Transport Canada | Transports Canada

Advisory Circular

Subject: **Operations on Runways with Unpaved Surfaces**

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TABLE OF CONTENTS

1.0 INTRODUCTION

(1) This Advisory Circular (AC) is provided for information and guidance purposes. It describes an example of an acceptable means, but not the only means, of demonstrating compliance with regulations and standards. This AC on its own does not change, create, amend or permit deviations from regulatory requirements, nor does it establish minimum standards.

1.1 Purpose

(1) The purpose of this document is to provide guidance to air operators for the safe operations of aeroplanes on runways with unpaved surfaces in accordance with the applicable *Canadian Aviation Regulations* (CARs) and Standards.

1.2 Applicability

(1) This document is applicable to all Transport Canada Civil Aviation (TCCA) employees, to individuals and organizations when they are exercising privileges granted to them under an External Ministerial Delegation of Authority. This information is also available to the aviation industry for information purposes.

1.3 Description of Changes

(1) Not applicable.

2.0 REFERENCES AND REQUIREMENTS

2.1 Reference Documents

(1) It is intended that the following reference materials be used in conjunction with this document:

(a) Part VI, Subpart 2 of the *Canadian Aviation Regulations* (CARs) — *General Operating and Flight Rules;*

(b) Standard 724 of the *Commercial Air Services Standard* (CASS) — *Commuter Operations - Aeroplanes;*

(c) Chapter 525 of the *Airworthiness Manual* (AWM) – *Transport Category Aeroplanes;*

(d) Advisory Circular (AC) 300-004— *Unpaved Runway Surfaces;*

(e) AC 525-006— *Operations from Unpaved Runway Surfaces*;

(f) AC 302-011 — *Airport Pavement Bearing Strength Reporting;*

(g) Transport Canada Publication (TP) 312— *Aerodrome Standards and Recommended Practices*;

(h) TP 5475, Historical Reference Document AK-67-09-280 —*Gravel Runways Condition Reporting Procedures and Surface Stability Test Methods*;

(i) Boeing Publication – 727-737— *Operation from Unimproved Airfields*;

(j) Boeing Document No. D6-24555, 1984-04-05—*High Load Penetrometer Soil Strength Tester*;

(k) Boeing Document No. D6-45222-1, 1980-10-03—*Airplane Requirements for Operations on Gravel Runways*;

(l) Federal Aviation Administration Advisory Circular (FAA AC) 25-7B, 2011-12-07 – *Flight Test Guide for Certification of Transport Category Airplanes*; and

(m) International Civil Aviation Organization (ICAO), DOC 9157-AN/901—*Aerodrome Design Manual, , Part 3 Pavements*, Second Edition – 1983.

2.2 Cancelled Documents

(1) As of the effective date of this document, the following document is cancelled:

(a) Commercial and Business Aviation Advisory Circular (CBAAC) No. 187, 2001-07-09, *Gravel Runway Operations – Limitations Contained in Aircraft Flight Manual Supplements Concerning Minimum Runway Surface Bearing Strength*; and

(b) Policy Letter Number 138, 2001-07-03 – *Gravel Runway Operations – Limitations Contained in Aircraft Flight Manuals Concerning Minimum Runway Surface Bearing Strength*.

(2) By default, it is understood that the publication of a new issue of a document automatically renders any earlier issues of the same document null and void.

2.3 Definitions and Abbreviations

(1) The following **definitions** are used in this document:

(a) **Air Operator**: The holder of an air operator certificate.

(b) **Aircraft Classification Number (ACN)**: a number expressing the relative structural loading effect of an aircraft on a pavement for a specified pavement type and a specified standard subgrade category (International Civil Aviation Organization [ICAO] pavement strength reporting format).

(c) **Aircraft Load Rating (ALR)**: a number expressing the relative structural loading effect of an aircraft on a pavement (Transport Canada strength reporting format).

(d) **California Bearing Ratio (CBR)**: A measure of the soil strength expressed as a ratio in percent of the force required to produce a given penetration of a standard flat-faced cylindrical piston into the soil compared to the force required to produce the same penetration in crushed limestone.

