



# Advisory Circular

**Subject:                      Measurement and Evaluation of Runway Roughness**

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## 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 guidelines for the measurement and evaluation of runway pavement surface roughness.

### 1.2 Applicability

- (1) This document applies to Canadian airport operators and is also available to the aviation industry and aerodrome community for information purposes.

### 1.3 Description of Changes

- (1) Revisions to Section 6.1 (1), (4), (5), and (6). Principal changes include revised terminology and roughness category descriptions. Also included is a new Table 1 summarizing the roughness criteria in numeric format.

## 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 III, Subpart 2 of the *Canadian Aviation Regulations (CARs) — Airports*;
  - (b) Transport Canada Publication (TP) 312 5<sup>th</sup> Edition — *Aerodrome Standards and Recommended Practices*;
  - (c) Advisory Circular (AC) 302-016 — *Airport Pavement Management System*;
  - (d) TP 892 (Historical Reference Document AK-68-22-000) — *Pavement Construction: Methods and Inspection*. (A newer version of this document was published by Public Works and Government Services Canada (PWGSS), Architecture and Engineering Services, Airport Engineering, as ASG-20, September 1996 — *Pavement Construction: Methods and Inspection*);
  - (e) Federal Aviation Administration Advisory Circular (FAA AC) 150/5380-9, 2009-09-30 — *Guidelines and Procedures for Measuring Airfield Pavement Roughness*;
  - (f) International Civil Aviation Organization (ICAO) Annex 14 to the *Convention on International Civil Aviation — International Standards and Recommended Practices: Aerodromes* (Seventh Edition, July 2016); and
  - (g) Boeing Document No. D6-81746 — *Runway Roughness Measurement, Quantification, and Application – The Boeing Method*;
  - (h) ASTM E1364, 1995 (Reapproved 2012) — *Standard Test Method for Measuring Road Roughness by Static Level Method*; and
  - (i) ASTM E2133, 2003 (Reapproved 2013) — *Standard Test Method for Using a Rolling Inclinometer to Measure Longitudinal and Transverse Profiles of a Traveled Surface*.

## 2.2 Cancelled Documents

- (1) Not applicable.
- (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) **Macro-texture**: the coarse-scale roughness of the pavement surface as a whole, created by the hills and valleys formed by aggregate particles; and
  - (b) **Micro-texture**: the fine-scale roughness of individual aggregate particles, which may not be discernible to the eye but should be apparent to the touch.
- (2) The following **abbreviations** are used in this document:
  - (a) **AC**: Advisory Circular
  - (b) **FAA**: Federal Aviation Administration
  - (c) **ICAO**: International Civil Aviation Organization
  - (d) **IRI**: International Roughness Index
  - (e) **RCI**: Riding Comfort Index
  - (f) **RMSVA**: Root Mean Square Vertical Acceleration
  - (g) **TP**: Transport Canada Publication

## 3.0 BACKGROUND

- (1) TP 312 5<sup>th</sup> Edition *Aerodrome Standards and Recommended Practices*, section 3.1.3.1 states as a standard that “The pavement of the runway is without irregularities that would result in reduced friction characteristics or adversely affect aircraft operations. *Note 1: Surface irregularities may adversely affect the take-off or landing of an aircraft by causing excessive bouncing, pitching, vibration, or other control difficulties.*” In addition, section 3.5.1.6 of TP 312 states as a standard that “The surface of a taxiway is without irregularities that may cause damage to aircraft structures.”
- (2) Airport pavement surfaces should be free from any irregularities that could be detrimental to aircraft operations. Runway surface smoothness is very important for safe operation of aircraft during takeoff and landing runs. Surface irregularities and roughness can affect the safety of aircraft operations by:
  - (a) subjecting the aircraft to excessive pitch and roll motions that may interfere with aircraft operational performance and control;
  - (b) causing aircraft structural damage and component fatigue through repeated ground-air-ground cycles;
  - (c) causing the aircraft to become airborne;
  - (d) reducing aircraft tire/pavement contact which can affect feedback from aircraft anti-skid braking systems and degrade aircraft performance; and
  - (e) causing vibration problems that make on-board instruments difficult for pilots to read.
- (3) Excessive roughness may also cause discomfort and alarm for passengers. However, aircraft suspension is designed for landing and not for ride quality.

