Gravel Runway Evaluation

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Advisory Circulars Applicability

- *AC 300-004: This document applies to Canadian airport operators and is also available to the aviation industry for information purposes.*
- *AC 302-011: This document applies to Canadian airport operators and is also available to the aviation industry for information purposes.*
- *AC 700-011: 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.*

Excerpt from Advisory Circular 300-004

- *"The purpose of this document is to outline methodologies for the measurement and reporting of surface shear strength for unpaved runways. In addition, the document outlines recommended practices for condition inspection, maintenance and repair of airport gravel surfaces and turf landing strips."*

Excerpt from Advisory Circular 700-011

- *"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."*

Airfield 'End User' Requirements

- Airlines must comply with their Aircraft Flight Manuals (AFM) when a minimum firmness is specified for gravel runways
- Most use Boeing's methodology
- Exceptions include:
  - Falcon 10, which uses the DCP
  - B1900, which specifies a PLR
- Where not specified in the AFM, Boeing's methodology is specified by Transport Canada

Advantages of a Gravel Runway

- Costs less to build
- Can be easily re-graded to eliminate roughness

Spring Reductions (Gravel)

Typical Subgrade Bearing Strengths for Subgrade Soil Classification Groups				
Subgrade Soil Type (Unified Soil Classification)	Usual Spring Reduction (%)	SUBGRADE BEARING STRENGTH (kN) 762-mm , 12.5-mm , 10 app.)		
			Design Value	
		Fall Range	Fall	Spring
GW – Well graded gravel	0	290-400	290	290
GP – Poorly graded gravel	10	180-335	220	200
GM – Gravel with silty fines	25	135-335	180	135
GC – Gravel with clay fines	25	110-245	145	110
SW – Well graded sand	10	135-335	180	160
SP – Poorly graded sand	20	110-200	135	110
SM – Sand with silty fines	45	95-190	120	65
SC – Sand with clay fines	25	65-155	85	65
ML – Silt with low liquid limit	50	90-180	110	55
CL – Clay with low liquid limit	25	65-135	85	65
MH – Silt with high liquid limit	50	25-90	40	29
CH – Clay with high liquid limit	45	25-90	50	30

Figure 19: Spring Reduction Factors Based On Soil Composition

Ref. 15: Transport Canada Document AK-68-31-006

CBR Rating Explained

- Surface shear strength of an unpaved runway is expressed as a CBR value.
- CBR is the ratio of the load bearing capacity of a given sample of soil to that of crushed limestone.
- The bearing strength of crushed limestone is the criteria to which other types of soil are compared.
- Limestone ***with maximum compaction*** has a CBR value of 100, which is expressed as CBR 100.
- A soil with CBR 10 has 10 per cent of the bearing strength of crushed limestone.

ASTM - The Canadian CBR Standard

- ASTM has developed standard test methods for both lab and field CBR measurements.
- The lab method, ASTM D1883, is useful at the design stage of a pavement but of limited use for operations.
- For measuring unpaved runway surface strength, ASTM *D4429 (disk and donut method)* is considered the definitive standard.

More about the ASTM Standard

- Large aggregates or stones can cause inaccurate results if a larger stone becomes embedded under the penetration piston.
- As setup for the ASTM D4429 test method can be laborious and time-consuming, this method is impractical for measuring unpaved runways

Boeing's Methodology

- In Canada, the most commonly used device for certifying aircraft on gravel runways and assessing gravel runways is the Boeing High Load Penetrometer.
- The CBR derived from the Boeing High Load Penetrometer should be considered as an estimate or index of CBR rather than an absolute value.
- ***The Boeing CBR Values are moderately conservative up to CBR 50 values.***

Frequency of Testing

AC 300-004 Section 6.2.6 states the minimum recommended frequency of testing is:

