Pavement Design Tools & Their Relevance to Canadian Airports

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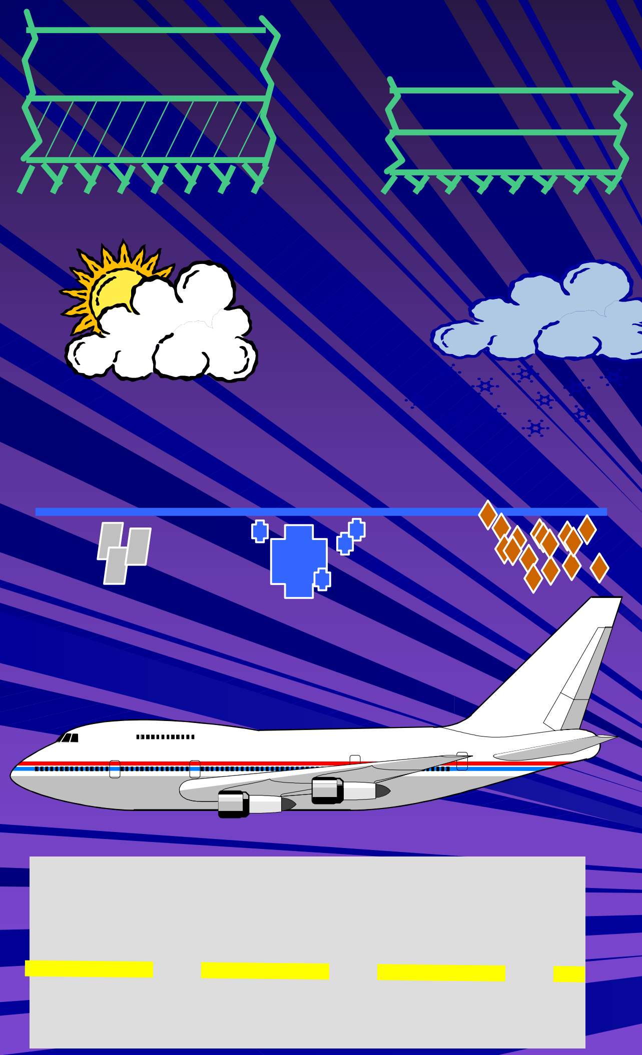
GTAA

Presentation Outline

- Introduction
- Background: Airport Pavement Design
- Airport Design Tools
- Relevance to Canadian Airports
- Conclusions
- Questions

