Republic of the Philippines
Department of Transportation and Communications
CIVIL AVIATION AUTHORITY OF THE PHILIPPINES
Office of the Director General
MIA Road corner Ninoy Aquino Ave., Pasay City,
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Advisory Circular

AC 139 – 04 - A

PAVEMENT STRENGTH

AND

OVERLOAD CONSIDERATIONS

September 2012

Advisory Circulars (AC) are intended to provide recommendations and guidance to illustrate a means, but not necessarily the only means, of complying with regulatory requirements, or to explain certain regulatory requirements by providing interpretative and explanatory material.

CAAP will generally accept that when the provisions of an Advisory Circular have been met, compliance with the relevant regulatory obligation has been satisfied.

Where an AC is referred to in a 'Note' within regulatory documentation, the AC remains as guidance material.

ACs should always be read in conjunction with the referenced regulations.

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Director General
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1. REFERENCES

1.1 This document may refer to portions of the following:

- Civil Aviation Authority Act of 2008, Republic Act No. 9497
- CAAP Manual of Standards for Aerodromes
- International Civil Aviation Organization (ICAO) Aerodrome Design Manual Part 3 – Pavements.

2. PURPOSE OF THIS ADVISORY CIRCULAR

2.1 The purpose of this AC is to provide aerodrome operators with guidance on how to meet specific requirements in relation to reporting the strength of aerodrome pavements, and how to assess requests for operations when aircraft classification number or tyre pressure values exceed pavement strength parameters.

2.2 Operators of aerodromes are required to provide pavements on which aeroplanes can operate safely and they are required to rate the strength of the pavements using the ICAO accepted ACN-PCN method and publish the rating in the Philippines AIP. This advisory circular briefly explains the ACN-PCN method and offers guidelines on what degree of overloading may be considered acceptable for an aerodrome pavement.

2.3 This AC is aimed at a variety of persons who have an interest in the strength of aerodrome pavements such as:

- operators of certified aerodrome;
- operators of registered aerodromes;
- aircraft operators conducting air transport operations;
- persons who specialize in aerodrome pavement design;
- approved persons and technical specialists employed to carry out safety inspections and technical inspections at aerodromes; and
- aerodrome reporting officers.

3. STATUS OF THIS AC

3.1 This is the first Advisory Circular (AC) to be written on the strength rating and loading capacity considerations for aerodrome pavements

4. ACRONYMS

AC	Advisory Circular
ACN	Aircraft Classification Number
AIP	Aeronautical Information Publication
AIS	Aeronautical Information Service
BAC	Boeing Aircraft Company
CBR	California Bearing Ratio
DSWL	Derived Single Wheel Load
FAA	United States Federal Aviation Administration
ICAO	International Civil Aviation Organization
MOS	CAAP Manual of Standards - Aerodromes
MTOW	Maximum Take-off Weight
OWE	Operating Weight Empty
PCA	Portland cement Association
PCN	Pavement Classification Number
TP	Tyre Pressure

5. DEFINITIONS

Aircraft Classification Number (ACN) – a number expressing the relative damaging effect of aircraft on a pavement for specified standard sub grade strength.

Pavement Classification Number (PCN) – a number expressing the bearing strength of a pavement.

Where other technical terms are used, they are defined when they first appear.

6. BACKGROUND

6.1 A large part of the guidance material presented is drawn from work done by ICAO and others in order to prepare a globally harmonized system for the description of pavement strength rating. Pavement strength ratings may be determined from initial pavement design and construction data, testing of in-situ pavements or observation of pavement behavior over extended periods of time.

6.2 In 1981 the International Civil Aviation Organization (ICAO) introduced a new method to identify the bearing strength of aerodrome pavements called the ACN-PCN method. This method for reporting the bearing strength of aerodrome pavements has been adopted in the Philippines and is incorporated in CAAP documentation, particularly in the Manual of Standards for Aerodromes.

7. AERODROME PAVEMENTS

7.1 The purpose of an aerodrome pavement is to provide a durable surface on which aircraft can take-off, land and manoeuvre safely.

What is a Pavement?

7.2 A pavement is a load carrying structure constructed on naturally occurring in-situ soil, referred to as the sub grade. The pavement may be composed of a number of horizontal courses termed bound or unbound as described below:

- An unbound course being composed of materials which are granular mechanically stabilised or treated with additives to improve their properties other than strength, such as plasticity. Under load the unbound course behaves as if its component parts were not bound together, although significant mechanical interlock may occur.

- A bound course is one in which the particles are bound together by additives such as lime, cement or bitumen, so that under load the course behaves as a continuous system able to develop tensile stresses without material separation.

7.3 Pavement courses are also known by their location and function within the pavement structure as described below:

- The surface course provides a wearing surface and provides a seal to prevent entry of water and air into the pavement structure and sub grade, so preventing weathering and disintegration.

- The base course is the main load carrying course within the pavement.

- The sub-base course is a course containing lesser quality material used to protect and separate the base course from the sub grade and vice versa.

7.4 The sub grade is the natural in-situ material on which the pavement is constructed. The use of select fill material may help improve the natural in-situ material and can also be a cost effective way to build up formation level.