(e) **Gravel Runway**: A type of runway with an unpaved surface constructed from a pavement with an unbound granular surface composed of sand, clay, crushed stone or other soil materials.

(f) **Paved Runway**: A runway pavement with a paved hard surface comprised of Asphaltic Concrete or Portland Cement Concrete.

(g) **Pavement**: The combination of sub-base, base course, and surface course placed on a subgrade to support the traffic load and distribute it to the subgrade (as per ICAO definition in the ICAO *Aerodrome Design Manual*). For the purposes of this Advisory Circular (AC), a pavement can be defined as the total construction built upon natural soil to produce a load carrying structure or surface.

(h) **Pavement Classification Number (PCN)**: a number expressing the bearing strength of a pavement for unrestricted operations (ICAO pavement strength reporting format).

(i) **Pavement Load Rating (PLR)**: a number expressing the bearing strength of a pavement for unrestricted operations (Transport Canada strength reporting format).

(j) **Surface Definition**: A definition of the surface for which the aircraft has been certified to operate from, normally provided in the *Aircraft Flight Manual* (AFM) or applicable supplement. Each type of surface should be defined so that it can be recognized, controlled and maintained in service. The definition should include specification and characteristics of the surface as necessary for safe operation.

(k) **Surface Treated or Seal Coated Runway**: An unpaved runway with a gravel surface covered by a thin layer of asphalt stabilized material, to prevent the penetration of water and facilitate drainage.

(l) **Unpaved Runway**: A runway pavement constructed with an unpaved surface.

(m) **Unpaved Surface**: A surface composed of unbound or natural materials. Unpaved surfaces may include gravel, coral, sand, clay, hard packed soil mixtures, grass, turf or sod.

(n) **Unprepared Surface**: Any naturally occurring surface used as a runway that has not been altered by man.

(2) The following **abbreviations** are used in this document:

(a) **AC**: Advisory Circular;

(b) **ACN**: Aircraft Classification Number;

(c) **AFM**: Aircraft Flight Manual or Aeroplane Flight Manual;

(d) **ALR**: Aircraft Load Rating;

(e) **ASTM**: American Society of Testing Materials;

(f) **CASS**: Commercial Air Service Standard;

(g) **CAR**: *Canadian Aviation Regulations*;

(h) **CBR**: California Bearing Ratio;

(i) **ICAO**: International Civil Aviation Organization;

(j) **PCN**: Pavement Classification Number;

(k) **PLR**: Pavement Load Rating;

(l) **STC**: Supplemental Type Certificate; and

(m) **TP**: Transport Canada Publication.

3.0 BACKGROUND

(1) This Advisory Circular (AC) applies to the operation of aeroplanes on runways constructed with unpaved and unprepared surfaces as defined above. Gravel and turf runways are common examples of runways constructed with unpaved surfaces.

(2) This AC should be used in conjunction with Transport Canada Civil Aviation’s AC 300-004 and AC 525-006, which apply to unpaved runway surface strength measurement and the certification of aeroplanes for unpaved runway operations respectively.

(3) For the purpose of this AC, a runway with an unpaved surface is any runway used for take-off and landing, where the surface layer is **not** a paved smooth hard surface such as Asphaltic Concrete or Portland Cement Concrete. Unpaved surfaces have also been referred to by industry as Unimproved Runways.

(4) Examples of unpaved surfaces include runways surfaced with gravel, coral, sand, clay, hard packed soil mixtures, grass, turf or sod. Unpaved surfaces can be naturally occurring **unprepared surfaces** or manually constructed pavements. Gravel runways are manually constructed pavements with the surface composed of unbound granular material.

(5) **Seal coated runway**s are gravel runway pavement structures covered with a thin layer of asphalt stabilized material to prevent the penetration of water and facilitate its drainage. Seal coated runways may lack the surface bearing strength of paved hard surfaced runways, and in this respect are more characteristic of runways with unpaved surfaces.

4.0 CLIMATIC AND WEAR EFFECTS

(1) Unpaved runways can be subject to wide variations in their strength and surface characteristics because of climatic effects and the effects of aircraft operations. Unpaved runways can achieve

their design strength and surface characteristics when maintained properly and are not subjected to excessive moisture.

