Unpaved Runway Strength Testing Correlation

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Outline

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Introduction

- An unpaved runway is defined as any runway "used for take-off and landing, where the surface layer is **not** a paved smooth hard surface such as Asphaltic concrete or Portland Cement Concrete" (AC 700-011, 2012).
- Unpaved runways may be the design of choice for reasons such as low traffic volumes/loadings, or simply due to the remoteness of location
- Many unpaved runways serve as a vital link to remote communities in Canada's North
- There are approximately 1000 unpaved runways in Canada

(Carmacks, 2017)

Introduction

(CIA World Factbook, 2017)

Introduction

- Some of the main advantages of operating an unpaved runway include:
  - Reduced capital cost of construction
  - Ease of grading maintenance
- Unique challenges exist in relation to unpaved runways:
  - Cubic metres of material can be dislodged with each take-off
  - Inadequate grading or crossfall can cause moisture variations, which may reduce strength
  - Bearing strength can vary greatly from season to season (spring is a particular challenge)

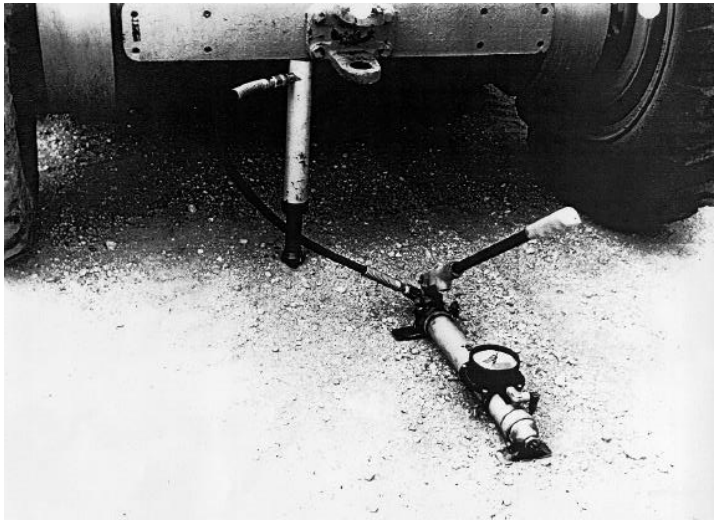
(Aviation Stack Exchange, 2014)

Strength Testing Methods

- If weakened surface strength is suspected, it is important to confirm whether or not operations may need to be suspended or reduced
- Failure to do so could result in severe damage to the pavement structure, or jeopardize user safety
- Boeing High Load Penetrometer is one of the most reliable methods of measuring gravel runway bearing strength
- In Russia, use of the Udarnik U-1 Drop Hammer is common
- It can be of benefit to relate the results reported from different methods for convenience of airport operations

