applied pavement TECHNOLOGY

# Adoption of Pavement Classification Rating (PCR)

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# Objectives

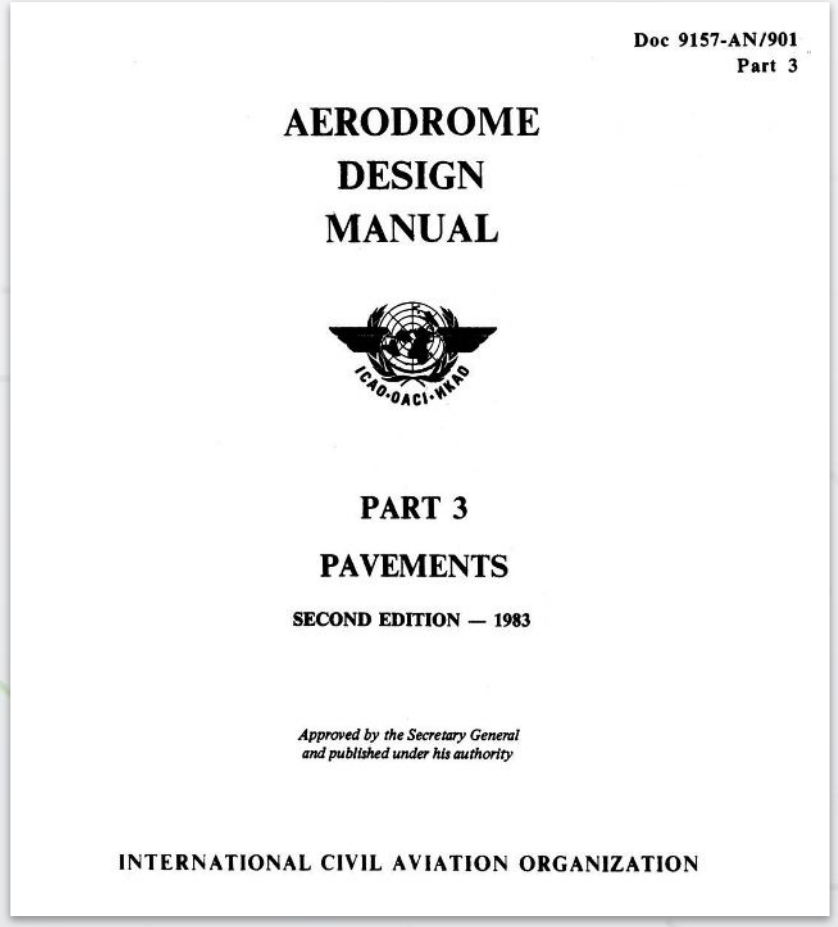
- Cover background information on ACR–PCR system
- Review Canadian DND examples where PCR results vary from past PCN results
- Demonstrate new PCR feature in DND–Directorate of Architecture and Engineering Services (DAES) pavement online portal

# ACR–PCR Concept

- A pavement with a determined PCR value can support an aircraft that has an ACR value equal to or less than the pavement's PCR (ACR ≤ PCR)
- Determines:
  - If a pavement can support current or projected traffic
  - If a specific aircraft can land at your airfield
    - Will limiting the aircraft weight allow for unrestricted operations?
- Aircraft with frequent operations on pavements with ACRs greater than the PCR can cause more damage than accounted for in the design and will reduce the expected life of the pavement

# History

- ICAO was founded in 1944 and promotes safe civil aviation around the world
- Prior to 1981, many strength reporting methods were adopted by various international agencies
- ICAO implemented the PCN system to quantify Airfield Pavement Structural Capacity in 1981
- ICAO developed and implemented the PCR in 2020 to modernize structural condition reporting
- In 2024, Transport Canada incorporated ACR–PCR as the standard method of reporting airport pavement strength


Doc 9157-AN/901
Part 3

AERODROME
DESIGN
MANUAL

PART 3

PAVEMENTS

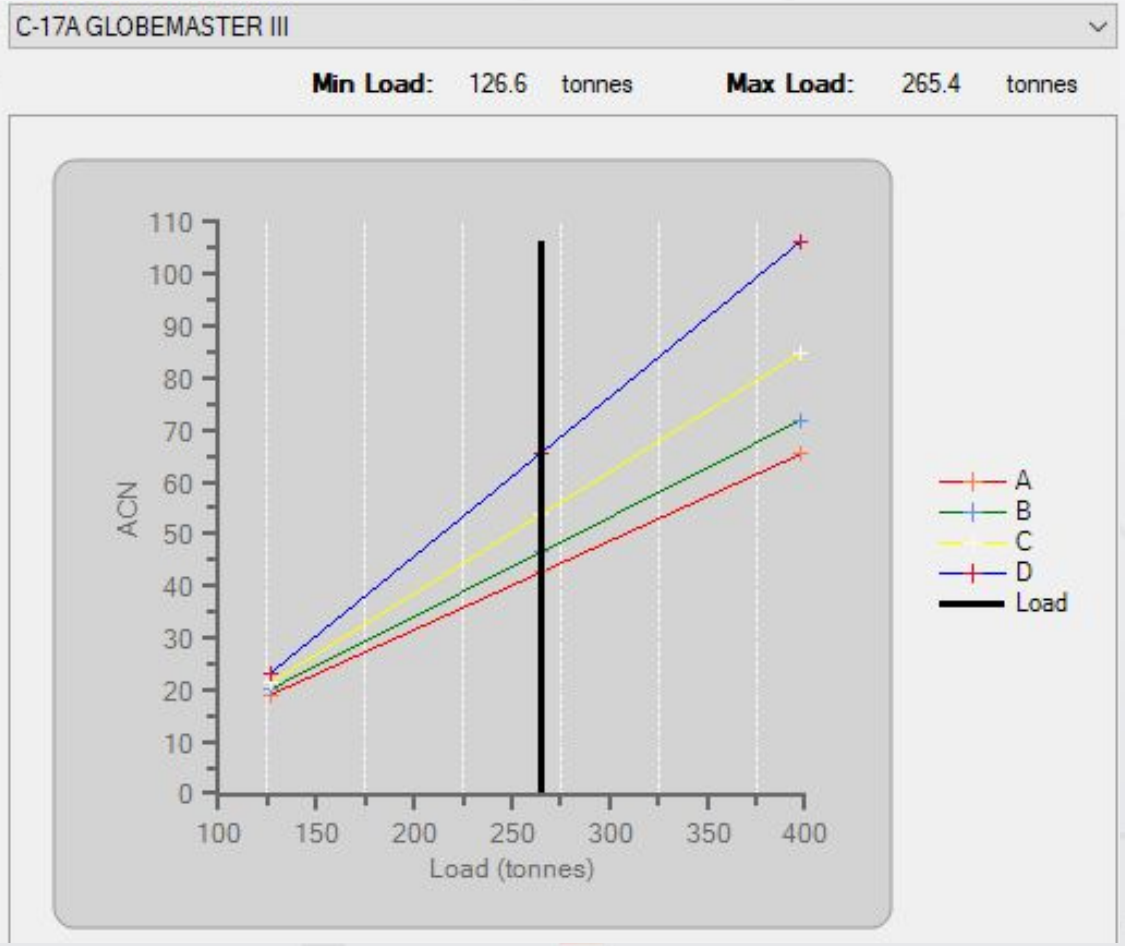
SECOND EDITION — 1983

*Approved by the Secretary General and published under his authority*

INTERNATIONAL CIVIL AVIATION ORGANIZATION

# PCN Overview

- ACNs are used to classify an aircraft's effect on pavement
- PCNs classify pavement load-carrying capacity using data for **only** critical aircraft's ACN
- ACN and PCN can be used to determine the Structural Index (ACN/PCN ratio) of a pavement