## 4.0 FACTORS IN EVALUATING PAVEMENT ROUGHNESS

### 4.1 What is Pavement Roughness

- (1) Pavement roughness (or lack of smoothness) exists when surface irregularities in the pavement profile are severe or extensive enough to interfere with the safe operation of aircraft, or cause damage or structural fatigue to an aircraft.
- (2) Pavement roughness, as discussed in this AC, is not the same as pavement texture, the fine-scale roughness of a pavement known as micro- and macro-texture that can be felt by running an open hand over the surface. Pavement texture and pavement grooving are not sources of roughness.

### 4.2 Causes of Pavement Roughness

- (1) There are a number of reasons why roughness occurs in airport pavements.
  - (a) Some minor roughness is usually built into new pavements because construction techniques are not perfect.
  - (b) Pavement surface roughness increases with time. As the pavement ages, cracks start to appear in the surface – especially thermal contraction cracks which will almost certainly occur in asphalt pavements during their first several winters of service. Surface cracking contributes to roughness.
  - (c) Differential movements within the pavement surface such as frost heave, settlements, and changes in subgrade soil conditions can result in surface roughness.
  - (d) As the pavement nears the end of its service life, roughness can increase rapidly as the surface begins to break down under traffic and maintenance patching becomes more extensive.

### 4.3 Pavement Construction Specifications

- (1) For acceptance of new pavement construction, roughness is typically measured with a straight edge.
- (2) Transport Canada historical specifications for acceptance testing of new pavement for surface irregularities are given in *ASG-20 Pavement Construction: Methods and Inspection* as follows:

“The surface of a finished (asphalt concrete or Portland cement concrete) pavement shall be within 5 mm of design grade, but not uniformly high or low, and shall have no irregularities exceeding 5 mm when checked with a 4.5 m straightedge placed in any direction.”
- (3) ICAO Annex 14, Attachment A, Section 5, gives the following recommended specifications for runway surface irregularities:

“ 5.1 In adopting tolerances for runway surface irregularities, the following standard of construction is achievable for short distances of 3 m and conforms to good engineering practice:

Except across the crown of a camber or across drainage channels, the finished surface of the wearing course is to be of such regularity that, when tested with a 3 m straight-edge placed anywhere in any direction on the surface, there is no deviation greater than 3 mm between the bottom of the straight-edge and the surface of the pavement anywhere along the straight-edge.

5.2 Caution should also be exercised when inserting runway lights or drainage grilles in runway surfaces to ensure that adequate smoothness of the surface is maintained.”
- (4) When designing and specifying tolerances to control runway surface irregularities, it is important to recognize that because surface roughness will increase with time as the pavement ages, the tolerances adopted for construction purposes should be more stringent than maintenance (aircraft operational) tolerances specified for roughness.

#### 4.4 Aircraft Response to Pavement Roughness

- (1) Measuring and evaluating roughness is a complex problem due to differences in aircraft size and performance. Response to roughness is dependent on the type of aircraft including its method of operation, weight, amount of lift achieved, wheelbase length, landing gear dynamics and the speed at which it encounters a bump or depression.
- (2) Aircraft response is also dependent on the height and length of the bump or depression, its location in the profile, and whether there are multiple, successive bumps that amplify their individual roughness effects.
- (3) Minimizing roughness levels in runway surface profiles is of primary importance because of the “committed” nature of aircraft takeoff and landing operations. Unlike an automobile that encounters a rough section of road pavement, an aircraft once it has begun a takeoff or landing operation, cannot slow down to alleviate the effects of roughness or veer off course to avoid a rough area of runway.
- (4) Pilot complaints of pavement roughness are often the first indication that something may be wrong with the pavement profile and that further investigation is required.

#### 4.5 Types of Runway Pavement Roughness

- (1) The measurement and analysis of runway pavement roughness should consider two types of roughness:
  - (a) Isolated bumps and depressions in the profile where an excessive change in elevation occurs in relation to the base length of the bump or depression. Short length bumps range from a practically a zero length bump such as occur with the abrupt elevation changes caused by concrete stepping up to about the wheelbase length of a typical passenger automobile. Long length bumps range up to about 60 metres and can have varying effects on an aircraft. Bump height/length analysis (Boeing Bump Method) can be used to identify isolated bumps and depressions.
  - (b) Average profile roughness levels for the entire runway (or subsections of the runway). Average profile roughness can be determined by analyzing a pavement profile to compute an average roughness index such as the International Roughness Index (IRI) or the Root Mean Square Vertical Acceleration (RMSVA)). An average roughness index can be included in an Airfield Pavement Management System (AC 302-016) as part of the non-destructive test data used in predicting future pavement conditions and the need for pavement rehabilitation.

