thickness calculations.

Top — Table 1. Input Traffic Data

No.	Aircraft Name	Gross Weight	Percent Gross Wt	Tire Press	Annual Deps	20-yr Coverages	6D Thick
1	A300-B4 STD	365,747	94.00	216.1	1,500	16,456	33.06
2	A319-100 std	141,978	92.60	172.6	1,200	6,443	24.09
3	Adv. B727-200 Basic	185,200	96.00	148.0	400	2,754	27.62
4	B737-300	140,000	90.86	201.0	6,000	31,003	27.51
5	B747-400	877,000	93.32	200.0	3,000	34,410	36.87
6	B767-200 ER	396,000	90.82	190.0	2,000	21,813	32.63
7	B777-200 ER	657,000	91.80	205.0	300	4,375	31.97
8	DC8-63	330,000	96.12	194.0	800	9,269	31.03

Middle — Table 2. PCN Values

No.	Aircraft Name	Critical Aircraft Total Equiv. Covs.	Thickness for Total Equiv. Covs.	Maximum Allowable Gross Weight	PCN at Indicated Code A(15)	B(10)	C(6)	D(3)	CDF
1	A300-B4 STD	156,937	36.54	330,524	40.5	44.7	54.0	69.9	0.6174
2	A319-100 std	>5,000,000	35.23	133,520	29.7	30.5	33.7	39.1	0.0004
3	Adv. B727-200 Basic	339,956	36.68	162,662	38.8	41.0	46.8	52.1	0.0477
4	B737-300	>5,000,000	35.34	130,515	30.4	31.9	35.5	39.6	0.0054
5	B747-400	47,121	37.42	772,687	45.2	49.7	59.7	79.8	4.2993
6	B767-200 ER	275,106	36.40	361,883	40.1	43.9	52.0	71.0	0.4668
7	B777-200 ER	90,959	35.95	608,938	44.4	49.8	60.4 <--- Max PCN	[illegible]	[illegible]32
8	DC8-63	326,269	36.10	302,294	38.5	43.0	51.7	65.4	0.1673

Bottom — Table 3. Flexible ACN at Indicated Gross Weight and Strength

No.	Aircraft Name	Gross Weight	% GW on Main Gear	Tire Pressure	A(15)	B(10)	C(6)	D(3)
1	A300-B4 STD	365,747	94.00	216.1	46.3	51.6	62.8	79.7
2	A319-100 std	141,978	92.60	172.6	31.9	32.8	36.4	42.1
3	Adv. B727-200 Basic	185,200	96.00	148.0	45.8	48.3	55.0	60.1
4	B737-300	140,000	90.86	201.0	33.0	34.8	38.8	42.8
5	B747-400	877,000	93.32	200.0	53.2	59.3	72.6	94.2
6	B767-200 ER	396,000	90.82	190.0	44.9	49.6	59.8	80.2
7	B777-200 ER	657,000	91.80	205.0	49.1	55.4	68.0	94.8
8	DC8-63	330,000	96.12	194.0	43.1	48.8	58.5	73.3

Individually, none of the aircraft in the traffic mix have requirements that exceed the existing pavement thickness requirements. However, even though each of these aircraft were included in the derivation of the allowable gross weight of the critical aircraft, the recommended PCN is not adequate for the larger aircraft. To resolve these kinds of problems the airport authority has three options when making a pavement strength rating selection:

1. Let the PCN remain as derived from the technical evaluation method, but retain local knowledge that there are some aircraft in the traffic mix that can be allowed to operate with ACNs that exceed the published PCN or at a reduced weight to not exceed the PCN.

2. Provide for an increased PCN by either adding an overlay or by reconstructing to accommodate aircraft with the higher ACNs.

3. Adjust the PCN upward to that of the aircraft with the highest ACN, but recognize the need to expect possible severe maintenance. This will result in earlier than planned reconstruction or overlay due to reduced pavement life.

The first option requires that the airport authority be constantly aware of the composition of the entire traffic mix in terms of operating gross weights and loading frequency. If the traffic mix has changes that affect the factors involved in developing a technically based PCN, then the PCN will need to be adjusted to reflect the changes. The airport authority will also have to internally make allowance for or prevent aircraft operations that exceed the PCN. The difficulty in doing this is that the magnitude of the PCN is out of step with the ACNs of some of the traffic.

The second option alleviates the problems discussed for the first option, but it does require additional expense to bring the pavement up to the strength required by the combination of aircraft in the traffic mix. However, providing the pavement strengthening will allow operations at the required strength and for the desired pavement life.

The third option has the benefit of allowing all aircraft in the traffic mix to operate as necessary. However, by increasing the PCN, which implies higher pavement strength, the pavement life will be reduced unless an increase in thickness is provided.

Each of these options is considered in the following discussion on pavement overloading—first for flexible pavement and then for rigid pavement.

1.2 ADJUSTMENTS FOR FLEXIBLE PAVEMENT OVERLOADS.

It is most efficient to describe the procedures for flexible pavement overloading by referencing flexible pavement technical evaluation example 2 in Appendix 3. In this example, aircraft of the traffic mix were found to exceed the pavement capability. The derived rating was found to be PCN 60/F/C/X/T.

a. Flexible Pavement Overload Illustration 1. The Bottom portion of Table A4-1 indicates that the B747-400 operates at a gross weight of 877,000 pounds, with an ACN of 73/F/C, the A300-B4 STD has a gross weight of 365,747 pounds and an ACN of 63/F/C, and the B777-200ER operates at a gross weight of 657,000 pounds, with an ACN of 68/F/C. Reduction of the gross weights to the rated PCN of 60/F/C/X/T would result in a gross weight for the B747-400 of 772,687 pounds, gross weight of 608,938 pounds for the B777-200ER, and a gross weight of 330,524 pounds for the A300-B4 STD. Although these limited operating weights would solve the problem of pavement loading, they have the disadvantage of restricting airline operations. Additionally, new traffic with aircraft having ACNs exceeding the PCN would also have to be restricted.

b. Flexible Pavement Overload Illustration 2. Rather than restricting operating weights, the airport could refurbish the pavement by adding an overlay. Using 2 inches as a starting point, recalculate the equivalent pavement thickness, shown in Figure A4-1.

Existing pavement after 2” overlay:
7 inch asphalt surface layer (P-401)
4 inch base layer (P-304)
6 inch base layer (P-209)
17 inches subbase layer (P-154)
Subgrade CBR 7

P-401 exceeds requirements by 2”.

P-304 plus P-209 exceed P-209 requirements. Portion of P-401 is converted to P-209. Excess P-209 and P-304 converted to P-154. This conversion results in 1.9 inches added to equivalent pavement thickness.

Equivalent Pavement:
5 inch asphalt surface layer (P-401)
8 inch base layer (P-209)
25.4 inch subbase layer (P-154)
38.4 inch total thickness
Subgrade CBR 7

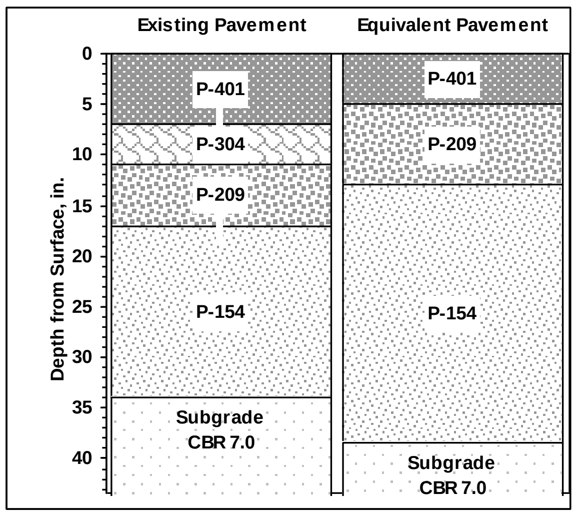

Figure A4-1. Flexible Pavement Overload Illustration 2 (Overlay Flexible Example 2 Cross-Section)

Run COMFAA with revised pavement parameters. The results are shown in the following table.

