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of Transportation

**Federal Aviation
Administration**

Advisory Circular

Subject: Guidelines and Procedures for
Measuring Airfield Pavement Roughness

Date: 9/30/2009
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AC No: 150/5380-9
Change:

- PURPOSE.** This Advisory Circular (AC) provides guidelines and procedures for measuring and evaluating runway roughness as identified by surface profile data of rigid and flexible airport pavements. The guidance in this AC provides technical procedures to quantify surface irregularities and to determine how surface irregularities may affect specific categories of airplanes.
- APPLICATION.** The FAA recommends the guidelines and standards in this AC for evaluating the roughness of new and existing paved surfaces. In general, use of this AC is not mandatory. However, use of this AC is mandatory for all projects funded with federal grant monies through the Airport Improvement Program (AIP) and with revenue from the Passenger Facility Charges (PFC) Program. See Grant Assurance No. 34, "Policies, Standards, and Specifications," and PFC Assurance No. 9, "Standards and Specifications."
- RELATED READING MATERIAL.** Appendix 1, Bibliography, lists further guidance and technical information.
- METRIC UNITS.** To promote consistency with International Civil Aviation Organization (ICAO) guidance, the text and figures include both metric and English dimensions. Dimensions are provided first in metric units. Readers should keep in mind that English units are based on operational significance and may not be exact equivalents.
- COMMENTS OR SUGGESTIONS** for improvements to this AC should be sent to—

Manager, Airport Engineering Division
Federal Aviation Administration
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A handwritten signature in black ink, appearing to read "Michael J. O'Donnell". The signature is stylized and cursive, with a large initial "M" and "J".

Michael J. O'Donnell
Director of Airport Safety and Standards

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FORWARD

This AC represents a first step towards defining and implementing basic pavement roughness criteria for airfield pavements. The criteria presented in this version of the AC is intended to address isolated bump events and does not address cyclic or harmonic events which can have a substantial impact on airplane components and operations. Future research in this area will attempt to define limits for gravitational forces experienced by airplane components (landing gear, wings, etc) and occupants.

CHAPTER 1. INTRODUCTION TO AIRPORT PAVEMENT ROUGHNESS

1.1 PURPOSE OF ADVISORY CIRCULAR. This AC provides airport operators with procedures to evaluate a pavement surface profile in terms of roughness and the impact pavement roughness may have on civilian airplanes.

1.2 IMPORTANT FACTOS IN EVALUATING PAVEMENT ROUGHNESS.

a. Pavement Surface Irregularities. Airport pavement surfaces must be free of irregularities that can impair safe operations, cause damage, or increase structural fatigue to an airplane. Engineers refer to these surface irregularities as pavement roughness or lack of smoothness. Due to large differences in airplane size and performance, the aviation industry has struggled with exactly how to quantify roughness in terms that have meaning to airplane operations.

b. Airfield versus Highway Roughness. The highway industry defines pavement smoothness/roughness in terms of the ride quality experienced by a passenger. Automotive manufacturers design suspension systems to reduce the impact of common surface irregularities and improve overall ride quality. In contrast, the primary purpose of an airplane suspension system is to absorb energy expended during landing. Airplane suspension systems have less capacity to dampen the impact of surface irregularities due to the magnitude of the energy that must be addressed during landing. Airfield pavement roughness is defined in terms of fatigue on aircraft components (increase stress and wear) and/ or other factors which may impair the safe operation of the aircraft (cockpit vibrations, excessive g-forces, etc.).

c. Categories of Airfield Pavement Roughness. The FAA groups airfield pavement roughness into two categories based on the dimensions and frequency of surface deviations:

1) Single Event Bump. Single event bumps are isolated events where changes in pavement elevation occur over a relatively short distance of 100 meters (328 feet) or less. Such elevation changes may occur as an abrupt vertical lip or as a more gradual deviation from a planned pavement profile. Depending on the operational speed and bump length, an airplane suspension system may not be able to fully absorb the energy produced when it encounters a bump. Airplane components and occupants feel the impact as a shock or sudden jolt.

Basic “straightedge” analysis can easily identify single event bumps. Riding the pavement in a passenger vehicle might reveal shorter length bumps, but finding longer length bumps might require a thorough analysis of the pavement profile.

2) Profile Roughness. The FAA defines profile roughness as surface profile deviations present over a portion of the runway that cause airplanes to respond in ways that can increase fatigue on airplane components, reduce braking action, impair cockpit operations, and/or cause discomfort to passengers. Response depends on airplane size, weight, and operation speed. Even when roughness does not cause discomfort to passengers, it may still affect the fatigue life of airplane components or decrease operational safety of the airplane. Depending upon airplane characteristics and operating speed, an airplane may be excited into

harmonic resonance due to profile roughness which can increase inertial forces or vibrations within the airplane structure. One example is resonant response in a 4-wheel truck pitch mode which elevates friction in the pivot joint.

In some cases, driving a pavement in a passenger vehicle can reveal profile roughness.

d. Passenger Comfort. Airport pavement roughness is **not** defined by perceived ride quality or passenger discomfort. Although important, passenger discomfort due to pavement surface irregularities is often not a significant issue since the degree of discomfort is small and the time of exposure is limited to a few seconds. Further, passenger discomfort often occurs during takeoff and landing operations when engine noise, aerodynamic noise, and/or horizontal acceleration or deceleration otherwise distract the passengers.

e. Factor Affecting Safe Airplane Operations. Stress on airplane components, reduced braking action, and the ability to view cockpit instrumentation can impact the safe operation of an airplane. Pavement surface irregularities may cause enough vibrations in the cockpit that pilots cannot focus on critical instrumentation or have difficulty manipulating the controls during takeoff or landing. Pavement surface irregularities can also cause increased stress on critical airplane components, which increases the risk of premature failure. Airplane response to surface irregularities can reduce braking capacity as the airplane responds to vertical acceleration. These factors can occur individually or in combination, depending on airplane response.