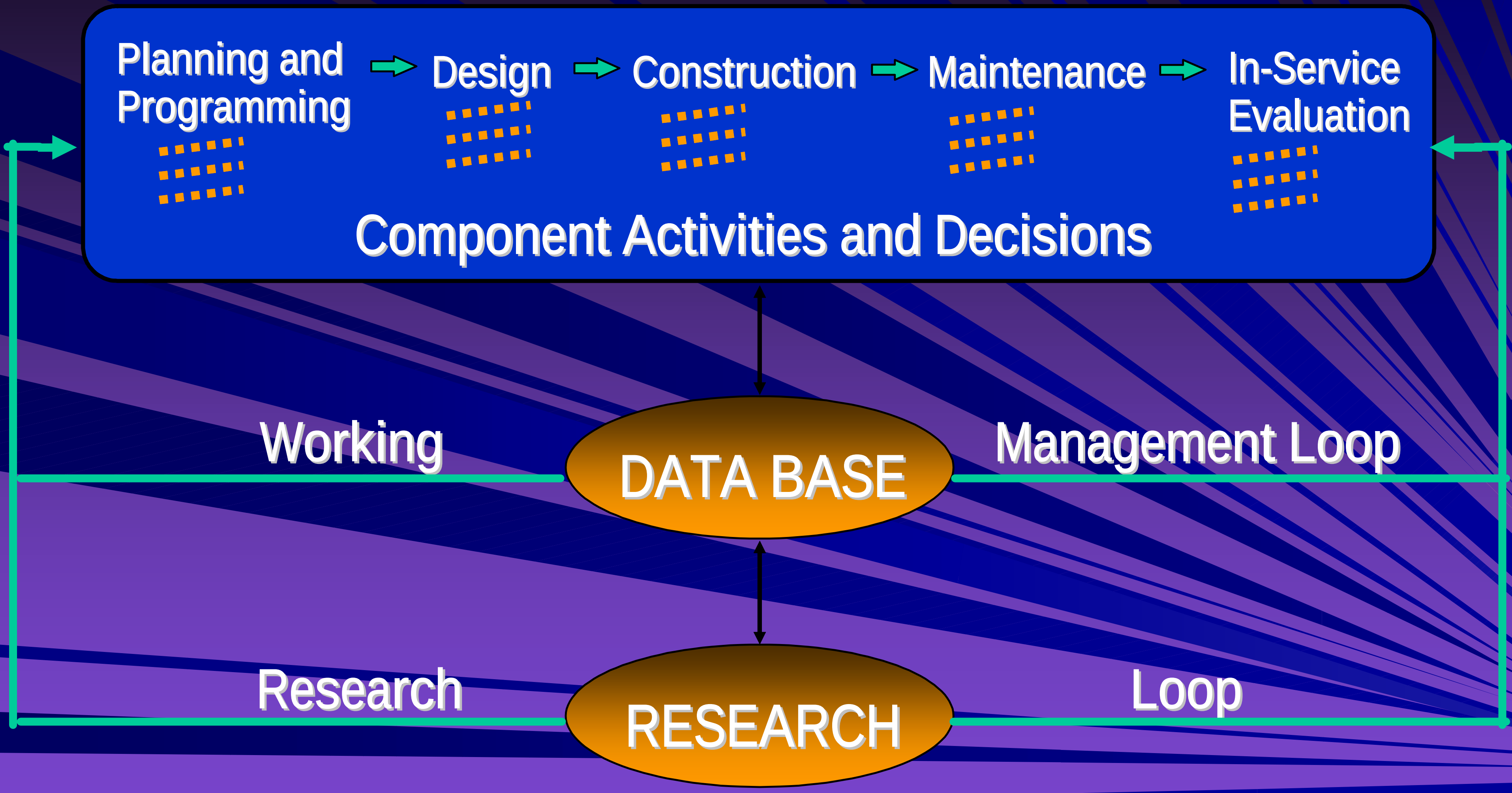
Introduction: Design

- Pavement Thickness
- Freezing Index (FI)
- Mean Annual Average Temperature (MAAT)
- Subgrade Type
- Design Aircraft
- Wheel Load
- Maximum Gross Weight
- Maximum Take-Off Weight
- Tire Contact Area
- Construction Constraints

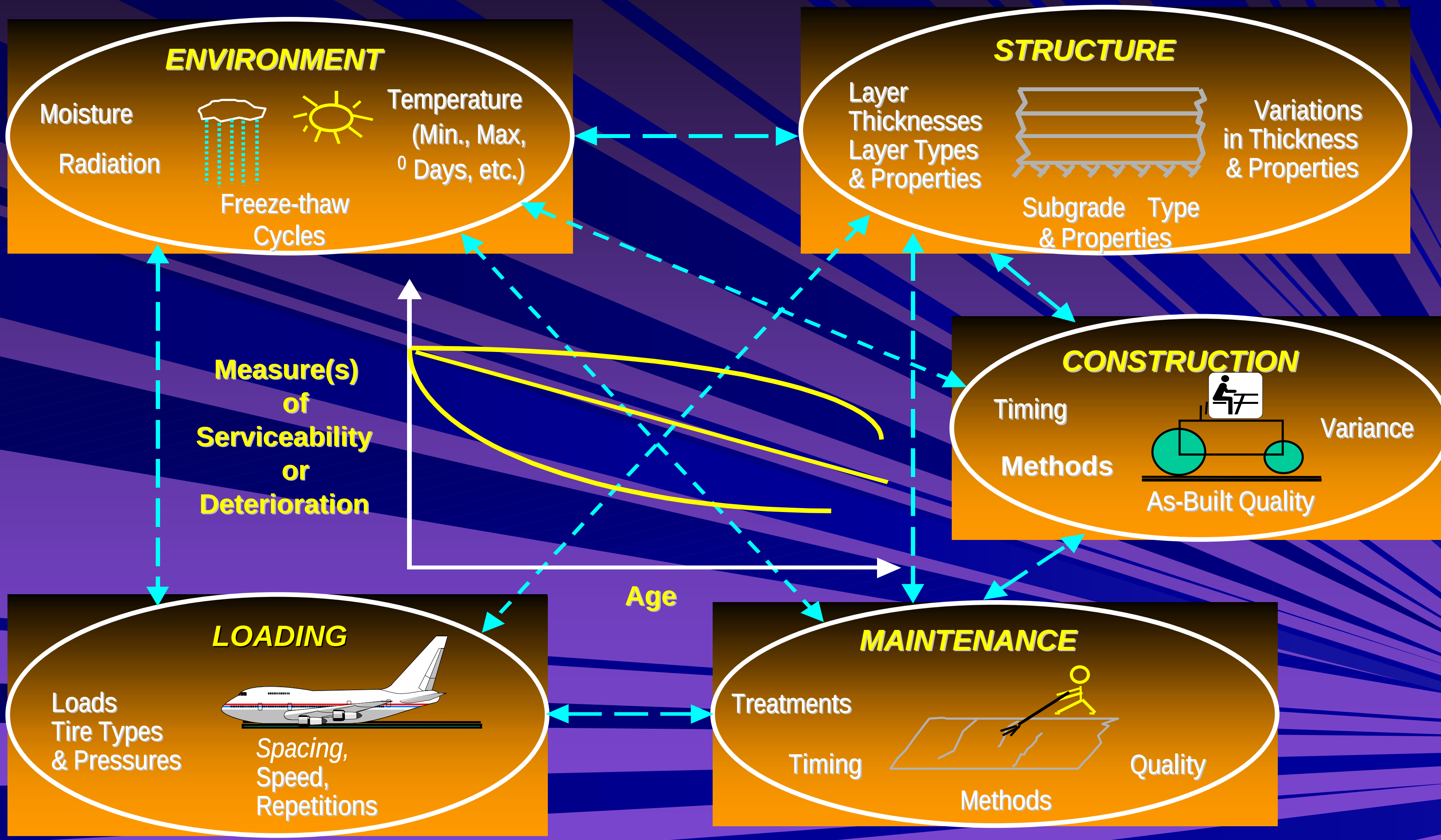


Design Aircraft?