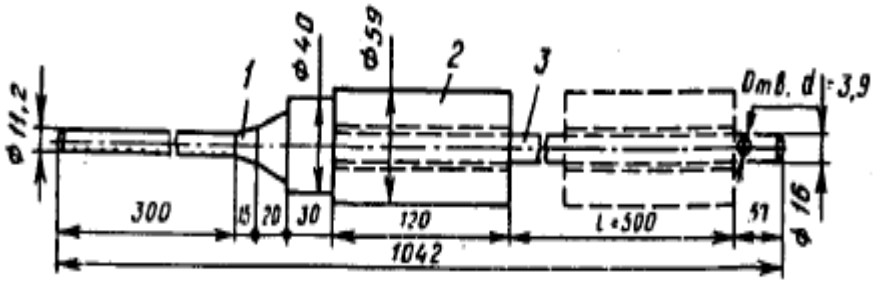
Strength Testing Methods

Boeing High Load Penetrometer



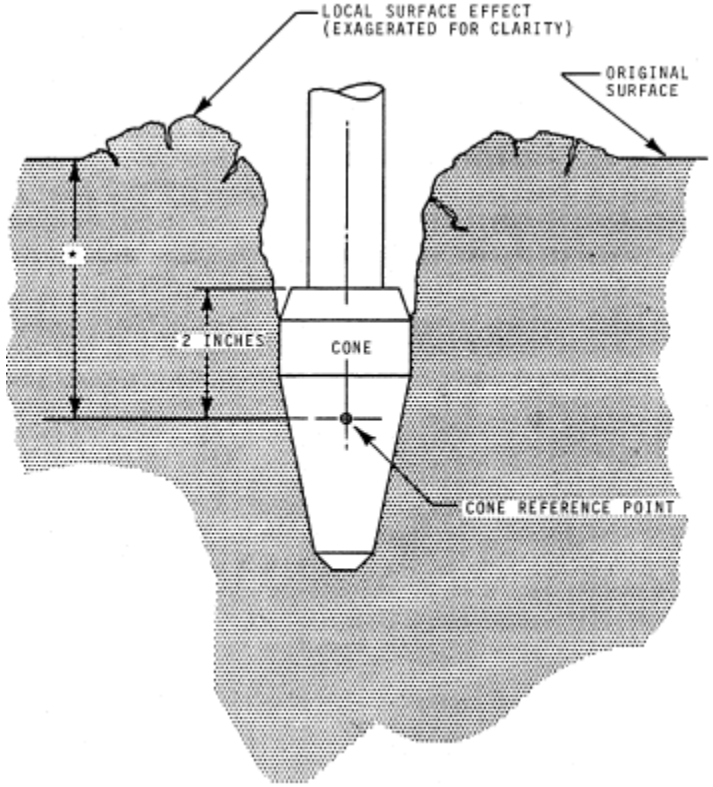
(Boeing, 1969)

Udarnik U-1 Drop Hammer



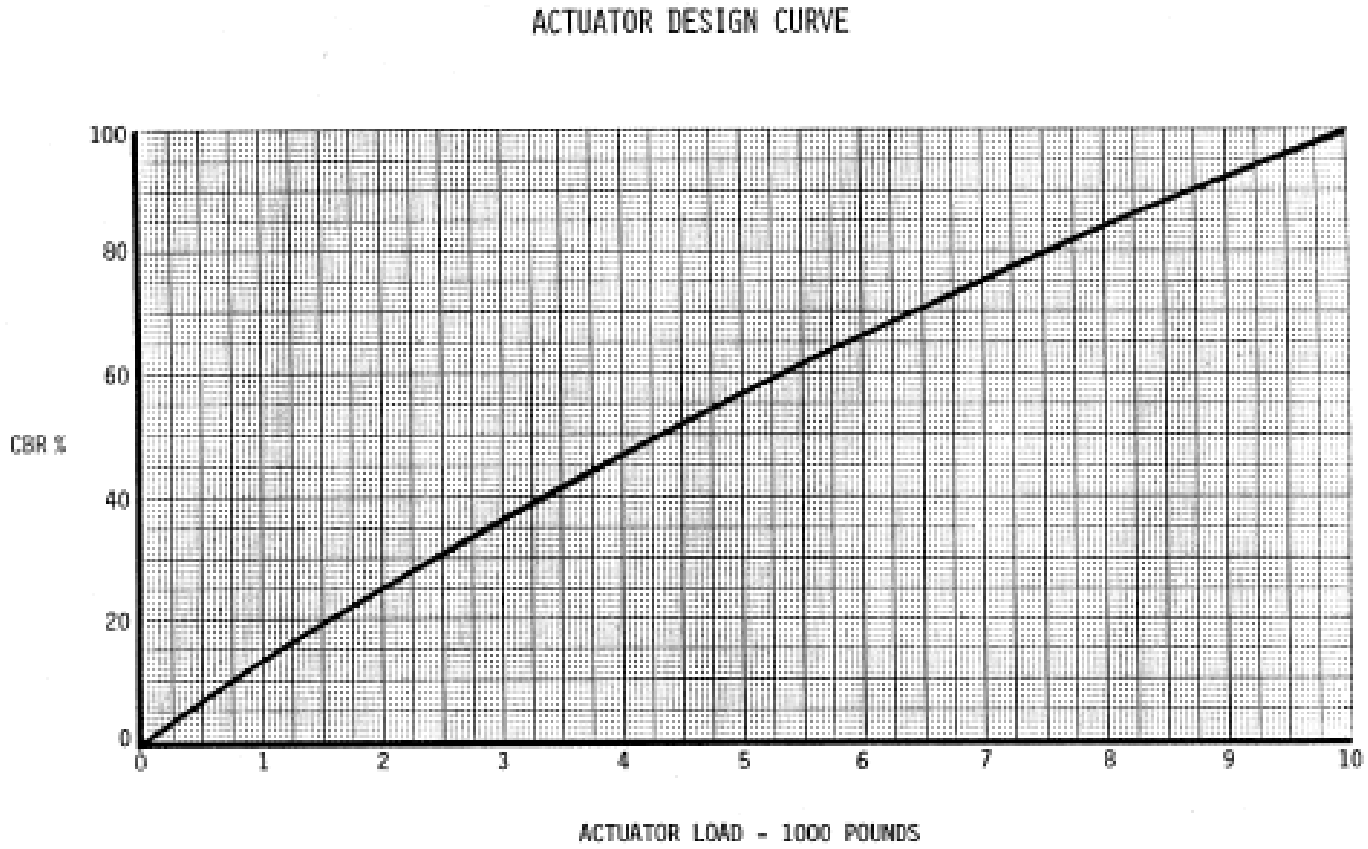
Strength Testing Methods – Boeing Penetrometer