(2) Conditions of excessive moisture, such as found during heavy precipitation, poor drainage or spring thaw can result in a significant degradation in runway surface strength. The degradation in surface strength may be enough to limit or completely restrict operational use.

(3) During periods of extended and deep frost, unpaved surfaces such as gravel runways can have strength characteristics similar to those of paved hard surfaces. (Refer to Section 8.2 of this AC.

(4) The following is a list of possible adverse climatic and wear effects on unpaved runways:

(a) Loss of material resulting in bare spots and sub-grade material appearing on the surface;

(b) Accumulation of loose, non-cohesive aggregates on surface because of material segregation;

(c) Formation of rutting in wheel paths;

(d) Persistence of damp or wet areas because of poor surface drainage;

(e) Soft areas during spring thaw or wet conditions;

(f) Differential heaving or depressions because of frost action;

(g) Runway roughness or longitudinal unevenness (waviness); and

(h) Vegetation growth.

(5) An unpaved runway such as a gravel runway may be restored to its nominal conditions by grading, compaction and rolling, the addition of material, improvement in drainage and the removal of vegetation.

5.0 EFFECTS ON AEROPLANE PERFORMANCE AND HANDLING

(1) The *Aircraft Flight Manual* (AFM) performance information (or data) is valid for only the type of surface the aeroplane has been certified to operate from, which is normally a paved, smooth, hard surfaced runway. Operations on unpaved runways may result in a degradation of the certified aeroplane performance. Aeroplane handling qualities may also be degraded because of the interaction of the tires with the unbound, granular or soft surfaces characteristic of unpaved runways.

5.1 Aeroplane Performance

(1) The reduced strength of the runway surface (compared to a paved hard surface) can result in deflection of the surface under an imposed aeroplane load. This deflection causes an increased rolling resistance (rolling coefficient of friction). During acceleration for take-off, the distance to accelerate the aircraft to a rotation, lift-off or decision speed will be increased. This will result in increased take-off distances and can result in increased accelerate-stop distances.

(2) The surface characteristics of an unpaved runway can have an adverse effect on the braking performance of the aircraft. A surface composed of loose unbound granular material may result in degraded braking performance compared to a paved hard surface. Brake anti-skid systems that are optimized for paved hard surfaces may not achieve the same performance on unpaved surfaces. The net effect may be increased stopping distances during a take-off (for the accelerate-stop case) and during landing.

(3) Procedures and equipment necessary to protect an aeroplane from the effects of loose granular material or debris may also have an adverse effect on performance.

5.2 Effect of Tire Pressure on Performance

(1) The rolling resistance of an aeroplane on an unpaved surface is proportional to the wheel tire pressure. Reducing tire pressure without changing the aeroplane weight, results in the

redistribution of the wheel load over a wider area. This may reduce runway surface deflection and tire rolling resistance.

(2) The reduction in tire pressure may however be limited by the tire design and the necessity to avoid excessive deflection of the tire under load. It may be necessary to reduce aircraft weights if operating under reduced tire pressures. Some aircraft are modified with oversize, floatation or balloon type low pressure tires for operations on soft unpaved surfaces.

(3) Any alterations of tire pressure, or types of tires used should be considered to be major modifications to an aircraft. These changes should undergo an aircraft type certification approval process, to ensure that all applicable airworthiness requirements are met.

5.3 Handling Characteristics

(1) The reduced strength and surface characteristics of an unpaved runway can result in degradation in the handling qualities of the aeroplane during take-off, landing, ground manoeuvring or braking. The use of nosewheel steering may be necessary for improved handling, or in some cases prohibited if incompatible with unpaved surfaces. The ground minimum control speed (V_{MCG}) may need to be increased to maintain the required directional control. Any changes to procedures such as the use of nosewheel steering or to speeds such as V_{MCG} are normally approved by the aircraft type certification process.

6.0 PROTECTION OF AEROPLANES FOR UNPAVED SURFACE OPERATIONS

(1) Operations on unpaved surfaces expose an aeroplane to hazards caused by the impingement and ingestion of stones, dust and debris. Aeroplanes may require modifications to install protective systems which may include various shields, deflectors, and filters, engine intake vortex dissipators, and abrasion resistant finishes.

