Guidance Material

For

Strength Rating of Aerodrome Pavements

October 2023

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Contents

Forward

Bhutan Civil Aviation Authority (BCAA) provides this Guidance Material (GM) as a supplementary material to that published in the Bhutan Aerodrome Standards (BAS). This GM provides guidance to aerodrome operator on requirements in relation to the strength rating of aerodrome pavements and overload operations. This GM explains certain regulatory requirements by providing interpretive and explanatory material.

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1. Introduction

1.1 Overview

1.1.1 The purpose of this guidance material is to provide aerodrome operators with guidance on the bearing strength of aerodrome pavements and the basis and procedures for establishing criteria to regulate the use of pavements by aircraft in accordance with the Bhutan Aerodrome Standards (BAS).

1.1.2 Operators of certified aerodromes are required to provide pavement strength information on which aeroplanes are able to operate safely at the aerodrome, rate the strength of the pavements using the BAS/ICAO accepted ACN-PCN method and publish the rating in the Aerodrome Manual and Aeronautical Information Publication (AIP). This guidance material explains the ACN-PCN method and offers guidelines on what degree of overloading may be considered acceptable for an aerodrome pavement.

1.2 Abbreviations and Glossary

GM	Guidance Material
ACN	Aircraft Classification Number
AIP	Aeronautical Information Publication
AIS	Aeronautical Information Service
B**CAA**	Bhutan Civil Aviation Authority
CBR	California Bearing Ratio
DSWL	Derived Single Wheel Load
ESWL	Equivalent Single Wheel Load
FAA	Federal Aviation Administration
ICAO	International Civil Aviation Organization
BAS	Bhutan Aerodrome Standards
MTOW	Maximum Take-off Weight
OWE	Operating Weight Empty
PCN	Pavement Classification Number
TP	Tyre Pressure
K value	Modulus of Subgrade Reaction for Rigid Pavement

Aircraft Classification Number (ACN)

A number expressing the relative effect of an aircraft on a pavement for a specified standard subgrade category.

Note. — The aircraft classification number is calculated with respect to the centre of gravity (CG) position which yields the critical loading on the critical gear. Normally the aftmost CG position appropriate to the maximum gross apron (ramp) mass is used to calculate the ACN. In exceptional cases the forwardmost CG position may result in the nose gear loading being more critical.

ICAO Doc 9157 Part 3

This refers to ICAO Document 9157 Aerodrome Design Manual Part 3 – Pavements.

Pavement Classification Number (PCN)

A number expressing the bearing strength of a pavement for unrestricted operations.

1.3 Aerodrome Pavements

1.3.1 In 1981 ICAO introduced a new method to identify the bearing strength of aerodrome pavements called the ACN-PCN method.

What is a pavement?

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

a) An unbound course being composed of materials which are granular, mechanically stabilized 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.

b) 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.

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

a) The surface course provides a wearing surface and provides a seal to prevent entry of water and air into the pavement structure and subgrade preventing weathering and disintegration.

b) The base course is the main load carrying course within the pavement.

c) The sub-base course is a course containing lesser quality material used to protect and separate the base course from the subgrade and vice versa. The sub-base course provides the platform upon which the base course is compacted.

1.3.4 The subgrade 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

1.3.5 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 subgrade, whereas a flexible pavement deforms and concentrates its effect on the subgrade. Therefore, the difference between the two pavement types is one of degree rather than of fundamental mechanism.

1.3.6 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.

1.3.7 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 subgrade. 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.

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

1.3.9 The choice of which pavement type to adopt should be 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

1.3.10 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:

a) Reduce subgrade stresses such that the subgrade is not overstressed and does not deform extensively.

b) Reduce pavement stresses such that the pavement courses are not overstressed and do not shear, crack or deform excessively. This is particularly important for aircraft of more than about 45,000 kgs, because they impose significant stresses on the upper pavement layers.

c) Protect the pavement structure and subgrade from the effects of the environment particularly moisture ingress.

1.3.11 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 subgrade.

1.3.12 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 subgrade.

1.3.13 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

1.3.14 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.

For both flexible and rigid pavement types, these have evolved from empirical to mechanistic-empirical methods, and finite element analysis methods are being introduced.