# PCN Classification

**Pavement Type**

R = rigid, concrete

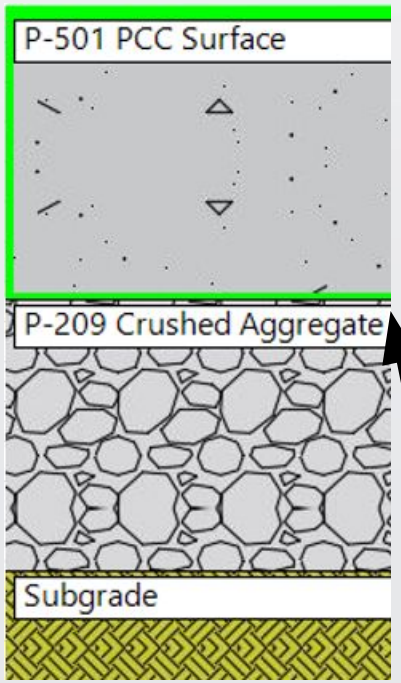
F = flexible, asphalt

**Evaluation Method**

T = technical

U = type of using aircraft

**56 / R / B / W / T**




**Subgrade Strength**

A = high, ≥ 13 CBR, ≥ 120 MN/m$^3$

B = med, > 8 CBR, > 60 MN/m$^3$

C = low, > 4 CBR, > 25 MN/m$^3$

D = ultra low, ≤ 4 CBR, ≤ 25 MN/m$^3$

**Tire Pressure**

W = high, no limit

X = med, ≤ 1.75 MPa

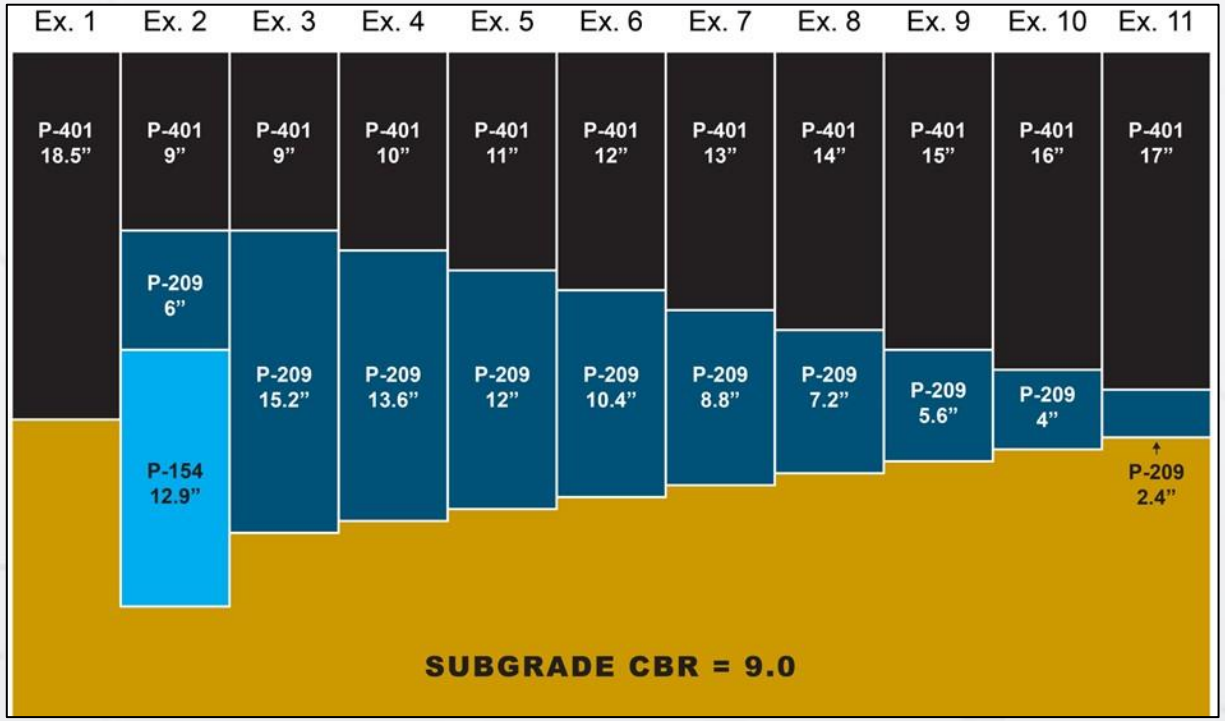
Y = low, ≤ 1.25 MPa

Z = very low, ≤ 0.5 MPa

**"Subgrade" strength for rigid pavements measured at the top-of-base**

# Issues with PCN

- 11 flexible pavements were analyzed, with varying asphalt and base thicknesses
  - All analyzed structures were structurally equivalent
- Despite differences, all had the same calculated PCN
- New classification system needed to address this issue




| Aircraft | Weight, kg | Gear Type | Tire Pressure, MPa | Departures |
|---|---|---|---|---|
| A319-100 | 68,400 | D | 1.25 | 3,500 |
| A320-200 | 78,403 | D | 1.38 | 10,000 |
| A321-200 | 93,905 | D | 1.50 | 2,000 |
| B737-700 | 70,307 | D | 1.36 | 15,000 |
| B737-900 | 85,366 | D | 1.52 | 30,000 |
| Gulfstream G-V | 41,232 | D | 1.30 | 10,000 |
| MD-11 | 287,124 | 2D/D1 | 1.42 | 5,000 |