(2) Operational procedures may also be required to reduce the potential for engine or airframe damage. This includes the gradual application of thrust or power to minimize the ingestion of materials by engines or damage to propellers. The use of reverse thrust may need to be limited or prohibited. Bleed systems may have to be configured to minimize the ingestion of dust.

(3) Aeroplane systems such as anti-skid and nose-wheel steering should be specifically evaluated for unpaved runway operations to determine and identify any handling differences.

(4) The combination of protective equipment and operational procedures may have an adverse effect on the aeroplane's performance. These modifications may also require revised Master Minimum Equipment List (MMEL)/ Minimum Equipment List (MEL) relief provisions.

7.0 CERTIFICATION OF AEROPLANES FOR UNPAVED SURFACE OPERATIONS

(1) Most aeroplanes are only designed and certified for operations on smooth paved hard surfaced runways. For operations on runways with unpaved surfaces, it may be necessary to install protective systems and account for the degradation of performance and handling qualities associated with unpaved runway operations.

(2) Any modifications having a significant or appreciable effect on the aeroplane require an Aircraft Certification approval, in the form of a Supplemental Type Certificate (STC) or an equivalent approval document. All applicable certification requirements, including aeroplane performance must be satisfied, when certifying a modification to an aeroplane, or the operation of the aeroplane on an unpaved runway.

(3) A supplement to the AFM, to provide the appropriate limitations, procedures and performance information (or data) for unpaved surface operations is normally required as part of a certification approval. The AFM supplement should also provide a surface definition to identify the characteristics of unpaved runway surfaces the aircraft has been certified to operate from. AC

525-006, *Operations from Unpaved Runway Surfaces,* provides the criteria for the certification of aeroplanes for operations on unpaved surfaces.

(4) For operations under Part VII of the *Canadian Aviation Regulations* (CARs), Subparts 704 and 705 of the CARs require that any determinations made for the purposes of the performance regulations of these sub-parts be based on approved performance data set out in the AFM. This means that performance information published in an AFM supplement for operations on unpaved runways must be followed for such operations.

(5) Many small aeroplanes and older large aeroplanes do not have aircraft certification approvals or flight manual information for unpaved runway operations. Some manufacturers have provided unapproved information, often called *Manufacturer's Data* as guidance for operations on specific unpaved surfaces. Many air operators do establish specific operational procedures for unpaved runway operations to protect their aeroplanes from any adverse effects, but may not account for degraded aeroplane performance.

8.0 REGULATORY PERFORMANCE REQUIREMENTS

(1) Section 602.07 of the CARs requires aircraft to be operated in accordance with limitations contained in the AFM or applicable supplement. All limitations for unpaved runway operations including the limitations concerning the minimum runway surface strength for which operations are certified must be complied with.

(2) For operations under Part VII of the CARs, Sections 704.45 and 705.55 of the CARs require that any determinations made for the purposes of these sections shall be based on approved performance data as set out in the AFM. Air operators must therefore respect minimum runway surface strength requirements when provided as performance data in an approved AFM or supplement to an AFM.

8.1 Operations from or to Gravel Runways (Propeller-Driven Aeroplanes)

(1) Subsection 724.44(1) of the *Canadian Air Service Standard* (CASS) is the standard for Subpart 704 of the CARs, *Operations from or to Unprepared Surfaces (Propeller-Driven Aeroplanes)*.

(2) Subsection 724.44(3) of the CASS is the standard for Subpart 704 of the CARs, *Operations from or to Gravel Runways (Propeller-Driven Aeroplanes)*. This standard requires performance adjustments for gravel runway operations when such information is not specifically addressed in the AFM, a supplement to the AFM or data from another source that is acceptable to the Minister.

(3) Paragraphs 724.44(3)(c) and 724.44(3)(d) of the CASS, provide performance factors to be applied to take-off and landing distance calculations for large and small propeller driven aeroplanes respectively. This additional distance is 10% of the dry hard runway distance for a small aeroplane (paragraph 724.44(3)(c) of the CASS) and 15% for a large aeroplane (paragraph 724.44(3)(d) of the CASS).