f. Pilot Response and Feedback. Pilot observations and complaints are an important factor in determining pavement roughness. Although pilot observations do not directly indicate that structural fatigue of airplane components is occurring, they are often the first sign that something is wrong with the pavement profile. The procedures in this AC use pilot observations to establish basic criteria for evaluation of pavement roughness.

g. Surface Texture. Pavement roughness, as discussed in this AC, is not the same as pavement texture. Pavement texture is the micro texture of the immediate pavement surface which contributes to friction between the airplane wheel and the pavement surface. Pavement texture and pavement grooving is not a source of roughness. See ASTM E 867-04, Terminology Relating to Vehicle-Pavement Systems, for definitions of texture.

h. Construction Standards. When constructed in accordance with the design standards of AC 150/5300-13, Airport Design, and the construction standards of AC 150/5370-10, Standards for Specifying Construction of Airports an airfield pavement should not have issues with surface irregularities. However, as a pavement ages, the surface profile may vary from the original design standards due to factors such as frost heave or subgrade settlement.

CHAPTER 2. EVALUATING SINGLE EVENT BUMPS IN RUNWAY PAVEMENT

2.1 INTRODUCTION TO SINGLE EVENT BUMP EVALUATION. Undesirable elevation changes on runway pavements can increase stress on airplane components, reduce braking action, make it difficult for pilots to read cockpit instrumentation, and/or cause discomfort to passengers. Typically, large wavelength bumps are the most prevalent but are not usually visible to the naked eye. The most critical bump height associated with these large wavelength bumps depends on the relationship between the wavelength and the natural frequency of the aircraft. Single step type bumps—or a vertical deviation with zero length, i.e. a vertical lip or fault in the pavement surface—rarely cause problems in service because the step size is usually within the acceptable range, as noted in Figure 2-3.

This chapter provides guidance on evaluating a pavement surface profile to identify potential single event surface deviations that can affect airplane operations. The guidance, based on fully loaded jet transport airplanes operating at near-rotation speeds (130 to 200 knots), is appropriate for runway applications. It provides conservative results for areas of pavement with slow moving traffic such as taxiways or aprons.

The derivation of the guidance is described in Boeing Document D6-81746, Runway Roughness Measurement, Quantification and Application – The Boeing Method. The aviation industry and International Civil Aviation Organization (ICAO) refer to this procedure as the “Boeing Bump” method.

2.2 BOEING BUMP EVENT IDENTIFICATION PROCEDURE.

a. Basic Procedure. The basis of the Boeing Bump method is to construct a virtual straightedge between two points on the longitudinal elevation profile of a runway and measure the deviation from the straightedge to the pavement surface. (NOTE: A virtual straightedge is an imaginary line between two points on the profile and is not intended to imply a physical tool or mechanism.) The procedure reports “bump height” as a maximum deviation (positive or negative) from the straightedge to the pavement surface as illustrated in Figure 2-1. Bump length is the shortest distance from either end of the straightedge to the location where the bump event is measured. The procedure plots bump height and bump length against the acceptance criteria in Figure 2-3.

b. Maximum Straightedge Length. The Boeing Bump procedure considers straightedge lengths (wavelengths) up to 120 meters (394 feet). Because the Boeing Bump procedure targets isolated bump events, “wavelength” terminology is replaced with “bump length”. Research cited by Boeing has demonstrated that bump lengths in excess of 120 meters (394 feet) do not contribute to dynamic airplane response or negatively impact the airplane.

c. Minimum Straightedge Length. The minimum length of the straightedge depends on the sample spacing or survey interval of the profile data. The minimum length is equal to twice the survey interval. The method requires a minimum of three profile data points to obtain a deviation from the straightedge, as demonstrated in Figure 2-2. The outer two points define the ends of the straightedge, and the interior point provides a profile deviation. The FAA

standard for sample spacing is 0.25 meters (0.82 feet) for evaluation of the Boeing Bump. Therefore, the minimum straightedge length is 0.5 meters (1.64 feet).