Pavement Types

7.5 Pavements are classified as either rigid or flexible depending on their relative stiffness. A rigid pavement is not totally rigid, the terminology is merely an arbitrary attempt to distinguish between pavement types both of which deform elastically to some degree. In particular, it is common to speak of Portland Cement Concrete pavements as ***rigid*** and all other pavements (e.g. bound bituminous concrete or unbound natural) as ***flexible***. A relatively stiff rigid pavement produces a uniform distribution of stress on the sub grade, whereas a flexible pavement deforms and concentrates its effect on the sub grade. Therefore, the difference between the two pavement types is one of degree rather than of fundamental mechanism.

7.6 A flexible pavement is a structure composed of one or more layers of bound or unbound materials and may either be unsurfaced (unsealed) or surfaced with bituminous concrete or a sprayed bituminous seal. The intensity of stresses within the pavement from aircraft loads diminishes significantly with depth. The quality requirements of the materials used in any of the pavement layers is dependent on its position within the pavement. The material used in the lower layers of a pavement may, for reason of economy and preservation of resources, be of lower quality than the material used in the upper pavement layers.

7.7 A rigid pavement is a structure comprising a layer of cement concrete (either steel-reinforced or unreinforced) which may be supported by a sub-base between the cement concrete and the sub grade. Unlike a conventional layered flexible pavement where both the base and sub-base layers contribute significantly to its structural properties, the major portion of the structural capacity of a rigid pavement is provided by the concrete base layer itself. This is because the high rigidity of the concrete slab distributes the load over a large area resulting in low stresses being applied to the underlying layers.

7.8 It is also possible to have composite pavements comprising a bituminous concrete overlay on a cement concrete pavement or vice versa.

7.9 The choice of which pavement type to adopt is made after consideration of the various matters such as pavement design, loading, tyre pressure, resistance to mechanical and chemical damage, ride quality, antiskid properties, construction, routine maintenance, major maintenance and construction costs.

Pavement Function

7.10 The basic function of a pavement is to support the applied aircraft loading within acceptable limits of riding quality and deterioration over its design life. While subjected to aircraft loading the pavement is to:

- reduce sub grade stresses such that the sub grade is not overstressed and does not deform extensively;
- reduce pavement stresses such that the pavement courses are not overstressed and do not crack or deform excessively; and
- protect the pavement structure and sub grade from the effects of the environment particularly moisture ingress.

7.11 The first two requirements are achieved by using the thickness of the pavement layers to disperse the concentrated surface load to stress levels acceptable for the materials encountered in the pavement and the sub grade.

7.12 The vertical stress that a material can carry without excessive deformation is referred to as its bearing strength/capacity. Hence the high quality materials should occur at the surface with a steady decrease in quality towards the sub grade.

7.13 The flexing of the pavement under load means that horizontal bending stresses are produced in each layer. Excessive horizontal stresses can create cracking in bound layers and horizontal deformation in unbound layers. Excessive vertical compressive strains in the pavement can produce deformations which lead to rutting of the pavement surface.

Pavement Design

7.14 Designing the pavement structure to support the applied aircraft loading within the limits of riding quality and deterioration over the design life of the pavement is the job of the pavement designer.

7.15 Design methodology for both flexible and rigid pavements types are well established and have been verified for the range of site and service conditions. There is a wealth of global knowledge captured in literature from sources such as ICAO, United States (US) Federal Aviation Administration (FAA) and Boeing Aircraft Company (BAC) together with a vast selection of text books on the subject to assist readers.

7.16 Knowledgeable and experienced pavement experts are available. ICAO is able to field expert pavement engineers. If you wish to seek the advice and assistance of a specialist in pavement design please contact AANSOO or ICAO.

8. STRENGTH OF AERODROME PAVEMENTS

8.1 The operator of an aerodrome regulated by CAAP is required under CAR-AERODROMES 2.1.020 (2) to comply with the standards set out in MOS according to the aircraft types using, and operations being conducted at, an aerodrome.

8.2 MOS Chapter 6, Sub-section 6.2.10.2 states *"CAAP does not specify a minimum requirement for runway bearing strength, however the bearing strength of a pavement shall be capable of withstanding the traffic of aircraft the pavement is intended to serve without any safety problems to aircraft".* The reason for not being able to specify a standard is because pavements are normally designed for a defined life. The actual life is a direct function of various factors such as the local environment, design aircraft, frequency of operations, pavement design methodology used, type of pavement and quality of pavement materials and sub grade.

8.3 It is the responsibility of the aerodrome operator to maintain the load bearing capacity of the pavement for the design or critical aircraft operating over the life of the pavement. A cost effective means of ensuring aerodrome pavements are properly maintained is for the aerodrome operator to put in place a pavement management system. Various pavement management systems have been developed and documented. They all use either serviceability or distress parameters as a measure of pavement performance.

8.4 MOS Chapter 6, Sub-section 6.2.10.1 states *"the pavement strength rating for a runway must be determined using the ACN–PCN pavement rating system"*. For a certified aerodrome the aerodrome operator is required under CAR-AERODROMES 2.2.065 to provide information on runways, including its strength rating, in the Aerodrome Manual and for this information to be passed to CAAP Aeronautical Information Service (AIS) for notification in AIP.

8.5 At a registered aerodrome, information on the pavement strength rating for each runway is to be provided when making an application for the registration of the aerodrome under CAR-AERODROMES 2.3.015. This information will be notified in AIP.