2 Strength of Aerodrome Pavements

2.1 The operator of a certified aerodrome shall ensure that the bearing strength of the aerodrome movement area pavements comply with the BAS.

2.2 Furthermore, that the bearing strength of a pavement intended for aircraft of mass greater than 5700 kg shall be made available using the aircraft classification number - pavement classification number (ACN-PCN) method.

2.3 The actual life being a direct function of various factors such as the local environment, design aircraft, frequency of operations, pavement design methodology, type of pavement and quality of pavement materials and subgrade.

2.4 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.

2.5 For a certified aerodrome the aerodrome operator is required to provide information on pavements, including its strength rating, to be reported in the Aerodrome Manual for the aerodrome and for this information to be passed to Aeronautical Information Service (AIS) for notification in AIP.

2.6 Serviceability inspections and annual technical inspection required to be undertaken at all certified aerodromes are meant to check for failure mechanisms in the pavement. Any significant deterioration of the surface of the pavement may be caused by weakening of the pavement material and/or subgrade, in which case, a review of the pavement strength rating may be necessary.

Pavement Life

2.7 Pavements are normally designed for a defined life and mix of traffic. The true-life expectancy of a pavement is a direct function of:

(a) environmental factors;
(b) quality of pavement material;
(c) traffic distribution;
(d) number of operations/repetitions of aircraft loading;
(e) aircraft characteristics - weight, tyre pressure wheel configuration; and overload operations.

2.8 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.

3 Aircraft Classification Number (ACN)

3.1 ACN of an aircraft shall be determined in accordance with the standard procedures associated with the ACN-PCN method.

Note. — The standard procedures for determining the ACN of an aircraft are given in the ICAO Aerodrome Design Manual (Doc 9157), Part 3. For convenience several aircraft types currently in use have been evaluated on rigid and flexible pavements founded on the four subgrade categories and the results tabulated in that manual.

3.2 The ACN expresses the effect of individual aircraft on different pavements by a single unique number, which varies according to pavement type and subgrade strength, without specifying a particular pavement thickness. It is twice the derived single-wheel load expressed in thousands of kilograms, with single-wheel tire pressure standardized at 1.25 megapascals (= 181 psi). Additionally, the derived single-wheel load is a function of the sub-grade strength. Four subgrade categories are defined (high, medium, low, and ultra-low) for each pavement type (flexible or rigid).

3.3 The ACN of an airplane is a function of not only its weight but also the design parameters of its landing gear such as the distances between the wheels of a multiple-wheel landing gear assembly.

3.4 ACN values for selected aircraft have been calculated by the ICAO. Manufacturers are required to calculate the ACN for a new aircraft as it comes into service and publish the results in the flight manual. The tables give ACN values for two weights, one at the maximum total weight authorized and the other at the operating weight when empty. If an aircraft is operating at an intermediate weight, the ACN value can be calculated by a linear variation between the limits. Extrapolation is not permissible.

3.5 For the purposes of determining the ACN, the behaviour of a pavement shall be classified as equivalent to a rigid or flexible construction.

3.6 The flexible pavements have four subgrade categories:

A. High Strength – CBR 15 (All CBR above 13%).

B. Medium Strength – CBR 10 (For CBR between 8% to 13%).

C. Low Strength – CBR 6 (For. CBR between 4% to 8%).

D. Ultra Low Strength – CBR 3 (For CBR below 4%).

Note: The California bearing ratio (CBR) is a penetration test for evaluation of the mechanical strength of natural ground, subgrades and base courses beneath new carriageway construction. It is performed by measuring the pressure required to penetrate soil or aggregate with a plunger of standard area. The measured pressure is then divided by the pressure required to achieve an equal penetration on a standard crushed rock material. The result is then multiplied by 100 and given as percentage.

3.7 The rigid pavements have four subgrade categories:

A. High Strength – Subgrade k = 150 MN/m3 (All k values above 120 MN/m3).

B. Medium Strength – k = 80 MN/m3 (For values between 60 and 120 MN/m3).

C. Low Strength – k = 40 MN/m3 (For values between 25 and 60 MN/m3).

D. Ultra Low Strength – k = 20 MN/m3 (All k values below 25 MN/m3).

Example: Aircraft: A320-200.