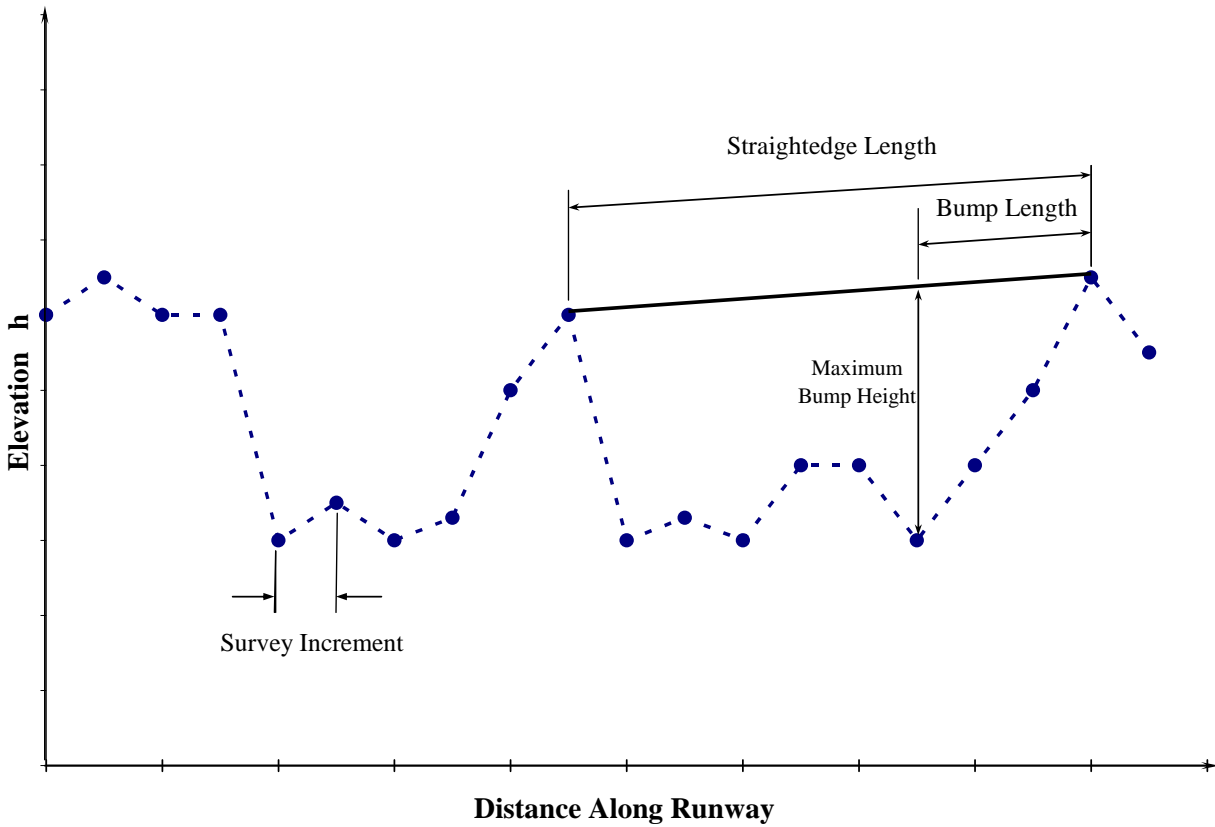


FIGURE 2-1. Schematic of Bump-Height Measurement

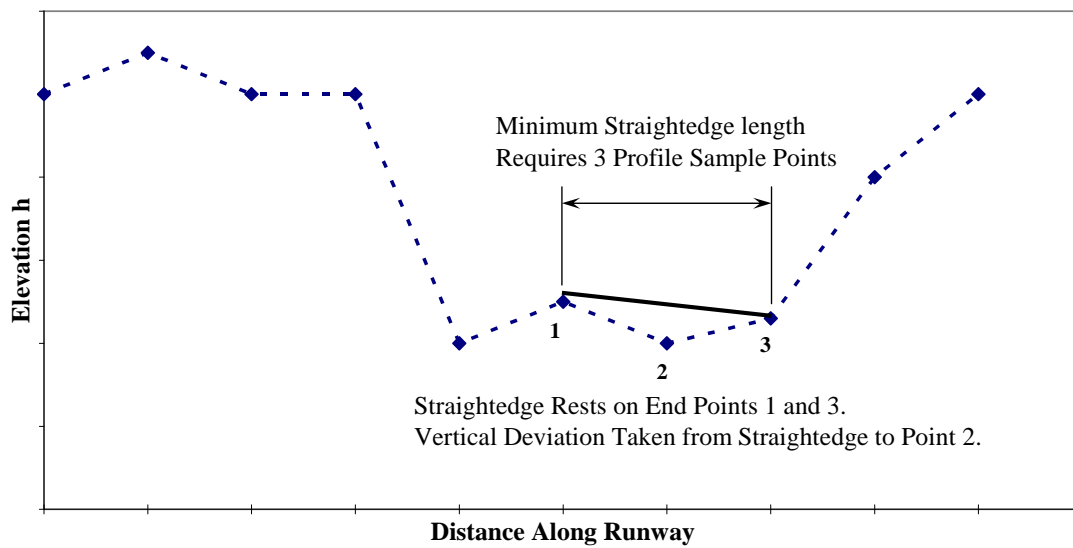


FIGURE 2-2. Minimum Straightedge Determination

d. Number of Straightedges Associated with a Survey Interval. The number of straightedges associated with any survey point depends on the dimension of the survey interval. Each point may have N_s straightedges associated with it, where:

$$N_s = (\text{Maximum Straightedge Length} / \text{Survey Interval}) - 1$$

Where:

Maximum Straightedge Length = 120 meters (394 feet)

Survey Interval = 0.25 meters (0.82 feet) units consistent with straightedge

For FAA standard configuration:

$$N_s = (120 / 0.25) - 1 = 479$$

At any profile sample point, the procedure allows construction of a straightedge with (a) the beginning of the straightedge at the sample point, (b) the end of the straightedge at the sample point, or (c) the sample point at any increment along the length of the straightedge. With each possible straightedge configuration, the procedure calculates bump height and bump length, as defined here:

(1) Bump Height. Bump height equals the maximum vertical distance from the straightedge to the profile sample point for all positions of the straightedge along the profile. Units are centimeters (inches).

(2) Bump Length. Bump length equals the smallest of (a) the distance from the bump height position to the start of the straightedge or (b) the distance from the end of the straightedge to the bump height position. Units are meters (feet).

e. Recommended Survey Interval. The accuracy of the Boeing Bump procedure, or its ability to represent field conditions, increases as the survey interval decreases. Because the accuracy of the procedure changes if the survey interval changes, the FAA requires a survey interval of 0.25 meters (0.82 feet) for evaluation of the Boeing Bump.

f. Recommended Survey Location. Airplane gear location relative to the centerline of a runway varies from airplane to airplane but it is not necessary to exactly match the location of the airplane gear with the location of the surface profile. The FAA recommends measuring the runway surface profile along the centerline and at a lateral offset (left and right) that approximates the aircraft using the airport. A 3.05 meter (10 feet) offset can effectively address Airplane Design Group (ADG) II and III airplanes, while a 5.22 meter (17.5 feet) offset can address ADG IV, V, and VI airplanes. Take measurements at all locations if traffic at a given facility contains all airplane groups. Evaluate each profile in accordance with paragraph 2.3. Avoid obvious surface deviations such as a longitudinal joint or a row of lights unless their impact on roughness is being evaluated.

g. Use of Inertial Profilometers with Highpass Filtering. Data processing for typical highway and light-weight inertial profilometers includes highpass filtering the accelerometer signal before integration to avoid offset errors and to reduce errors due to traveling on changing grades

and braking and accelerating the test vehicle. Highpass filtering can have a significant effect on the computation of the Boeing Bump Index (see paragraph 2.4a) and simulated airplane accelerations because these computations take account of longer disturbances in the profiles than in the computation of typical highway indexes such as the IRI. Typical highway and light-weight inertial profilers also generate significant errors if profiles are measured during acceleration, braking, and cornering of the test vehicle. Threshold-to-threshold runway profiles are therefore difficult to measure without introducing significant errors close to the thresholds. For this reason, the use of inertial profilers that include highpass filtering is not recommended for measuring profiles which are to be used for computing BBI indexes or simulated airplane accelerations on airport pavements.