### 5.0 PAVEMENT SURFACE PROFILE MEASUREMENT

- (1) Measurement of the pavement longitudinal surface profile can be used to both assess the severity of isolated bumps and to compute an average level of profile roughness using various indices.
- (2) When using profile techniques, it may not be necessary to profile the entire length of the runway but only the section known to be rough.

#### 5.1 Measurement Equipment

- (1) Measuring runway profiles for runway roughness analysis requires the use of a “Class I” measuring device with a vertical resolution of 0.01 mm.
- (2) The conventional rod and level survey is usually the standard against which other types of profiling equipment are evaluated against. However, conventional rod and level methods are too slow other than for other than short profile lengths. ASTM E1364 gives a test method for

measuring the longitudinal profile of a pavement surface by static level for the purpose of obtaining a roughness index.

- (3) An inclinometer based profiler (“walking profiler”), is a hand operated device mounted on a rigid beam up to 0.305 m (1 foot) in length. The profile is created by measuring the beam inclination, which progresses along the length of the pavement section in steps that are equal to the length of the beam. Both the distance and the elevation are recorded at each step in order to create the profile. An inclinometer-based profiler is faster than a rod and level survey since it can be operated at speeds up to 4 km/hr. ASTM E2133 gives a test method for measuring longitudinal profiles on paved surfaces using a rolling inclinometer travelling at walking speed.
- (4) Inertial profilers (both “lightweight” and “highspeed”) are profiling devices utilizing a test vehicle mounted platform to carry a laser or acoustic equipment measuring the distance from the platform to the pavement surface, and an accelerometer tracking elevation of the platform. Inertial profilers typically include high pass filtering in the processing of the accelerometer signal to reduce errors from changing grades and from braking and accelerating the test vehicle. High pass filtering can have a significant effect on calculations using the Boeing Bump Method and on aircraft roughness simulations because of the relatively longer base lengths being evaluated. In addition, inertial profilers generate significant profile errors during braking and acceleration of the test vehicle. For these reasons, the use of inertial profilers with high pass filtering is not recommended for the measuring of runway profiles for the purpose of roughness analysis using the Boeing Bump Method or for aircraft roughness computer simulations.

## 5.2 Survey Interval

- (1) A full analysis of roughness characteristics requires a profile defined by elevations measured at an interval not exceeding 0.305 m (1 foot). The Federal Aviation Administration (FAA) software (PROFAA) described subsequently requires a profile survey interval of 0.25 m (0.82 ft) for evaluation of the Boeing Bump.
- (2) Profile measurements obtained by conventional rod and level survey at spacings not exceeding 3 metres can also be used to perform bump height/length analyses for bump lengths greater than twice the elevation interval spacing. However, rod and level surveys using 3 metre spacings are not acceptable for the computation of roughness indices such as RCI, IRI and RMSVA.

## 5.3 Survey Location

- (1) Runway surface profile measurements are normally made at 3.0 metre offsets right and left of the runway longitudinal centreline to approximate the wheel path of moderately sized aircraft. It may also be desirable to obtain measurements along the runway centreline to assess nose wheel roughness and at an offset of 5 to 6 metres (nominally 5.25 metres) of the runway centreline to approximate the outer gear wheel path of wide-bodied aircraft.

## 6.0 PAVEMENT ROUGHNESS ANALYSIS METHODS

### 6.1 Profile “Bump Height/Length” Analysis (Boeing Bump Method)

- (1) Guidance on evaluating a pavement surface profile to identify isolated bumps/depressions that may affect aircraft operations is given in Attachment A, Section 5. to ICAO Annex 14. The runway roughness criteria as given in Figure A-3 of ICAO Annex 14, is termed “bump height/length” analysis or “Boeing Bump” method. Figure 1 of this AC also gives the bump height/length criteria for isolated bumps (adapted from Figure A-3 of ICAO Annex 14). The runway roughness criteria is summarized in numeric format in Table 1.
- (2) The basis of the bump height/length analysis is to construct a virtual straightedge between two points on the elevation profile and measure the deviation from the straightedge to the pavement surface. The “bump height” is the maximum deviation (positive or negative) from the straightedge

to the pavement surface and the “bump length” is the shortest distance from either end of the straightedge to the location where the bump is measured. The minimum straightedge length is twice the runway profile survey interval. The determination of bump height and bump length is illustrated in Figure 2.

