RUNWAY ROUGHNESS CONSIDERATIONS

SWIFT 2013

Chris Olidis, P.Eng.
PRESENTATION OUTLINE

- A general overview of runway roughness
- Assessing roughness for new construction
- Assessing roughness of in service runways using the Boeing Bump Index
- Features that can influence roughness
WHY IS ROUGHNESS IMPORTANT

- Affects aircraft performance during take off and landing
- Dynamic forces from rough pavement can accelerate fatigue damage to aircraft components
- Dynamic loading reduces pavement life
- To a lesser extent, user complaints from pilots and passengers
NEW CONSTRUCTION

- Roughness is an indicator of construction quality
- Build a pavement smoother, it stays smoother longer
- Roughness for acceptance of new construction is typically measured with a straight edge
STRAIGHT EDGE ACCEPTANCE TESTING

- **Transport Canada**
  - The surface of a finished pavement shall be within 5 mm of the design grade, but not uniformly high or low and shall have no irregularities exceeding 5 mm when checked with a 4.5 m straight edge placed in any direction.

- **FAA**
  - The finished surface of the final course of pavement shall not vary more than ¼ inch when evaluated with a 16 foot straightedge.
STRAIGHT EDGE
CALIFORNIA PROFILOGRAPH

- An FAA additional(optional) acceptance test
  - The Contractor shall furnish a 25 foot wheel base California type profilograph and competent operator to measure pavement surface deviations.
  - The profile index will be determined in accordance with ASTM E 1274 using a 0.2-inch blanking band. Within each 1/10th mile subsection, all areas represented by high points having a deviation in excess of 0.4 inch in 25 feet or less shall be removed by the contractor using an approved equipment.
CALIFORNIA PROFILOGRAPH
ACCEPTANCE OF NEW CONSTRUCTION

- From an operational perspective, aircraft are not affected by such small wavelength deviations
- Is acceptance based on straight edge or PI too conservative?
- Roughness is an indicator of construction quality
- Build a pavement smoother, it stays smoother longer
TYPES OF ROUGHNESS

- Discrete bumps create impact loading that can accelerate fatigue damage, as well as rattle equipment, crew, and passengers.
- Repeated large wavelength bumps can induce harmonics and can accelerate fatigue damage to both the aircraft and the pavement.
- Repeated short wavelength bumps can cause heat build up in struts/suspension.
RIDE COMFORT INDEX

- Historical Transport Canada method was the ride comfort index (RCI)

- Subjective rating of ride quality by a panel of raters using passenger vehicle driving at 80 km/hr

- 0 (very poor) to 10 (very good)

- Pilot complaints expected when RCI < 5

- Aircraft suspension designed for landing not ride quality
RUNWAY PROFILE MEASUREMENT

- There are various equipment types to efficiently and objectively measure runway profiles
- Contact (walking inclinometer) profilers
  - DipStick, SurPRO, etc
- Non-contact (inertial) profilers
  - Lightweight and high speed laser
LIGHTWEIGHT AND HIGH SPEED PROFILERS
RUNWAY DATA

- ARA had a database of profile measurements from a number of runways
- The profile data was processed using the ProFAA software developed by FAA
- The Boeing Bump Index was the measure used for profile assessment
DATA COLLECTION

- Longitudinal profile measurements were completed with an ICC SurPRO 2000
- The equipment is portable and fully automated
- Includes 2 inclinometers, 1 optical distance encoder and a temperature sensor
- Meets World Bank Class 1 requirements for profiling devices
DATA COLLECTION PLAN

- Profile measurements were completed along the centreline, as well as 3.0 and 5.25 m offsets
- SurPRO was modified to include a laser target sensor to ensure operator maintains constant offset from centreline
- After initial warm up, the equipment inclinometers were calibrated by closed loop survey
- All data collected at speeds below 4 kph.
ProFAA can simulate the following indices:

- Straight Edge
- Profile Index (PI)
- International Roughness Index (IRI)
- RMS Bandpass
- *Boeing Bump*
BOEING BUMP METHOD

- D6-81746 Runway Roughness Measurement, Quantification and Application – The Boeing Method
- FAA AC 150/5380-9 Guidelines and Procedures for Measuring Airfield Pavement Roughness
- The method is user friendly
- Does not consider detailed analysis of aircraft response
BOEING BUMP METHOD

- Measures the deviation from a virtual straightedge to the pavement surface
BOEING BUMP INDEX

- Considers a virtual straight edge bump length from 0.5 m to 120 m
- Boeing Bump Index (BBI) is determined by calculating a ratio of the measured bump height to the limit of acceptable bump height, for each straight edge length
  - BBI < 1 is considered acceptable
  - BBI > 1 is considered excessive or unacceptable
PRIMARY RUNWAY – SITE 1

BBI Acceptable
CROSSWIND RUNWAY – SITE 1
CROSSWIND RUNWAY – SITE 1
BBI ANALYSIS – SITE 1

Bump Peak (Station 0+390)

Depression Peak (Station 0+417)
RUNWAY ANALYSIS – SITE 2

ACP Runway - PCC Ends
RUNWAY ANALYSIS – SITE 2

Depression Peak (Station 0+496)

Roaming Rump Plot, Index = 1.042 [Excessive], H = -8.65cm, L = -14.0m, EL = 60.0m

Excessive – Station 0+494 to 0+497
RUNWAY ANALYSIS – SITE 3
RUNWAY ANALYSIS – SITE 3
RUNWAY ANALYSIS – SITE 3

Boeing Bump Plot, Index = 1.718 (exceeds the Unacceptable limit by 39.1 per cent), H = 16.91cm, L = 21.5m, EL = 60.0m
RUNWAY ROUGHNESS CONSIDERATIONS

- Runway intersections can be challenging to ensure a smooth pavement and maintain drainage
- Seasonal freeze thaw and permafrost degradation
- Post construction related settlement of embankment and underground services
- Pavement deterioration
COMMON CAUSES OF ROUGHNESS
COMMON CAUSES OF ROUGHNESS
COMMON CAUSES OF ROUGHNESS
COMMON CAUSES OF ROUGHNESS
COMMON CAUSES OF ROUGHNESS