ACN at maximum weight (725 kN):

Flexible pavement subgrades: A - 37; B - 39; C - 44; D - 50;

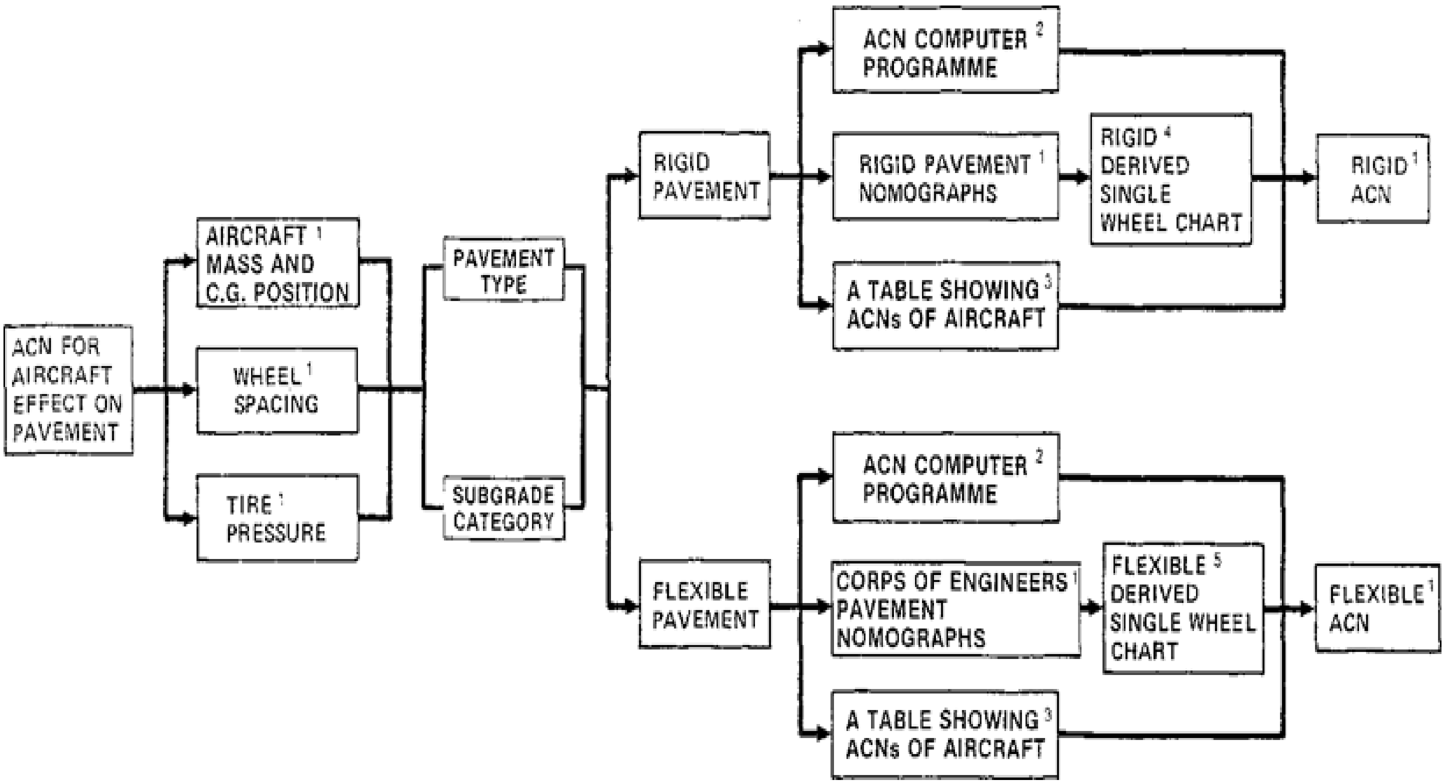
Rigid pavement subgrades: A - 40; B - 43; C - 45; D - 48;

ACN at minimum weight (402 kN):

Flexible pavement subgrades: A - 19; B - 19; C - 21; D - 25;