2.3 EVALUATION OF BOEING BUMP PARAMETERS.

a. Bump Evaluation Procedures. Evaluate each combination of bump height and bump length against Figure 2-3. Figure 2-3 reproduces the criteria presented in Figure 10 of Boeing Document D6-81746 and shows the boundaries of Acceptable, Excessive, or Unacceptable pavement roughness associated with a single bump event. Boeing developed the criteria based upon operational experience for single bump events describing the general condition of a runway pavement. The criteria do not provide a detailed analysis of airplane response nor do they attempt to address the problem of root-mean-square roughness. The criteria also do not address the effects of a series of long wavelength undulation where airplane frequency response is important. By eliminating the root-mean-square and frequency response factors, this simplified procedure can be applied to all jet transport airplanes regardless of structural design or physical characteristics.

b. Evaluation Criteria. The evaluation criteria in Figure 2-3 define operational conditions and structural impact to the airplane.

1) Acceptable. The FAA expects newly constructed or rehabilitated pavement to result in bump height and length combinations that fall within the lower region of the acceptable range. Construction tolerances described in Items P-401 and P-501 of AC 150/5370-10 allow 0.64 centimeters (0.25 inches) in 4.8 meters (16 feet), as indicated in Figure 2-3. Operations in this range are acceptable for all airplanes. As a pavement ages, various factors such as frost heave or isolated pavement failures may lead to bump height and length combinations that approach the limit of the acceptable range.

Experience indicates that pilots begin reporting excessive roughness as conditions move closer to the excessive range. When pilot reports begin to occur, airport operators should start identifying the bump locations and preparing for corrective actions. These preparations should include scheduled maintenance activity to monitor the pavement profile.

Whenever roughness is above the acceptable zone, airplane gear fatigue becomes more critical than passenger discomfort or cockpit acceleration limitations.

2) Excessive. The FAA encourages airport operators to repair pavements as roughness levels enter the excessive zone. Airplane response to excessive levels of roughness becomes noticeably intolerable to both airplane crews and passengers. Roughness of this

magnitude will create acute discomfort for all occupants in the airplane. Instrument interference in the cockpit may be severe. This roughness level may also result in a short-term inability to steer the airplane as well as excessive reduction in nose and main gear fatigue life. Immediate pavement repairs are necessary at this level but closure of the affected pavement is not required.

3) Unacceptable. Roughness levels in the unacceptable zone warrant immediate closure of the affected pavement. Repairs are necessary to restore the pavement to an acceptable level.

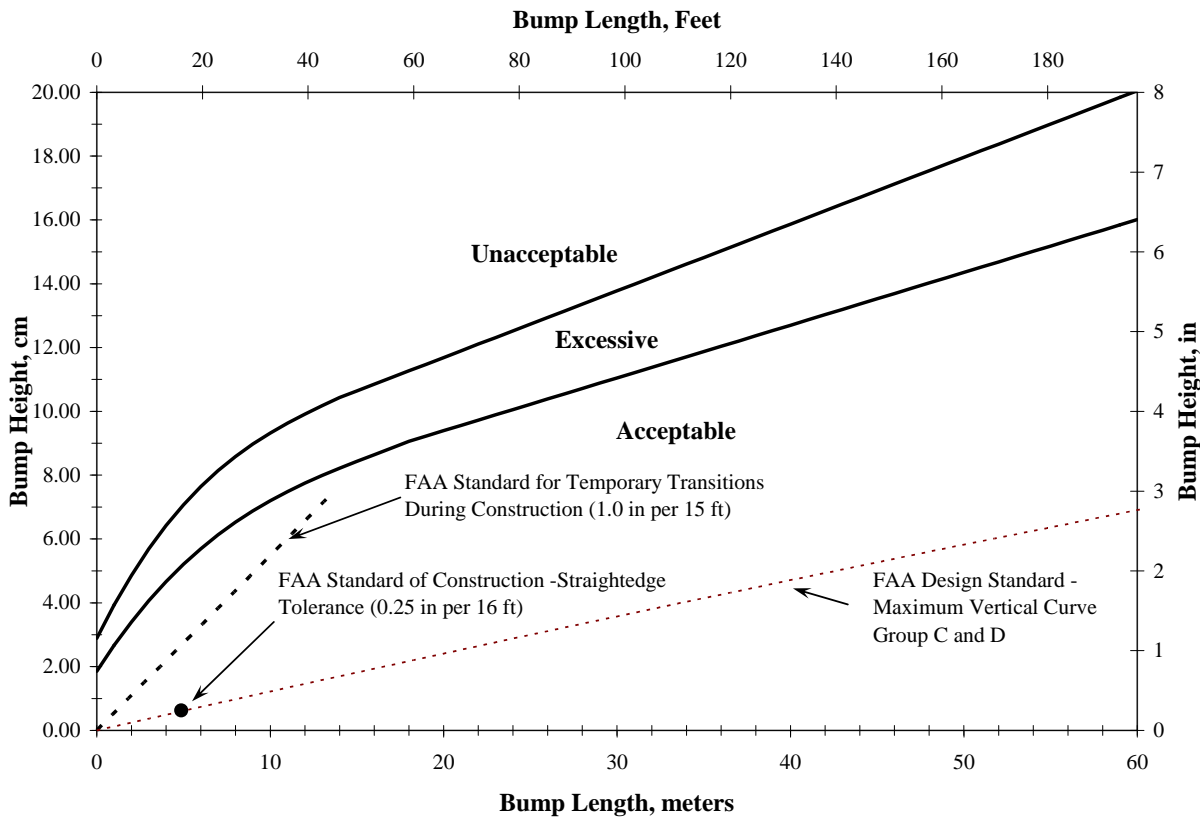


FIGURE 2-3. SINGLE EVENT BUMP - ROUGHNESS ACCEPTANCE CRITERIA

2.4 DEVELOPMENT OF THE BOEING BUMP INDEX.

a. Need for Boeing Bump Index. Applying the Boeing Bump method to a pavement profile can be a time-consuming and tedious task because each point in the profile survey must be evaluated for all possible straightedge lengths. For any particular case of runway roughness, both bump height and bump length are significant, particularly when considering strategies for reducing roughness through maintenance.