Introduction



Introduction

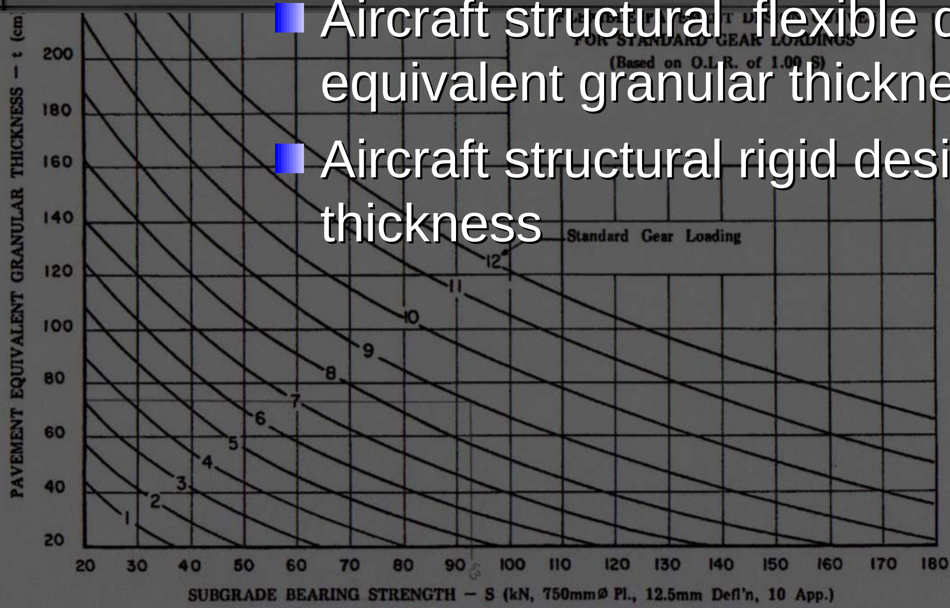


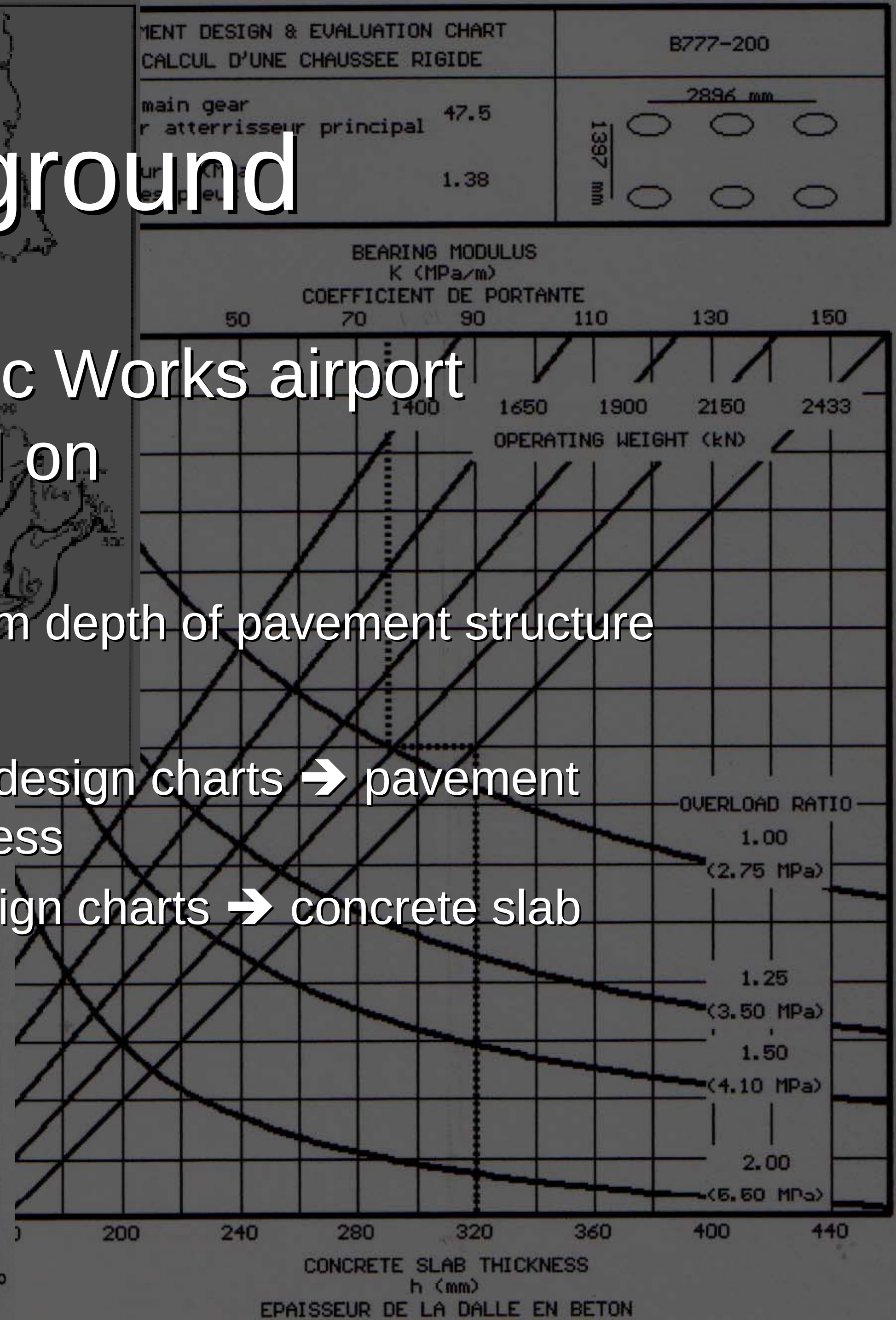
Flexible Design Methods

- Transport Canada (TC)
- Federal Aviation Administration (FAA) CBR Method
- FAA Layered Elastic Design (LEDFAA)
- Asphalt Institute SW-1
- Australian Airport Pavement Structural Design System (APSDS)

Background

- Transport Canada/Public Works airport pavement design based on
  - Frost protection
    - Freezing Index ➔ minimum depth of pavement structure
  - Gear loading
    - Aircraft structural flexible design charts ➔ pavement equivalent granular thickness