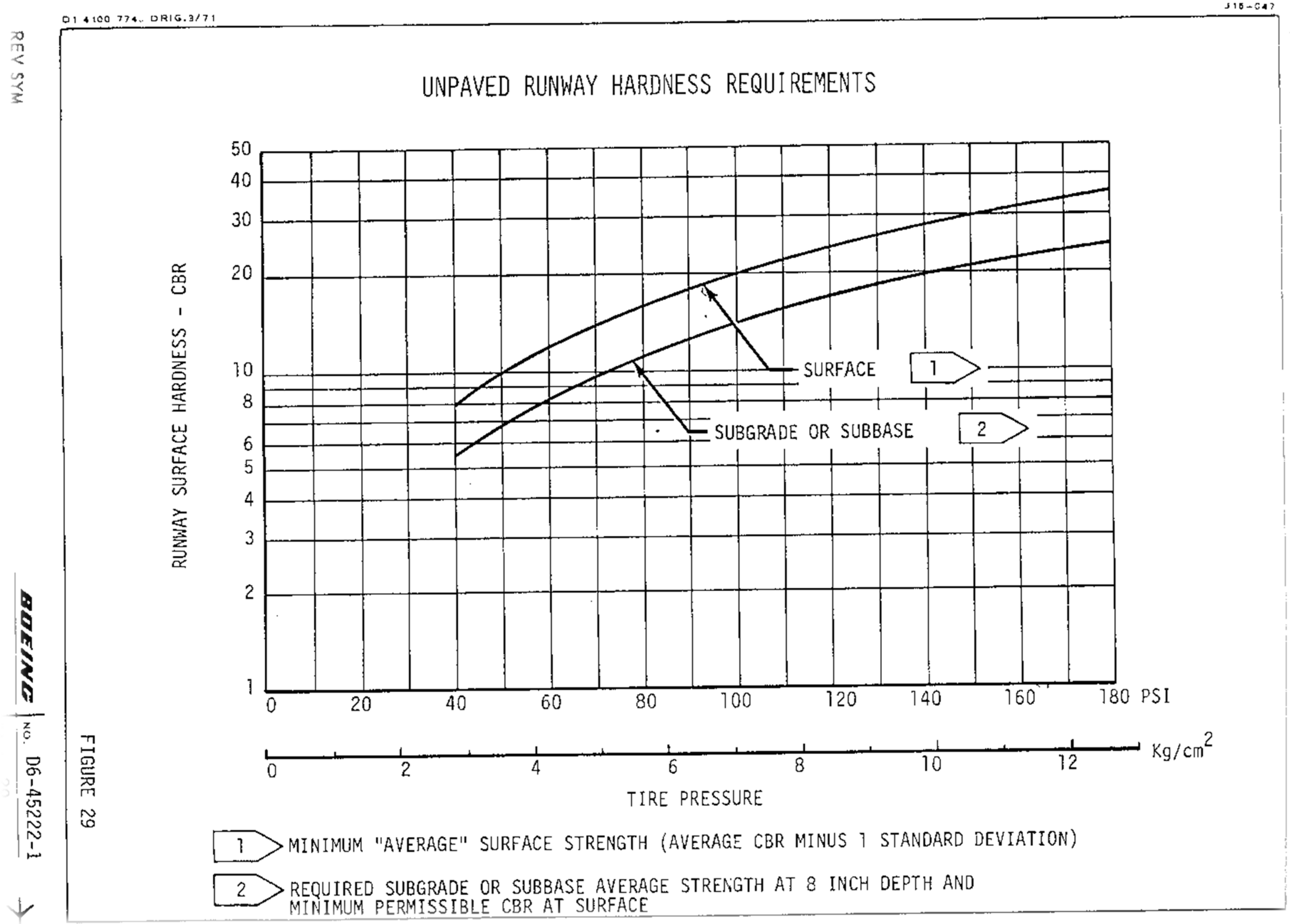
- every three years
- after any construction to any part of the runway surface (other than normal grading and compaction)
- If there is suspected degradation in surface shear strength (i.e. rutting, pilot complaints)
- when the runway has been inactive and not maintained for one season.