Table A4-2. Flexible Pavement Overload Illustration 2

```
                    CBR = 7.00 (Subgrade Category is C)
     Evaluation pavement thickness = 38.40 in
  Pass to Traffic Cycle (PtoTC) Ratio = 1.00
    Maximum number of wheels per gear = 6
   Maximum number of gears per aircraft = 4

At least one aircraft has 4 or more wheels per gear.  The FAA recommends a reference section assuming
5 inches of HMA and 8 inches of crushed aggregate for equivalent thickness calculations.
```

Top — Table 1. Input Traffic Data

No.	Aircraft Name	Gross Weight	Percent Gross Wt	Tire Press	Annual Deps	20-yr Coverages	6D Thick
1	A300-B4 STD	365,747	94.00	216.1	1,500	16,456	33.06
2	A319-100 std	141,978	92.60	172.6	1,200	6,443	24.09
3	Adv. B727-200 Basic	185,200	96.00	148.0	400	2,754	27.62
4	B737-300	140,000	90.86	201.0	6,000	31,003	27.51
5	B747-400	877,000	93.32	200.0	3,000	34,410	36.87
6	B767-200 ER	396,000	90.82	190.0	2,000	21,813	32.63
7	B777-200 ER	657,000	91.80	205.0	300	4,375	31.97
8	DC8-63	330,000	96.12	194.0	800	9,269	31.03

Middle — Table 2. PCN Values (**Column 3**)

No.	Aircraft Name	Critical Aircraft Total Equiv. Covs.	Thickness for Total Equiv. Covs.	Maximum Allowable Gross Weight	PCN at Indicated Code A(15)	B(10)	C(6)	D(3)	CDF
1	A300-B4 STD	360,423	37.53	377,305	48.2	53.9	65.7	82.9	0.0203
2	A319-100 std	>5,000,000	38.12	143,712	32.4	33.3	36.9	42.7	0.0000
3	Adv. B727-200 Basic	556,441	37.36	193,965	48.9	51.1	58.2	63.3	0.0022
4	B737-300	>5,000,000	38.06	142,157	33.7	35.5	39.5	43.5	0.0000
5	B747-400	37,671	37.03	919,090	Max PCN --->		78.1	100.1	0.4058
6	B767-200 ER	781,644	37.60	406,820	46.5	51.4	62.4	83.1	0.0124
7	B777-200 ER	1,292,038	37.97	666,322	50.1	56.5	69.5	96.7	0.0015
8	DC8-63	1,995,912	37.79	337,692	44.5	50.4	60.5	75.5	0.0021

Bottom — Table 3. Flexible ACN at Indicated Gross Weight and Strength

No.	Aircraft Name	Gross Weight	% GW on Main Gear	Tire Pressure	A(15)	B(10)	C(6)	D(3)
1	A300-B4 STD	365,747	94.00	216.1	46.3	51.6	62.8	79.7
2	A319-100 std	141,978	92.60	172.6	31.9	32.8	36.4	42.1
3	Adv. B727-200 Basic	185,200	96.00	148.0	45.8	48.3	55.0	60.1
4	B737-300	140,000	90.86	201.0	33.0	34.8	38.8	42.8
5	B747-400	877,000	93.32	200.0	53.2	59.3	72.6	94.2
6	B767-200 ER	396,000	90.82	190.0	44.9	49.6	59.8	80.2
7	B777-200 ER	657,000	91.80	205.0	49.1	55.4	68.0	94.8
8	DC8-63	330,000	96.12	194.0	43.1	48.8	58.5	73.3

The results show that a 2-inch overlay meets existing traffic requirements.

This example is only intended to illustrate the effect of pavement thickness on the PCN rating. Overlay thickness requirements for pavement design purposes should be determined using AC 150/5320-6.

c. Flexible Pavement Overload Illustration 3. This example will illustrate the effect of ICAO allowable overloading in which the ACN is no more than 10 percent above the PCN and the number of traffic cycles does not exceed 5 percent of the total annual traffic.

Table A4-1 is repeated here as Table A4-3, but with some changes. First, the aircraft that have minimal impact on the pavement are removed for this analysis. In this example, when the CDF for the aircraft is less than 1 percent, the aircraft is removed. The departures from these aircraft are not used in the 5 percent overload criteria. Second, the airport now plans to provide access to the B777-200LR with an ACN of 84/F/C/W, nearly 10 percent higher than the existing PCN of 78/F/C/W. The total annual departures of the traffic that have substantial impact on the pavement is 6,500. Five percent of the total (325) is used as the annual departure level of the proposed aircraft.

Table A4-3. Flexible Pavement Overload Illustration 3

```
                                    CBR = 7.00 (Subgrade Category is C)
               Evaluation pavement thickness = 38.40 in
         Pass to Traffic Cycle (PtoTC) Ratio = 1.00
           Maximum number of wheels per gear = 6
        Maximum number of gears per aircraft = 4

At least one aircraft has 4 or more wheels per gear.  The FAA recommends a reference section assuming
5 inches of HMA and 8 inches of crushed aggregate for equivalent thickness calculations.
```

Top — Table 1. Input Traffic Data

No.	Aircraft Name	Gross Weight	Percent Gross Wt	Tire Press	Annual Deps	20-yr Coverages	6D Thick
1	A300-B4 STD	365,747	94.00	216.1	1,500	16,456	33.06
2	A319-100 std	141,978	92.60	172.6	~~1,200~~	6,443	24.09
3	Adv. B727-200 Basic	185,200	96.00	148.0	~~400~~	2,754	27.62
4	B737-300	140,000	90.86	201.0	~~6,000~~	31,003	27.51
5	B747-400	877,000	93.32	200.0	3,000	34,410	36.87
6	B767-200 ER	396,000	90.82	190.0	2,000	21,813	32.63
7	B777-200 ER	657,000	91.80	205.0	~~300~~	4,375	31.97
8	DC8-63	330,000	96.12	194.0	~~800~~	9,269	31.03
					6,500 total		

Middle — Table 2. PCN Values

No.	Aircraft Name	Critical Aircraft Total Equiv. Covs.	Thickness for Total Equiv. Covs. (Column 3)	Maximum Allowable Gross Weight	PCN at Indicated Code A(15)	B(10)	C(6)	D(3)	CDF
1	A300-B4 STD	360,423	37.53	377,305	48.2	53.9	65.7	82.9	0.0203
2	A319-100 std	>5,000,000	38.12	143,712	32.4	33.3	<1% damage --->		0.0000
3	Adv. B727-200 Basic	556,441	37.36	193,965	48.9	51.1	<1% damage --->		0.0022
4	B737-300	>5,000,000	38.06	142,157	33.7	35.5	<1% damage --->		0.0000
5	B747-400	37,671	37.03	919,090	Max PCN --->		78.1	100.1	0.4058
6	B767-200 ER	781,644	37.60	406,820	46.5	51.4	62.4	83.1	0.0124
7	B777-200 ER	1,292,038	37.97	666,322	50.1	56.5	<1% damage --->		0.0015
8	DC8-63	1,995,912	37.79	337,692	44.5	50.4	<1% damage --->		0.0021