**PCN: 76/F/B/X/T**

# Use of ACR-PCR System

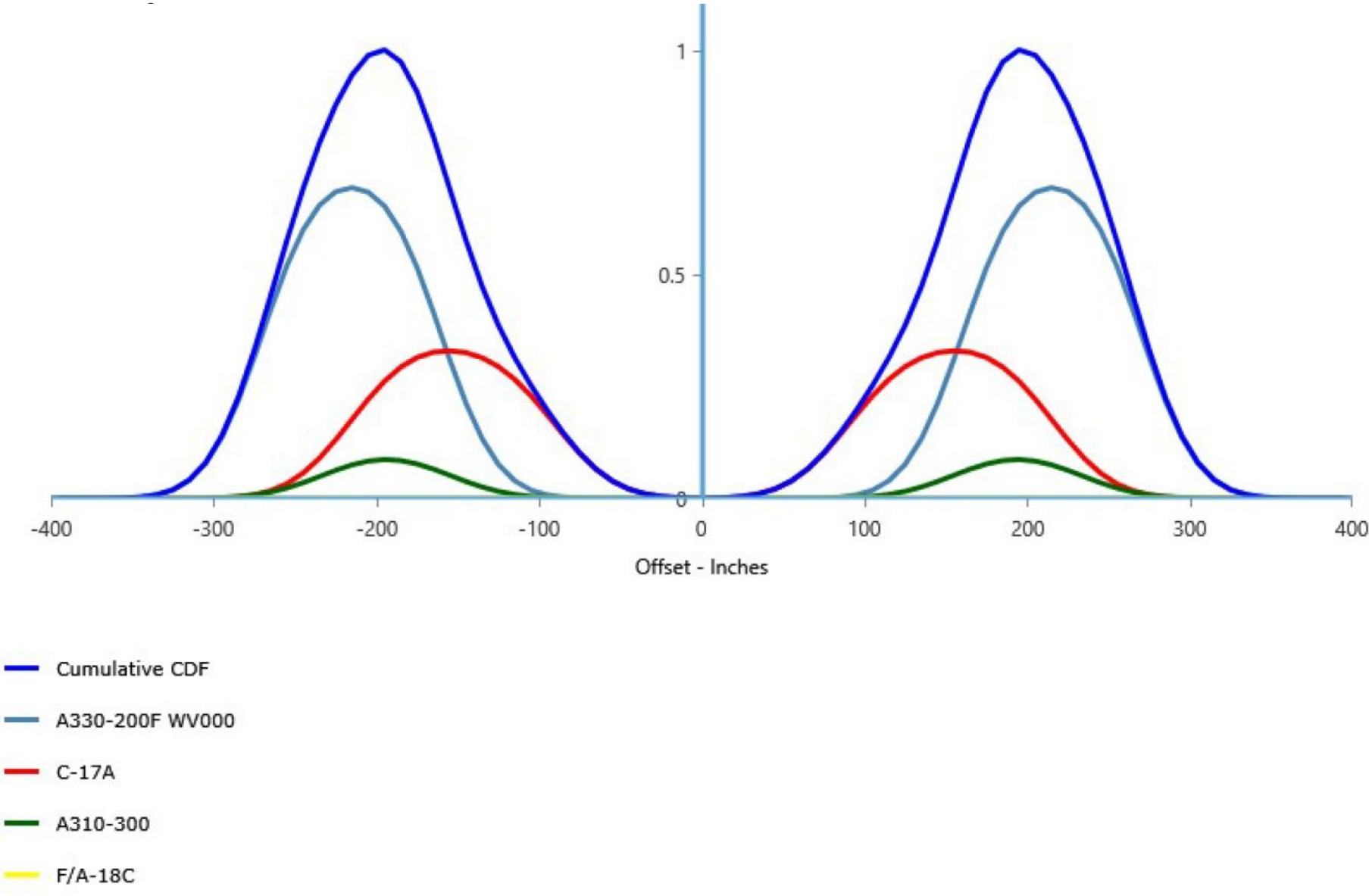
- Determine if:
  - Pavement can support current or projected aircraft fleet mix
  - A certain aircraft can land at your airport (i.e., once, regularly, unlimited)
  - An aircraft can operate at a restricted weight for unlimited or restricted operations
- Assess the amount of damage an aircraft will impart on a pavement
  - Every aircraft “damages” pavement – Cumulative Damage Factor (CDF)
  - Method to assess if damage on pavement is more than design indicated
  - Aircraft operating at ACR over PCR will reduce the life of the pavement
  - Rarely will an aircraft overload lead to a catastrophic structural failure

# PCR Overview

- PCR system developed to improve on the PCN system
- Based on mechanistic-empirical methods
- Pavement design approach through cumulative aircraft traffic patterns using Linear Elastic Analysis (LEA)
  - LEA assumes the pavement can be analyzed as homogenous, elastic, isotropic layers stacked together
  - LEA allows individual wheel loads to be combined to obtain a combined response for aircraft gear loads
  - Entire traffic mix is accounted for instead of only critical aircraft

# CDF Example

- CDF is influenced by all aircraft in mix and is dependent on gear



# PCR Classification

Pavement Type
R = rigid, concrete
F = flexible, asphalt

Evaluation Method
T = technical
U = type of using aircraft

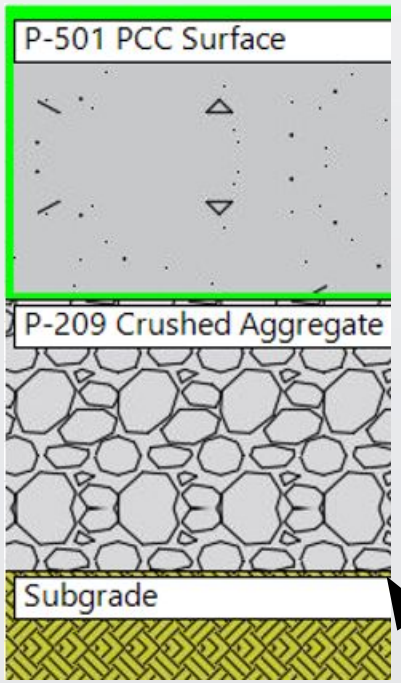
PCR (ACR)

**(485 / R / B) / W / T**

## ACR Components

Subgrade Strength
A = high, ≥ 150 MPa (E)
B = med, > 100 MPa (E)
C = low, > 60 MPa (E)
D = ultra low, ≤ 60 MPa (E)

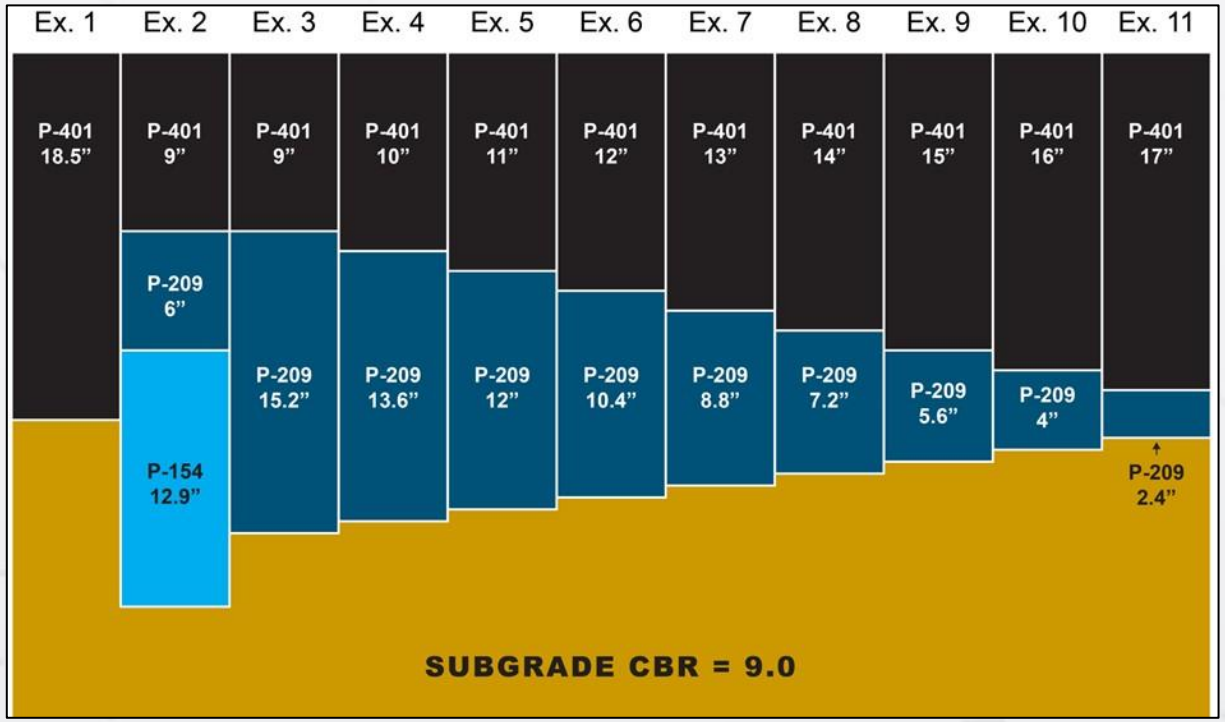
Tire Pressure
W = high, no limit
X = med, ≤ 1.75 MPa
Y = low, ≤ 1.25 MPa
Z = very low, ≤ 0.5 MPa