(4) Paragraphs 724.44(3)(c) and 724.44(3)(d) of the CASS allow credit for up to 5000 feet of dry hard surface runway data to be used as the basis of the factored take-off, accelerate-stop and landing distances for gravel runway operations. No credit is allowed for the use of a clearway. This means that the longest gravel runway CASS 724.44(3) is valid for is 5500 feet for a small propeller driven aeroplane (based on a performance factor of 10%) and 5750 feet for a large propeller driven aeroplane (based on a performance factor of 15%).

(5) When computing a maximum allowable take-off weight based on the available runway length, the length of the gravel runway should be divided by 1.1 to compute the AFM distance on a dry hard runway for a small aeroplane (paragraph 724.44(3)(c) of the CASS) and 1.15 for a large aeroplane (paragraph 724.44(3)(d) of the CASS).

(6) For example, if a large aeroplane is taking off on a 4000 foot gravel runway, the maximum allowable take-off weight computed in the AFM, would be calculated based on a dry hard runway with a length of 4000/1.15 = 3478 feet.

(7) The performance factors provided in the CASS are based upon a ratio of Tire Pressure in Pounds Per Square Inch (psi) to CBR as measured by the Boeing Penetrometer of 5 or less. Any values of this ratio greater than 5 invalidate the performance factors provided in the paragraphs of this CASS. An air operator should therefore ensure that the maximum tire pressure of the aeroplane is limited accordingly to satisfy this ratio.

(8) For example, if an air operator is operating on a gravel runway with an assessed surface CBR of 25, the tire pressure shall be limited to not exceed 125 psi (5 x 25). Any reduction in tire pressure to satisfy this ratio must continue to comply with the applicable aircraft certification and airworthiness requirements.

(9) The performance factors provided by the CASS are also valid for a minimum surface CBR value of 8, as measured by the **Boeing Penetrometer**. This CBR value indicates a very low surface strength and would likely practical only for very small aeroplanes, considering the maximum associated tire pressure of 40 psi. An air operator should exercise caution when operating on such low strength unpaved runway surfaces.

(10) Paragraphs 724.44(3)(c) and 724.44(3)(d) of the CASS do not allow credit for the use of reverse thrust in the calculation of weight to meet the available Accelerate Stop Distance and Landing distance. These paragraphs also do not allow the use of clearways in the calculation of take-off performance.

8.2 Frozen Unpaved Runways

(1) During periods of extended and deep frost, unpaved surfaces such as gravel runways can have strength characteristics similar to those of runways with paved hard surfaces. Operational experience has indicated that two weeks of ambient temperatures of –20°C or lower may be necessary for an unpaved runway to achieve strength similar to a paved hard surfaced runway. Once frozen solid, the runway will remain in this state, until ambient temperatures increase to above freezing.

(2) It is still necessary to consider the characteristics of the frozen unpaved runway to ensure the correct operational considerations are applied. While the frozen unpaved runway may have the same surface strength as a paved hard surfaced runway, it is necessary to ensure that the runway also meets all requirements including smoothness criteria. The surface characteristics of the frozen surface should also be considered to ensure the required braking performance is met.

(3) All applicable AFM performance factors should be applied for frozen unpaved runway operations. The performance factors for operations contained in CASS 724.44(3) should be applied when operating in accordance with this standard.

(4) If the frozen runway is covered with frozen contaminant such as compacted snow, the air operator should take into account the effects of the contaminant when calculating take-off and landing performance.

8.3 Dispatch Limitations

(1) Sections 704.49 and 705.60 of the CARs require the application of dispatch factors for landing at destination and alternate aerodromes. These factors should be applied to the required unpaved runway landing distance for the runway(s) being dispatched to. The wet runway dispatch limitations for turbo-jet powered aeroplanes as required by Sections 704.50 and 705.61 of the CARs need not be applied, unless specifically required by the applicable AFM or the surface is observed to be wet enough to adversely affect braking performance.

(2) Air operators should exercise caution when dispatching to unpaved runways where the regulatory dispatch limitations do not apply. The unpaved runway landing distances are based upon AFM landing distances with no additional distance margins. The AFM landing distances are derived from landing distance demonstrations that employ more aggressive landing techniques than that used during normal operations. The possibility of a runway overrun or excursion may increase when landing on an unpaved runway under limiting conditions. Air operators should consider reducing landing weight to provide a safety margin to landing distances.