Bottom — Table 3. Flexible ACN at Indicated Gross Weight and Strength

No.	Aircraft Name	Gross Weight	% GW on Main Gear	Tire Pressure	A(15)	B(10)	C(6)	D(3)
1	A300-B4 STD	365,747	94.00	216.1	46.3	51.6	62.8	79.7
2	A319-100 std	141,978	92.60	172.6	31.9	32.8	36.4	42.1
3	Adv. B727-200 Basic	185,200	96.00	148.0	45.8	48.3	55.0	60.1
4	B737-300	140,000	90.86	201.0	33.0	34.8	38.8	42.8
5	B747-400	877,000	93.32	200.0	53.2	59.3	72.6	94.2
6	B767-200 ER	396,000	90.82	190.0	44.9	49.6	59.8	80.2
7	B777-200 ER	657,000	91.80	205.0	49.1	55.4	68.0	94.8
8	DC8-63	330,000	96.12	194.0	43.1	48.8	58.5	73.3

The CDF analysis of the new traffic mix, shown in Table A4-4, reveals that the effect of the heavier B777-LR on the pavement is not an overload and the airport can change the PCN of the pavement to 87/F/C/W/T. If 1,000 annual are used, the PCN of the pavement matches the ACN of the B777-200LR at 754,000 pounds.

Table A4-4. Potential Overload Impact on Flexible Pavement PCN

```
                                CBR = 7.00 (Subgrade Category is C)
          Evaluation pavement thickness = 38.40 in
        Pass to Traffic Cycle (PtoTC) Ratio = 1.00
          Maximum number of wheels per gear = 6
        Maximum number of gears per aircraft = 4
```

At least one aircraft has 4 or more wheels per gear. The FAA recommends a reference section assuming 5 inches of HMA and 8 inches of crushed aggregate for equivalent thickness calculations.

Top — Table 1. Input Traffic Data

No.	Aircraft Name	Gross Weight	Percent Gross Wt	Tire Press	Annual Deps	20-yr Coverages	6D Thick
1	A300-B4 STD	365,747	94.00	216.1	1,500	16,456	33.06
2	A319-100 std	141,978	92.60	172.6	1,200	6,443	24.09
3	Adv. B727-200 Basic	185,200	96.00	148.0	400	2,754	27.62
4	B737-300	140,000	90.86	201.0	6,000	31,003	27.51
5	B747-400	877,000	93.32	200.0	3,000	34,410	36.87
6	B767-200 ER	396,000	90.82	190.0	2,000	21,813	32.63
7	B777-200 ER	657,000	91.80	205.0	300	4,375	31.97
8	DC8-63	330,000	96.12	194.0	800	9,269	31.03
9	B777-200LR	754,000	91.68	218.0	325	4,920	35.62

Middle — Table 2. PCN Values

No.	Aircraft Name	Critical Aircraft Total Equiv. Covs.	Thickness for Total Equiv. Covs.	Maximum Allowable Gross Weight	PCN at Indicated Code A(15)	B(10)	C(6)	D(3)	CDF
1	A300-B4 STD	508,978	37.92	372,139	47.4	52.9	64.4	81.5	0.0203
2	A319-100 std	>5,000,000	38.24	142,952	32.2	33.1	36.7	42.4	0.0000
3	Adv. B727-200 Basic	785,789	37.81	190,059	47.5	49.8	56.7	61.9	0.0022
4	B737-300	>5,000,000	38.21	141,211	33.4	35.2	39.2	43.2	0.0000
5	B747-400	53,197	37.63	900,145	55.0	61.5	75.6	97.5	0.4058
6	B767-200 ER	1,103,813	37.95	401,992	45.8	50.6	61.3	81.8	0.0124
7	B777-200 ER	1,824,575	38.16	662,135	49.6	56.0	68.9	95.9	0.0015
8	DC8-63	2,818,564	38.06	334,265	43.9	49.7	59.6	74.5	0.0021
9	B777-200LR	16,856	37.71	771,241	Max PCN --->		87.2	117.7	0.1831

Bottom — Table 3. Flexible ACN at Indicated Gross Weight and Strength

No.	Aircraft Name	Gross Weight	% GW on Main Gear	Tire Pressure	A(15)	B(10)	C(6)	D(3)
1	A300-B4 STD	365,747	94.00	216.1	46.3	51.6	62.8	79.7
2	A319-100 std	141,978	92.60	172.6	31.9	32.8	36.4	42.1
3	Adv. B727-200 Basic	185,200	96.00	148.0	45.8	48.3	55.0	60.1
4	B737-300	140,000	90.86	201.0	33.0	34.8	38.8	42.8
5	B747-400	877,000	93.32	200.0	53.2	59.3	72.6	94.2
6	B767-200 ER	396,000	90.82	190.0	44.9	49.6	59.8	80.2
7	B777-200 ER	657,000	91.80	205.0	49.1	55.4	68.0	94.8
8	DC8-63	330,000	96.12	194.0	43.1	48.8	58.5	73.3
9	B777-200LR	754,000	91.68	218.0	Max ACN --->		84.0	114.1

This example shows the impact on required pavement thickness and on PCN of a new aircraft that is within the ICAO guidelines of no more than 10 percent overload and no more than 5 percent traffic increase. Knowing the impact of new aircraft on pavement thickness requirements, the airport authority can make a decision as to the relative effects.

Although these examples were for specific conditions as described, the methods can also be applied to any other potential traffic overloading condition.

1.3 ADJUSTMENTS FOR RIGID PAVEMENT OVERLOADS.

As was done for the flexible pavement overload illustration, the procedures for rigid pavement overloading can best be explained by continuing the first rigid pavement technical evaluation example in Appendix 3 (Paragraph 2.4a). In this example, for which the derived PCN was 56/R/B/W/T, the B747-400 and the B777-200ER were found to exceed the pavement capability, as shown in the Bottom portion of Table A3-7. This requires that adjustments be made to allow these aircraft to operate at their desired gross weight. These adjustments take the form of either a reduced pavement life or an overlay to increase the pavement strength. The overlay must provide a minimum 64/R/B/W/T PCN.

A second overload illustration examines the effect of occasional traffic of aircraft with ACNs that exceeds the PCN.

a. Rigid Overload Illustration 1. Rather than restricting operating weights, the airport could refurbish the pavement by adding an overlay. Using 1 inch as a starting point, recalculate the equivalent pavement thickness, shown in Table A4-5.

Table A4-5. Rigid Pavement Overload Illustration 1

```
                         k Value = 241.0 lbs/in^3 (Subgrade Category is B)
                flexural strength = 700.0 psi
     Evaluation pavement thickness = 15.00 in
  Pass to Traffic Cycle (PtoTC) Ratio = 1.00

     Maximum number of wheels per gear = 6
    Maximum number of gears per aircraft = 4
```

Top — Table 1. Input Traffic Data

No.	Aircraft Name	Gross Weight	Percent Gross Wt	Tire Press	Annual Deps	20-yr Coverages	6D Thick
1	A300-B4 STD	365,747	94.00	216.1	1,500	8,228	13.01
2	A319-100 std	141,978	92.60	172.6	1,200	6,443	11.51
3	Adv. B727-200 Basic	185,200	96.00	148.0	400	2,754	12.82
4	B737-300	140,000	90.86	201.0	6,000	31,003	13.19
5	B747-400	877,000	93.32	200.0	3,000	17,205	14.13
6	B767-200 ER	396,000	90.82	190.0	2,000	10,907	12.55
7	B777-200 ER	657,000	91.80	205.0	300	1,458	11.29
8	DC8-63	330,000	96.12	194.0	800	4,634	12.22