8.6 Serviceability inspections and annual technical inspection required to be undertaken at all certified aerodromes (annual safety inspections are required at registered aerodromes) are meant to check for failure mechanisms in the pavement. Any significant deterioration of the surface of the pavement, however caused (e.g. by weakening of the pavement material and/or sub grade), is discovered, a review of the pavement strength rating may be necessary.

9. REPORTING STRENGTH OF AERODROME PAVEMENTS

9.1 A pavement strength rating is a set of pavement parameters which can be applied to determine a maximum allowable aircraft operational weight. Its purpose is to protect the pavement and ensure a practical and economical life is maintained.

9.2 The simplest rating system is one which defines the maximum aircraft weight and/or tyre pressure or the largest aircraft type which can operate unrestricted on the pavement. This system is only used for light aircraft (below 5,700 kg MTOM) aerodromes.

9.3 The ACN–PCN method of rating aerodrome pavements developed initially as a pavement strength rating method, not a pavement design method, and compares the damaging effect of an aircraft with a maximum ramp weight above 5,700 kg (ACN) with the supportive capability or bearing strength of the pavements on which they intend to operate (PCN). ICAO introduced the method as a standard to identify the bearing strength of aerodrome pavements (ICAO Annex 14 Aerodromes, Volume I – Aerodrome Design and Operations) in 1981. It was then adopted by ICAO member States and the method has been incorporated in CAAP standards for aerodromes in the Philippines. A detailed description of the method is in the ICAO Aerodrome Design Manual, Part 3 – Pavements.

10. AIRCRAFT CLASSIFICATION NUMBER

10.1 The first step to calculating the ACN is to translate the aircraft for which the ACN is being derived into a single wheel load which would have the same pavement thickness requirement as the aircraft. This single wheel load is the derived single wheel load (DSWL) and the ACN of the aircraft is numerically two times the DSWL expressed in thousands of kilograms. The ***'two'*** factor is used to give a more usable range of numbers for the ACN.
ACN = (2 x DSWL) /1000

10.2 The DSWL is defined as a load acting through a single wheel with a tyre inflated to 1250 kPa which results in the same pavement thickness as the aircraft for which the ACN is being calculated. Pavement thickness required for the aircraft is determined from established methods used for the design of aerodrome pavements. By reverse design the DSWL, and in turn, the ACN is derived.

10.3 The ACN of an aeroplane implies that the aeroplane landing gear configuration, tyre pressure and load result in the critical pavement stress in any pavement overlying the given standard sub grade category as a single wheel load having the same ACN or any other aeroplane with the same ACN.

Flexible Pavement Operations

10.4 The US Corps of Engineers Report S–77–1 is used to calculate pavements thickness for 10,000 coverages of the actual aircraft for four standard sub grade California Bearing Ratio (CBR) values (CBR 3, 6, 10 and 15). The four identified standard sub grade strengths are representative of the range of sub grade strength encountered in the field.

A ***coverage*** is defined as the application of the maximum stress on a point in a pavement surface. Each time one wheel load passes over a point, one coverage is being applied at that point. Example – A single wheel load traffic is applied in a normal distribution around a central point in such a manner that results in a total of 100 passes of the single wheel being distributed over a certain width. The distribution is made up of 16 passes in the central strip and total of 42 passes from combined strips on each side of the central strip. The number of coverages applied to that section where the maximum accumulation of load occurs is where the 16 passes occurred or 16 coverages

Rigid Pavement Operations

10.5 The Portland Cement Association (PCA) rigid pavement design method is used to determine the pavement thickness required for the loading of the actual aircraft and the DSWL for the same pavement thickness.

10.6 Reference pavement thicknesses are calculated for four standard sub grade strengths referenced to Westergaard's modulus of sub grade reaction, K (20, 40, 80 and 150

MN/m3), a standard concrete flexural stress of 2.75 MPa and concrete modulus of elasticity of 27,580 MPa.

10.7 Following a similar approach to that described above for flexible pavements a mathematical relationship can be established between ACN, pavement thickness and modulus of sub grade reaction: $ACN = 0.0219\, K^{0.6524} * t^{\,2.059} K^{0.011}$

where t = slab thickness in cm; and
K = modulus of sub grade reaction (MN/m3)

Presenting ACN Values

10.8 ACN values for both flexible and rigid pavement operations are published by aircraft manufacturers in their Aeroplane Characteristics for Airport Planning Manuals.

10.9 The ACN values for an aircraft of known tyre pressure can be presented graphically by plotting ACN (vertical axis) versus the mass (horizontal axis) of the aircraft for the four standard sub grade strengths. Calculating the ACN values at operating mass empty and maximum ramp or take–off mass and drawing a straight line (an approximation) between the two values allows interpolation of ACN values for intermediate aircraft mass.

10.10 A list of ACN values for various aircraft found in commercial service throughout the world today has been compiled from various international sources and is presented in Appendix A of this AC.

11. PAVEMENT CLASSIFICATION NUMBER

11.1 Determining the PCN is more troublesome than determining the ACN because in the development of the ACN each aircraft characteristic is fixed. However each aerodrome pavement needs to be evaluated individually to determine its rating based on the knowledge of construction and operations. Where possible the pavement rating should be based on a technical evaluation.

11.2 In keeping with the concept of the ACN–PCN method, a pavement is rated in terms of 10,000 coverages of the design aircraft.