**Subgrade strength for all pavements measured at the subgrade**

# Benefits of PCR

- Seven of the same 11 flexible pavements were analyzed
- With updated classification system, six of the sections would be overloaded with the MD-11
  - ACR = 697
- PCR system can better classify pavements by their structural capacity




| Thicknesses, cm | | | PCN | PCR |
|---|---|---|---|---|
| Surface | Agg. Base | Agg. Subbase | | |
| 47.0 | - | - | 76/F/B/X/T | 775/F/C/X/T |
| 22.9 | 15.2 | 32.8 | 76/F/B/X/T | 625/F/C/X/T |
| 22.9 | 38.6 | - | 76/F/B/X/T | 526/F/C/X/T |
| 27.9 | 30.5 | - | 76/F/B/X/T | 549/F/C/X/T |

# Example of PCR Adoption for Canadian DND Airfields

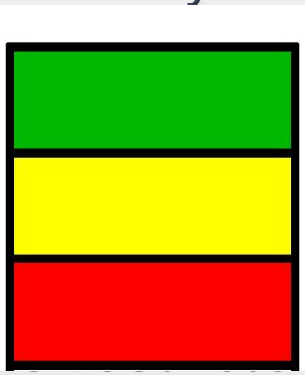
# Cold Lake PCR Implementation

- ACR/PCR evaluation conducted by Englobe to update classifications from PCN to PCR system
- The ACR/PCR ratio can be referred to as the SI:

$$\frac{\text{Aircraft Classification Rating}}{\text{Pavement Classification Rating}} = \text{Structural Index}$$

# Cold Lake PCR Implementation Caveats

- DND currently uses a modified Structural Index (SI) metric with maximum take-off weights considered for network level analysis
  - Maximum take-off weights uncommon during daily operations
  - DAES is evaluating sensitivity of adjust SI metric
- ACRs exceeding 10% of the reported PCR a overload situation requests are sent to DAES
- DAES has published a higher PCR than the calculated value when:
  - PCR analysis showed a weaker pavement than past ACN/PCN analysis
  - **AND** no structural distress