    - Aircraft structural rigid design charts ➔ concrete slab thickness





ASG-19, TC/PW

INPUTS

- Freezing Index
- Subgrade bearing strength/surface bearing modulus
- Aircraft (weight, tire pressure, % on main gear)

OUTPUTS

- FLEXIBLE: Pavement equivalent granular thickness, t

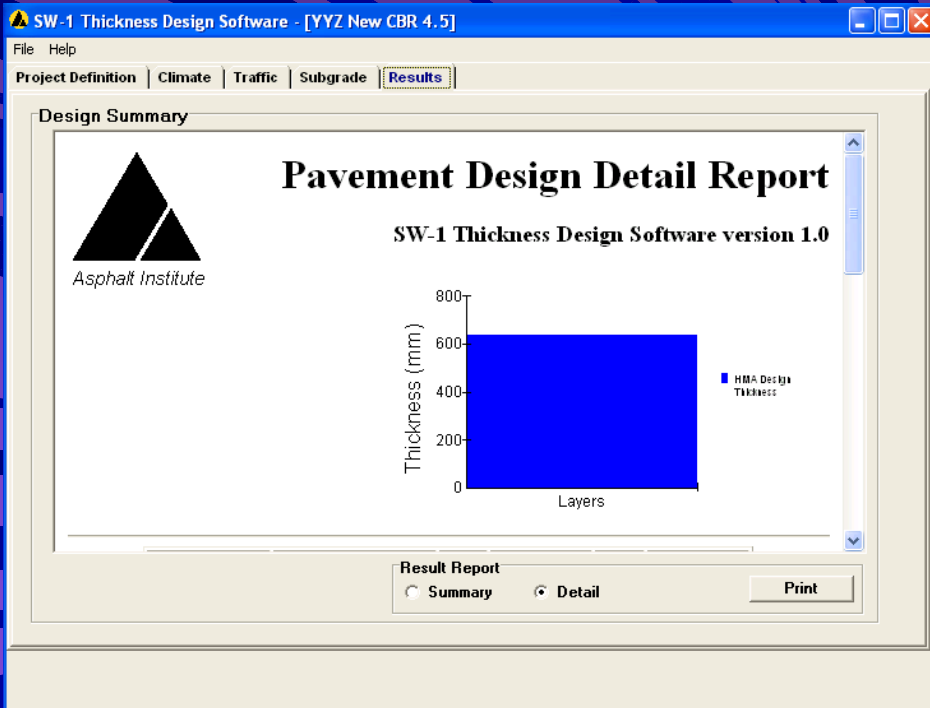
SW-1, Asphalt Institute

INPUTS

- Mean annual air temperature
- Aircraft type
- Movements in design period
- Subgrade strength measure

OUTPUTS

- Required thickness of new HMA pavement



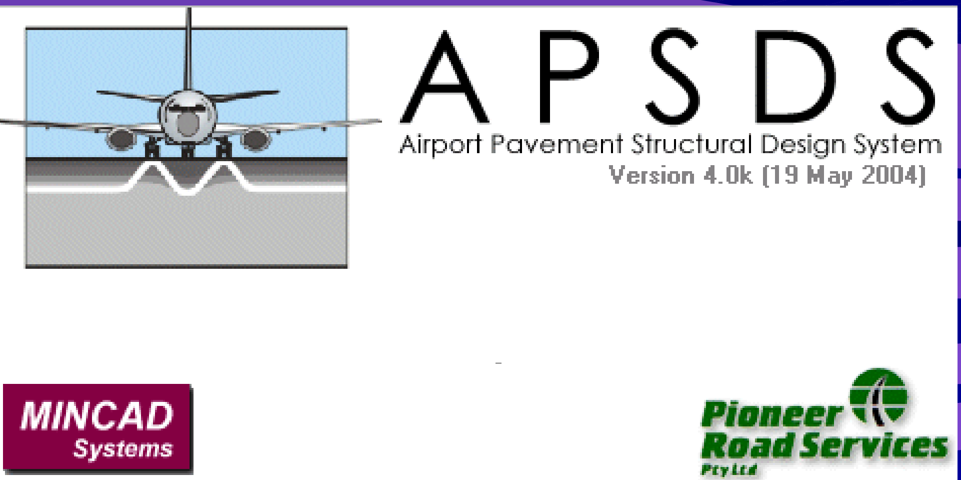
APSDS, MINCAD (Australia)

