SIERRA LEONE CIVIL AVIATION AUTHORITY

ADVISORY CIRCULAR

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Strength Rating of Aerodrome Pavements

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1 GENERAL

The Sierra Leone Civil Aviation Authority's Advisory Circulars contains information about standards, practices and procedures that the Authority has found to be an Acceptable Means of Compliance (AMC) with the associated Regulations.

An AMC is not intended to be the only means of compliance with a Regulation, and consideration will be given to other methods of compliance that may be presented to the Authority

Information considered directive in nature is described in this AC in terms such as "shall" and "must", indicating the actions are mandatory. Guidance information is described in terms such as "should" and "may" indicating the actions are desirable or permissive, but not mandatory

1.1 Purpose

This Advisory Circular provides methods, acceptable to the Authority, for showing compliance with the Strength Rating of Aerodrome Pavements requirements of SLCAR Part 14A as well as explanatory and interpretative material to assist in showing compliance. The calculation of declared distances is to allow pilots to determine aircraft loading and performance requirements.

It explains the ACN-PCN method and offers guidelines on what degree of overloading that may be considered acceptable for an aerodrome pavement.

1.2 Applicability

This guidance is applicable to aerodrome operators, aircraft operators or any persons involved in the design and construction of airfield pavement.

1.3 Description of Changes

This is the first AC to be issued on this subject.

1.4 Reference

(a) SLCAR Part 14A – Aerodrome Design and Operations

(b) SLCAR Part 14C _ Certification of Aerodromes

(c) Annex 14 Vol. I – Aerodrome Design and Operations

(d) ICAO Doc 9137 – Aerodrome Service Manual Part 2 (Pavements)

(e) ICAO Doc 9157 – Aerodrome Design Manual Part 3 (Pavements)

1.5 Cancelled Documents

Not Applicable

2 INTRODUCTION

Operators of regulated aerodromes are required to provide pavements on which aeroplanes can operate safely and they are required to rate the strength of the pavements as specified in 2.6 of the SLCAR's Part 14A and publish the rating in the Aeronautical Information Publication (AIP).

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

2.1 Description of Pavement Structures

(a) 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:

(i) 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.

(ii) 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.

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

(i) 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.

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

(iii) 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.

(iv) As already mentioned, 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.

2.2 Types of Pavement

(a) 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.

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

(c) The choice of which pavement type to adopt shall be made after consideration of the various matters such as pavement design, loading, tire pressure, resistance to mechanical and chemical damage, ride quality, anti-skid properties, construction, routine maintenance, major maintenance and construction costs.

(d) **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 are 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.

(e) **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 concrete base layer itself provides the major portion of the structural capacity of a rigid pavement. 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.

2.3 Pavement Function

(a) 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:

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

(ii) 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 kg, because they impose significant stresses on the upper pavement layers.

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

(b) 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.

(c) 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.

(d) 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.

2.4 Pavement Design

(a) 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.

(b) It is important to note that the design of heavy-duty aircraft pavements is not the same as that of roads, and their design methods must be distinguished.

For further Guidance on the design of aircraft pavement please refer to ICAO Doc 9157, Part 1 and Part 3- Aerodrome Design Manual

Pavement design software are also available from the FAA - COMFAA, FAARFIELD, LEDFAA, and airport pavement software from Australia includes APSDS. There are also a few pavement engineering text books that specifically include airport pavements, such as Yoder & Witczak, Principles of Pavement Design.

3 STRENGTH OF AERODROME PAVEMENTS

The operator of an aerodrome is required to ensure the bearing strength of aerodrome movement area pavements complies with the standards set out in the SLCAR’s Part 14A, Chapter 2, section 2.6.

3.1 Defining Strength of Aerodrome Pavements

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.