Rigid pavement subgrades: A - 20; B - 21; C - 23; D - 24;

3.8 The flow chart, below, briefly explains how the ACNs of aircraft are computed under the ACN- PCN method.



ACN FOR AIRCRAFT EFFECT ON PAVEMENT
AIRCRAFT 1 MASS AND C.G. POSITION
WHEEL 1 SPACING
TIRE 1 PRESSURE
PAVEMENT TYPE
SUBGRADE CATEGORY
RIGID PAVEMENT
FLEXIBLE PAVEMENT
ACN COMPUTER 2 PROGRAMME
RIGID PAVEMENT 1 NOMOGRAPHS
RIGID 4 DERIVED SINGLE WHEEL CHART
A TABLE SHOWING 3 ACNs OF AIRCRAFT
RIGID 1 ACN
ACN COMPUTER 2 PROGRAMME
CORPS OF ENGINEERS 1 PAVEMENT NOMOGRAPHS
FLEXIBLE 5 DERIVED SINGLE WHEEL CHART
A TABLE SHOWING 3 ACNs OF AIRCRAFT
FLEXIBLE 1 ACN

4 ACN – PCN METHOD

4.1 At the outset, it needs to be noted that the ACN-PCN method is meant only for publication of pavement strength data in the Aeronautical Information Publications (AIPs). It is not intended for design or evaluation of pavements, nor does it contemplate the use of a specific method by the aerodrome operator either for the design or evaluation of pavements. In fact, the ACN-PCN method does permit the use of any design/evaluation method of their choice. To this end, the method shifts the emphasis from evaluation of pavements to evaluation of load rating of aircraft (ACN) and includes a standard procedure for evaluation of the load rating of aircraft. The strength of a pavement is reported under the method in terms of the load rating of the aircraft which the pavement can accept on an unrestricted basis. The aerodrome operator can use any method of choice to determine the load rating of the pavement. If, in the absence of technical evaluation, aircraft experience is used, then the aerodrome operator would compute the ACN of the most critical aircraft using the procedures defined in ICAO Doc 9157 Part 3, convert this figure into an equivalent PCN and publish it in the AIP as the load rating of the pavement. The PCN so reported would indicate that an aircraft with an ACN equal to or less than that figure can operate on the pavement subject to any limitation on the tire pressure.

4.2 The ACN-PCN method contemplates the reporting of pavement strengths on a continuous scale. The lower end of the scale is zero and there is no upper end. Additionally, the same scale is used to measure the load ratings of both aircraft and pavements.

4.3 To facilitate the use of the method, aircraft manufacturers will publish, in the documents detailing the characteristics of their aircraft, ACNs computed at two different masses: maximum apron mass, and a representative operating mass empty, both on rigid and flexible pavements and for the four standard subgrade strength categories. Nevertheless, for the sake of convenience Annex 14, Attachment B and Appendix 5 of ICAO Doc 9157 Part 3, contain tables showing the ACNs of a number of aircraft. It is to be noted that the mass used in the ACN calculation is a "static" mass and that no allowance is made for an increase in loading through dynamic effects.

4.4 The ACN-PCN method reports the following information in respect of each pavement:

a) pavement type;
b) subgrade category;
c) maximum tire pressure allowable; and
d) pavement evaluation method used.

The above data are primarily intended to enable aircraft operators to determine the permissible aircraft types and operating masses, and the aircraft manufacturers to ensure compatibility between airport pavements and aircraft under development. There is, however, no need to report the actual subgrade strength or the maximum tire pressure allowable. Consequently, the subgrade strengths and tire pressures normally encountered have been grouped into categories. It would be sufficient for the aerodrome operator to identify the categories appropriate to its pavement.

5 Defining strength of aerodrome pavements

5.1 A pavement strength rating is a set of pavement parameters with a number which can be translated into an allowable aircraft gross weight. Its purpose is to protect the pavement and ensure a practical and economical life is maintained.