To summarize the bump criteria and compare computed bump criteria with other measures of roughness, the FAA created an additional parameter for the Boeing Bump procedure. This new index, called the “Boeing Bump Index” (BBI), is determined by the following process:

(1) For a selected sample point in the profile, compute the bump height and bump length for all straightedge lengths.

(2) For each straightedge length, compute the limit of acceptable bump height (upper limit of the acceptable zone) for the computed bump length.

(3) For each straightedge length, compute the ratio (measured bump height) / (limit of acceptable bump height).

(4) Repeat steps 1 through 4 for all sample points in the profile.

The BBI for the selected sample point is the largest of all values computed in step 3 for the selected sample point. If the computed index value is less than 1.0 roughness falls in the acceptable zone: if it is greater than 1.0, it fall in the excessive or unacceptable zone.

b. Development of Software to Compute the Boeing Bump Index. To assist in the development of a computer program to calculate the BBI, the FAA created mathematical models of the lower and upper criteria curves, as given below:

1) Lower Limit Curve (upper limit of the acceptable zone)

$$H = 1.713187 + 0.800872L - 0.031265L^2 + 0.000549L^3 \quad (\text{for } L < 20 \text{ meters})$$

$$H = 6.4 + 0.16L \quad (\text{for } 20 < L < 60 \text{ meters})$$

2) Upper Limit Curve (upper limit of the excessive zone)

$$H = 2.747222 + 1.433399L - 0.183730L^2 + 0.013426L^3 \quad (\text{for } L < 5 \text{ meters})$$

$$H = 2.7590 + 1.085822L - 0.053024L^2 + 0.001077L^3 \quad (\text{for } 5 < L < 20 \text{ meters})$$

$$H = 7.775 + 0.20375L \quad (\text{for } 20 < L < 60 \text{ meters})$$

Where:

H = Bump height (centimeters)

L = Bump length (meters)

c. ProFAA Software. The FAA developed the ProFAA software to help calculate of the BBI. Chapter 3 provides additional information on the use of this software which the FAA makes available on its website (www.faa.gov).

d. Comparison with hte Original Boeing Bump Procedure. The Boeing Bump Index procedure varies slightly from the original Boeing Bump procedure because the latter method was based on manual data processing. Further,

(1) The bump length defined in Boeing Document D6-81746 is at a local minimum or maximum. There can be multiple local minima or maxima for a given straightedge length. Presumably the worst combination of bump height and length governs with this method.

(2) ProFAA bump length is for the combination that gives the maximum BBI at a profile point, which is not necessarily at a maximum or minimum.

2.5 PAVEMENT ROUGHNESS EVALUATION USING THE BOEING BUMP INDEX.

a. Boeing Bump Index Evaluation Criteria. Evaluation of a pavement profile with the BBI is similar to that done with the Boeing Bump method. Since the BBI is based on the same three zones of roughness, the descriptions of these zones in paragraph 2.3b apply to the corresponding ranges of the BBI.

Figure 2-4 expresses the concepts of Figure 2-3 in terms of BBI versus bump length. Figure 2-4 recreates the acceptable, excessive, and unacceptable evaluation zones of Figure 2-3 in terms of BBI. When the BBI value is below 1.0, the Boeing bump criteria is in the acceptable zone. Values of BBI greater than 1.0 fall in either the excessive or unacceptable zones.