3.2 Concept of the ACN-PCN method

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

(b) Information on pavement type for ACN-PCN determination, subgrade strength category, maximum allowable tire pressure category and evaluation method shall be reported as follows:

(i) Pavement type for ACN-PCN determination:

	Code
Rigid pavement	R
Flexible pavement	F

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

(ii) Subgrade strength category:

	Code
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	A
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.	B
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.	C
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.	D

(iii)Maximum allowable tire pressure category:

	Code
Unlimited: no pressure limit	W
High: pressure limited to 1.75 MPa	X
Medium: pressure limited to 1.25 MPa	Y
Low: pressure limited to 0.50 MPa	Z

Note - Where the pavement is used by large aircraft or aircraft with tire pressures in the upper categories referred to in the table (iii) above, particular attention should be given to the integrity of light fittings in the pavement and pavement joints.

4 UNRATED PAVEMENTS

(a) Where the aerodrome pavements consists of a natural surface or a gravel surface of low bearing capacity and a pavement strength rating cannot realistically be assigned to the pavement, the entry in the AIP has traditionally been reported as ‘unrated’. The unrated pavement fills the gap where the strength of the pavement has never been determined using either a technical evaluation or from aircraft usage. This is normally applicable to non-certified or non-registered aerodromes where testing for soft wet surfaces is the simplified method of assessing the suitability of the runway pavement.

(b) The following guidelines describe the method of assessing the bearing strength of unrated pavements. At registered aerodromes the results of the assessment shall be translated to the pavement strength rating as defined by the ACN – PCN method. Where an assessment suggests the pavement is suitable for aircraft in excess of 5700 kg this shall be followed up by a technical evaluation to more accurately define the bearing strength limitations of the pavement.

4.1 Assessing the Bearing Strength of Unrated Pavements

(a) The bearing capacity of unrated pavements is dependent on such factors as the type of material used to construct the pavement, the moisture condition and degree of compaction of the pavement material. Unrated pavements are generally suitable for regular operations under ‘**dry to depth**’ conditions.

(b) Under dry to depth conditions, the bearing capacity of the surface may be considerably greater than under wet conditions and this would allow the nominated aircraft types to operate.

(c) After rain when the natural material has high moisture content on the surface and to some depth, the pavement is obviously not dry to depth. After prolonged rainfall the natural material may have high moisture content to considerable depth. After a short dry period a surface crust can form while the underlying material can still be wet and of inadequate strength. In this situation a more detailed investigation is required to determine if the pavement is dry to depth.

***Note -** For further guidance on assessment methods of unrated or low grade pavements see ICAO Doc 9157 (Aerodrome Design Manual – Part 3)*

5 PAVEMENT OVERLOAD

(a) In theory an aircraft of a known mass and specified operating tire 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 tire pressure limitation.

(b) If the ACN (see in appendix 1) 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 if the tire pressure of the aircraft intending to operate on a pavement exceeds the maximum allowable tire pressure for the pavement.

(c) 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.

(d) Pavements can sustain some overload, that is, pavement ratings are not absolute. There may be good reason why overload operations shall 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.

5.1 Pavement Life

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

(i) Environmental factors; quality of pavement material, traffic distribution

(ii) Number of operations/repetitions of aircraft loading;

(iii) Aircraft characteristics – weight, tire pressure wheel configuration and overload operations

(b) 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.

(c) Naturally the consequences of repeated overloads may lead to the following failure conditions:

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

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

(iii) surface rutting and cracking of the seal surface and stripping of aggregate due to high tire pressure; and

(iv) High maintenance costs.

In respect of aircraft operations:

(v) reduced braking characteristics by reducing the tire/pavement 20 interaction; it may lead to an increase in the required operational length of runway; has potential to increase structural fatigue to aircraft;

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

(vii) Cause discomfort to passengers.

(d) Design life for new pavement structure (rigid and flexible) is estimated at 20 years with the use of the FAAFIELD design software program before considering any major maintenance. Nonetheless, design life can be set between 1 to 50 years depending on several factors including, environmental, availability of equipments and construction materials, human capacity etc. Consequently, due to design and analytical errors most airfield pavement structures have failed to meet this expectation and as a result have significantly affect the operations at many airports around the world as well as reduces it safety ratings.

(e) When the expected design life is short lived, the aerodrome operator should undergo rehabilitation of the pavement surface by introducing a pavement overlay. Design life for an overlay should be set at the functional life of the pavement prior to damage but not exceeding 12 years.

