Meeting Unpaved Runway Standards: A Discussion of Transport Canada’s 2012 Advisory Circulars
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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.”
“The purpose of this document is to outline methodologies for reporting airside pavement bearing strengths at Canadian airports. The document reviews Transport Canada’s Pavement Load Rating (PLR) system and the International Civil Aviation Organization (ICAO) Pavement Classification Number (PCN) system. Correlations between the two systems are presented to enable determination of Pavement Classification Numbers from existing Pavement Load Ratings.”
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.
Visit [www.cbrtech.ca](http://www.cbrtech.ca) and click on ‘Our Services’ to access the Transport Canada Advisory Circular links listed in the sidebar.

- AC 300–004 – gravel runway airfields
- AC 302–011 – paved runway airfields
- AC 700–011 – airlines with gravel runway operations
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
Disadvantages of a Gravel Runway

- This runway type can significantly vary in strength due to:
  - Climate issues (spring thaw)
  - Moisture variations with inadequate transverse slope and poor drainage
  - Effects of aircraft: the B 737 jet-pipe velocity of 400 mph at three-foot elevation can move five cubic meters of gravel with each take-off
  - Wheel braking scars surface materials
## Spring Reductions (Gravel)

### Typical Subgrade Bearing Strengths for Subgrade Soil Classification Groups

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

Figure 19: Spring Reduction Factors Based On Soil Composition  
Ref. 15: Transport Canada Document AK-68-31-006
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.
Dynamic (Drop) Cone Penetrometer

- A comparison of surface strength measurements using the Dynamic Cone Penetrometer and the Boeing High Load Penetrometer on the same runway surface is not currently available.
- The Dynamic Cone Penetrometer is not the same as CBR because it compares impact rather than constant rate of loading.
The Shock Penetrometer is not the same as CBR because it compares impact rather than constant rate of loading.

When testing was done on the same runway, surface strength measurements using the Shock Penetrometer had significant differences in CBR values compared to the Boeing Penetrometer.
PLR Applies to Gravel Runways

- The Pavement Load Rating (PLR) of a gravel surfaced pavement is determined as described for flexible pavements in AC 300–004, Section 6.1
- Tire pressure limitation for gravel pavements may be determined based on surface (shear) strength.
Determining Gravel PLR and PCN

- To determine a gravel runway’s PLR and PCN, the sub–base firmness (CBR rating) must be determined.
- The airfield operator creates the depth and composition of the man–made layers above Mother Nature’s soil.
- For an objective engineering report, CBR Tech recommends forwarding this information to APMS (www.apms.nl) in The Netherlands.
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, Boeing's methodology is to reduce the average CBR Value by one standard deviation.
Boeing's Generic Chart

UNPAVED RUNWAY HARDNESS REQUIREMENTS

RUNWAY SURFACE HARDNESS - CBR

TIRE PRESSURE

0 2 4 6 8 10 12 Kg/cm²

0 20 40 60 80 100 120 140 160 180 PSI

1. MINIMUM "AVERAGE" SURFACE STRENGTH (AVERAGE CBR MINUS 1 STANDARD DEVIATION)

2. REQUIRED SUBGRADE OR SUBBASE AVERAGE STRENGTH AT 8 INCH DEPTH AND MINIMUM PERMISSIBLE CBR AT SURFACE
Gravel Aircraft Equipment

Gravel Runway Capability

- Nose Gear Deflector Fairing
- Abrasion Resistant Finish
- Fiberglass Addition to Inboard TE Flaps
- Metal Edge Band on Elephant Ear Fairing
- Vortex Dissipators
- Main Gear Deflectors

Stainless Steel Material for:
- ATC Antenna
- DME Antenna
B 727 Gravel Landing
PWA On Arctic Gravel Runway
Gravel Runway Strength Critical for Nose Gear in Turns –
Note that Support at Main Gear is Still Adequate
Runway Failure
Braking Scarification During Landing
Poor Runway Material
Good Maintenance
Failed Surface Strength
DRAINAGE

Subsurface Failure

- Immediately after spring thaw
- Prior freeze-up was wet (soils were saturated)
- Poor side drainage for weight bearing
- C130 at full power (4 X 4700 HP) with brakes applied
Boeing’s gravel methodology has satisfied many aircraft types including:

- Boeing 727 & 737
- Hercules
- Electra
- F–27 / 28
- Bombardier Challenger & CL215/415
- De Havilland Dash 7 & Dash–8 100/200/300/400
- Convair 340/440/580/640
- Lear 25
- HS–748
- ATR 42
- Citation
- Dornier 328
- Saab 340
- B 1900 and lighter types
Demo of Boeing’s Penetrometer

- THERE ARE BOEING PENETROMETERS IN THIS ROOM
- MIKE, TERRY, AND I WILL PROVIDE CLOSE-UP DESCRIPTIONS OF THEIR OPERATION
Questions?