Middle — Table 2. PCN Values

No.	Aircraft Name	Critical Aircraft Total Equiv. Covs.	Thickness for Total Equiv. Covs.	Maximum Allowable Gross Weight	PCN at Indicated Code A(552)	B(295)	C(147)	D(74)	CDF
1	A300-B4 STD	62,275	14.73	374,690	50.2	59.3	69.2	78.0	0.0965
2	A319-100 std	443,570	14.76	146,322	35.9	38.4	40.7	42.7	0.0106
3	Adv. B727-200 Basic	32,743	14.72	192,182	51.6	55.1	58.3	60.9	0.0614
4	B737-300	219,728	14.75	144,426	39.6	41.6	43.5	45.1	0.1030
5	B747-400	33,750	14.72	903,532	54.9	65.7	77.8	88.8	0.3722
6	B767-200 ER	165,760	14.75	406,183	45.0	53.8	64.2	73.9	0.0480
7	B777-200 ER	221,741	14.75	676,0[illegible]	Max PCN ---> [illegible]	66.6	86.5	105.7	0.0048
8	DC8-63	100,727	14.74	338,943	46.5	55.4	64.6	72.7	0.0336

Bottom — Table 3. Rigid ACN at Indicated Gross Weight and Strength

No.	Aircraft Name	Gross Weight	% GW on Main Gear	Tire Pressure	A(552)	B(295)	C(147)	D(74)
1	A300-B4 STD	365,747	94.00	216.1	48.5	57.3	66.9	75.5
2	A319-100 std	141,978	92.60	172.6	34.7	37.1	39.3	41.2
3	Adv. B727-200 Basic	185,200	96.00	148.0	49.3	52.7	55.8	58.3
4	B737-300	140,000	90.86	201.0	38.2	40.1	42.0	43.5
5	B747-400	877,000	93.32	200.0	52.6	63.0	74.6	85.3
6	B767-200 ER	396,000	90.82	190.0	43.4	51.9	62.0	71.4
7	B777-200 ER	657,000	91.80	205[illegible]	Max ACN ---> [illegible]	63.6	82.6	101.2
8	DC8-63	330,000	96.12	194.0	44.8	53.3	62.2	70.2

The results show that a 1-inch concrete overlay meets existing traffic requirements.

This example is only intended to illustrate the effect of pavement thickness on the PCN rating. The FAA does not recommend a 1-inch overlay. Overlay thickness requirements for pavement design purposes should be determined using AC 150/5320-6 guidance.

b. Rigid Pavement Overload Illustration 2. This example illustrates the effect of ICAO allowable overloading in which the ACN is no more than 5 percent above the PCN and the number of traffic cycles does not exceed 5 percent of the total annual traffic.

Table A3-8 is repeated here as Table A4-6, but with two changes. Departures of aircraft traffic that contribute little or no structural impact on the pavement are not in the 5 percent overload criteria. Second, the airport now plans to provide access to cargo traffic using the A380-800F freighter, with an ACN of 70.7, about 5 percent higher than the existing PCN of 66.6. The total annual departures of the traffic is 14,900. Five percent of the total (745) is used as the annual departure level of the freighter. The results are shown in Table A4-7. The analysis shows that the added freighter traffic, while causing more damage to the pavement, results in no overload and the airport could change the PCN to 71/R/B/W/T.

Table A4-6. Rigid Pavement Overload Illustration

```
                     k Value = 241.0 lbs/in^3 (Subgrade Category is B)
              flexural strength = 700.0 psi
   Evaluation pavement thickness = 15.00 in
Pass to Traffic Cycle (PtoTC) Ratio = 1.00

   Maximum number of wheels per gear = 6
 Maximum number of gears per aircraft = 4
```

Top — Table 1. Input Traffic Data

No.	Aircraft Name	Gross Weight	Percent Gross Wt	Tire Press	Annual Deps	20-yr Coverages	6D Thick
1	A300-B4 STD	365,747	94.00	216.1	1,500	8,228	13.01
2	A319-100 std	141,978	92.60	172.6	1,200	6,443	11.51
3	Adv. B727-200 Basic	185,200	96.00	148.0	400	2,754	12.82
4	B737-300	140,000	90.86	201.0	6,000	31,003	13.19
5	B747-400	877,000	93.32	200.0	3,000	17,205	14.13
6	B767-200 ER	396,000	90.82	190.0	2,000	10,907	12.55
7	B777-200 ER	657,000	91.80	205.0	~~800~~	1,458	11.29
8	DC8-63	330,000	96.12	194.0	800	4,634	12.22
					14,900 total		

Middle — Table 2. PCN Values

No.	Aircraft Name	Critical Aircraft Total Equiv. Covs.	Thickness for Total Equiv. Covs.	Maximum Allowable Gross Weight	PCN at Indicated Code A(552)	B(295)	C(147)	D(74)	CDF
1	A300-B4 STD	62,275	14.73	374,690	50.2	59.3	69.2	78.0	0.0965
2	A319-100 std	443,570	14.76	146,322	35.9	38.4	40.7	42.7	0.0106
3	Adv. B727-200 Basic	32,743	14.72	192,182	51.6	55.1	58.3	60.9	0.0614
4	B737-300	219,728	14.75	144,426	39.6	41.6	43.5	45.1	0.1030
5	B747-400	33,750	14.72	903,532	54.9	65.7	77.8	88.8	0.3722
6	B767-200 ER	165,760	14.75	406,183	45.0	53.8	64.2	73.9	0.0480
7	B777-200 ER	221,741	14.75	676,0	Max PCN --->	66.6	<1% damage --->		0.0048
8	DC8-63	100,727	14.74	338,943	46.5	55.4	64.6	72.7	0.0336

Bottom — Table 3. Rigid ACN at Indicated Gross Weight and Strength

No.	Aircraft Name	Gross Weight	% GW on Main Gear	Tire Pressure	A(552)	B(295)	C(147)	D(74)
1	A300-B4 STD	365,747	94.00	216.1	48.5	57.3	66.9	75.5
2	A319-100 std	141,978	92.60	172.6	34.7	37.1	39.3	41.2
3	Adv. B727-200 Basic	185,200	96.00	148.0	49.3	52.7	55.8	58.3
4	B737-300	140,000	90.86	201.0	38.2	40.1	42.0	43.5
5	B747-400	877,000	93.32	200.0	52.6	63.0	74.6	85.3
6	B767-200 ER	396,000	90.82	190.0	43.4	51.9	62.0	71.4
7	B777-200 ER	657,000	91.80	205	Max ACN --->	63.6	82.6	101.2
8	DC8-63	330,000	96.12	194.0	44.8	53.3	62.2	70.2

```
                       k Value = 241.0 lbs/in^3 (Subgrade Category is B)
            flexural strength = 700.0 psi
 Evaluation pavement thickness = 15.00 in
  Pass to Traffic Cycle (PtoTC) Ratio = 1.00

   Maximum number of wheels per gear = 6
  Maximum number of gears per aircraft = 4
```

Top — Table 1. Input Traffic Data

No.	Aircraft Name	Gross Weight	Percent Gross Wt	Tire Press	Annual Deps	20-yr Coverages	6D Thick
1	A300-B4 STD	365,747	94.00	216.1	1,500	8,228	13.01
2	A319-100 std	141,978	92.60	172.6	1,200	6,443	11.51
3	Adv. B727-200 Basic	185,200	96.00	148.0	400	2,754	12.82
4	B737-300	140,000	90.86	201.0	6,000	31,003	13.19
5	B747-400	877,000	93.32	200.0	3,000	17,205	14.13
6	B767-200 ER	396,000	90.82	190.0	2,000	10,907	12.55
7	B777-200 ER	657,000	91.80	205.0	~~800~~	1,458	11.29
8	DC8-63	330,000	96.12	194.0	800	4,634	12.22
					14,900 total		