9.0 MINIMUM REQUIRED SURFACE STRENGTH

(1) The surface strength of an unpaved runway needs to be established for unpaved runway operations. The required performance information for a specific set of conditions as published in an AFM or supplement for a specific type of unpaved runway (e.g. Gravel) will not be assured unless the unpaved runway meets or exceeds the AFM strength requirement. The strength of a gravel runway for operations in accordance with CASS 724.44(3) should be measured to assure that a Tire Pressure to CBR ratio of 5 is not exceeded.

(2) Most aircraft manufacturers have adopted the CBR as an expression of unpaved runway surface strength. CBR is the ratio of the load bearing capability of a given sample of soil compared to that of crushed limestone. The CBR of a given soil test is expressed in a percentage ranging from 0 to 100% or a whole number ranging from 0 to 100. When the CBR of the actual unpaved runway is greater than or equal to the minimum CBR value published in the AFM or supplement, the published AFM performance should be achievable.

(3) CBR has been accepted as the most common index of expressing unpaved runway surface strength. CBR should be considered an index of runway surface strength as opposed to an absolute or true value of shear strength, because of the dependence of the CBR value on the measuring device used. For this reason it is essential an air operator know and understand the measuring device used to establish a required CBR value published in an AFM or supplement.

(4) Most manufacturers identify the required CBR for operations in the AFM or associated supplement. One manufacturer in their AFM supplement has provided an International Civil Aviation Organization (ICAO) Aircraft Classification Number (ACN) and Transport Canada Aircraft Load Rating (ALR) numbers for their aircraft instead of CBR to establish the required gravel runway strength for operations. The air operator of this type of aircraft should ensure that the corresponding Pavement Classification Number (PCN) or Pavement Load Rating (PLR) of the runway is sufficient to satisfy the ACN or ALR requirements respectively.

10.0 MEASUREMENT OF SURFACE STRENGTH

(1) The standard for CBR measurement is that of the American Society of Testing Materials (ASTM), which has standards for the laboratory and on site (Field In-place) testing of CBR. The ASTM D4429 standard applies to *Field In-Place* testing and consists of measuring the deflection of a piston (through a flat plate) into the soil against a large reactive load. The ASTM method also specifies soil conditions including moisture content for which CBR results are valid.

(2) The ASTM method has proven to be impractical for the CBR measurements on unpaved runways because of the relatively laborious set-up required this measurement method. Some aircraft manufacturers have developed simpler CBR measurement methods for unpaved runway operations.

10.1 The Boeing High Load Penetrometer

(1) This measurement device is commonly used in North America. The test apparatus consists of a hydraulic cylinder to provide a large penetration force at a test probe. The test probe is driven into the unpaved surface to a specified depth (typically 4 inches/10 cm) by increasing hydraulic pressure within the cylinder. The hydraulic cylinder is normally positioned against the frame of a heavy vehicle, which serves as a large reactive load.

(2) The Boeing High Load Penetrometer is similar to the ASTM method in set-up except a probe rather than a piston is applied against the surface. A CBR value is derived from the pressure required to drive the probe to the specified depth. The CBR values derived from the Boeing High Load Penetrometer are approximately 10% less than the values derived from the in-field ASTM method for a piston penetration of 0.5 inches. (The ASTM method requires readings to be taken at 0.1 and 0.2 inches). The Boeing High Load Penetrometer is more practical than the ASTM method for operational use, because of its simpler set-up and reasonably close CBR values to the ASTM method.

10.2 The Sliding Weight Shock Penetrometer

(1) Some European aircraft manufacturers use a device called a sliding weight shock penetrometer. This device uses a sliding weight which is repeatedly raised to a specified height and dropped along a long rod to drive a probe into the surface to a specified depth. A CBR value is derived from the number of drops of the sliding weight required to drive the probe to a specified depth.

(2) The force available to drive the probe into the surface is relatively small in comparison to the hydraulic force available by the ASTM method and Boeing High Load Penetrometer. The CBR derived from a shock penetrometer may under-read the CBR derived from the Boeing penetrometer on the same surface by a factor ranging from 2 to 4. The presence of small stones as small as one half inch (12.5 mm) in diameter may result in artificially high readings. Shock penetrometer values may only be valid for relatively softer surfaces because of the relatively low penetration forces available from this device.