5.2 The BAS requires that the bearing strength of a pavement shall be determined.

5.3 The bearing strength of a pavement intended for aircraft of apron (ramp) mass greater than 5700 kg shall be made available using the aircraft classification number - pavement classification number (ACN-PCN) method by reporting all of the following information:

(a) the pavement classification number (PCN);
(b) pavement type for ACN-PCN determination;
(c) subgrade strength category;
(d) maximum allowable tire pressure category or maximum allowable tire pressure value; and
(e) evaluation method.

Note:- If necessary, PCNs may be published to an accuracy of one-tenth of a whole number.

5.4 The pavement classification number (PCN) reported shall indicate that an aircraft with an aircraft classification number (ACN) equal to or less than the reported PCN can operate on the pavement subject to any limitation on the tire pressure, or aircraft all-up mass for specified aircraft type(s).

Note:- Different PCNs may be reported if the strength of the pavement is subject to significant seasonal variation.

5.5 Information on pavement type for ACN-PCN determination, subgrade strength category, maximum allowable tire pressure category and evaluation method shall be reported using the following codes:

a) Pavement type for ACN-PCN determination:	Code
Rigid pavement	F
Flexible pavement	F

Note - If the actual construction is composite or non-standard, include a note to that effect (see example 2 below).

b) Subgrade strength category:

There are eight standard subgrade values (i.e., four rigid pavement k values and four flexible pavement CBR values) used, rather than a continuous scale of subgrade strengths. The grouping of subgrades with a standard value at the mid-range of each group is considered to be entirely adequate for reporting. The subgrade strength categories are identified as high, medium, low and ultra low and assigned the following numerical values:

High strength: characterized by K = 150 MN/m3 and representing all K values above 120 MN/m3 for rigid pavements, and by CBR = 15 and representing all CBR values above 13 for flexible pavements.

Medium strength: characterized by K = 80 MN/m3 and representing a range in K of 60 to 120 MN/m3 for rigid pavements, and by CBR = 10 and representing a range in CBR of 8 to 13 for flexible pavements

Low strength: characterized by K = 40 MN/m3 and representing a range in K of 25 to 60 MN/m3 for rigid pavements, and by CBR = 6 and representing a range in CBR of 4 to 8 for flexible pavements.

Ultra low strength: characterized by K = 20 MN/m3 and representing all K values below 25 MN/m3 for rigid pavements, and by CBR = 3 and representing all CBR values below 4 for flexible pavements.

c) Maximum allowable tire pressure category:

The results of pavement research and re-evaluation of old test results reaffirm that except f unusual pavement construction (i.e., flexible pavements with a thin asphaltic concrete cover o weak upper layers), tire pressure effects are secondary to load and wheel spacing, and m therefore be categorized in four groups for reporting purposes as:

Unlimited: no pressure limit

High: pressure limited to 1.75 MPa

Medium: pressure limited to 1.25 MPa

Low: pressure limited to 0.50 MPa

d) Evaluation method:

Technical evaluation: representing a specific study of the pavement characteristics and application of pavement behaviour technology.

Using aircraft experience: representing a knowledge of the specific type and mass of aircraft satisfactorily being supported under regular use

5.6 The ACN-PCN method above is not meant for light aircraft. Therefore, for the bearing strength of a pavement intended for aircraft of apron (ramp) mass equal to or less than 5 700 kg, the reporting of the following two elements is used:

(a) maximum allowable aircraft mass; and
(b) maximum allowable tire pressure (actual tire pressure limit is used)

Example: 4 000 kg/0.50 MPa.

Reporting PCN

5.7 The aerodrome operator shall ensure that the pavement strength rating is reported in the AIP.

5.8 If a pavement shows signs of distress the PCN and allowable tyre pressure may need to be reduced. If the PCN is reduced then some of the aircraft using the pavement may have ACNs that exceed the new PCN the consequences of which are; a weight restriction on those aircraft, acceptance of the resulting overload by the aerodrome operator or consideration of pavement strengthening.

5.9 In theory an aircraft of a known mass and specified operating tyre pressure can operate on a pavement so long as the ACN of the aircraft is less than or equal to the published PCN of the pavement, subject to tyre pressure limitation.

5.10 If the ACN of the aircraft intending to operate on the pavement is greater than the PCN of the pavement the aerodrome operator will need to assess whether to allow the operation to take place. Similarly so if the tyre pressure of the aircraft intending to operate on a pavement exceeds the maximum allowable tyre pressure for the pavement.