Middle — Table 2. PCN Values

No.	Aircraft Name	Critical Aircraft Total Equiv. Covs.	Thickness for Total Equiv. Covs.	Maximum Allowable Gross Weight	PCN at Indicated Code A(552)	B(295)	C(147)	D(74)	CDF
1	A300-B4 STD	62,275	14.73	374,690	50.2	59.3	69.2	78.0	0.0965
2	A319-100 std	443,570	14.76	146,322	35.9	38.4	40.7	42.7	0.0106
3	Adv. B727-200 Basic	32,743	14.72	192,182	51.6	55.1	58.3	60.9	0.0614
4	B737-300	219,728	14.75	144,426	39.6	41.6	43.5	45.1	0.1030
5	B747-400	33,750	14.72	903,532	54.9	65.7	77.8	88.8	0.3722
6	B767-200 ER	165,760	14.75	406,183	45.0	53.8	64.2	73.9	0.0480
7	B777-200 ER	221,741	14.75	676,0[illegible]	Max PCN --->	66.[illegible]	<1% damage --->		0.0048
8	DC8-63	100,727	14.74	338,943	46.5	55.4	64.6	72.7	0.0336
								CDF total --->	0.7301

Bottom — Table 3. Rigid ACN at Indicated Gross Weight and Strength

No.	Aircraft Name	Gross Weight	% GW on Main Gear	Tire Pressure	A(552)	B(295)	C(147)	D(74)
1	A300-B4 STD	365,747	94.00	216.1	48.5	57.3	66.9	75.5
2	A319-100 std	141,978	92.60	172.6	34.7	37.1	39.3	41.2
3	Adv. B727-200 Basic	185,200	96.00	148.0	49.3	52.7	55.8	58.3
4	B737-300	140,000	90.86	201.0	38.2	40.1	42.0	43.5
5	B747-400	877,000	93.32	200.0	52.6	63.0	74.6	85.3
6	B767-200 ER	396,000	90.82	190.0	43.4	51.9	62.0	71.4
7	B777-200 ER	657,000	91.80	205[illegible]	Max ACN --->	63.6	82.6	101.2
8	DC8-63	330,000	96.12	194.0	44.8	53.3	62.2	70.2

The CDF analysis of the two traffic mixes, shows the effect of the freighter on the pavement. The added loads from the freighter reduces the pavement life, but the life is meets the FAA Westergaard method assumptions since the required thickness is less than the existing thickness for all aircraft.

Table A4-7. Potential Rigid Pavement Overload Illustration 2, Results

```
            Evaluation pavement thickness = 15.00 in
      Pass to Traffic Cycle (PtoTC) Ratio = 1.00

        Maximum number of wheels per gear = 6
       Maximum number of gears per aircraft = 4
```

Top

Results Table 1. Input Traffic Data

No.	Aircraft Name	Gross Weight	Percent Gross Wt	Tire Press	Annual Deps	20-yr Coverages	6D Thick
1	A300-B4 STD	365,747	94.00	216.1	1,500	8,228	13.01
2	A319-100 std	141,978	92.60	172.6	1,200	6,443	11.51
3	Adv. B727-200 Basic	185,200	96.00	148.0	400	2,754	12.82
4	B737-300	140,000	90.86	201.0	6,000	31,003	13.19
5	B747-400	877,000	93.32	200.0	3,000	17,205	14.13
6	B767-200 ER	396,000	90.82	190.0	2,000	10,907	12.55
7	B777-200 ER	657,000	91.80	205.0	300	1,458	11.29
8	DC8-63	330,000	96.12	194.0	800	4,634	12.22
9	A380-800F Basic Body	1,272,000	57.03	218.0	745	3,557	12.44
10	A380-800F Basic Wing	1,272,000	38.02	218.0	745	3,957	13.54

Middle

Results Table 2. PCN Values

No.	Aircraft Name	Critical Aircraft Total Equiv. Covs.	Thickness for Total Equiv. Covs.	Maximum Allowable Gross Weight	PCN at Indicated Code A(552)	B(295)	C(147)	D(74)	CDF
1	A300-B4 STD	81,154	14.96	367,125	48.7	57.6	67.3	75.9	0.0965
2	A319-100 std	578,038	14.96	142,650	34.9	37.3	39.5	41.4	0.0106
3	Adv. B727-200 Basic	42,668	14.96	186,285	49.6	53.1	56.2	58.7	0.0614
4	B737-300	286,338	14.96	140,686	38.4	40.4	42.2	43.7	0.1030
5	B747-400	43,982	14.96	881,103	53.0	63.4	75.1	85.8	0.3722
6	B767-200 ER	216,010	14.96	397,586	43.7	52.2	62.3	71.8	0.0480
7	B777-200 ER	288,962	14.96	659,941	50.0	64.0	83.2	101.9	0.0048
8	DC8-63	131,263	14.96	331,389	45.1	53.6	62.6	70.6	0.0336
9	A380-800F Basic Body	82,920	14.96	1,277,65	Max PCN --->	71.2	92.9	115.4	0.0408
10	A380-800F Basic Wing	20,855	14.95	1,278,763	58.8	69.0	81.9	94.5	0.1805

CDF total 0.9514

Bottom

Results Table 3. Rigid ACN at Indicated Gross Weight and Strength

No.	Aircraft Name	Gross Weight	% GW on Main Gear	Tire Pressure	A(552)	B(295)	C(147)	D(74)
1	A300-B4 STD	365,747	94.00	216.1	48.5	57.3	66.9	75.5
2	A319-100 std	141,978	92.60	172.6	34.7	37.1	39.3	41.2
3	Adv. B727-200 Basic	185,200	96.00	148.0	49.3	52.7	55.8	58.3
4	B737-300	140,000	90.86	201.0	38.2	40.1	42.0	43.5
5	B747-400	877,000	93.32	200.0	52.6	63.0	74.6	85.3
6	B767-200 ER	396,000	90.82	190.0	43.4	51.9	62.0	71.4
7	B777-200 ER	657,000	91.80	205.0	49.7	63.6	82.6	101.2
8	DC8-63	330,000	96.12	194.0	44.8	53.3	62.2	70.2
9	A380-800F Basic Body	1,272,000	57.03	21	Max ACN --->	70.7	92.2	114.6
10	A380-800F Basic Wing	1,272,000	38.02	218.0	58.4	68.5	81.3	93.8

This example shows the impact both on required pavement thickness and on PCN of a new aircraft that is within the ICAO guidelines of no more than 5 percent overload and no more than 5 percent traffic increase. Knowing the impact of new aircraft on pavement thickness requirements, the airport authority can make a decision as to the relative effects.

Although these examples were for specific conditions as described, the methods can also be applied to any other potential traffic overloading condition.

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APPENDIX 5. REPORTING CHANGES TO CERTAIN AIRPORT RUNWAY DATA ELEMENTS

This Advisory Circular affects the following airport runway data.