11.3 If the pavement strength is assessed as adequate for 10,000 coverages by a particular aircraft at a specified gross weight and tyre pressure, the ACN of that aircraft is adopted as the PCN for the pavement. It is assumed in the evaluation that despite previous usage the pavement still has 10,000 coverages of life remaining. This case is typically encountered when pavements are re-rated for new aircraft types and represents a reasonable approach especially where details of previous usage are not known.

11.4 For new pavements the design aircraft and the sub grade strength is known or may be checked by field and laboratory testing. The adopted PCN for the pavement is the ACN of the design aircraft.

11.5 Where the design basis for a pavement is unknown or the adequacy of the pavement for a particular aircraft loading, usually the current aircraft, is unknown, a technical evaluation of the pavement and sub grade should be carried out. The aim of a technical evaluation is to measure the pavement thickness and assess the strength of pavement and sub grade material. The in-situ evaluation to determine the pavement thickness and sub grade strength for flexible pavements follows civil engineering process.

11.6 Where little information is available about a pavement but it has performed satisfactorily under regular use by a specific aircraft, the ACN of that aircraft may be adopted as the PCN for the pavement. The pavement thickness and subgrade strength should be determined and compared with that required by the aircraft using the pavement in order to support this assessment.

11.7 The aerodrome operator may engage the service of a specialist in the field of pavement strength evaluation to determine the strength characteristics of the aerodrome pavements. See paragraph 6.16 for details.

12. PAVEMENT STRENGTH RATING

12.1 The strength rating of an aerodrome pavement intended to be used by aircraft of maximum ramp weight of more than 5,700 kg is to be designated by reporting parameters as indicated in the following example:

PCN 39/ F/A/W/T

39 - the PCN number reflecting the maximum ACN of aircraft to operate on the pavement;
F - Flexible pavement **(**or **R** – rigid pavement);
A - Sub grade strength category, (A, B, C or D from strongest to weakest);
W - Tyre pressure category (W, X, Y, Z from highest to lowest)
T - Method of evaluation (T - technical evaluation or **U** – based on aircraft usage).

Tyre Pressure

12.5 A question often asked when assessing pavements for aircraft suitability is what tyre pressure limit can be accommodated by the pavement?

12.6 The interaction between the aircraft tyre and the pavement is complex. A tyre exerts a pressure at the surface of a pavement which depends on its inflation pressure.

12.7 The walls of high pressure tyres are in tension and the contact pressure is less than the tyre pressure. For low pressure tyres the contact pressure is greater than the tyre pressure. Low pressure tyres are not common with the heavy loads typically associated with aircraft pavements. In most cases an assumption is made that the contact pressure is uniformly distributed over the contact area and contact pressure is equal to tyre pressure. Contact area is also assumed to be circular for ease of calculations whereas the tyre imprint takes on the shape of an ellipse.

12.8 The pressure reduces with depth to an insignificant level. The pavement thickness is that required to ensure the stresses in the pavement layers and sub grade do not exceed their capacity.

12.9 Tyre manufacturers always strive towards using higher inflation pressure. This is because higher tyre pressure is associated with higher safe tyre loading. Low pressure is associated with higher tyre deformation which leads to heat buildup and premature failure of tyres. Within limits higher tyre pressure will make tyres run cooler and a longer tyre life is expected. Low tyre pressures may also increase the danger of aquaplaning and may influence skid resistance.

12.10 When deciding on the maximum allowable tyre pressure, the type and quality of the surface course and quality and compaction of the pavement material immediately underlying the surface course are important factors to be considered.

12.11 The following guidelines are provided for different surface courses:

- Portland cement concrete surface course - 2000 kPa;
- Bituminous concrete surface course (asphalt) - 1400 to 1750 kPa;
- Bituminous seal on good quality fine crushed rock or well graded gravel with hard durable stone with high compaction - 1000 kPa;
- Bituminous seal on crushed rock or gravel with moderate compaction - 550 to 1000 kPa;
- Bituminous seal on crushed rock or gravel with low compaction values and pavements of unknown compaction built before 1950 - 600 kPa; and
- Grass or gravel surfaced pavements - 450 to 550 kPa.

12.12 One question sometimes asked is why is there a need to report the tyre pressure limitation of a pavement separately when the tyre pressure of the design or critical aircraft is included in the calculation of the ACN and adopted as the PCN of the pavement:

- The load imposed by an aircraft on a pavement is the mass of the aircraft acting through the main wheels which is applied to the pavement surface through the tyres inflated to a certain tyre pressure. The expression for the thickness of the pavement overlying the sub grade contains both the mass and the inflated tyre pressure but it is the mass of the aircraft which has the greatest influence on the thickness of the pavement; and

- The tyre pressure influences the top of the pavement but it is the stress generated from the mass of the aircraft which is influential throughout the pavement layers. The ACN, and the derived PCN, reflect the thickness of pavement required to protect the sub grade material. The additional tyre pressure parameter is required in the pavement strength rating to define the stress limitation of the surface layer of the pavement comprising the riding surface and the surface of the sub-base material.

Method of Evaluating Pavement Strength Rating

12.13 The ACN-PCN method recognises two pavement evaluation methods. If the evaluation is determined from a technical study i.e., an assessment of pavement and sub grade parameters necessary to enable the PCN value to be calculated, the evaluation method is coded **T**.