5.11 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 for emergency reasons, e.g. A380 overflying Nadi Airport requiring to land for refueling or a medical emergency onboard. These operations will not be permitted without the approval of the aerodrome operator. The CAAF shall be notified immediately after the event and a report filed as applicable.

5.12 Pavements can sustain some overload, that is, pavement ratings are not absolute. 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.

Interaction between tyre and pavement

5.13 A tyre exerts a pressure at the surface of a pavement which depends on its tyre inflation pressure. The contact pressure between the pavement and tyre differs from the tyre pressure, the difference depending on the magnitude of the tyre pressure. The walls of high pressure tyres are in tension and the contact pressure is less than the tyre pressure whereas for low pressure tyres the contact pressure is greater than the tyre pressure.

5.14 Tyre pressure reduces with the depth of the pavement to an insignificant level. The pavement thickness is required to ensure the stresses in the pavement layers and subgrade do not exceed their capacity.

6 EXAMPLES OF PAVEMENT STRENGTH RATING

6.1 For pavements used by aircraft of maximum ramp mass greater than 5700 kg:

(a) PCN 39/F/A/1200 (174)/T

the bearing strength of a flexible pavement on a high strength subgrade has been assessed by technical evaluation to be PCN 39 and the maximum tyre pressure allowable is 1200 kPa (174 psi).

(b) PCN 11/F/C/Y1/U

the bearing strength of a flexible pavement on a low strength subgrade has been assessed by using aircraft experience to be PCN 11 and the maximum tyre pressure allowable is limited to 1000 kPa.

(c) PCN 80 / R / B / W / T

the bearing strength of a rigid pavement, resting on a medium strength subgrade, has been assessed by technical evaluation to be PCN 80 and there is no tire pressure limitation, then the reported information would be:

(d) PCN 50 / F / A / Y / U

the bearing strength of a composite pavement, behaving like a flexible pavement and resting on a high strength subgrade, has been assessed by using aircraft experience to be PCN 50 and the maximum tire pressure allowable is 1.25 MPa, then the reported information would be:

Note.— Composite construction.

(e) PCN 40 / F / B / 0.80 MPa /T

the bearing strength of a flexible pavement, resting on a medium strength subgrade, has been assessed by technical evaluation to be PCN 40 and the maximum allowable tire pressure is 0.80 MPa, then the reported information would be:

(f) If a pavement is subject to a B747-400 all-up mass limitation of 390 000 kg, then the reported information would include the following note.

Note.— The reported PCN is subject to a B747-400 all-up mass limitation of 390 000 kg.

6.2 For pavements used by aircraft of maximum ramp mass equal to or less than 5700 kg:

3,500 kg/550 kPa

the bearing strength of a flexible pavement has been assessed as suitable for aircraft of maximum ramp mass not more than 3500 kg and tyre pressure limitation of not more than 550 kPa.

6.3 Below are additional scenarios

(a) Find the ACN of A330-200 with All-up mass 2137kN on a rigid pavement resting on a medium strength subgrade (i.e. k = 80). The tire pressure of the main wheels is 1.34 MPa.

Solution:

The ACN of the aircraft from the table in Appendix A is **56**.

(b) An AIP contains the following information related to a runway pavement:

PCN of the pavement = 80
Pavement type=rigid Subgrade category=medium strength Tire pressure limitation= nil

Determine whether the pavement can accept the following aircraft at the indicated operating masses and tire pressures:

Mass Tire pressure

Airbus A300 Model B2 at 142 000kg 1.23MPa B7
47-100 at 334751kg 1.55MPa
Concorde at 185066kg 1.26MPa DC-
10-40 at 253105kg 1.17MPa

Solution:
ACNs of these aircraft from ICAO Doc 9157 Part 3 Appendix 5 are 44, 51, 71 and 53, respectively.

Since the pavement in question has a PCN of 80 it can accept all of these aircraft.