(3) Air operators should be aware that any surface CBR values derived from a shock penetrometer will under read a CBR value derived from another strength measuring device such as the Boeing high load penetrometer by a significant factor.

10.3 Dynamic Cone Penetrometer

(1) Then dynamic cone penetrometer is similar in principal to the sliding weight shock penetrometer. The dynamic cone penetrometer follows the ASTM D6951/D6951M, 2009—*Standard Test Method for the Use of the Dynamic Cone Penetrometer in Shallow Pavement Applications.* The forces capable from the Dynamic Cone Penetrometer are similar to those of the Sliding Weight Shock Penetrometer. Caution should also be exercised when establishing the strength of an unpaved runway in terms of CBR when derived from this device.

10.4 Operational use of California Bearing Ratio values

(1) The CBR value derived from other than the ASTM method should be treated as an index of surface strength rather than an absolute value of CBR. The method used to measure an unpaved runway for operational use should be the same method used to derive the minimum CBR published in the AFM or supplement. For example, if the CBR value published in the AFM or AFM supplement was derived using the Boeing High Load Penetrometer, the runway intended for operational use should be assessed using the Boeing High Load Penetrometer.

Note: *Many AFM's do not identify the measuring device used to establish the minimum or required CBR for operational use.*

(2) Hazardously misleading results may occur if a Boeing high load penetrometer is used to measure the surface strength of an unpaved runway to comply with a minimum required CBR established using a sliding weight shock penetrometer. For example, the CBR derived from a Boeing High Load penetrometer would have to be in the range of 30 to 60 to satisfy an AFM requirement for a CBR of 15, if based on the shock penetrometer (based on an error factor of 2 to 4 between the two devices).

(3) It is the responsibility of an air operator to clearly understand the basis of a required CBR value, required by the AFM or supplement for unpaved runway operation. The operator should determine from the aircraft manufacturer or other sources, the CBR device used in establishing the required CBR as published in the AFM or AFM supplement.

Note: *It is the air operator's responsibility to identify the measuring device and method used in an AFM or supplement to obtain a required CBR.*

(4) The air operator must reconcile strength values if different devices are used between the required and measured CBR for operational use. It may be necessary to apply conversion or correlation factors if the methods used to derive CBR for the AFM or supplement differ from those used to assess an unpaved runway for operational use. The air operator may need to conduct an engineering analysis or contact an aircraft manufacturer for this information.

10.5 Measurement of Unpaved Runway Surface Strength

(1) The manufacturer's instructions of the measuring device for gravel runway strength measurements should be followed. Measurements are normally taken along the length of the runway in the anticipated main landing gear wheel paths and at specific intervals (normally 100 - 200 feet (30-60m)). The measurement locations should be evenly staggered between the two wheel paths. Spot measurements should also be made along taxiways and aprons or other areas suspected to be soft.

(2) A minimum of 20 measurements should be taken when measuring the surface strength of an unpaved runway to account for the non-uniform strength characteristics of an unpaved runway. The published runway surface strength CBR value should be the average of the all of the measurements taken on the runway minus one standard deviation (i.e. CBR = $X - \sigma$).

(3) The strength of an unpaved runway will vary with moisture and time of year. When the strength of an unpaved runway is measured during its weakest annual condition, normally soon after spring thaw, it is likely the strength of the runway will be sufficient during the remainder of the year, unless exposed to prolonged precipitation. The air operator should continually monitor the condition of the unpaved runway to ensure that strength requirements continue to be met for operational use.

(4) Measurements may also be required at additional depths if required by the AFM supplement or by the specific test methodology applicable to the measuring device.

11.0 INFORMATION MANAGEMENT

(1) Not applicable.

12.0 DOCUMENT HISTORY

(1) Not applicable.

13.0 CONTACT OFFICE

Suggestions for amendment to this document are invited, and should be submitted to:Chief, Commercial Flight Standards via the following e-mail address:

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Transport Canada documents or intranet pages mentioned in this document are available upon request.