***Note** - additional guidance on overlay operations can be found in FAA AC 150/5320-6G (Airport pavement design and evaluation)*

6 OVERLOAD GUIDELINES

6.1 Using ACN vs. PCN

(a) The aerodrome operator shall decide the pavement overload which is allowable for the aerodrome, and also adopt an appropriate overload policy. This requires consideration of the pavement strength and condition, aircraft frequency and weight, pavement inspection and management procedures, and other commercial and political considerations.

(b) The following are recommended pavement overload guidelines:

(i) occasional movements on a flexible pavement by aircraft with an ACN not exceeding 10 per cent of the reported PCN shall not adversely affect the pavement;

(ii) occasional movements on a rigid pavement by aircraft with an ACN not exceeding 5 per cent of the reported PCN shall not adversely affect the pavement;

(iii) where the pavement structure is unknown a limitation of 5 per cent shall apply;

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

(v) overload movements are not be permitted on pavements exhibiting signs of distress or failure;

(vi) overloading shall be avoided during periods when the strength of the pavement or subgrade could be weakened by water; and

(vii) The condition of the pavement shall be regularly reviewed.

(c) These overload guidelines are appropriate and provide a balance between commercial demand and risk management for the aerodrome operator.

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

(e) 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. 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.

(f) Overloads by aircraft with an ACN greater than 50 per cent of the reported PCN shall only be undertaken in an emergency.

(g) Overloads not exceeding 100 per cent shall 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.

6.2 Using Pavement Life

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.

6.3 Use of COMFAA to assess impact on pavement life from overload operations

(a) The advent of modern computing techniques has meant that the impact on pavement life from aircraft overloads can now be readily estimated without resorting to the production of elaborate overload curves or pavement life charts.

(b) The FAA developed COMFAA computer program, mentioned earlier in this Advisory Circular, enables computation of ACN values and calculates total flexible pavement thickness and rigid pavement slab thickness. The program may readily be used to assess the impact on the pavement life from an overloading aircraft. First the pavement thickness required for the overloading aircraft is determined. The resulting thickness is compared to that of the existing pavement and the additional pavement thickness required could be translated into the additional equivalent coverage of the design aircraft which the pavement would be subjected to if the overload operations were allowed to proceed. The reduction in pavement life caused by the overloading aircraft operations can then be estimated.

6.4 Tire Pressure Overload

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

7 AIRCRAFT GROSS WEIGHT

(a) The permissible tire pressure may be increased using the factor obtained in the graph up a limit of 1400 KPa, provided that no more than four movements within a seven day period are proposed for these general aviation aircraft

(b) Derivation of theoretical guidelines for tire pressure overloads is more difficult than that for weight overload in that there is no well accepted relationship between allowable tire pressure, measurable properties of pavement materials and number of allowable operations

(c) As a general rule, tire pressure overloads greater than 50 per cent shall only be allowed under special circumstances. When significant tire pressure overloads are allowed, an inspection of the pavement shall be carried out before and after the operation to determine whether there has been significant damage done to the pavement.

(d) It is important to remember that the final decision to allow a pavement to be overloaded shall be based on full recognition of the actual pavement condition and pavement life history.

8 PAVEMENT CONCESSIONS

(a) Normally an aeroplane with an ACN value greater than the PCN of the aerodrome pavements or operating with a tire 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.

(b) In combination with the overload guidelines described earlier the aerodrome operator shall also consider the following when assessing an application for a pavement concession:

(i) The safety of the operation;

(ii) 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;

(iii)The probability of pavement damage;

(iv)majority of one-off operations requiring a concession are not likely to cause pavement damage or may cause only minor damage in localized areas;

(v) basis of pavement design;

(vi)report on pavement evaluation and condition;

(vii) data on aircraft usage;

(viii) reports on damage caused by previous operations;

(ix)overload operations shall not normally be permitted on pavements exhibiting signs of distress of failure;

(x) are operations one-off, short term or long term; and

(xi)local conditions e.g. recent prolonged rainfall causing loss of subgrade strength, the social and economic importance of the operation i.e.