7 Pavement overload

7.1 Overloading of pavements can result either from loads too large or from a substantially increased application rate or both. Loads larger than the defined (design or evaluation) load shorten the design life whilst smaller loads extend it. With the exception of massive overloading, pavements in their structural behaviour are not subject to a particular limiting load above which they suddenly or catastrophically fail. Behaviour is such that a pavement can sustain a definable load for an expected number of repetitions during its design life. As a result, occasional minor overloading is acceptable, when expedient, with only limited loss in pavement life expectancy and relatively small acceleration of pavement deterioration.

7.2 It is recommended that the aerodrome operator decide the pavement overload which is allowable for the aerodrome, and also adopt an appropriate overload policy, an example of an overload policy is contained in Appendix B to this GM. This requires consideration of the pavement strength and condition, aircraft frequency and weight, pavement inspection and management procedures, and other commercial and political considerations.

7.3 For those operations in which magnitude of overload and/or the frequency of use do not justify a detailed analysis the following criteria are suggested:

(a) for flexible pavements, occasional movements by aircraft with ACN not exceeding 10 per cent above the reported PCN shall not adversely affect the pavement;

(b) for rigid or composite pavements, in which a rigid pavement layer provides a primary element of the structure, occasional movements by aircraft with ACN not exceeding 5 per cent above the reported PCN shall not adversely affect the pavement;

(c) if the pavement structure is unknown, the 5 per cent limitation shall apply; and

(d) the annual number of overload movements shall not exceed approximately 5 per cent of the total annual aircraft movements.

7.4 Such overload movements should not normally be permitted on pavements exhibiting signs of distress or failure. Furthermore, overloading should be avoided when the strength of the pavement or its subgrade could be weakened by water. Where overload operations are conducted, the aerodrome operator should review the relevant pavement condition regularly 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 pavement.

7.5 For those aircraft operations where the magnitude of overload and/or the frequency of use exceed the limits of the criteria given in 7.3 above, it is recommended that allowing the operations to be determined on the basis of a detailed engineering analysis comparing the individual aircraft load to the structural capability of the pavement.

7.6 An alternative to choosing the amount of overload which would be acceptable on a pavement is the impact on the life of the pavement from overload operations. If the reduction in pavement life is allowable by the pavement management system in place at the aerodrome the decision may be taken to allow the overload operations.

7.7 The aerodrome operator shall also ensure a detailed engineering analysis of the airside pavements is carried out to determine the maximum overloads which could safely be allowed in the event that an "emergency only" type of aircraft operation is required on short notice. The determination of "emergency only" overload limits shall be based on ensuring the safety of the aircraft from pavement surface "break-through" during the "emergency" operation.

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

(a) excessive roughness caused by general loss of shape after repeated operations by heavy wheel loads;

(b) cracking of the seal surface where deflections caused are high or compaction of the pavement material is poor;

(c) surface rutting and cracking of the seal surface and stripping of aggregate due to high tyre pressure; and high maintenance costs,

(d) reduced braking characteristics by reducing the tyre/pavement interaction;

(e) it may lead to an increase in the required operational length of runway;

(f) has potential to increase structural fatigue to aircraft;

(g) increase the likelihood of foreign object damage to aircraft structures from loose stones and material

(h) cause discomfort to passengers.

8 Pavement concessions

8.1 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 pavement concession has been approved by the aerodrome operator for the period of operations. A pavement concession given to the aircraft operator formalizes the acceptance of the heavier aircraft and sets conditions under which the operation will be accepted.

8.2 In combination with the overload guidelines in section 7, the aerodrome operator should also consider the following when assessing an application for a pavement concession:

a) The safety of the operation:
i.) 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;

b) The probability of pavement damage:
i.) majority of one-off operations requiring a concession are not likely to cause pavement damage or may cause only minor damage in localized areas;
ii.) basis of pavement design;
iii.) report on pavement evaluation and condition; iv.) data on aircraft usage;
v.) reports on damage caused by previous operations;
vi.) overload operations should not normally be permitted on pavements exhibiting signs of distress of failure;
vii.) are operations one-off, short term or long term; and
viii.) local conditions e.g. recent prolonged rainfall causing loss of subgrade strength;

c) The social and economic importance of the operation:
i.) are alternative aircraft available;
ii.) 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;
iii.) are the operations politically desirable e.g. Head of State visits, Ministerial flights etc.;