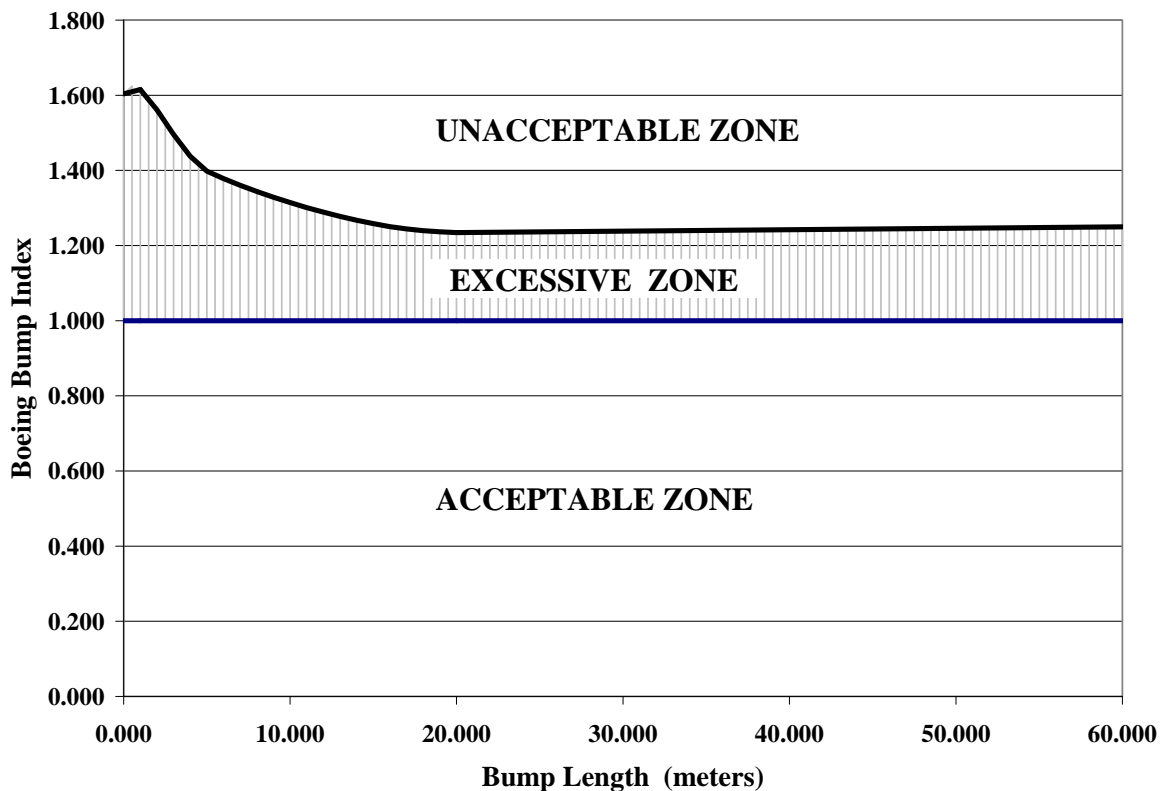


FIGURE 2-4 BOEING BUMP INDEX - ROUGHNESS ACCEPTANCE CRITERIA

b. ProFAA Reporting of Boeing Bump Index. The ProFAA software calculates the BBI for all survey intervals in a pavement profile. ProFAA will record each time a profile

exceeds the acceptable and excessive zones and produce a report indicating each occurrence. Chapter 3 provides additional information and an example of the BBI calculation output from ProFAA.

2.6 TEMPORARY PAVEMENT TRANSITIONS DURING CONSTRUCTION.

Airports often require that a pavement be available to airplanes between phases of construction work so pavement construction often occurs in segments during off-peak hours. As a result pavement projects often take several phases to complete. During these phases, the pavement surface may not be uniform and may require temporary ramps to allow aircraft to transition from elevation to elevation. Most often, this condition is associated with construction of Hot-Mix asphalt.

Advisory Circular 150/5370-13, Offpeak Construction of Airport Pavements Using Hot-Mix Asphalt, provides guidance on offpeak construction using Hot-Mix asphalt. AC 150/5370-13 recommends a 4.57 meter (15 feet) ramp for each 2.54 centimeters (1 inch) of elevation change. Figure 2-3 shows how this criterion compares against the upper limit of the acceptable roughness zone. To avoid exceeding the upper limit of the acceptable zone, elevation changes greater than 7.62 centimeters (3 inches) require adjustment of the ramp length.

CHAPTER 3 USING ProFAA SOFTWARE

3.1 DEVELOPMENT OF ProFAA SOFTWARE. The FAA’s ProFAA software can accept input data from various formats, convert the input data into the preferred format, and calculate the BBI and other pavement roughness parameters.

3.2 DATA INPUT INTO ProFAA. ProFAA accepts data files in binary format for a single profile at 0.984 inches (25 millimeters) spacing. The numbers for the elevation samples are stored sequentially in IEEE 754 single precision floating point format. The sample spacing is assumed to be constant and distance information is not included. The files are designated by the three-letter extension “pro”. After the profile has been read into ProFAA, and the BBI computation selected, the software lowpass filters it with a sixth-order Butterworth filter at a cutoff frequency of 0.6096 cycles/inch (2 cycles/meter) and takes every fourth sample to give a sample spacing of 0.25 meter (0.8202 feet). The software then runs the profile through a subroutine for calculating BBI and displays the results on the output screen, as described later.

a. Data Format Conversion. Since the profile data file format accepted by ProFAA is not commonly output by commercial profile equipment, and different formats are used by different equipment manufacturers, the software includes a conversion utility program called “Convert Profile Format” to convert the most common profile data formats to that required by ProFAA. Figure 2-5 shows a screen shot of the program with an example conversion displayed. The output files always have the linear trend removed by forcing the start and end samples to be zero.

b. ProFAA Input and Output Formats. Table 2-1 lists available input and output formats associated with ProFAA. The software allows any combination of input and output formats.

Input Format	Output Format
ERD	ProFAA
ASTM	ERD
ProFAA	ASTM
Text	Text
	CSV

TABLE 2-1. INPUT AND OUTPUT FILE FORMATS FOR CONVERT PROFILE FORMAT

ERD	Format developed at the University of Michigan Transportation Research Institute.
ASTM F	Format specified in ASTM E2560 developed from the Federal Highway Administration’s ProVAL file format.
ProFAA	Format used by the ProFAA software.
Text	Single column (CRLF delimiters) of ASCII numerical values representing elevation values at constant sample spacing. See the example in paragraph 3.2c.
CSV	Comma delimited list of ASCII numerical values representing elevation values at constant sample spacing. See the example below.

This is an example of the first 27 samples of a profile converted to CSV format: Note the first sample is zero.

0.000000,-0.009628,-0.050756,-0.068883,-0.060211,-0.065839,-0.076467,-0.081894,-0.088522,-0.073250,-0.080278,-0.078406,-0.070933,-0.069461,-0.074489,-0.084417,-0.085144,-0.096472,-0.104800,-0.105828,-0.095856,-0.094983,-0.105911,-0.089639,-0.108767,-0.099394,-0.112622,-