(1) are alternative aircraft available;

(2) 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;

(3) are the operations politically desirable e.g. Head of State visits, Ministerial flights etc.;

(4) are the operations of significant commercial importance to the community;

(5) are the operations essential or desirable militarily; and

(6) The consequence of any pavement damage:

a) the cost of repairs to any pavement damage;

b) the resources available to repair any damage;

c) the disruption to routine operations caused by any damage or repairs; and

d) where the 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, the licensee shall consider seeking compensation directly from the aircraft operator for part or all of the repair costs involved.

(c) Other considerations:

Are the physical characteristics of the aerodrome movement area suitable for the intended operations of the overloading aircraft, for example, parking and manoeuvrability

APPENDIX 1 - AIRCRAFT CLASSIFICATION NUMBER

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 table below:

The ACN values have been determined for operations on flexible and rigid pavements overlying the four standards subgrade strengths by aircraft operating at maximum takeoff weight (MTOW), operating empty weight (OEW) and a given operating tire pressure (TP).

Units of weight (mass) are kilograms and units of tire pressure are kilopascals.

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

The operator 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 a specific weight or tire pressure, use of computer programs such as COMFAA may be used.

AIRCRAFT CLASSIFICATION NUMBER

Aircraft type	MTOW (kg) OEW (kg) TP (kg)	Flexible Pavement Subgrade CBR%				Rigid Pavement Subgrade K in MN/m^3			
		A 15	B 10	C 6	D 3	A K150	B K80	C K40	D K20
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	56	62	75	106	55	67	88	110

	281233 1470	23	25	28	36	26	27	31	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
ATR 42 -200	18559 11217 720	9 5	10 5	11 6	13 7	10 6	11 6	12 7	12 7
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
B737-BBJ	77826 42942 1470	43 21	45 22	50 24	55 28	50 24	52 26	54 27	56 28

Aircraft type	MTOW (kg) OEW (kg) TP (kg)	Flexible Pavement Subgrade CBR%				Rigid Pavement Subgrade K in MN/m³			
		A **15**	**B** **10**	**C** **6**	**D** **3**	**A** **K150**	**B** **K80**	**C** **K40**	**D** **K20**
B727-200	78517 45887 1150	42 23	44 23	50 25	55 30	47 24	50 26	52 28	54 29
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	33 16	35 16	39 18	43 21	38 18	40 19	42 20	43 21

	1340								
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
B747-200B	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
B757-200	115634 58123 1240	34 14	38 15	47 17	60 23	32 13	38 15	45 18	52 20
B767-200	141520 80890 1172	37 18.7	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

Aircraft type	MTOW (kg) OEW (kg) TP (kg)	Flexible Pavement Subgrade CBR%				Rigid Pavement Subgrade K in MN/m³			
		A 15	B 10	C 6	D 3	A K150	B K80	C K40	D K20
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
B777-300ER	352441 167830 1550	64 24	71 25	89 29	120 40	66 27	86 28	110 35	132 43
B787-9	245847 115350 1470	67 27	73 28	87 31	119 38	60 26	70 27	82 30	95 35
BAe 125 -800	12483 6858 1007	6.6 3.2	7.0 3.4	8 3.8	8.7 4.4	7.9 3.9	8.2 4.1	8.6 4.3	8.8 4.5
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	14 7	16 8	18 9	20 11	16 8	17 9	18 10	19 10

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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 525B Citation Jet 3	6396 5700 910	6	7	7	7	7	7	7	7
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
Cessna 560 Citation V	7650 5712 1000	7 4	7 5	7 5	7 5	7 4	7 5	7 5	7 5