- (3) The Boeing Bump method considers straightedge lengths (wavelengths) up to 120 metres. An isolated bump analysis involves computing all bump height/length combinations in the profile up to a bump length of approximately 60 metres and comparing the results of each combination against the criteria in Figure A-3 of ICAO Annex 14 (or Figure 1 of this AC). Because of the extensive number of bump height/length combinations, computer software is normally required for the performance of an isolated bump analysis.
- (4) The guidelines below will assist in interpreting the effect that isolated bumps/depressions are likely to have on aircraft response and in determining the need for corrective action. The descriptive headings refer to the four regions defined by Figure A-3 of ICAO Annex 14.
  - (a) “Acceptable region” – Bump height/length combinations in this region should not adversely affect aircraft operations.
  - (b) “Tolerable region” – For bump height/length combinations in this region, corrective maintenance action should be planned. The runway may remain in service. This region is the start of possible passenger and pilot discomfort.
  - (c) “Excessive region” – For bump/height length combinations in this region, corrective maintenance should be taken immediately to restore the condition to within the acceptable limit region. The runway may remain in service but should be repaired within a reasonable period. This region could lead to the risk of possible aircraft structural damage due to a single event or fatigue failure over time.
  - (d) “Unacceptable region” – For bump height/length combinations in this region, the area of the runway where the roughness has been identified warrants closure. Repairs have to be made to restore the condition to within the acceptable limit region and the aircraft operators may be advised accordingly. This region runs the extreme risk of a structural failure and has to be addressed immediately,
- (5) The maximum tolerable step type bump, such as that would exist between adjacent slabs, is simply the bump height corresponding to zero bump length at the upper end of the tolerable region of the roughness criteria of Figure 1. The bump height at this location is 1.75 cm.
- (6) An isolated bump height/length analysis does not, however, account for the combined contributions to roughness of multiple or sequential bumps or for long wavelength harmonic effects.
- (7) An isolated bump height/length analysis should be performed when pilot complaints of objectionable bumps/depressions in the runway pavement surface have been received.

**Table 1 - Runway Roughness Criteria for Isolated Bumps**

Surface irregularity (bump)	Length of irregularity (m)								
	3	6	9	12	15	20	30	45	60
Acceptable surface irregularity height (cm)	2.9	3.8	4.5	5	5.4	5.9	6.5	8.5	10
Tolerable surface irregularity height (cm)	3.9	5.5	6.8	7.8	8.6	9.6	11	13.6	16
Excessive surface irregularity height (cm)	5.8	7.6	9.1	10	10.8	11.9	13.9	17	20