INPUTS

- Traffic
- Wander statistics
- Layered system (material, thickness and strength)

OUTPUTS

- Material type (asphalt vs. subgrade)
- Maximum damage values (damage factor & critical strain) for each aircraft
- Maximum of total damage



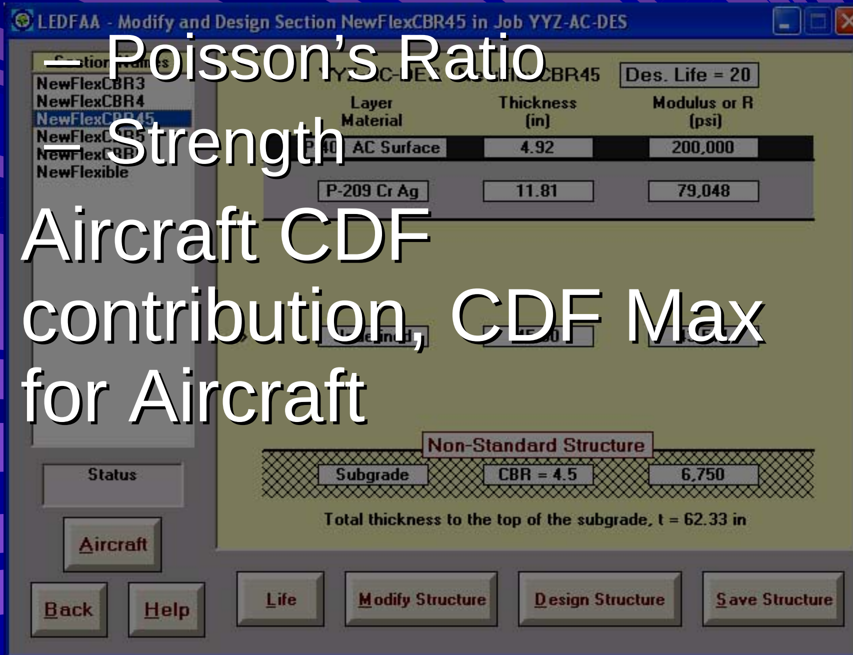
LEDFAA , FAA

INPUTS

- Pavement structure properties
  - Layer material
  - Layer thickness
  - Layer strength
- Aircraft properties
  - gross taxi weight
  - annual departures
  - % annual growth

OUTPUTS

- Surface, base, subbase, subgrade
  - Thickness
  - Modulus
  - Poisson’s Ratio
  - Strength
- Aircraft CDF contribution, CDF Max for Aircraft

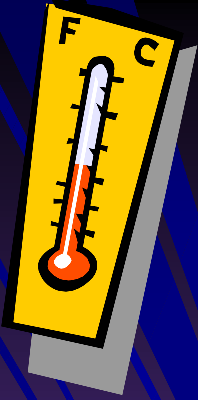


Equivalent Granular Thickness

- Granular Base Equivalency (GBE) is a measure expressing the contribution of each pavement component of an equivalent thickness of granular base

Component	Thickness (mm)	GBE
Asphalt concrete	100	100 x 2 = 200
Crushed base	250	250 x 1 = 250
Granular base	500	500 x 1 = 500
Total thickness	850	EGT = 950

TAC, 1997

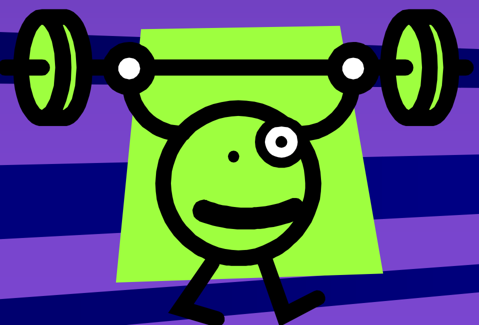


Design Method Inputs

Design Method	Climate	Traffic	Subgrade Strength
TC	X*	X[1,2]	X
FAA	X*	X[2]	X
LEDFAA		X	X
SW-1	X**	X[2]	X
APSDS		X	X