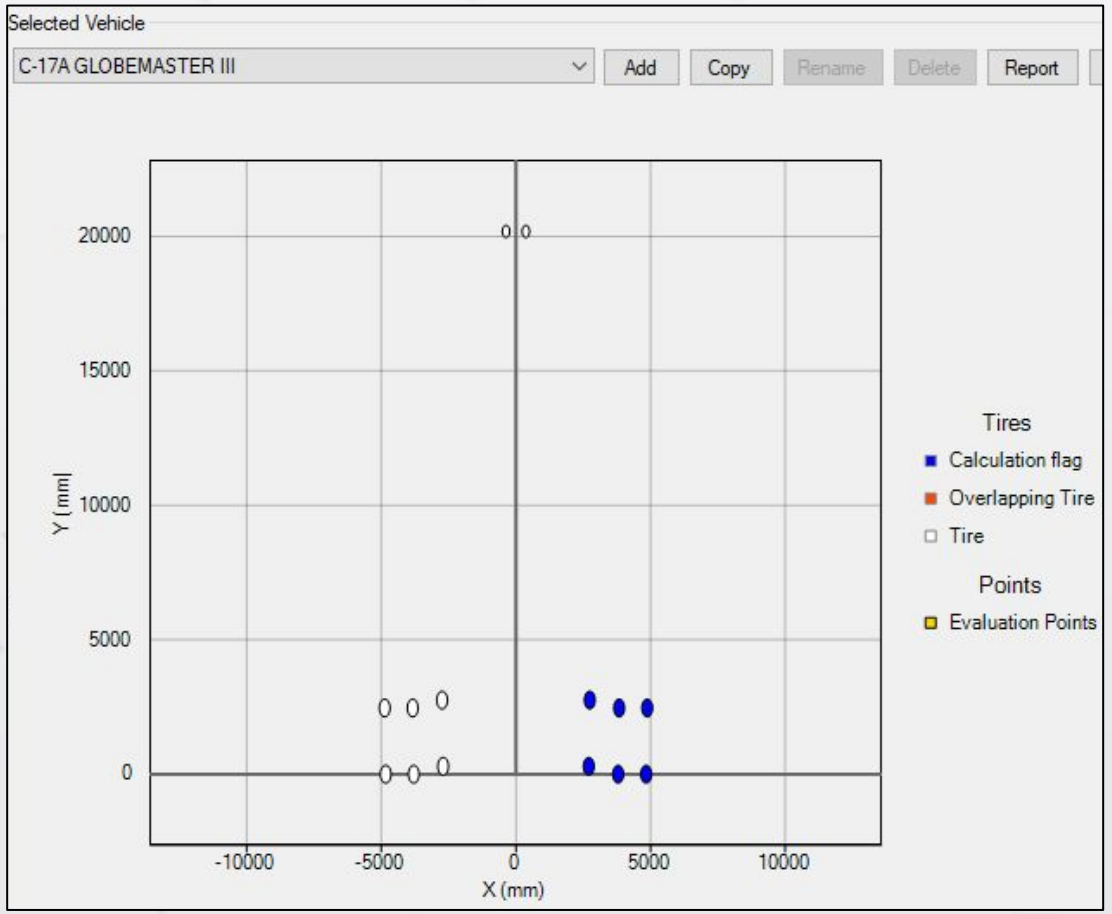
GOOD: ACR/PCR <1.25

FAIR: 1.25 ≤ ACR/PCR ≤ 1.50

POOR: ACR/PCR >1.50

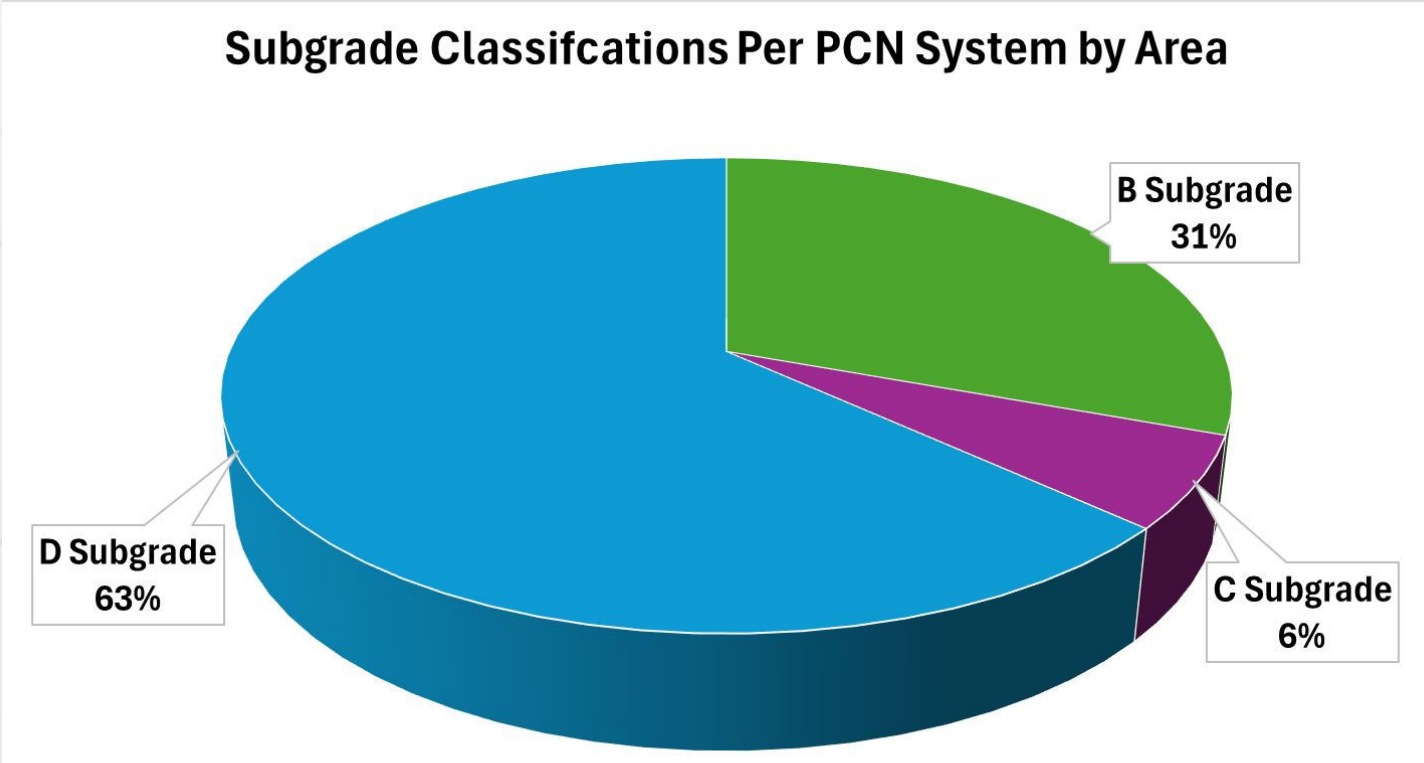
# Cold Lake PCR Implementation

- What are the impacts for Cold Lake on the transition from PCNs to PCRs?
  - How much of this impact is attributed to mechanical changes within the strength computations?
- To evaluate changes, a single aircraft traffic mix was applied:
  - 50,000 passes of the CC-177 at 265,352 kilograms
  - PCRs presented are for educational purposes, as published PCRs are based on the anticipated 20-year traffic mix

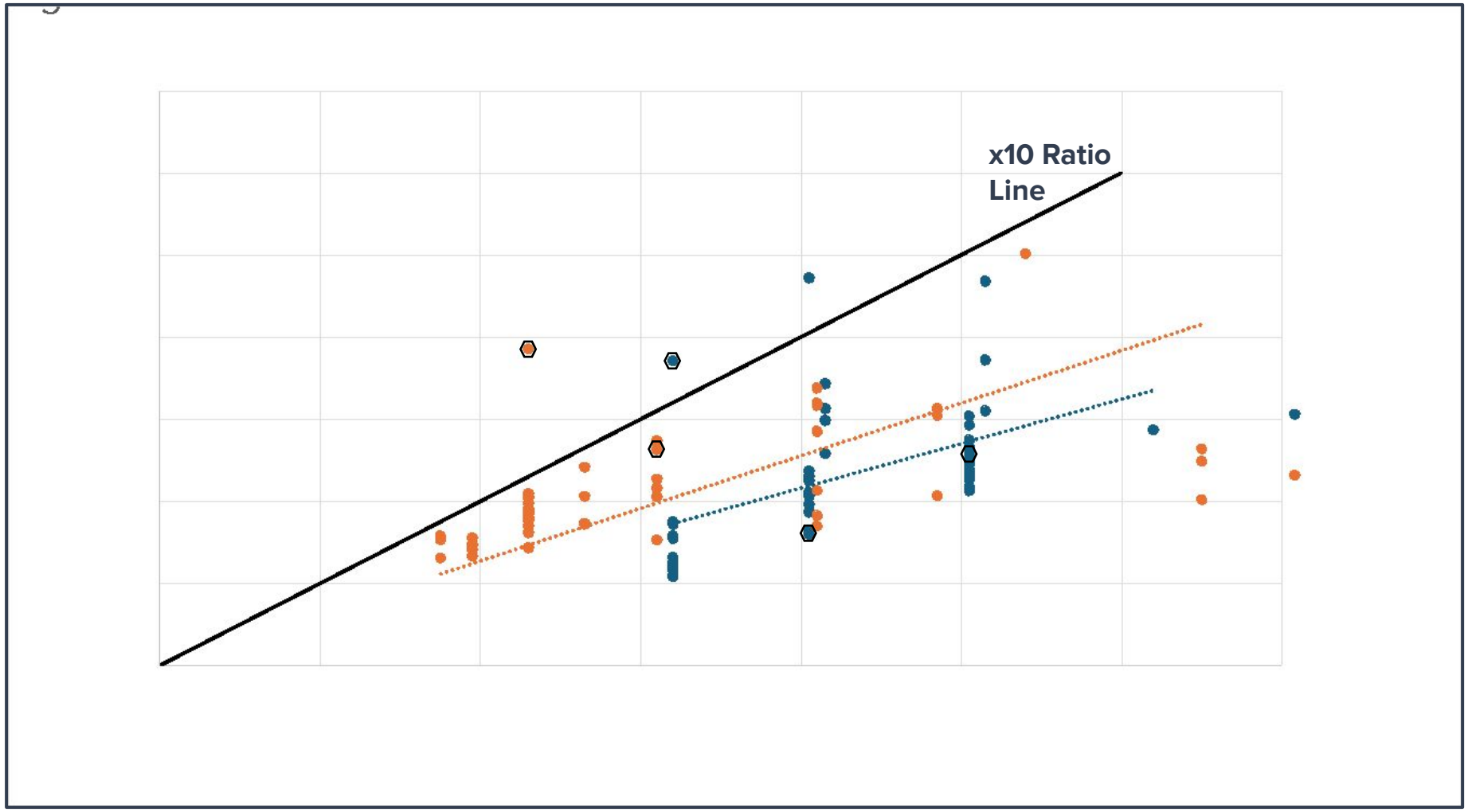


# Cold Lake Subgrade Category Changes

- Under PCN system, a mixture of subgrade categories were present
- Under PCR system, only subgrade category D is present
  - All changes are for rigid pavements