12.14 If the strength is assessed as suitable for the aircraft currently using the pavement without causing any distress to the pavement, then the greatest ACN value of the aircraft types is reported as the PCN for the pavement. The evaluation method in this case is coded **U**.

12.15 Each aerodrome pavement should be evaluated individually to determine its rating based on the knowledge of construction and operations. Where possible, the pavement rating should be based on a technical evaluation.

13. PAVEMENT OVERLOAD

13.1 Aerodrome pavements are designed and consequently rated to be able to withstand a specific number of repetitions or loadings by the critical or design aircraft without needing major pavement maintenance. There may be times when aircraft imposing more severe loadings than that which the pavement was designed for will seek approval to operate. These operations will not be permitted without the approval of the aerodrome operator.

13.2 Pavements can sustain some overload without immediate safety concern. There may be good reason why overload operations should be approved. For instance the design traffic is operating at less than design capacity and limited overload may not reduce the life of the pavement or depending on the overload may only marginally reduce the life of the pavement. This reduction in pavement life may be preferred to the alternative of refusing a desirable operation or having to strengthen the pavement for infrequent operations.

Pavement Life

13.3 Pavements are normally designed for a defined life, for example, 10,000 coverages for US Corps of Engineers flexible pavements design method, but the true life expectancy of a pavement is a direct function of environmental factors, quality of pavement material used, traffic distribution, number of operations/repetitions of aircraft loading, aircraft characteristics - weight, tyre pressure wheel configuration and overload operations.

13.4 At some stage in the life cycle of the pavement, failure modes will start appearing. The pavement is a structure and like all structures which are exposed to repeated loadings will eventually fail. The pavement distress can be arrested by following planned maintenance practices in accordance with an established pavement management system.

13.5 The consequences of repeated overloads may lead to the following failure conditions:

- excessive roughness caused by general loss of shape after repeated operations by heavy wheel loads;
- cracking of the seal surface where deflections caused are high or compaction of the pavement material is poor;
- surface rutting and cracking of the seal surface and stripping of aggregate due to high tyre pressure; and
- high maintenance costs.

In respect of aircraft operations these runway failure conditions can induce:

- reduced braking characteristics by reducing the tyre/pavement interaction;
- potentially an increase in the required operational length of runway;
- potentially increased structural fatigue to aircraft;
- increased likelihood of foreign object damage to aircraft structures from loose stones and debris; and
- discomfort to passengers.

14. PAVEMENT OVERLOAD GUIDELINES: ACN-PCN

14.1 Different pavement overload criteria have been used by various civil aviation authorities, depending on specific national circumstances. ICAO guidelines are the most commonly used and are also the most conservative which makes them

Appropriate for the major airports receiving a large number of aircraft movements by heavy aircraft. The aerodrome operator should adopt criteria which are compatible with the pavement management system in place at the aerodrome. In most situations the ICAO system is safe and effective.

14.2 ICAO guidelines for pavement overload allow for:

- occasional movements on a flexible pavement by aircraft with an ACN not exceeding 10 percent of the reported PCN;
- occasional movements on a rigid pavement by aircraft with an ACN not exceeding 5 percent of the reported PCN;
- where the pavement structure is unknown, a limitation of 5 percent should apply;
- the number of overload movements should not exceed approximately 5 percent of the total annual aircraft movements;
- overload movements are not be permitted on pavements exhibiting signs of distress or failure;
- overloading should be avoided during periods when the strength of the pavement or sub grade could be weakened by water; and
- the condition of the pavement should be regularly reviewed.

After the first cycle of operations, an inspection of the pavement is made by a senior pavement engineer. If there is no evidence of progressive deterioration of the pavement, an additional cycle of operations may be permitted. This procedure can be repeated as many times as necessary. When signs of progressive deterioration begin to appear, the overload operations on the pavement be stopped or continued but with a reduced aircraft weight.

Pavement failures are progressive, and signs of distress will be clearly evident well before the pavement deteriorates to the point where the operational safety of the aircraft is jeopardised. Remember seasonal climatic variations may affect the strength of pavements and sub grades.

14.3 If necessary and agreed to by the Director General in advance of an operation, additional overload factors may be applied as follows:

- An overload by aircraft with an ACN up to but not exceeding 10 percent of the reported PCN is acceptable provided:

- ✓ the pavement is more than twelve months old;
- ✓ the pavement is not showing signs of distress; and
- ✓ overload operations do not exceed 5 per cent of the annual departures and are spread throughout the year;

- An overload by aircraft with an ACN greater than 10 percent but not exceeding 25 percent of the reported PCN requires:

  - ✓ regular inspections of the pavement by a competent person and there shall be an immediate curtailment of such overload operations as soon as distress becomes evident;

14.4 An overload by aircraft with an ACN greater than 25 percent of the reported ACN may only be undertaken under special circumstances and with prior approval of the CAAP. Such approval will require a safety assessment which:

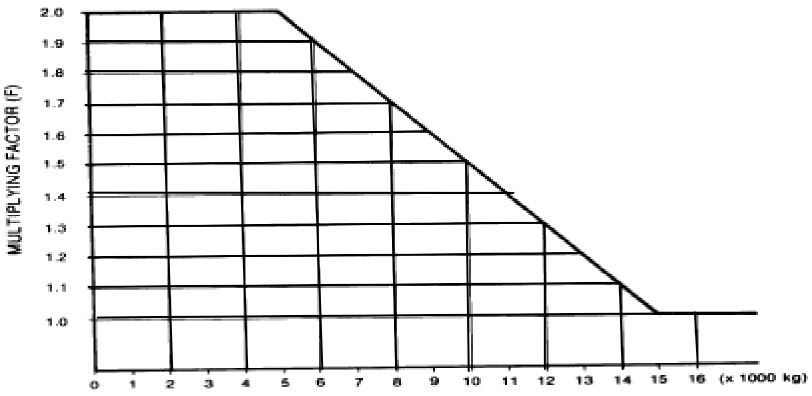
- considers the requirement for the operation and alternative options;
- provides details of the aircraft type to be used;
- reviews the aircraft manufacturer’s data and specifications if available;
- ensures scrutiny of pavement construction records and test data by a qualified pavement engineer; and
- requires a thorough inspection by a pavement engineer before and on completion of each overload movement to assess any signs of pavement distress.

14.5 It is more appropriate to allow overloads in the 10 to 25 percent range provided the pavement has a satisfactorily performance history.

Tyre Pressure Overload

14.6 Experience has shown that the problem of tyre pressure overload is greatest with low gross weight high tyre pressure aircraft such as executive jets. Based on engineering judgement, the allowable tyre pressure for these aircraft can be increased by the factors shown in the graph below, without adversely affecting pavement life.

PERMANENT TYRE PRESSURE CONCESSIONS



AIRCRAFT GROSS WEIGHT

14.7 The permissible tyre pressure may be increased using the factor obtained in the graph up to a limit of 1400 kPa, provided that no more than four movements within a seven day period are permitted for aircraft above 5,700 kg maximum gross weight.

14.8 Derivation of theoretical guidelines for tyre pressure overloads is more difficult than that for weight overload in that there is no well accepted relationship between allowable tyre pressure, measurable properties of pavement materials and number of allowable operations. As an approximation tyre pressure may be substituted for weight when estimating allowable overload operations.

14.9 As a general rule, tyre pressure overloads greater than 50 percent should only be allowed under special circumstances. It is important to remember that the final decision to allow an aircraft to overload a pavement with a tyre pressure in excess of that which the pavement is rated for still requires full recognition of all the relevant factors listed earlier including existing pavement condition and performance.

14.10 An inspection of the pavement should be carried out before and after the operation to determine whether there has been significant damage done to the pavement.

Note: ***It is important to remember that the final decision to allow a pavement to be overloaded still requires full recognition of the actual pavement condition and pavement life history.***

15. PAVEMENT CONCESSIONS

15.1 Normally an aeroplane with an ACN value greater than the PCN of the aerodrome pavements or operating with a tyre pressure greater than that which the pavement is rated for, will not be permitted to operate at the aerodrome unless a formal permission, such as a pavement concession or similar, has been granted by the aerodrome operator for the period of operations. In combination with the overload guidelines described earlier the aerodrome operator should also consider the following when assessing an application for a pavement concession:

- The safety of the operation:
  - ✓ where overloading of the pavement is so severe that damage to aircraft is likely and the safety of the occupants is in doubt a pavement concession is not to be approved;
- The probability of pavement damage:
  - ✓ majority of one-off operations requiring a concession are not likely to cause pavement damage or may cause only minor damage in localised areas;
  - ✓ basis of pavement design;
  - ✓ report on pavement evaluation and condition;
  - ✓ data on aircraft usage;
  - ✓ reports on damage caused by previous operations;
  - ✓ overload operations should not be permitted on pavements exhibiting signs of distress or failure;
  - ✓ are operations one-off, short term or long term; and
  - ✓ local conditions e.g., recent prolonged rainfall causing loss of subgrade strength;
- The social and economic importance of the operation:
  - ✓ are alternative aircraft available;
  - ✓ are the operations for humanitarian or compassionate reasons e.g., urgent medical evacuation, flood or disaster relief. These are rarely refused unless there is doubt about the safety of the operation;
  - ✓ are the operations politically desirable e.g., Head of State visit;
  - ✓ are the operations of significant commercial importance to the community;
  - ✓ are the operations essential or desirable militarily;
- The consequence of any pavement damage:
  - ✓ the cost of repairs to any pavement damage;
  - ✓ the resources available to repair any damage;
  - ✓ the disruption to routine operations caused by any damage or repairs; and
  - ✓ where the aerodrome operator considers that the damage resulting from aircraft operations under pavement concessions has been caused by the aircraft operator's carelessness or non compliance with the conditions of the pavement concession, he should require compensation directly from the aircraft operator for part or all of the repair costs involved; and

- Other considerations:
  - ✓ are the physical characteristics of the aerodrome movement area suitable for the intended operations of the overloading aircraft, for example, parking and manoeuvring.

APPENDIX A - TABULATION OF ACN VALUES

To assist with general use, ACN values for various aircraft types operating on flexible and rigid pavements are provided in the following tables.

The ACN values have been determined for operations on flexible and rigid pavements overlying the four standards sub grade strengths by aircraft operating at maximum take-off weight (MTOW) and operating weight empty (OWE) and a given operating tyre pressure (TP).