*** Freezing Index   ** Mean Average Air Temperature**

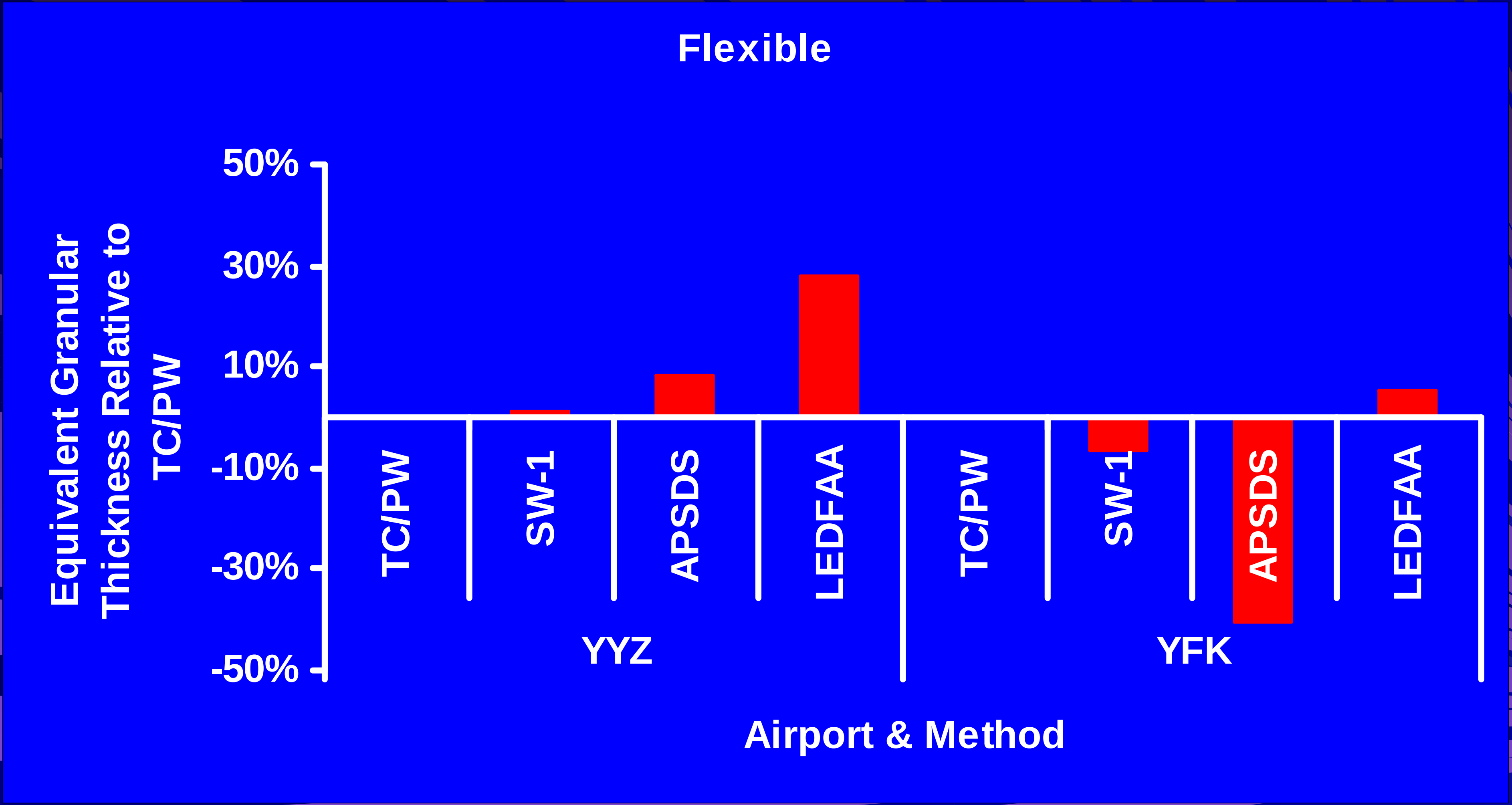
[1] No volume consideration   [2] Design aircraft concept