1.0 Allowable Gross Weight.

FAA pavement design guidance has been revised. Previously, the aircraft gross weight data referred to a "design aircraft." The term is no longer used. Aircraft gross weight data reported using the guidance in this AC is calculated based on the PCN of the pavement.

a. Source of Data. The source for Runway Weight Bearing Capacity Data is the FAA Engineer or Program Manager at the local FAA Regional Office (RO) or FAA Airports District Office (ADO). Currently, RO and ADO specialists may submit changes to single wheel type landing gear (S), dual wheel type landing gear (D), dual tandem wheel type landing gear (2D), and double dual tandem wheel type landing gear (2D/2D2) electronically to FAA Air Traffic Aeronautical Information Services for publication in FAA flight information manuals using the secure web site 5010WEB, monitored by GCR & Associates on behalf of the FAA. State airport inspectors may not submit changes to Runway Weight Bearing Capacity Data directly to Aeronautical Information Services for publication. Instead, they must submit the data changes to the RO and ADO for validation, and in turn, the RO or ADO submits changes to Runway Weight Bearing Capacity Data electronically to Aeronautical Information Services using the steps enumerated above on behalf of the State Aviation Agency.

b. Reporting Allowable Gross Weight. For purposes of airport runway data elements generally published on FAA Form 5010, Airport Master Record, the Allowable Gross Weight is the maximum weight expressed in thousands of pounds that aircraft with a specific main gear configuration can operate on a pavement. A list of PCN-based maximum gross weights for reporting Runway Weight Bearing Capacity Data has been developed. The listing is posted on the FAA website with this AC. Local experience can be considered to report a lower weight, but higher weights are not recommended.

1.1 Pavement Classification Number (PCN).

a. Source of Data. The source for Pavement Classification Number (PCN) data is the airport operator. FAA Part 139 airport inspectors and State non-Part 139 airport inspectors are instructed to request PCN data from the airport manager as part of the manager interview before an airport inspection. If the airport manager has PCN data, the inspector may accept the data for immediate publication in flight information publications; however, if the airport manager does not have PCN data, then the inspector has no PCN data available for publication.

b. Reporting PCN. For purposes of airport runway data elements generally published on FAA Form 5010, Airport Master Record, the PCN is a number that expresses the load-carrying capacity of a pavement based on all aircraft traffic that regularly operates on the pavement. The PCN determined earlier (see Appendices 1 through 3) is the PCN to report.

2.0 Assigning Aircraft Gross Weight Data.

Tables A5-1 and A5-2 summarize the process used to assign allowable aircraft gross weight. Table A5-1 shows the flexible ACNs. Table A5-2 shows the rigid ACNs. Allowable gross weight is based on aircraft gear configuration as issued in FAA Order 5300.7, Standard Naming Convention for Aircraft Landing Gear Configurations (October 6, 2005), coupled with tire pressure and wheel spacing ranges. The ACN for these standard aircraft results in a recommended maximum gross weight for Runway Weight Bearing Capacity. See Chapter 3 for instructions for using the COMFAA software to determine ACN values under certain conditions. The COMFAA external file will be posted on the FAA website.

Table A5-1. Flexible ACN Data Used to Establish Allowable Gross Weight

Results Table 3. Flexible ACN at Indicated Gross Weight and Strength

No.	Aircraft Name	Gross Weight	% GW on Main Gear	Tire Pressure	A(15)	B(10)	C(6)	D(3)
1	S-7.5std	7,500	95.00	52.5	1.4	1.9	2.5	2.8
2	S-15std	15,000	95.00	60.0	3.2	4.2	5.2	5.8
3	S-30std	30,000	95.00	75.0	8.0	9.6	11.3	11.8
4	S-45std	45,000	95.00	90.0	13.7	16.1	17.5	18.3
5	S-60std	60,000	95.00	105.0	20.3	22.6	23.7	24.8
6	S-75std	75,000	95.00	120.0	27.4	29.8	30.2	31.3
7	S-90st	90,000	95.00	135.0	35.1	37.2	36.9	37.8
8	S-105std	105,000	95.00	150.0	42.4	43.6	43.2	44.4
9	S-120std	120,000	95.00	165.0	50.5	50.3	50.5	51.0
10	D-37.5	37,500	95.00	65.0	5.5	7.1	8.8	10.9
11	D-50	50,000	95.00	80.0	8.9	11.0	12.9	15.2
12	D-75	75,000	95.00	110.0	16.9	19.0	21.8	24.0
13	D-100	100,000	95.00	140.0	25.8	27.6	30.7	32.8
14	D-125	125,000	95.00	150.0	31.7	33.6	37.8	40.7
15	D-150	150,000	95.00	160.0	37.4	39.3	44.5	48.5
16	D-175	175,000	95.00	180.0	44.0	47.1	52.5	56.8
17	D-200	200,000	95.00	200.0	51.1	54.7	60.4	65.2
18	D-225	225,000	95.00	220.0	58.3	62.1	68.3	73.5
19	D-250	250,000	95.00	240.0	65.3	69.3	76.1	81.7
20	2D-100	100,000	95.00	120.0	10.6	11.5	13.9	17.4
21	2D-150	150,000	95.00	140.0	18.2	20.3	24.2	29.6
22	2D-200	200,000	95.00	160.0	26.4	30.2	35.0	42.9
23	2D-250	250,000	95.00	170.0	34.1	39.2	45.4	55.5
24	2D-300	300,000	95.00	190.0	42.3	48.4	56.0	68.1
25	2D-350	350,000	95.00	190.0	49.5	56.9	66.2	80.4
26	2D-400	400,000	95.00	200.0	56.6	64.9	76.2	92.4
27	2D-450	450,000	95.00	210.0	62.3	71.8	85.3	103.8
28	2D-500	500,000	95.00	220.0	67.3	76.4	92.2	113.8
29	2D-550	550,000	95.00	230.0	70.9	79.3	96.1	121.6
30	2D/2D2-40	640,000	95.00	210.0	36.6	39.6	46.2	63.1
31	2D/2D2-50	800,000	95.00	220.0	48.9	53.7	64.9	85.6
32	2D/2D2-60	960,000	95.00	230.0	62.2	69.4	85.9	108.3
33	2D/2D2-70	1,120,000	95.00	240.0	77.7	87.4	108.4	131.1
34	3D-40	480,000	95.00	210.0	34.2	37.5	44.4	62.9
35	3D-50	600,000	95.00	220.0	46.4	51.2	62.4	87.4
36	3D-60	720,000	95.00	230.0	60.1	66.8	83.1	113.1
37	3D-70	840,000	95.00	240.0	74.6	83.7	105.9	138.6
38	2D/3D2-40W	800,000	36.75	210.0	32.7	34.5	38.7	51.3
39	2D/3D2-50W	1,000,000	36.75	220.0	43.0	46.0	52.5	72.1
40	2D/3D2-60W	1,200,000	36.75	230.0	54.1	58.6	68.4	93.6
41	2D/3D2-70W	1,400,000	36.75	240.0	65.6	72.2	86.7	115.4
42	2D/3D2-40B	800,000	55.75	210.0	30.8	33.1	38.0	52.0
43	2D/3D2-50B	1,000,000	55.75	220.0	41.0	44.7	52.5	74.1
44	2D/3D2-60B	1,200,000	55.75	230.0	52.5	57.4	69.0	97.4
45	2D/3D2-70B	1,400,000	55.75	240.0	65.3	71.7	87.7	121.8