Figure 1 – Runway Roughness Criteria for Isolated Bumps

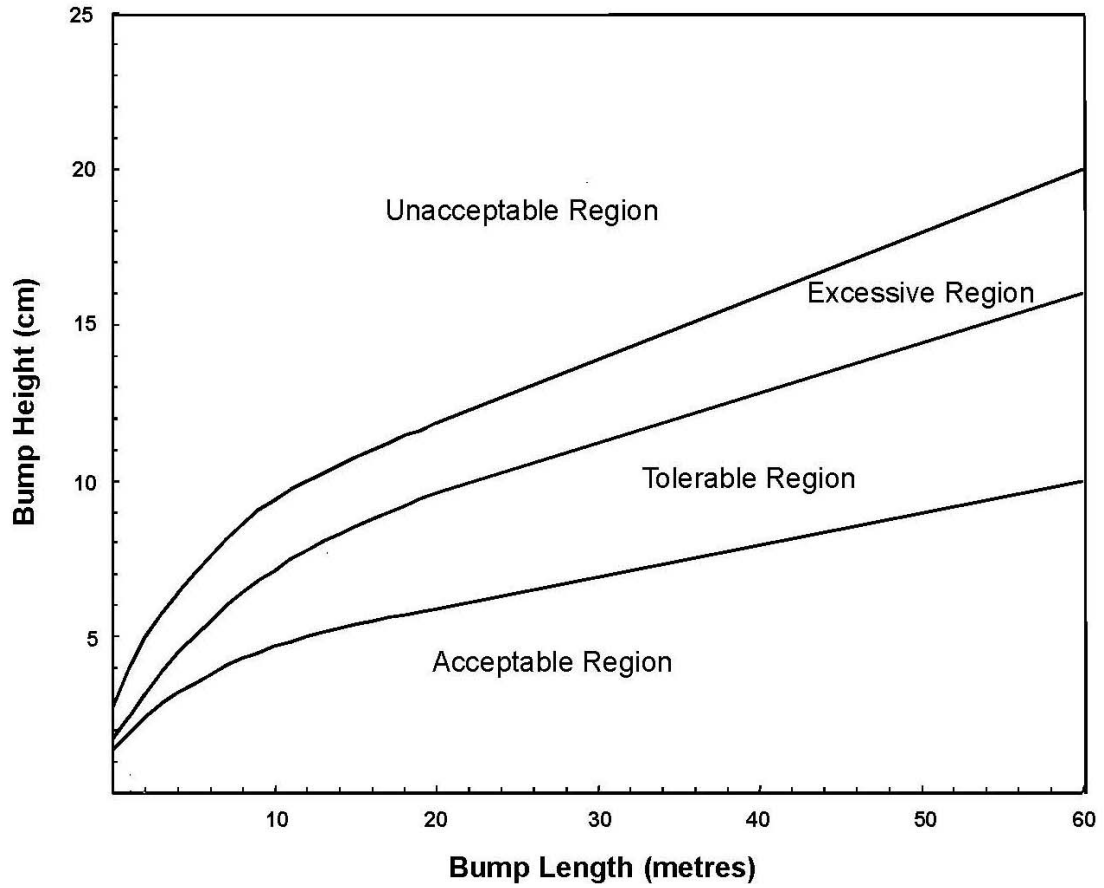
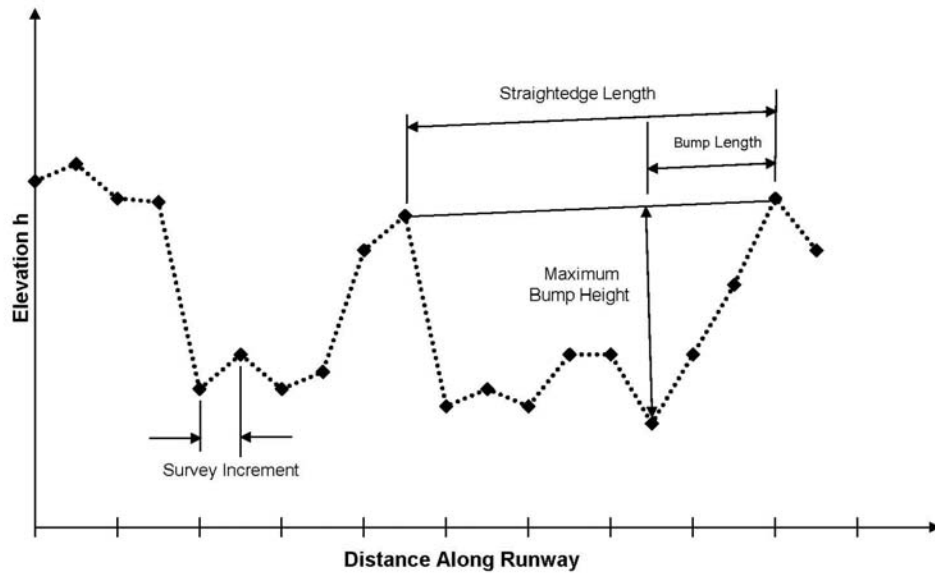


Figure 2 – Bump Height Measurement



**6.2 Profile Indices (Average Runway Roughness)**

(1) The following roughness indices can be computed from a runway profile to express the average level of roughness.

(a) International Roughness Index (IRI)

The International Roughness Index (IRI) is a commonly used highway roughness index. The IRI can be computed for 100 metre sections to identify any portions of the runway profile that have higher roughness levels and for the entire runway profile. The IRI is computed in accordance with ASTM E1364.