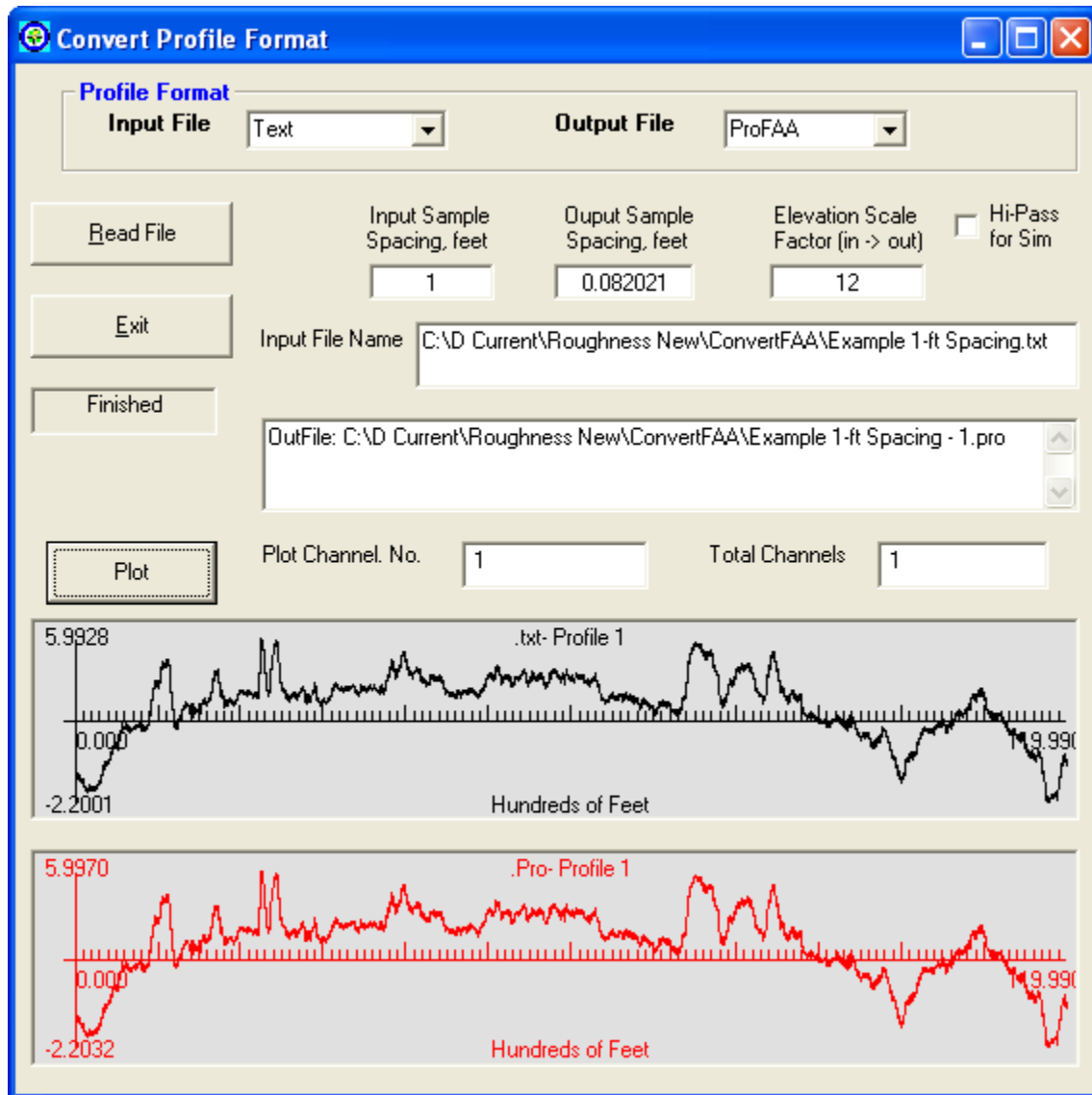


FIGURE 2-5 SCREEN SHOT OF CONVERT PROFILE FORMAT PROGRAM

c. Data Format Conversion Example. Figure 2-5 shows an example where the input file is in Text format and the output is in ProFAA format. Table 2-2 shows data for the first 7.62 meters (25 feet) of this profile. The data was originally prepared in a spreadsheet and included the longitudinal distance associated with each profile data point (column A). As noted in paragraph 2.2a, the longitudinal spacing must be constant. To prepare the data for the

ProFAA software, the distance data was removed and the file saved in text format (see column C in Table 2-2).

The required sample spacing for ProFAA is 25 millimeters (0.082021 feet) and the sample spacing of the input file is 1 foot (0.305 meter). The software uses inches as the unit for output file elevation values and feet for the elevation values in the input file. Therefore, the value entered in the “Elevation Scale Factor” text box shown in Figure 2-5 is 12 inches/foot.

Data as originated in Spreadsheet format (notice that distance data was included)			Data as stored in Text format (distance data omitted)
A	B		C
Distance (feet)	Elevation (Feet)		Example 1-foot spacing
0	-0.0003		-0.0003
1	0.0125		0.0125
2	0.000		0.000
3	-0.0033		-0.0033
4	-0.0085		-0.0085
5	-0.0207		-0.0207
6	-0.0358		-0.0358
7	-0.0351		-0.0351
8	-0.0482		-0.0482
9	-0.042		-0.042
10	-0.0512		-0.0512
11	-0.0499		-0.0499
12	-0.0649		-0.0649
13	-0.0548		-0.0548
14	-0.0548		-0.0548
15	-0.0554		-0.0554
16	-0.0548		-0.0548
17	-0.0551		-0.0551
18	-0.0679		-0.0679
19	-0.0597		-0.0597
20	-0.059		-0.059
21	-0.064		-0.064
22	-0.0574		-0.0574
23	-0.0604		-0.0604
24	-0.0682		-0.0682
25	-0.0646		-0.0646

TABLE 2-2. SAMPLE DATA AS SHOWN IN FIGURE 2.5

d. Use of the Convert Profile Format Program.

(1) Press the “Read File” button to bring up a standard Windows file selection dialog box.

(2) Select the file. Once the program converts it, you can load it into ProFAA.

(3) Press the “Plot” button to plot the input and output files on the screen so you can verify the conversion visually. If the input file has multiple profiles—e.g. columns of data for left, center, and right profiles—enter the profile to be plotted in the “Plot Channel No.” text box. The numerical value entered must correspond to the column where the data is stored.

When the input sample spacing is larger than the output sample spacing, the conversion process fits cubic splines through the input profile points and calculates the output elevation values from the cubic splines at the output sample spacing. When the input sample spacing is smaller than the output sample spacing, the software lowpass filters the input profile to prevent aliasing and fits cubic splines to the filtered input profile points. The output elevation values are then calculated from the splines at the output sample spacing.

e. Compute the BBI.