# Cold Lake PCR vs. PCN Ratio



# Cold Lake Example Sections

| Section | Pavement Type | Thicknesses, cm | | | PCR | PCN |
|---|---|---|---|---|---|---|
| | | Surface | Base | Subbase | | |
| Apron-01 | Concrete | 35.1 | 27.5 | 17.0 | 527/R/D/W/T | 62/R/B/W/T |
| Taxiway-01 | Concrete | 30.6 | 28.3 | - | 772/R/D/W/T | 46/R/B/W/T |
| Taxiway-02 | Asphalt | 23.0 | 35.3 | 61.7 | 330/F/D/X/T | 81/F/D/W/T |
| Taxiway-03 | Asphalt | 16.2 | 50.7 | 53.1 | 743/F/D/X/T | 64/F/D/W/T |
| Taxiway-04 | Asphalt | 24.2 | 54.0 | 41.9 | 521/F/D/X/T | 101/F/D/W/T |

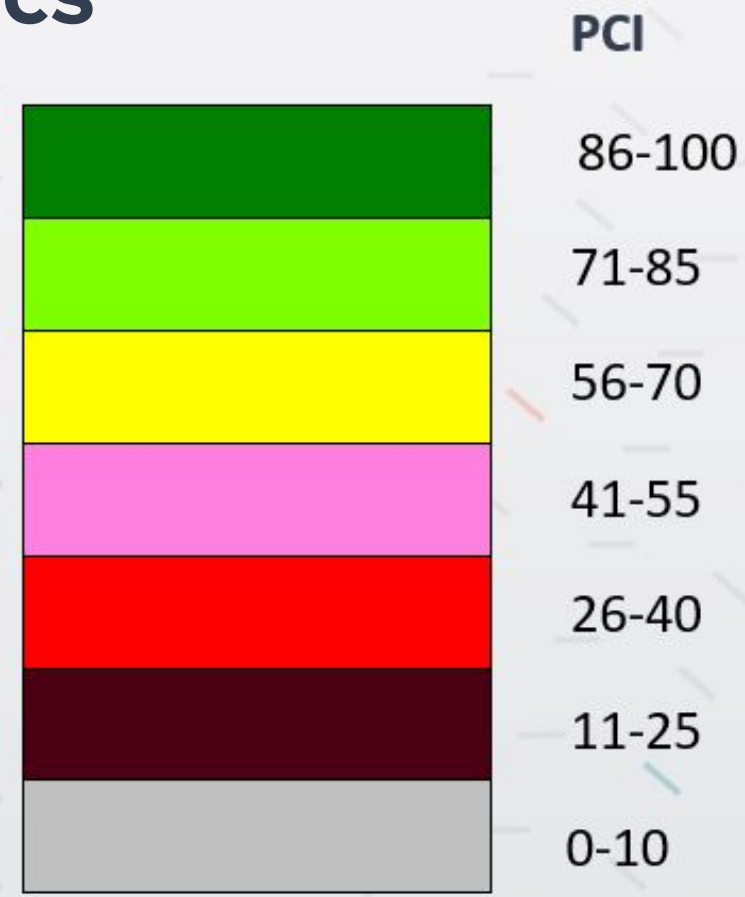
# Cold Lake SI Changes

- Three example sections had an SI increase (weaker pavement structure)
- Two example sections had an SI decrease (stronger pavement structure)

| Section | Pavement Type | ACR | PCR | ACR/PCR | ACN | PCN | PCR Subgrade | ACN/PCN | SI Delta |
|---|---|---|---|---|---|---|---|---|---|
| Apron-01 | Concrete | 731.5 | 527 | 1.39 | 65.7 | 62 | B | 1.06 | +0.33 |
| Taxiway-01 | Concrete | 731.5 | 772 | 0.95 | 65.7 | 46 | B | 1.43 | -0.48 |
| Taxiway-02 | Asphalt | 704.4 | 330 | 2.13 | 70.5 | 81 | D | 0.87 | +1.26 |
| Taxiway-03 | Asphalt | 704.4 | 743 | 0.95 | 70.5 | 64 | D | 1.10 | -0.15 |
| Taxiway-04 | Asphalt | 704.4 | 521 | 1.35 | 70.5 | 101 | D | 0.70 | +0.65 |

# Do SI Changes Align with Metrics

- What are the trends in the Pavement Condition Index (PCI)?
  - Are PCI deductions controlled by Load-Related Distresses (LRD)?
- Should the pavement be near (or past) the end of its design life?
- Is this pavement used by a CC-177 significantly?
  - In reality, the traffic mix is more representative of actual traffic

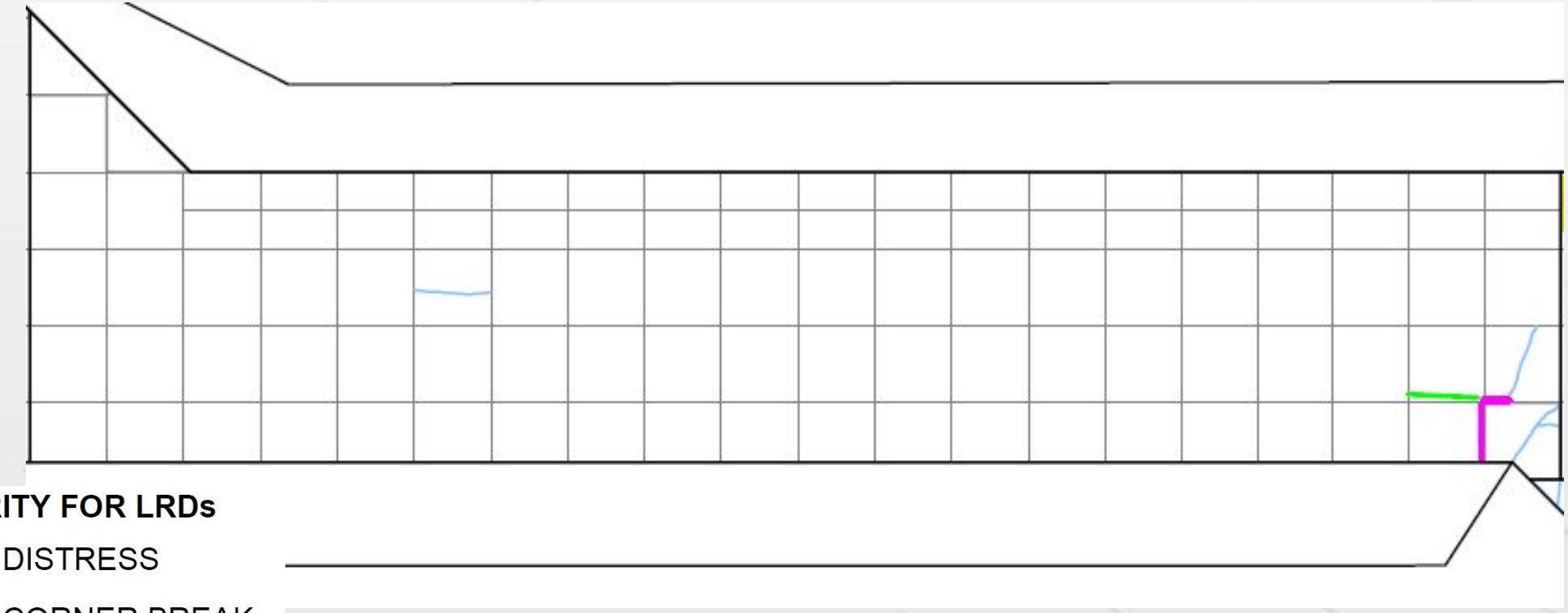


# Taxiway-01

- Constructed in 1959
  - Localized maintenance in 2021
- ACN/PCN (CC-177 only) = 1.43
- ACR/PCR (CC-177 only) = 0.95
  - Published ACR/PCR is GOOD
- Frequently used by fighters

| Year | PCI | Percent LRDs |
|---|---|---|
| 2013 | 80 | 14 |
| 2019 | 73 | 14 |
| 2024 | 84 | 9 |