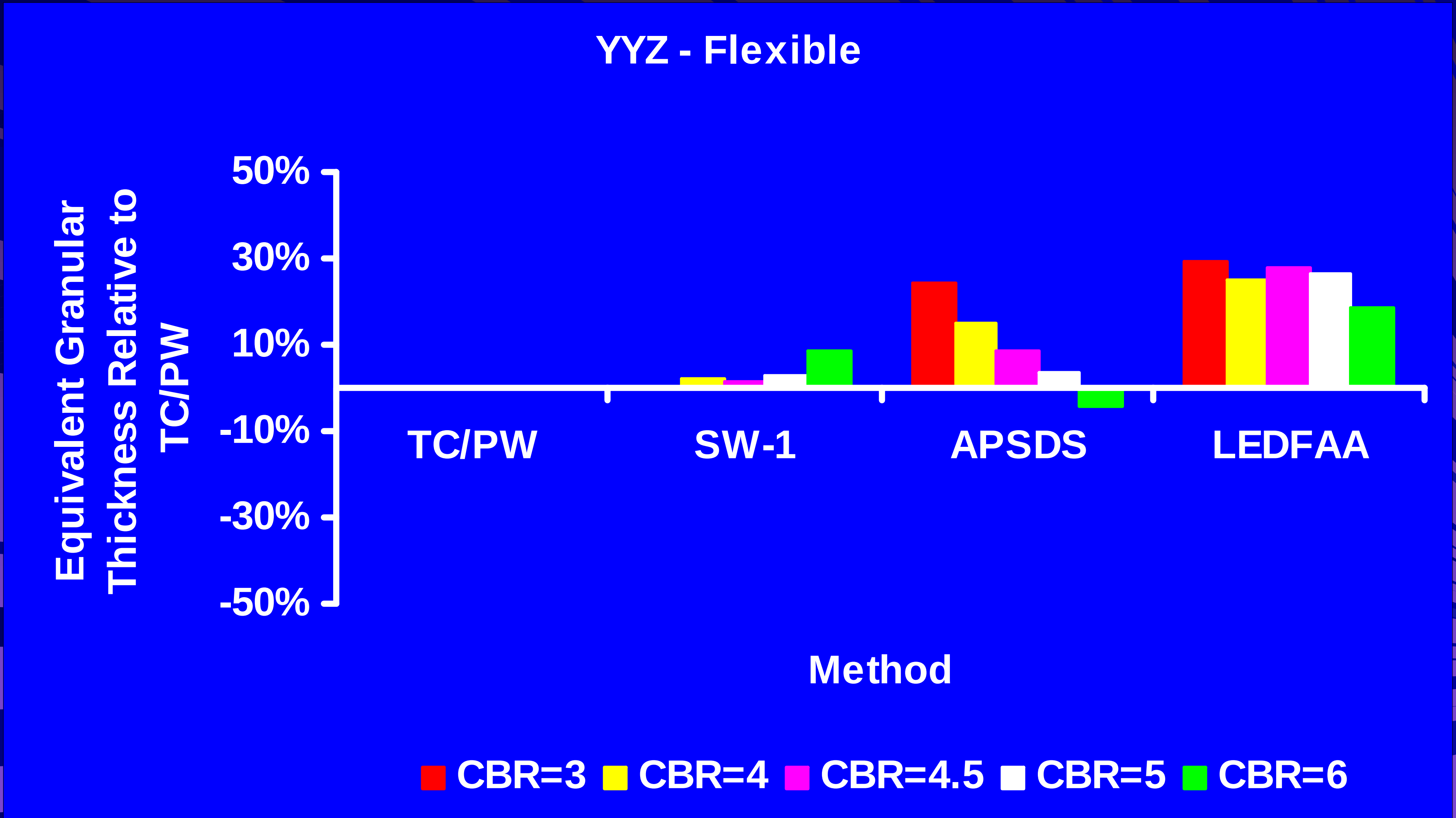
Design Inputs

Design Inputs		Airport	
		Toronto (YYZ)	Waterloo (YKF)
Climate	FI (^{o}C-days)	598	711
	MAAT (^{o}C)	10	7.2
Traffic	Aircraft	A330-300, A340-300, A340-500/600, B747-400, B777-200ER, B777-200LR, B777-300ER, L-1011-500 MD-11	A320-200, BAe-146-100, Challenger, Dash 8, Cessna 152, 172, 210, 650, Convair 440, Falcon, DC-4, Gulfstream, Learjet, Piper Seminole, Saab 340
Material Layers	Surface	125 mm AC	100 mm AC
	Base	300 mm Granular A	300 mm Granular A
	Subbase	900 mm Granular B	340 mm Granular B
	Subgrade	CBR=4.5, S=77.75	CBR=4.5, S=77.75