Acceptable *Aircraft* Tire Pressure Values

If no Aircraft Flight Manual limitations exist:

- A runway has sufficient surface strength for aircraft operations when:
  Tire pressure in psi =< CBR value X 5
- CBR should be measured with the Boeing High Load Penetrometer.
- For a conservative CBR rating, reduce the average CBR Value by one standard deviation.

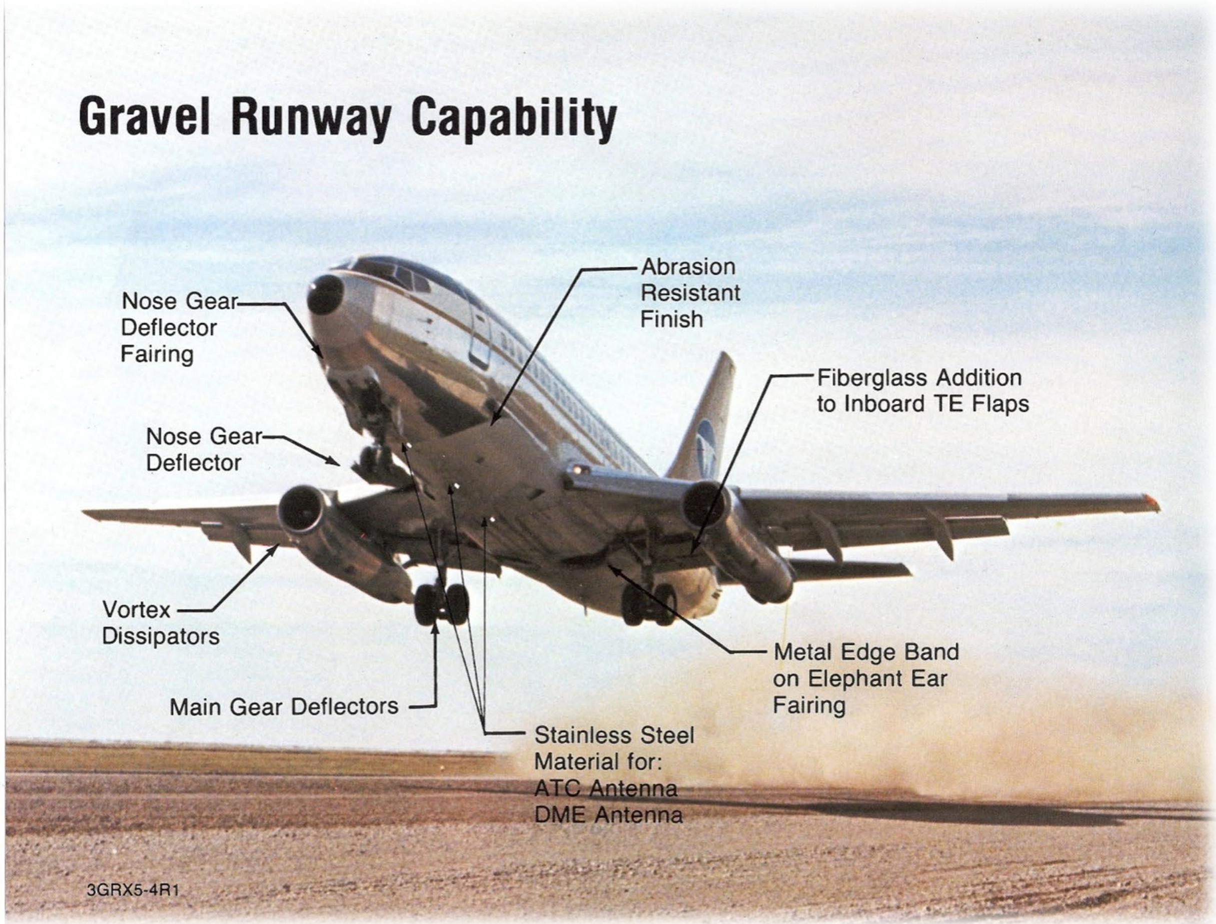
Boeing's Generic Chart



Boeing's Penetrometer

- A cone of specific dimensions is attached to a hydraulic cylinder assembly
- Hydraulic pressure extends that cone below the surface
- The hydraulic pressure required to extend the cone is converted to a CBR Value
- Boeing's surface CBR determines the additional rolling friction that will affect the take-off roll
- Boeing's CBR Value at lower depths are an excellent indication of that runway's weight bearing capacity

Gravel Aircraft Equipment



B 727 Gravel Landing

PWA On Arctic Gravel Runway

B 737 Failure

Gravel Runway Strength Critical for Nose Gear in Turns - Note that Support at Main Gear is Still Adequate

B 737 Failure

Effect of Operation on Too Soft Surface - Nose Gear Causes Plowing in Turns at Low Speed

Braking Scarification During Landing

Poor Runway Material
Good Maintenance

Failed Surface Strength

CBR Okay, But Runway Failed

- Immediately after spring thaw
- Preceding freeze-up was wet (soils were saturated)
- Poor side drainage for weight bearing
- Poor crown

DRAINAGE

SUBSURFACE FAILURE

10 Plus Passenger Aircraft Certification

- ALL AIRCRAFT HAVE SIMILAR SPECIFICATIONS
- Aircraft certification ensures engine-failure safety during all phases of flight:
- Maximum aircraft weights are reduced to ensure safety speed can be attained on the runway length available
- Penalties apply for many factors including additional rolling friction on gravel runways