Table A5-2. Rigid ACN Data Used to Establish Allowable Gross Weight

Results Table 3. Rigid ACN at Indicated Gross Weight and Strength

No.	Aircraft Name	Gross Weight	% GW on Main Gear	Tire Pressure	A(552)	B(295)	C(147)	D(74)
1	S-7.5std	7,500	95.00	52.5	2.1	2.2	2.3	2.2
2	S-15std	15,000	95.00	60.0	4.3	4.5	4.7	4.8
3	S-30std	30,000	95.00	75.0	9.3	9.7	10.0	10.2
4	S-45std	45,000	95.00	90.0	14.9	15.4	15.8	16.1
5	S-60std	60,000	95.00	105.0	21.1	21.6	22.1	22.4
6	S-75std	75,000	95.00	120.0	27.7	28.2	28.7	29.0
7	S-90st	90,000	95.00	135.0	34.8	35.2	35.6	35.9
8	S-105std	105,000	95.00	150.0	42.2	42.6	42.9	43.1
9	S-120std	120,000	95.00	165.0	50.0	50.2	50.4	50.5
10	D-37.5	37,500	95.00	65.0	7.3	8.1	9.0	9.6
11	D-50	50,000	95.00	80.0	11.0	12.1	13.0	13.8
12	D-75	75,000	95.00	110.0	19.4	20.8	22.0	23.0
13	D-100	100,000	95.00	140.0	28.7	30.3	31.7	32.8
14	D-125	125,000	95.00	150.0	35.1	37.1	39.0	40.4
15	D-150	150,000	95.00	160.0	41.3	43.8	46.1	47.9
16	D-175	175,000	95.00	180.0	49.8	52.6	55.1	57.1
17	D-200	200,000	95.00	200.0	58.6	61.5	64.2	66.4
18	D-225	225,000	95.00	220.0	67.4	70.6	73.4	75.8
19	D-250	250,000	95.00	240.0	76.4	79.7	82.7	85.2
20	2D-100	100,000	95.00	120.0	10.3	12.2	14.6	16.9
21	2D-150	150,000	95.00	140.0	18.5	22.1	26.0	29.6
22	2D-200	200,000	95.00	160.0	28.1	33.2	38.5	43.1
23	2D-250	250,000	95.00	170.0	36.6	43.2	49.8	55.5
24	2D-300	300,000	95.00	190.0	45.8	53.8	61.7	68.4
25	2D-350	350,000	95.00	190.0	52.9	62.4	71.8	79.8
26	2D-400	400,000	95.00	200.0	60.2	71.0	81.8	91.0
27	2D-450	450,000	95.00	210.0	66.3	78.3	90.5	101.0
28	2D-500	500,000	95.00	220.0	70.1	83.0	96.6	108.5
29	2D-550	550,000	95.00	230.0	72.0	85.0	99.7	113.0
30	2D/2D2-40	640,000	95.00	210.0	36.2	42.2	49.9	57.6
31	2D/2D2-50	800,000	95.00	220.0	49.4	58.4	68.8	78.4
32	2D/2D2-60	960,000	95.00	230.0	64.7	76.5	89.4	100.9
33	2D/2D2-70	1,120,000	95.00	240.0	81.9	96.5	111.7	124.9
34	3D-40	480,000	95.00	210.0	34.9	41.6	53.5	66.7
35	3D-50	600,000	95.00	220.0	47.3	59.5	76.7	94.0
36	3D-60	720,000	95.00	230.0	62.9	80.8	103.2	124.1
37	3D-70	840,000	95.00	240.0	80.7	104.3	131.4	155.7
38	2D/3D2-40W	800,000	36.75	210.0	31.4	35.1	40.8	47.5
39	2D/3D2-50W	1,000,000	36.75	220.0	41.5	47.4	55.8	64.8
40	2D/3D2-60W	1,200,000	36.75	230.0	53.1	61.5	72.5	83.6
41	2D/3D2-70W	1,400,000	36.75	240.0	65.9	77.0	90.7	103.8
42	2D/3D2-40B	800,000	55.75	210.0	34.0	34.8	42.9	54.2
43	2D/3D2-50B	1,000,000	55.75	220.0	43.3	47.9	61.1	76.9
44	2D/3D2-60B	1,200,000	55.75	230.0	52.6	63.7	82.2	102.2
45	2D/3D2-70B	1,400,000	55.75	240.0	65.5	82.0	105.9	129.9

The data in the tables were used to develop a list of maximum gross weights for Runway Weight Bearing Capacity Data. The listings that correlates gross weights with known PCN values for flexible and rigid pavement (see Appendix 6) provide recommended maximum gross weights based on PCN determination.

There will be cases where the gross weight of an aircraft exceeds the gross weight in Tables A5-1 and A5-2 for a reported PCN determined using the procedures in Appendices 1 through 3. The values in the tables are not as accurate as the gross weights associated with the ACN assigned by the aircraft manufacturer. The reported PCN is the basis for data in the tables, and the airport manager should rely on the reported PCN rather than the gross weight data in the table when the ACN of the departing or landing aircraft is known.

Table A5-3 shows the format of the list and brief instructions on its use. The first example shown in the table is for a pavement that supports single, dual, and dual tandem wheel gear aircraft, and the airport can report a PCN of 30 with subgrade category B support. At the intersection of the PCN value with the gear types SW, DW, and DTWS and Subgrade Support Category B, 76,000 pounds is the maximum allowable gross weight for single wheel aircraft, 115,000 pounds is the maximum allowable gross weight for dual wheel aircraft, and 215,000 pounds is the maximum allowable gross weight for dual tandem wheel aircraft. Local experience can be considered to use a lower weight, but higher weights are not recommended.

Table A5-3. Excerpt From Listing of Maximum Gross Weight Data Based on PCN of Pavement–Example 1 and 2

FLEXIBLE PCN					RIGID PCN			
Airplane gross weight (1,000's lbs) for each Subgrade Category B								
	SW	DW	DTW	DDTW	SW	DW	DTW	DDTW
	B(10)	B(10)	B(10)	B(10)	B(295)	B(295)	B(295)	B(295)
PCN								
23	62	90	180	----	64	80	160	----
24	64	90	185	----	66	85	160	----
25	[illegible]	[illegible]	[illegible]	----	69	85	165	----
30	76	115	215	----	80	100	190	----
35	87	140	245	----	91	120	215	----
37	91	145	260	620	[illegible]	130	225	----
40	98	160	275	660	101	140	245	630
45	111	175	305	720	111	160	265	680
4[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5								
5								

PCN = 43RBWT, perform straight line interpolation

The second example in the table is for a pavement that supports aircraft with single and dual wheel gear configurations. The pavement has a PCN of 43/R/B/W/T. The gross weights at the intersection of the PCN value for a B category subgrade with each gear type is between PCN values 40 and 45. Straight line interpolation between values is recommended. Single wheel gross weight is 107,000 pounds. Dual wheel gross weight is 152,000. Local experience can be considered to use lower weights, but higher weights are not recommended.

APPENDIX 6. MAXIMUM AIRCRAFT GROSS WEIGHT TABLES FOR FAA FORM 5010 REPORTING BASED ON PCN DETERMINATION

Table A6-A. Subgrade Strength Category A

	FLEXIBLE PCN Subgrade Category A				RIGID PCN Subgrade Category A			
	Aircraft gross weight (1,000's lbs): Subgrade Category A							
	SW A(15)	DW A(15)	DTW A(15)	DDTW A(15)	SW A(552)	DW A(552)	DTW A(552)	DDTW A(552)
PCN								
3	15	---	---	---	---	---	---	---
4	18	---	---	---	14	---	---	---
5	21	---	---	---	17	---	---	---
6	25	40	---	---	21	---	---	---
7	27	45	---	---	23	35	---	---
8	30	45	---	---	27	40	---	---
9	33	50	---	---	30	45	---	---
10	36	55	95	---	32	50	100	---
12	41	60	110	---	38	55	115	---
13	44	65	120	---	41	60	120	---
14	47	65	125	---	43	60	125	---
15	49	70	130	---	46	65	135	---
16	51	75	140	---	49	65	140	---
17	53	75	145	---	51	70	145	---
18	56	80	150	---	53	70	150	---
19	58	80	160	---	56	75	155	---
20	60	85	165	---	58	80	160	---
25	71	100	195	---	70	90	190	---
30	81	120	230	---	81	110	220	---
34	89	140	260	---	89	125	245	625
35	91	145	265	630	92	130	250	635
40	102	165	295	700	102	150	275	700
45	111	185	335	770	112	165	310	765
48	116	195	355	810	116	175	335	800
49	---	195	360	820	---	175	340	810
50	---	200	370	835	---	180	350	825
55	---	220	410	900	---	195	385	880
60	---	240	460	960	---	210	425	930
65	---	---	520	1015	---	225	485	980
70	---	---	---	1065	---	240	---	1030
71	---	---	---	1075	---	240	---	1040
72	---	---	---	1085	---	---	---	1050
75	---	---	---	---	---	---	---	1080

Note: When the PCN falls between two values, use straight line interpolation to determine the allowable gross weight for the gear types.