iv.) are the operations of significant commercial importance to the community; v.) are the operations essential or desirable militarily;

d) The consequence of any pavement damage:
i.) the cost of repairs to any pavement damage;
ii.) the resources available to repair any damage;
iii.) the disruption to routine operations caused by any damage or repairs; and
iv.) where the licensee 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, the licensee should consider seeking compensation directly from the aircraft operator for part or all of the repair costs involved;

e) Other considerations; are the physical characteristics of the aerodrome movement area suitable for the intended operations of the overloading aircraft, for example, parking and maneuverability.

9 General

9.1 References

i. BAS
ii. ICAO Annex 14, Volume I;
iii. Doc 9157, Aerodrome Design Manual Part 3 – Pavements;
iv. Doc 9137, Airport Services Manual Part 2 – Pavement Surface Condition.

APPENDIX A

AIRCRAFT CLASSIFICATION NUMBER

Aircraft type	All-up mass [kN]	Tire pressure (MPa)	ACN FOR FLEXIBLE PAVEMENT SUBGRADES – CBR (%)				ACN FOR RIGID PAVEMENT SUBGRADES – k[MPa/m]			
			High 15	Medium 10	Low 6	Ultra-low 3	High 150	Medium 80	Low 40	Very low 20
1	2	4	5	6	7	8	9	10	11	12
A320-200	759 441	1.44	41 22	42 22	47 24	53 28	46 24	49 26	51 27	53 29
A330-200	2137 1650	1.34	57 42	62 44	72 50	98 67	48 37	56 40	66 47	78 55
A330-200	2264 1650	1.42	62 42	67 45	78 50	106 67	53 37	61 41	73 48	85 55
A330-300	2088 1638	1.31	55 41	60 44	70 50	94 66	46 36	54 39	64 46	75 54
A330-300	2137 1657	1.33	57 41	61 41	71 50	96 66	47 37	55 40	65 46	77 54
A330-300	2264 1697	1.42	62 44	68 47	79 53	107 70	54 39	62 43	74 50	86 58
B737-800	777 406	1.47	44 21	46 21	51 23	56 26	51 24	53 25	56 26	57 27
B737-900	777 420	1.47	44 21	46 22	51 24	56 28	51 24	53 26	56 27	57 28
B777-200	2433 1400	1.38	51 25	58 27	71 31	99 43	40 23	50 23	65 28	81 35
B777-300	2945 1600	1.48	68 30	76 32	97 38	129 53	54 27	69 28	89 35	109 43
B787-8	2240 1690	1.57	61 42	71 49	84 57	96 66	60 42	66 45	81 53	106 73
B787-9	2498 1980	1.54	65 46	76 52	90 61	103 71	66 47	73 50	88 58	118 80

**Uplifted from Transport Canada technical Evaluation Engineering document*

APPENDIX B

The following overload guidelines provide a balance between commercial demand and risk management for the aerodrome operator:

a) The ICAO guidelines are conservative and make them appropriate for the major aerodromes receiving a large number of aircraft movements by heavy aircraft.

b) An overload by aircraft with an ACN up to but not exceeding 10 per cent of the reported PCN is generally considered acceptable provided:

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

c) An overload by aircraft with an ACN greater than 10 per cent or more than 10 per cent but not exceeding 25 per cent of the reported PCN requires regular inspections of the pavement by a competent person and there should be an immediate curtailment of such overload operations as soon as distress becomes evident.

d) An overload by aircraft with an ACN greater than 25 per cent but not exceeding 50 per cent of the reported ACN may be undertaken under special circumstances including:

i.) scrutiny of available pavement construction records and test data by a qualified pavement engineer; and
ii.) a thorough inspection by a pavement engineer before and on completion of the movement to assess any signs of pavement distress.

e) Overloads by aircraft with an ACN greater than 50 per cent of the reported PCN should only be undertaken in an emergency;

f) Overloads not exceeding 100 per cent should only be considered in the case of small aeroplanes operating into aerodromes which do not show signs of pavement distress and where the pavement and subgrade material is not subject to moisture ingress.

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