Units of weight are kilograms and units of tyre pressure are kilopascals.

Specific ACN values for a particular aircraft should be obtained from the aircraft manufacturer.

The reader is reminded that for aircraft not included in this list, the ACN values can be obtained from the aeroplane manufacturer or, where ACN values are sought for specific weight or tyre pressure, use of computer programs such as COMFAA may be used.

For computer programs such as COMFAA, consult with staff of AANSOO at CAAP Manila.

Aircraft Type	**MTOW OWE TP**	**Flexible Pavement Sub grade CBR%**				**Rigid Pavement Sub grade K in MN/m3**			
		A 15	**B 10**	**C 6**	**D 3**	**A K150**	**B K80**	**C K40**	**D K20**
A300-B4	165900 88505 1240	47 21	52 22	63 26	82 34	42 19	50 21	60 25	69 29
A310-200	132900 76890 1080	36 18	39 19	48 22	63 29	31 16	38 18	46 21	53 25
A310-300	150916 112980 1190	44 30	49 33	61 39	77 52	40 27	48 32	57 38	65 44
A319-100	75865 38952 1380	39 18	40 18	44 20	50 22	44 20	46 21	48 22	50 23
A320-100	68013 39768 1210	35 19	36 19	40 21	46 24	38 20	41 22	43 23	45 24
A320-200	77395 44968 1440	41 22	42 22	47 24	53 28	46 24	49 26	51 27	53 28
A321-100	78414 47000 1280	42 23	44 24	49 25	55 30	47 25	50 27	52 29	54 30
A330–300	212000 121870 580	55 29	60 30	69 33	94 41	47 28	54 27	64 31	75 36
A340–300	271000 129300 1380	59 24	64 25	74 28	100 34	50 25	58 24	69 26	80 30
A340 500,600	366072 178448 1420	70 29	76 31	90 34	121 42	60 29	70 28	83 32	97 37
A380-800	562262 281233 1470	56 23	62 25	75 28	106 36	55 26	67 27	88 31	110 38
Antonov AN 124 -100	391972 203940 1030	51 20	60 23	77 27	107 40	35 17	48 18	73 23	100 32
Antonov AN 225	600000 458865 1130	63 41	75 48	95 62	132 88	45 30	61 39	89 55	125 75
Argossy	42276 22150 620	17 8	20 9	23 10	28 13	19 9	21 10	23 11	25 12
ATR 42 - 200	18559 11217 720	9 5	10 5	11 6	13 7	10 6	11 6	12 7	12 7

Aircraft Type	MTOW OWE TP	Flexible Pavement Sub grade CBR%				Rigid Pavement Sub grade K in MN/m3			
		A **15**	**B** **10**	**C** **6**	**D** **3**	**A** **K150**	**B** **K80**	**C** **K40**	**D** **K20**
ATR 72	21516 12746 790	11 6	12 6	14 7	15 8	13 7	14 7	14 8	15 8
B707-320C	152407 67495 1240	44 16	50 17	60 19	76 25	41 15	49 16	58 19	66 22
B717 100,200,300	54885 32110 1048	31 16	33 17	37 19	40 22	35 18	37 19	38 20	40 21
B727-200	78517 45887 1150	42 23	44 23	50 25	55 30	47 24	50 26	52 28	54 29
B737-200	58327 30591 1260	31 15	32 15	37 16	41 19	35 16	37 18	39 19	41 19
B737-300	63527 33140 1400	35 16	37 17	41 18	45 21	40 19	42 20	44 21	46 22
B737-400	68320 35689 1280	38 18	40 18	45 20	49 23	43 20	45 21	47 22	49 23
B737-500	60774 32630 1340	33 16	35 16	39 18	43 21	38 18	40 19	42 20	43 21
B737-600	65770 36400 1300	35 18	36 18	40 19	45 22	39 19	41 21	44 22	45 23
B737–700	70359 37728 1390	38 18	40 19	44 20	49 23	43 21	46 22	48 23	50 24
B737–800	79230 41400 1470	44 21	46 21	51 23	56 26	51 23	53 25	55 26	57 27
B737-900	79230 42827 1470	44 21	46 22	51 24	56 28	51 24	53 25	55 27	57 28
B747-SP	302727 140000 1139	38 15	42 15.5	51 17	69 22	32 13.5	38 14	46 16	53 19
B747-200B	364200 173320 1400	51 20	57 22	69 24	91 31	47 19	56 21	66 24	76 28
B747-300	379100 174820 1296	53 20	60 22	74 24	95 31	48 18	57 20	68 24	79 28
B747-400	398192 183546 1380	59 23	66 24	82 27	105 35	54 20	65 23	77 27	88 31