(b) Root Mean Square Vertical Acceleration (RMSVA)

The Root Mean Square Vertical Acceleration (RMSVA) is another profile index that can be used to express an average level of roughness. The RMSVA can be computed for 100 meter sections to identify any portions of the runway that have high roughness levels and for the entire length of the runway. The RMSVA of a pavement profile is calculated using the following mathematical expression:

$$RMSVA_b = \sqrt{\frac{\sum_{i=k+1}^{i=n-k} VA(i)^2}{n - 2k}}$$

where the Vertical Acceleration (VA) is defined as:

$$VA(i) = \frac{y(i+k) + y(i-k) - 2y(i)}{b^2}$$

and where:

RMSVA<sub>b</sub> = Root Mean Square Vertical Acceleration (mm/m<sup>2</sup>) calculated for a base length b

VA(i) = vertical acceleration (mm/m<sup>2</sup>) at profile point “i”

n = number of profile elevations

i = index designating the i<sup>th</sup> profile point

b = base length (m) used for RMSVA<sub>b</sub> calculation (1.5m preferred)

(Note: “b” is the distance between profile point “i - k” and “i” and equally the distance between profile point “i” and “i + k”)

dx = distance between profile points (m)

k = b / dx

y(i) = elevation (mm) at profile point “i”

(2) Due to the complexity of the calculations involved, the computation of IRI and RMSVA, roughness indices from a longitudinal surface profile make computer software an essential requirement.

**6.3 Riding Comfort Index (RCI)**

- (1) The historical Transport Canada method of assessing runway pavement roughness is called the Riding Comfort Index (RCI). The RCI is a subjective method of rating the roughness of a pavement on a scale of 0 to 10 while riding in an automobile, with a RCI of 0 representing a very poor ride quality and a RCI of 10 representing a very good ride quality. The RCI, however, does not indicate the presence of individual bumps of excessive magnitude as aircraft respond to profile irregularities of longer wavelength not affecting automobile ride.
- (2) Although the RCI represents a subjective measure of ride quality while riding in an automobile, the index gives a general indication of the average level of pavement roughness experienced by a pilot. For a runway receiving turbojet traffic, pilot complaints can be expected when the RCI falls below 5 and are almost certainly received if the RCI falls below 4. If pilot complaints of runway roughness are received and the RCI is at an acceptable level, then the runway profile should be evaluated for individual bumps of excessive magnitude.
- (3) Correlations have been established between the RCI and the profile roughness indices described above (IRI and RMSVA) and can be used to determine a corresponding RCI value as follows:
  - (a) The following equation can be used for determination of RCI values from IRI values:
 
$$RCI = 10 * e^{(-0.255 * IRI)}$$
 where:  
 RCI = Riding Comfort Index  
 e = base of the natural logarithm (2.71828)  
 IRI = International Roughness Index (mm/m) calculated from a measured profile
  - (b) The following equation can be used for determination of RCI values from RMSVA profile indices:
 
$$RCI = 10 * e^{(-0.366 * RMSVA_b)}$$
 where:  
 RCI = Riding Comfort Index  
 e = base of the natural logarithm (2.71828)  
 RMSVA = Root Mean Square Vertical Acceleration (mm/m<sup>2</sup>) calculated from a measured profile using a base length “b” equal to 1.5 m
  - (c) If RMSVA is determined at a base length other than 1.5 metres, then the following equation can be used for the determination of RCI values from RMSVA profile indices:
 
$$RCI = 10 * e^{(c * RMSVA_b)}$$
 where:  

$$c = (-0.355 * b) + 0.164$$
 and:  
 b = The base length (metres) used for determination of the RMSVA<sub>b</sub> profile index.
- (4) If RCI values are computed from both the IRI and the RMSVA, then two RCI values can be averaged to represent the average level of profile roughness.

- (5) The RCI can be computed for 100 metre sections to identify any sections of the runway profile that have higher roughness levels. However, roughness guidelines are based on the RCI average for the entire runway.
- (6) Table 1 gives historical Transport Canada runway roughness guidelines based on the average RCI for the entire length of the runway longitudinal profile.

**Table 2 – Historical Runway Roughness Guidelines based on RCI**

Historical Restoration Guidelines	Turbojet Traffic	Non-Turbojet Traffic
	When Runway Average “RCI” is Less Than	
Corrective Action Planned	5.0	4.0
Corrective Action Taken	4.0	3.0

**6.4 Computerized Aircraft Roughness Simulation**

- (1) When the longitudinal surface profile of a runway pavement has been measured, aircraft mathematical simulation techniques can also be used to assess the response of an aircraft to multiple event roughness present in the profile and to identify the severity and location of the roughness. Computer software is required to simulate the takeoff, landing or constant speed run of an aircraft over the length of the profile with aircraft ride quality being assessed in terms of the vertical acceleration of the landing gear.
- (2) Although standard criteria are not available for evaluating the results of aircraft roughness simulations, limiting the peak vertical acceleration experienced by aircraft landing gear to below 0.35 to 0.40 g’s (acceleration due to gravity) is generally considered an achievable and acceptable objective.
- (3) Computer simulations of aircraft takeoff and landing runs over a surface profile give the closest representation of how an aircraft is likely to respond to both short and long wavelength roughness present in the profile. Many roughness cause/effect variables that are not considered in other techniques are factored into the simulation including multiple event roughness in the profile, aircraft landing gear dynamics, bump encounter speed, ground-borne aircraft mass, and airport site environmental and elevation influences.