# Taxiway-01 LRD Distress Map



**DISTRESS/SEVERITY FOR LRDs**

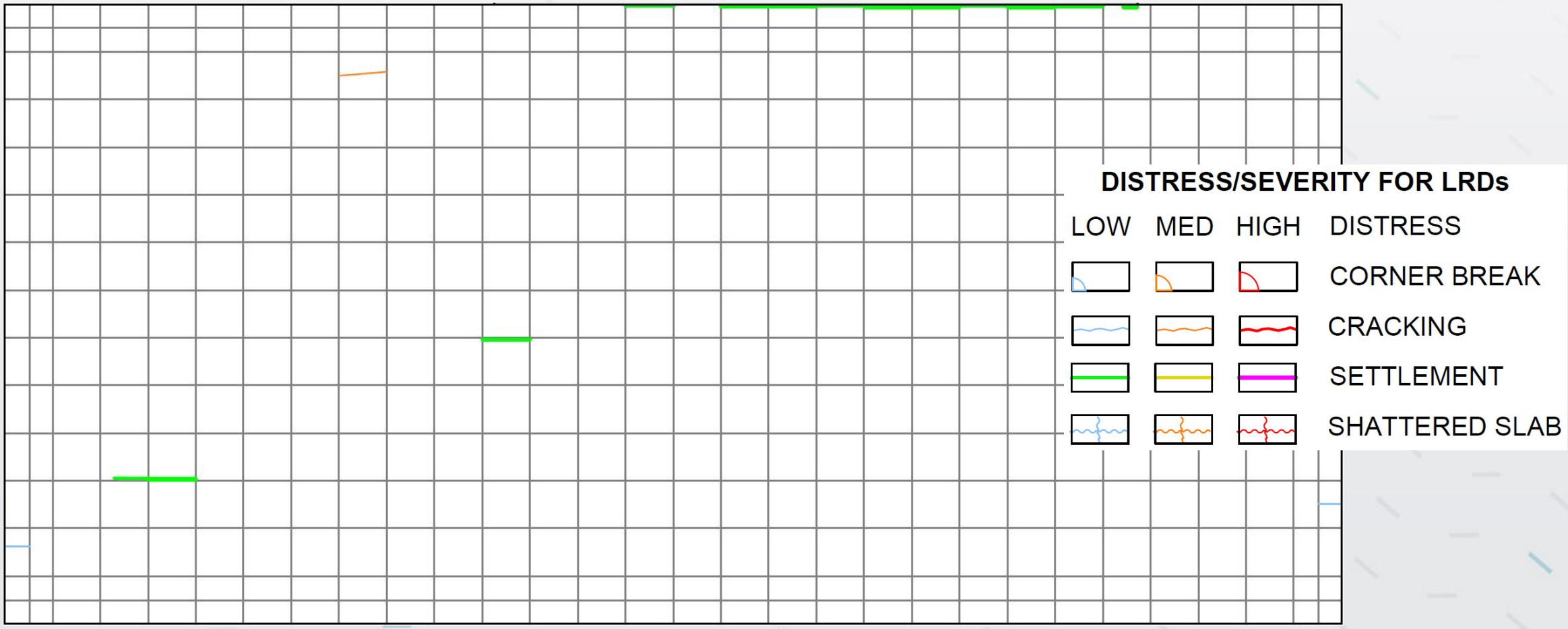
| LOW | MED | HIGH | DISTRESS |
|---|---|---|---|
| | | | CORNER BREAK |
| | | | CRACKING |
| | | | SETTLEMENT |
| | | | SHATTERED SLAB |

# Apron-01

- Constructed in 2002
- ACN/PCN (CC-177 only) = 1.06
- ACR/PCR (CC-177 only) = 1.39
  - Published ACR/PCR is GOOD
- Mostly used by light aircraft

| Year | PCI | Percent LRDs |
|---|---|---|
| 2013 | 69 | 0 |
| 2019 | 67 | 2 |
| 2024 | 67 | 6 |

# Apron-01 LRD Distress Map



# Taxiway-02

- Constructed in 1954
  - Three rehabilitations
  - Most recent in 2002
- ACN/PCN (CC-177 only) = 0.87
- ACR/PCR (CC-177 only) = 2.13
  - Published ACR/PCR is FAIR
- Frequently used by fighters

| Year | PCI | Percent LRDs |
|---|---|---|
| 2013 | 67 | 35 |
| 2019 | 56 | 48 |
| 2024 | 50 | 49 |

# Taxiway-03

- Constructed in 1959
  - Two rehabilitations
  - Most recent in 2005
- ACN/PCN (CC-177 only) = 1.10
- ACR/PCR (CC-177 only) = 0.95
  - Published ACR/PCR is POOR
- Frequently used by fighters

| Year | PCI | Percent LRDs |
|---|---|---|
| 2013 | 66 | 40 |
| 2019 | 58 | 40 |
| 2024 | 48 | 46 |