- Features a conical tipped rod which is slowly forced into structure
- Requires a high reactive load to use properly
  - Use of grader is best suited as reaction force
- Typically inserted to a depth of 100mm at a steady rate
- Pressure reading is taken shortly after reaching 100mm depth
- Curves relate actuator load or penetrometer gage to California Bearing Ratio (CBR)



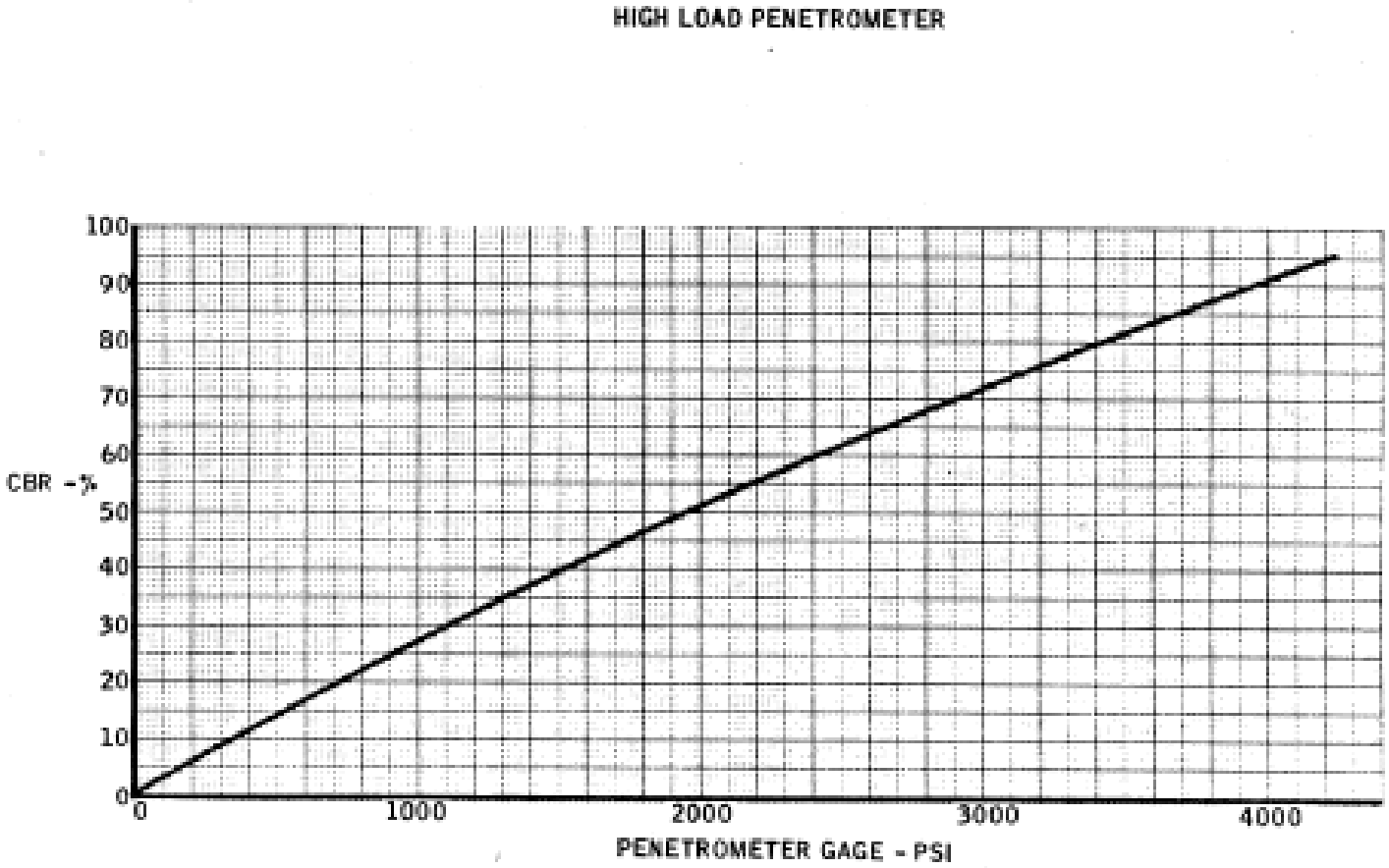
(Boeing, 1969)