**7.0 CORRECTIVE ACTION TO RESTORE SMOOTHNESS**

- (1) Section 2.5.1.1 of TP312 5<sup>th</sup> Edition indicates that “Information on the condition of the manoeuvring area and the operational status of related facilities is communicated to the appropriate aeronautical information service units, and similar information of operational significance to the air traffic services units, to enable those units to provide the necessary information to arriving and departing aircraft. The information is kept up to date and changes in conditions are reported without delay.”  
  
Section 2.5.1.2 indicates that “The condition of the movement area and the operational status of related facilities are monitored and reports on matters of operational significance or affecting aircraft performance are communicated to AIS where provided, or the aircrew directly, in respect of the following: ..... b) rough or broken surfaces on a runway...”
- (2) The decision on when and what type of corrective action is needed to restore surface smoothness will depend on the roughness analysis method used and on the type, location,

severity and extent of unacceptable roughness found in the surface – for example, localized versus general roughness found throughout the surface area. An excessive level of roughness is the justification for approximately 15 to 20 percent of airport pavement restoration projects.

- (3) When a runway surface profile is determined to contain a bump classified as “Excessive” as defined by Figure 1 (or Figure A-3 of ICAO Annex 14), corrective action should be taken immediately but the runway may remain in service.
- (4) When a runway surface profile is determined to contain a bump classified as “Unacceptable” as defined by Figure 1, the area of the runway where the bump is located warrants closure until such time as corrective action has been taken to restore surface smoothness.
- (5) Corrective measures (such as levelling and grinding) can be applied to a computerized pavement surface profile and the roughness analysis re-run to assess the effectiveness of the correction in alleviating the roughness problem.

## **8.0 FREQUENCY AND TIMING OF ROUGHNESS MEASUREMENTS**

- (1) The frequency and timing of roughness measurements is established by the airport authority. Pilot complaints of pavement roughness are often the first indication that there may be something wrong with the pavement profile and that further investigation (roughness measurements) may be required. The roughness level of pavement surfaces will increase with time as the pavement ages and as various structural defects develop.
- (2) It is also desirable to measure the longitudinal surface profiles of new, reconstructed and resurfaced paved runways prior to or as soon as possible following the commissioning of the new surface. Measuring the surface profile of the runway surface will also serve as a check on the adequacy of construction as well as provide a reference or “benchmark” against which subsequent roughness measurement and deterioration can be assessed throughout the life of the pavement.

## **9.0 SOFTWARE APPLICATIONS FOR PAVEMENT ROUGHNESS ANALYSIS**

- (1) The FAA has software available on their web site called “ProFAA” which provides the capability to simulate roughness evaluation procedures and calculate associated roughness indices as follows:
  - (a) Straight Edge
  - (b) Boeing Bump
  - (c) International Roughness Index (IRI)
  - (d) California Profilograph
  - (e) RMS BandpassIn addition, the software has the capability to simulate aircraft response for a library of representative aircraft and to calculate root mean square vertical accelerations and dynamic strut loads from the simulated responses.
- (2) Other proprietary software is available for the mathematical simulation of aircraft response to a runway profile. The types of analyses include aircraft takeoff and landing simulations to calculate “g” forces and aircraft constant velocity simulations to study the effects of speed on aircraft response to roughness in terms of the vertical acceleration of the landing gear.

**10.0 INFORMATION MANAGEMENT**

- (1) Not applicable.

**11.0 DOCUMENT HISTORY**

- (1) Advisory Circular (AC) 302-023 Issue 01, RDIMS 10840432 (E), 10840456 (F), dated 2015-09-16 – *Measurement and Evaluation of Runway Roughness*.

**12.0 CONTACT OFFICE**

For more information, please contact:

<http://www.tc.gc.ca/eng/regions.htm>

Suggestions for amendment to this document are invited, and should be submitted via:

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