(1) To compute the BBI for the profile in the output file (in this example, “Example 1-ft Spacing – 1.pro”), start ProFAA, read the file into the program, and select the Boeing Bump Index in the list of indexes. Figure 2-6 shows a screen shot of ProFAA after these operations have been carried out.

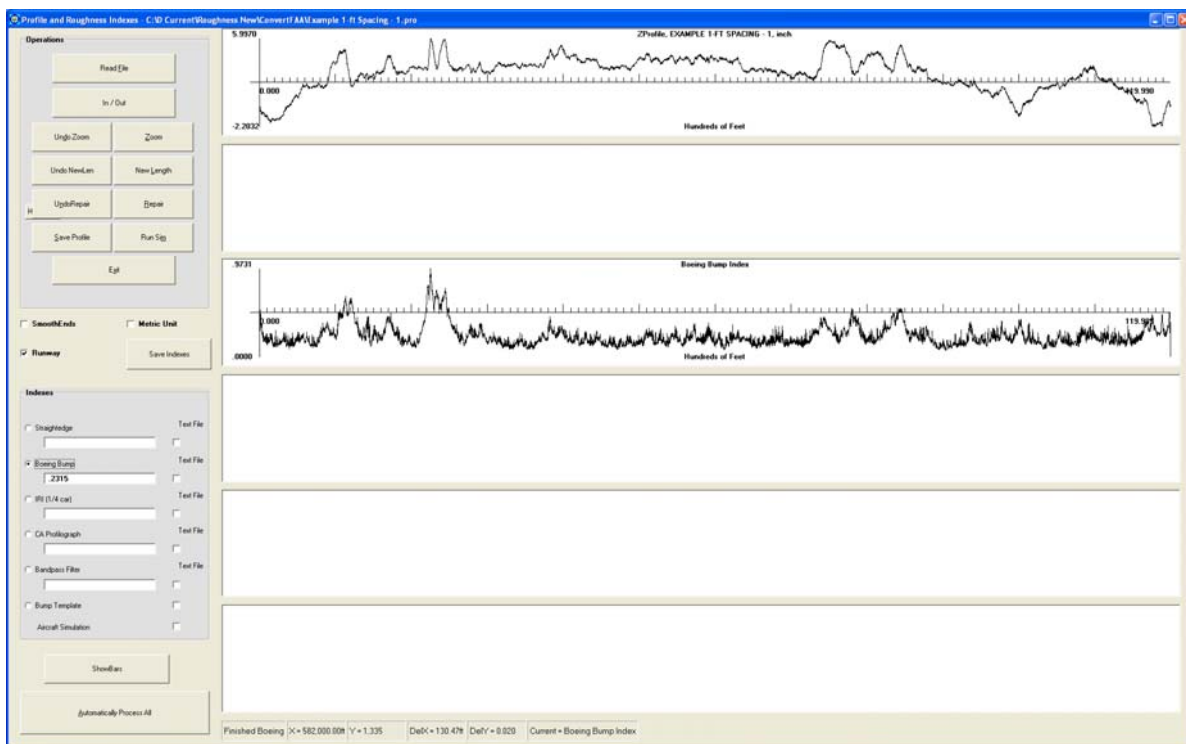


FIGURE 2-6. SCREEN SHOT OF ProFAA SHOWING THE EXAMPLE PROFILE AND THE BBI COMPUTED FROM THE PROFILE

The profile is quite rough with a maximum BBI of 0.973 about 3139 meters (10,300 feet) from one end.

(2) To examine the rough section in more detail, press the “Zoom” Button and click to the left and right of the section to be zoomed. Figure 2-7 shows the result.

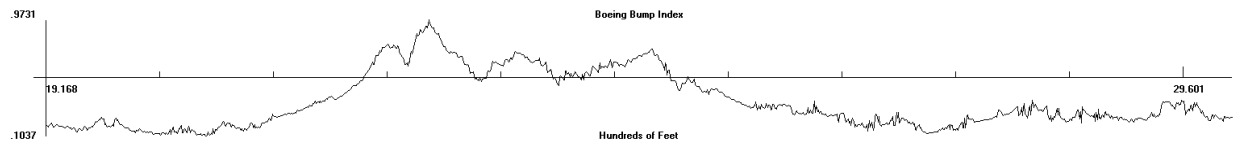


FIGURE 2-7 ZOOMED PORTION OF THE BBI PLOT

(3) Right click the mouse pointer at a position in the zoomed plot where you want the value of the BBI to be read. A second view of the plot in the vicinity of the clicked point will appear in one of the picture boxes below the BBI plot with relevant information on the calculation, including the position of the straightedge from which the BBI was calculated. Figure 2-8 shows the result when the mouse pointer was right clicked at the position of the maximum BBI.

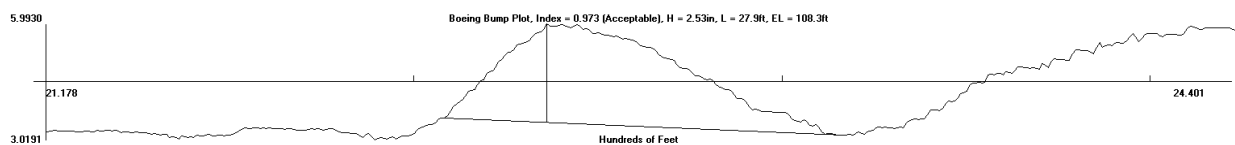


FIGURE 2-8 DETAILS OF THE BBI AT A SELECTED POINT

The following information is displayed in the title of the plot:

Boeing Bump Index = 0.973 (Acceptable)
 H (Bump Height) = 2.53 in (6.43 centimeters)
 L (Bump Length) = 27.9 ft (8.5 meters)
 EL (Straightedge length) = 108.3 ft (33 meters)

If the BBI is in the excessive or unacceptable zones the program replaces the “Acceptable” indication in the BBI line with either “Excessive” or “Unacceptable.”

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APPENDIX 1. BIBLIOGRAPHY

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