Aircraft type	MTOW (kg) OEW (kg) TP (kg)	Flexible Pavement Subgrade CBR%				Rigid Pavement Subgrade K in MN/m^3			
		A **15**	**B** **10**	**C** **6**	**D** **3**	**A** **K150**	**B** **K80**	**C** **K40**	**D** **K20**
Cessna 560 XL	9180 5916 1500	9 6	9 6	9 6	9 6	9 6	9 6	9 6	9 6
Cessna 650 III/VI	10098 5712 1160	6 3	7 3	7 3	8 4	7 3	8 4	8 4	8 4
Cessna 650 VII	10608 6324 1160	7 3	7 3	8 4	8 4	8 4	8 4	8 4	8 5
Cessna 750 X	16320 9792 1310	10 5	11 6	12 6	12 7	12 6	12 7	13 7	13 7
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 2000	16728 9486 1360	9	10	11	12	11	12	12	13
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
Fairchild Metro 227	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 (kg) OEW (kg)TP (kPa)**	**Flexible Pavement Subgrade CBR %**				**Rigid Pavement Subgrade K in MN/m³**			
		A 15	**B 10**	**C 6**	**D 3**	**A K150**	**B K80**	**C K40**	**D K20**
F/A- 18 S	23542 10523 1723	22.5 10	21.6 9.7	21.5 9.6	21 9.5	23.4 10.4	23.2 10.3	23 10.2	22.8 10.2
Fokker 100	46090 24779 940	25 12	27 13	31 14	33 16	28 13	30 14	31 15	33 16
Fokker 50	20904 12746	9 5	11 6	13 7	14 8	11 6	12 7	13 7	13 8

	590								
Fokker F27-500	20904 12236 570	9 5	11 5	13 6	14 8	11 6	12 6	13 7	13 7
Fokker F28-1000	33140 17845 530	14 6	17 8	20 9	23 11	16 8	18 9	20 9	21 10
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
GG III	31824 17340 1210	19 9	20 9	22 10	23 12	22 11	23 11	23 12	24 12
GG IV	34068 19278 1210	20 10	22 11	24 12	25 13	24 12	25 13	25 13	26 14
GG V	41310 21930 1370	26 12	28 13	30 14	31 15	31 14	32 15	32 16	33 16
Hercules C130	79333 36709 670	29 12	34 14	37 15	43 17	33 14	36 15	39 16	42 18
HS-748	20183 11786 550	7.7 4	9.5 4.8	11.1 5.6	13 7	9.6 5	10.5 5.5	11.3 6	12 6.4
HS/BAe 125	11420 6220 830	6 3	6 3	7 3	8 4	7 3	7 4	8 4	8 4
Ilyushin IL-76T	171000 83819 640	24 9	27 10	34 12	45 16	29 11	33 13	30 14	34 14
Jetstream 31,32	7036 5710 390	3 3	4 3	5 4	6 5	4 4	5 4	5 4	5 4
Jetstream 41	10910 6424 830	5 3	5 3	6 3	7 4	6 3	6 3	7 4	7 4
Learjet 24F	6322 5710 790	3 3	3 3	4 3	4 4	4 3	4 4	4 4	4 4

Aircraft Type	MTOW (kg) OEW (kg)TP (kPa)	Flexible Pavement Subgrade CBR %				Rigid Pavement Subgrade K in MN/m^3			
		A **15**	**B** **10**	**C** **6**	**D** **3**	**A** **K150**	**B** **K80**	**C** **K40**	**D** **K20**
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 40, 45	9996 6222 790	5 3	6 3	7 4	7 4	6 4	7 4	7 4	7 4
Learjet 55B,C	9891 5914 1240	6 3	6 3	7 3	7 4	7 4	7 4	7 4	7 4
Learjet 60	10812 6426 1480	6 3	7 4	7 4	8 4	8 4	8 4	8 5	8 5
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
MD-90-30	71277 39972 1140	41 20	43 21	48 24	52 27	46 23	48 24	50 26	52 27
Orion P3A	61235 27000 1310	35 13	38 14	42 15	44 17	41 15	43 16	44 17	46 18
SAAB 340 A,B	13358 8259 820	6 4	6 4	8 4	9 5	7 4	8 4	8 5	9 5
Shorts 330	10400 6730 550	6 4	8 5	9 6	9 6	7 5	8 5	8 5	8 5
Shorts 360	12338	7	9	10	11	9	9	9	9

	7851 540	5	6	7	7	6	6	6	6
Westwind I	10660 6066 1050	9 5.1	9.3 5.3	9.2 5.3	9.4 5.4	9.1 5.2	9.1 5.2	9.2 5.2	9.2 5.3