Aircraft Type	MTOW OWE TP	Flexible Pavement Sub grade CBR%				Rigid Pavement Sub grade K in MN/m3			
		A 15	**B 10**	**C 6**	**D 3**	**A K150**	**B K80**	**C K40**	**D K20**
B767-200	141520 80890 1172	37 19	40 19	48 22	66 28	32 16	38 18	45 21	53 25
B767-200 ER	157400 80890 1260	42 19	46 20	55 22	75 28	37 17	44 19	53 22	61 25
B767-300	159685 87694 1380	44 21	49 22	59 25	79 33	40 19	48 22	57 25	65 29
B767-300 ER	172820 88000 1260	48 21	53 22	65 25	86 32	41 18	50 20	60 24	70 28
B777–200ER	287861 136945 1480	49 19	54 20	67 23	93 30	50 22	63 22	82 26	100 33
B777-300	300300 159277 1480	53 23	59 25	73 28	101 38	54 20	69 27	89 33	108 42
BAe 146-200	42419 23962 970	22 11	23 12	26 13	29 15	24 12	26 13	27 14	29 15
Beech 1900	7750 5710 670	3 2	4 3	4 3	5 4	4 3	4 3	5 3	5 4
Beech King Air 300	6832 5710 730	3 2	3 3	4 3	4 4	4 3	4 3	4 3	4 3
Bombardier Challenger 800	24166 15397 1120	13 8	14 8	16 9	17 10	16 9	16 10	17 10	18 11
Bombardier CRJ 900	38442 21617 1060	21 10	21 11	24 12	27 14	23 12	24 12	26 13	27 14
Bombardier Dash 8-300	19578 11828 670	8 4	9 5	11 6	13 7	10 5	11 6	11 6	12 7
Bombardier Dash 8-400	29265 17130 670	14 7	16 8	18 9	20 11	16 8	17 9	18 10	19 10
Canadair CL-600	19590 10000 1316	10.6 4.8	11.4 4.9	12.5 5.4	13 6.3	12.8 5.8	13.3 6.1	13.7 6.3	14.1 6.6
Cessna 550S2	6940 4146 830	5.3 3.2	5.8 3.4	5.8 3.5	6.1 3.6	5.5 3.3	5.6 3.3	5.6 3.4	5.7 3.4

Aircraft Type	MTOW OWE TP	Flexible Pavement Sub grade CBR%				Rigid Pavement Sub grade K in MN/m3			
		A 15	**B 10**	**C 6**	**D 3**	**A K150**	**B K80**	**C K40**	**D K20**
Cessna Citation 3	9525 5670 1013	5.5 2.8	5.9 3.0	6.3 3.4	6.6 3.8	6.5 3.5	6.7 3.6	6.9 3.8	7 3.9
C141B Starlifter	158359 61182 1310	52 15	60 16	73 18	88 24	51 14	61 16	70 19	78 22
C 5 Galaxy	379634 169780 770	31 11	33 12	40 14	51 17	28 12	31 13	37 13	45 15
Dassault Falcon 10	8565 5710 930	5 3	5 3	6 4	6 4	6 4	6 4	6 4	6 4
Dassault Falcon 50	17600 9600 1400	9.6 4.6	9.9 4.8	11 5.1	12 6	11.4 5.6	11.8 5.8	12.2 6.1	12.5 6.3
Dassault Falcon 900	20598 10503 1300	11 5	12 5	14 6	15 7	14 6	14 7	15 7	15 7
DHC4 Caribou	13256 9177 280	2 1	3 2	5 3	7 4	4 2	4 3	5 3	6 4
DHC7 Dash 7	21311 12236 740	10 5	12 6	13 7	15 8	12 6	13 7	14 7	14 8
Dornier SA227	7545 5710 730	3 2	4 3	4 3	5 4	4 3	5 3	5 3	5 4
Brasilia Embraer 120	11600 7150 830	5.4 3.1	5.9 3.5	6.7 3.8	7.8 4.6	7.2 4.1	7.5 4.5	7.8 4.7	8.1 4.9
Embraer 170	37525 21210 1040	20 10	21 11	24 12	26 14	22 11	24 12	25 13	26 14
Embraer 190	49048 26104 1100	28 14	30 14	33 16	35 18	31 15	33 16	35 17	36 18
Embraer ERJ 145	24167 12542 900	14 6	15 6	16 7	17 8	16 7	16 8	17 8	18 8

Aircraft Type	MTOW OWE TP	Flexible Pavement Sub grade CBR%				Rigid Pavement Sub grade K in MN/m3			
		A **15**	**B** **10**	**C** **6**	**D** **3**	**A** **K150**	**B** **K80**	**C** **K40**	**D** **K20**
GG II	28100 16000 930	15.4 7.7	16.6 8	18.3 9.3	19 10.5	17.6 9.0	18.4 9.5	19 10	19.7 10.4
Hercules C130	79333 36709 670	29 12	34 14	37 15	43 17	33 14	36 15	39 16	42 18
Ilyushin IL76T	171000 83819 640	24 9	27 10	34 12	45 16	29 11	33 13	30 14	34 14
Learjet 24F	6322 5710 790	3 3	3 3	4 3	4 4	4 3	4 4	4 4	4 4
Lear 35A	7824 4132 1080	3.9 1.9	4 1.9	4.6 2.1	5.1 2.4	4.7 2.2	4.9 2.3	5.1 2.5	5.3 2.6
Learjet 55B,C	9891 5914 1240	6 3	6 3	7 3	7 4	7 4	7 4	7 4	7 4
Lockheed C130-H	70300 35000 550	23 10	28 13	32 15	37 16	26 13	29 14	32 15	35 16
Lockheed C130-JH	70300 35000 725	27 12	30 14	33 15	38 17	30 14	33 15	35 16	38 17
MD-81	64037 35690 1140	36 18	38 19	43 21	46 24	41 20	43 21	45 23	46 24