Strength Testing Methods – Boeing Penetrometer



(Boeing, 1969)

Strength Testing Methods – Boeing Penetrometer



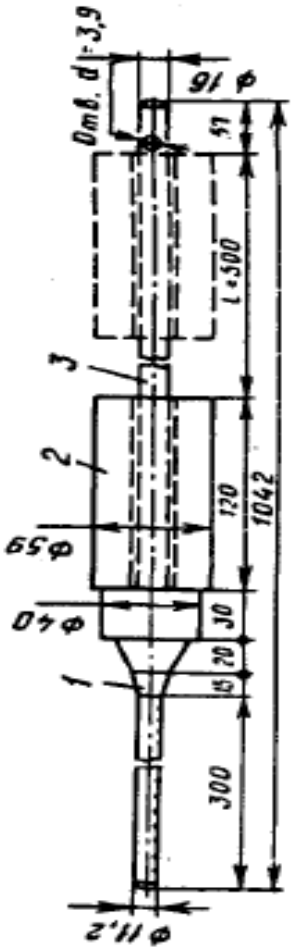
(Boeing, 1969)

Strength Testing Methods – Boeing Penetrometer

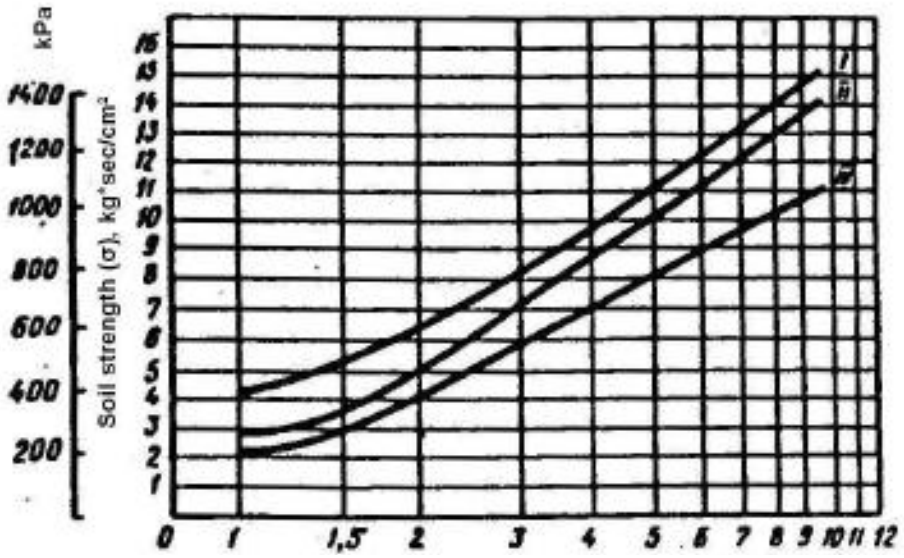
- Boeing High Load Penetrometer test procedure best replicates the loading mechanism exhibited by aircraft on the pavement structure
- Accuracy depends on ensuring a high enough reactive force is used during the procedure
- Without adequately heavy equipment on site, false confidence in runway bearing strength is likely