- Critical engine fail at safety speed
  - Accelerate-stop on runway (+ stopway)
  - And continue:
    - Attain 35-foot altitude at end of runway (+ clearway)
    - 1ST SEGMENT CLIMB (obstacles a major consideration)
    - 2ND SEGMENT CLIMB (obstacles a major consideration)
    - Clean-up phase
      - ENROUTE OBSTACLE CLIMB

AIRCRAFT PERFORMANCE
50 feet over the far runway end?

FACTORS AFFECTING AIRCRAFT PERFORMANCE

- RUNWAY DATA
  - Gravel Runway firmness (rolling friction)
    - CBR, PLR, and PCN
  - Length (Clearways and Stopways)
  - Line-up Criteria
  - Slope (net slope –end-to-end)
- DEPARTURE OBSTACLES
  - Distance From Runway End
  - Elevation Above Runway End
- ATMOSPHERIC CONDITIONS
  - Elevation
  - Temperature
  - Wind Speed & Direction

Decreased Performance & Direction Control Indicated by Packer & Aircraft Shoving & Rutting Mandatory to Displace Threshold

SURFACE IS GRANULAR, DEFICIENT IN FINES, MOISTURE SATURATED

B737 Runway Degredation

Fresh Lift Insufficient Finds

AIRFIELD OPERATOR'S GOAL

- Maximize the end users benefit in a SAFE, ECONOMICAL, and LEGAL manner
- SAFE is:
  - Compliance with the Aircraft Certification Flight Manual
- ECONOMICAL is:
  - Cost effective for both the aircraft operator plus for the airfield operator
- LEGAL should only be considered if safe and economical)
  - Airfield Licensing and Exemptions
  - Declare available facilities, stopway, clearways, obstacles
  - Minimize performance reductions, clearways, trees.

CBR Technology Inc.

- Incorporated 25 years ago
- Gord Drysdale: 55+ years aviation experience
- Mike Boyle: 40+ years aviation experience
- Ray Clement, P.Eng.
- Rob Butler BSc (Honors Physics), MBA

Visit www.cbrtech.ca

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Questions?

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