Table A6-B. Subgrade Strength Category B

	FLEXIBLE PCN Subgrade Category B				RIGID PCN Subgrade Category B			
	Airplane gross weight (1,000's lbs): Subgrade Category B							
PCN	SW B(10)	DW B(10)	DTW B(10)	DDTW B(10)	SW B(295)	DW B(295)	DTW B(295)	DDTW B(295)
3	15	---	---	---	14	---	---	---
6	23	35	---	---	22	---	---	---
7	26	40	---	---	25	35	---	---
8	29	45	100	---	28	40	---	---
9	32	50	105	---	32	45	---	---
10	34	50	110	---	34	50	---	---
11	36	55	120	---	37	50	100	---
12	38	60	125	---	39	55	105	---
13	41	60	130	---	42	55	110	---
14	43	65	135	---	45	60	115	---
16	48	70	150	---	50	65	130	---
18	52	75	160	---	55	70	140	---
20	57	80	170	---	59	75	150	---
22	62	90	180	---	64	80	160	---
24	66	95	190	---	69	85	165	---
25	76	115	215	---	80	100	190	---
30	87	140	245	---	91	120	215	---
35	91	145	260	620	95	130	225	---
37	98	160	275	660	101	140	245	630
40	111	175	305	720	111	160	265	680
45	116	185	325	755	116	165	280	715
48	---	190	335	780	---	170	290	735
50	---	210	370	835	---	185	325	785
55	---	225	400	885	---	200	355	835
60	---	---	440	935	---	215	385	880
65	---	---	505	985	---	230	420	925
70	---	---	---	1005	---	235	435	940
72	---	---	---	1015	---	240	440	950
73	---	---	---	1025	---	240	450	960
74	---	---	---	1035	---	---	455	965
75	---	---	---	1045	---	---	470	975
76	---	---	---	1055	---	---	490	985
77	---	---	---	1065	---	---	515	990
78	---	---	---	1080	---	---	---	1010
80	---	---	---	---	---	---	---	1050
85	---	---	---	---	---	---	---	1085
89	---	---	---	---	---	---	---	---

Note: When the PCN falls between two values, use straight line interpolation to determine the allowable gross weight for the gear types.

Table A6-C. Subgrade Strength Category C

	FLEXIBLE PCN Subgrade Category C				RIGID PCN Subgrade Category C			
Airplane gross weight (1,000's lbs): Subgrade Category C								
PCN	SW C(6)	DW C(6)	DTW C(6)	DDTW C(6)	SW C(147)	DW C(147)	DTW C(147)	DDTW C(147)
4	12	---	---	---	13	---	---	---
6	17	---	---	---	19	---	---	---
8	22	---	---	---	25	---	---	---
10	27	40	---	---	31	40	---	---
12	32	50	---	---	36	50	---	---
13	35	50	100	---	38	50	---	---
14	37	55	105	---	41	55	100	---
15	40	60	110	---	44	55	105	---
20	52	70	135	---	56	70	130	---
25	64	85	160	---	68	85	150	---
30	76	100	180	---	79	100	170	---
35	87	120	205	---	90	115	190	---
40	99	140	230	---	100	135	215	---
43	106	150	245	625	107	145	230	---
45	111	155	255	640	111	150	235	---
46	113	160	260	650	113	155	240	---
47	115	165	265	660	115	155	245	625
48	116	165	270	670	116	160	250	635
50	---	170	280	690	---	165	260	655
55	---	190	305	735	---	180	280	700
60	---	205	330	780	---	195	305	745
65	---	220	355	820	---	205	330	785
70	---	240	385	860	---	220	355	830
71	---	240	390	870	---	225	360	835
75	---	---	415	900	---	235	385	870
76	---	---	420	905	---	240	390	875
77	---	---	425	915	---	240	395	885
80	---	---	440	940	---	---	410	910
85	---	---	480	975	---	---	440	945
88	---	---	520	1000	---	---	465	970
90	---	---	---	1015	---	---	490	985
92	---	---	---	1030	---	---	525	1000
95	---	---	---	1050	---	---	---	1025
100	---	---	---	1085	---	---	---	1060
102	---	---	---	---	---	---	---	1075
103	---	---	---	---	---	---	---	1080

Note: When the PCN falls between two values, use straight line interpolation to determine the allowable gross weight for the gear types.

Table A6-D. Subgrade Strength Category D

	FLEXIBLE PCN Subgrade Category D				RIGID PCN Subgrade Category D			
	Airplane gross weight (1,000's lbs): Subgrade Category D							
	SW	DW	DTW	DDTW	SW	DW	DTW	DDTW
PCN	D(3)	D(3)	D(3)	D(3)	D(74)	D(74)	D(74)	D(74)
4	---	---	---	---	13	---	---	---
5	13	---	---	---	16	---	---	---
6	16	---	---	---	19	---	---	---
8	21	---	---	---	24	---	---	---
10	26	---	---	---	30	40	---	---
11	29	40	---	---	32	45	---	---
12	31	40	---	---	35	45	---	---
15	38	50	---	---	43	55	---	---
16	40	55	---	---	46	55	100	---
20	50	65	115	---	55	70	115	---
25	62	80	135	---	67	80	135	---
30	74	95	155	---	78	95	155	---
35	85	110	175	---	89	110	175	---
40	97	125	195	---	100	130	195	---
45	109	145	215	---	111	145	215	---
48	116	155	225	---	116	155	225	---
50	---	160	235	---	---	160	235	---
54	---	170	250	---	---	170	250	625
59	---	185	270	625	---	185	270	665
60	---	190	275	630	---	185	275	675
65	---	205	295	670	---	200	295	715
70	---	220	320	705	---	215	320	755
75	---	235	340	740	---	230	345	790
77	---	245	350	755	---	235	350	810
80	---	---	360	780	---	240	365	830
85	---	---	380	815	---	---	390	865
90	---	---	405	850	---	---	415	905
95	---	---	425	885	---	---	440	940
100	---	---	450	920	---	---	475	975
105	---	---	475	960	---	---	530	1010
110	---	---	510	995	---	---	---	1045
113	---	---	530	1015	---	---	---	1065
115	---	---	---	1030	---	---	---	1080
116	---	---	---	1040	---	---	---	1085
120	---	---	---	1065	---	---	---	---
122	---	---	---	1080	---	---	---	---

Note: When the PCN falls between two values, use straight line interpolation to determine the allowable gross weight for the gear types.

APPENDIX 7. RELATED READING MATERIAL

The following publications were used during the development of this AC:

a. AC 150/5320-6, Airport Pavement Design and Evaluation . The FAA makes this publication available for free on the FAA website at http://www.faa.gov.

b. ICAO Bulletin, Official Magazine of International Civil Aviation, Airport Technology, Volume 35, No. 1, Montreal, Quebec, Canada H3A 2R2, January 1980.

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