Strength Testing Methods – Udarnik U-1

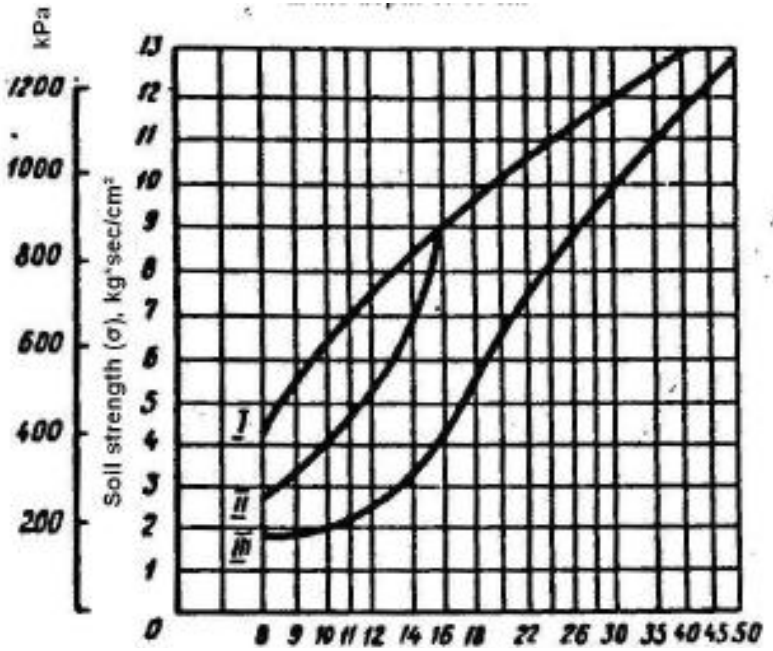
- Features 11.2mm diameter rod, hammer contact area, and a 2.5kg weight
- Hand operated – the weight is raised 50cm (to the top) and released
- The weight is dropped repeatedly until the tip has been driven 10cm into the structure and count is recorded
- Count is continued until the rod is driven to a depth of 30cm
- Strength is determined as a mean of the σ10 and σ30 measurements



Strength Testing Methods – Udarnik U-1



Strokes required to reach a depth of 10cm



Strokes required to reach a depth of 30cm

Strength Testing Methods – Udarnik U-1

- Udarnik U-1 is a very simple to use testing method
- Empirical correlations relate stroke counts to bearing strength
- Aircraft Flight Manuals specify bearing strength in terms of CBA
  - A calibration of Udarnik results to CBA is the easiest way of allowing Udarnik U-1 results to be relied upon for operations

Methodology

- A representative range of unpaved runway samples must be identified to ensure robustness
- A useful range of moisture contents must also be identified
- Finally, a range of percent compaction must also be identified

(Dual Manufacturing Co., 2016)

(Tradebit, 2017)

Methodology

		Moisture Content				
% Compaction		**x1**	**x2**	**x3**	**x4**	
	y1	4 trials a11	4 trials a12	4 trials a13	4 trials a14	**a1-**
	y2	4 trials a21	4 trials a22	4 trials a23	4 trials a24	**a2-**
	y3	4 trials a31	4 trials a32	4 trials a33	4 trials a34	**a3-**
		a-1	**a-2**	**a-3**	**a-4**	**Grand Average**

Methodology

- Experimental procedure involves use of factorial design
- For each sample pavement type included in the experiment, 96 runs would be required to complete the entire factorial design
  - 4 runs for each combination of factors: 3 x 4 x 4 = 48
  - Performed twice (once for each test method): 48 x 2 = 96
- Use of a fractional factorial design will allow statistical inference to be made without having to perform all 96 trials
- This allows more sample types to be considered

Methodology

- Testing will be performed in laboratory at the University of Waterloo
- Soil sieves will be used to create appropriate gradations for the pavement samples
- After grading, the material is thoroughly mixed, and then quartered
- Samples are then prepared to the appropriate moisture content and compaction level
- Test procedure is then performed, and the sample discarded after testing

Conclusion

- It is hoped that the experiment will yield statistically significant results which relate Udarnik U-1 readings to California Bearing Ratio as measured by the Boeing High Load Penetrometer
- If successful, the Udarnik U-1 could be used to supplement Boing High Load Penetrometer readings when resources are unavailable

(Australian Aviation, 2017)

Thank you

Questions?

References

Federal Aviation Administration. (2009). *Advisory Circular 150/5320-6E: Airport Pavement Design and Evaluation*. Washington DC: U.S. Department of Transportation.

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