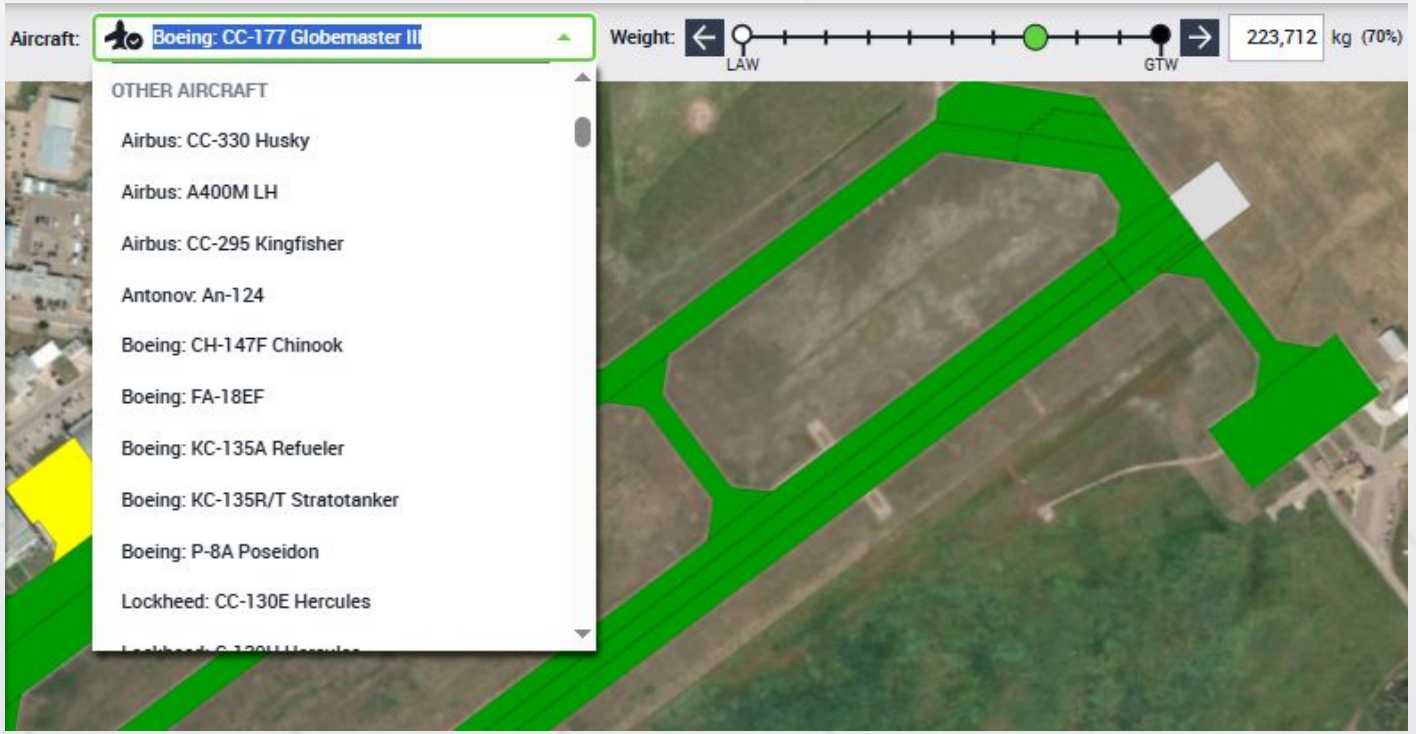
# Taxiway-04

- Constructed in 1954
  - Three rehabilitations
  - Most recent in 2005
- ACN/PCN (CC-177 only) = 0.70
- ACR/PCR (CC-177 only) = 1.35
  - Published ACR/PCR is GOOD
- Commonly used by fighters

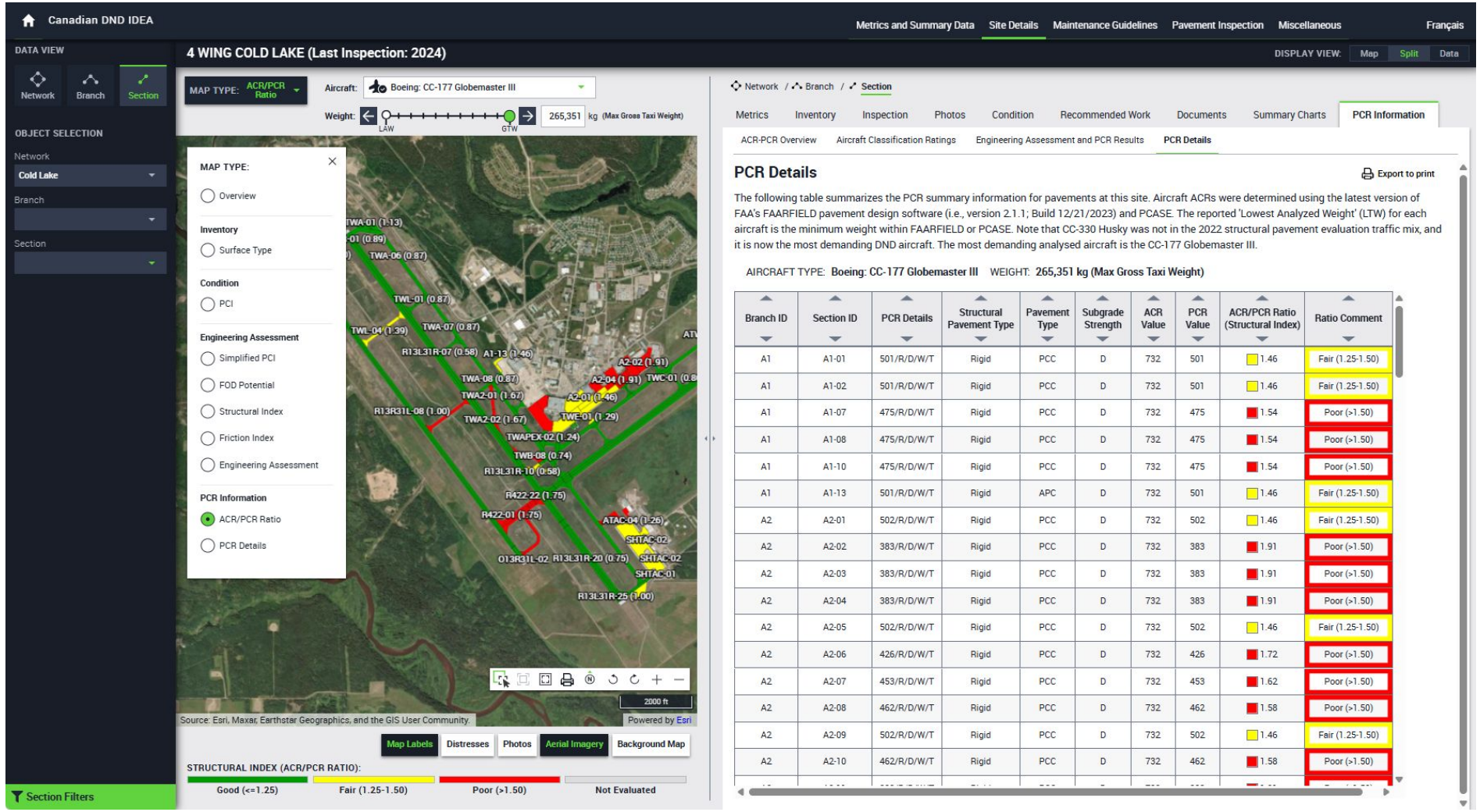
| Year | PCI | Percent LRDs |
|---|---|---|
| 2013 | 69 | 0 |
| 2019 | 68 | 0 |
| 2024 | 64 | 0 |

# Online Portal PCR Feature

- DAES online portal now contains PCR information for Cold Lake
  - New feature provides easily access to PCR data
  - Feature to be added to other sites
- Customizable aircraft weights allow for theoretical analysis
- Illustrates which aircrafts can use specific facilities without overloading the pavement



# Live Demo of Online Portal PCR Feature




[Portal Link]

# Acknowledgements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- FAA

# Technical Acronyms

- ACN – Aircraft Classification Number
- ACR – Aircraft Classification Rating
- CDF – Cumulative Damage Factor
- LEA – Linear Elastic Analysis
- LRD – Load-Related Distresses
- PCI – Pavement Condition Index
- PCN – Pavement Classification Number
- PCR – Pavement Classification Rating
- SI – Structural Index