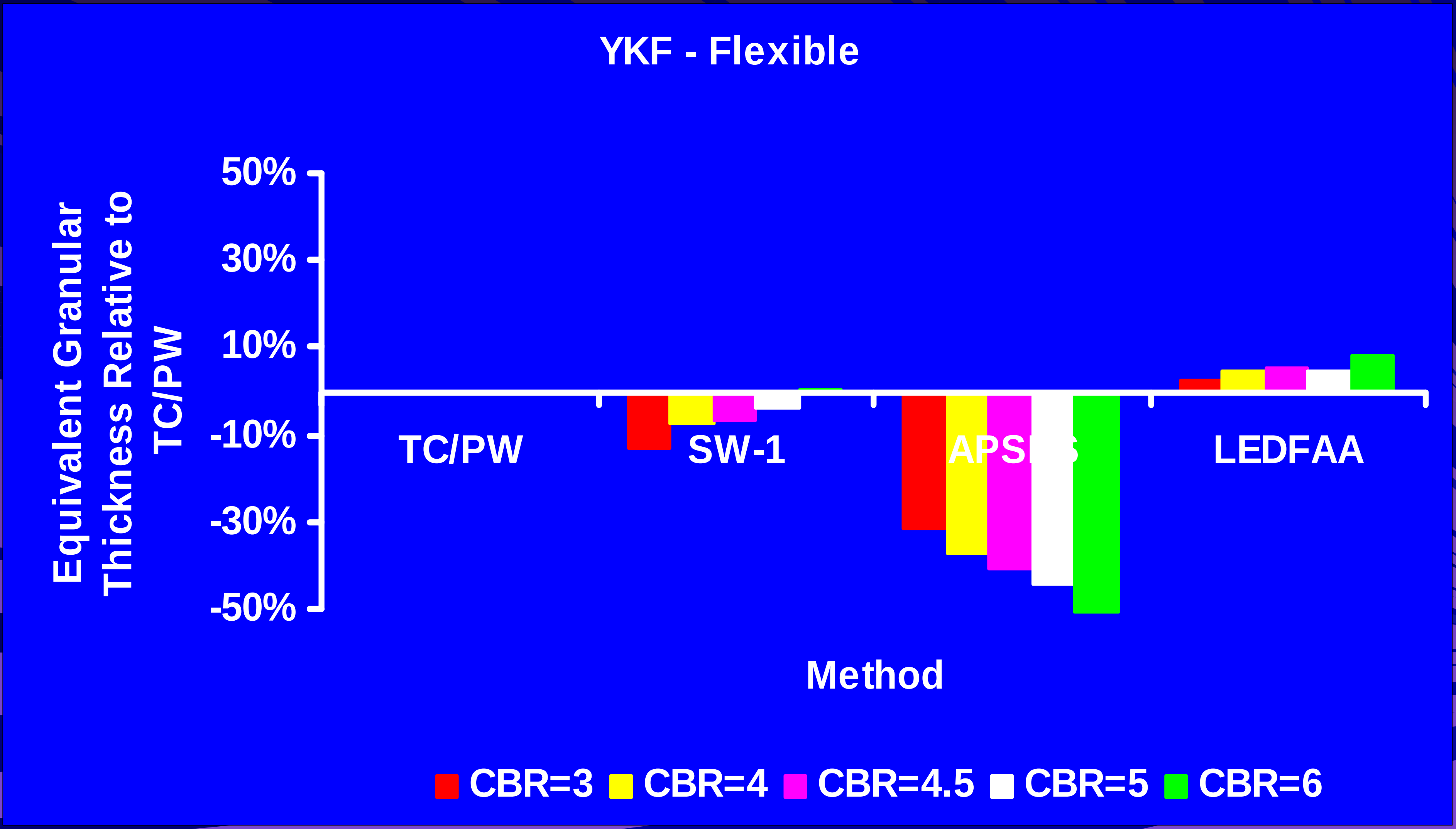
Flexible


Flexible
50%
30%
10%
-10%
-30%
-50%
Equivalent Granular Thickness Relative to TC/PW
TC/PW
SW-1
APSDS
LEDFAA
TC/PW
SW-1
APSDS
LEDFAA
YYZ
YFK
Airport & Method

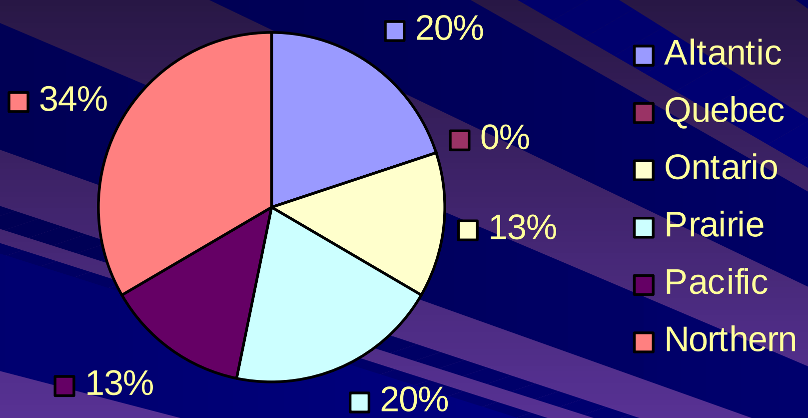
Toronto (YYZ) - Flexible



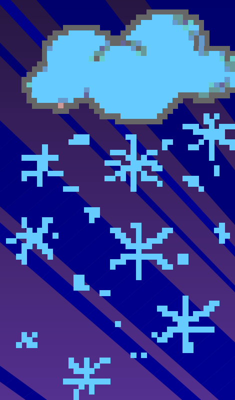
Waterloo (YKF) - Flexible

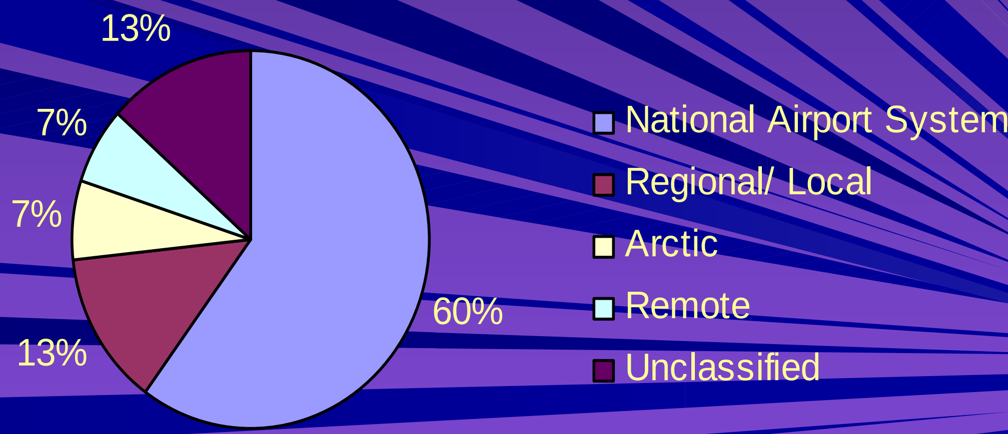


Sources of Data



Airport Region

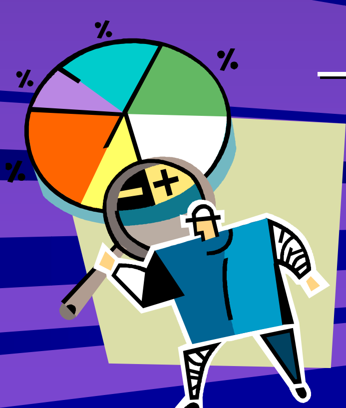




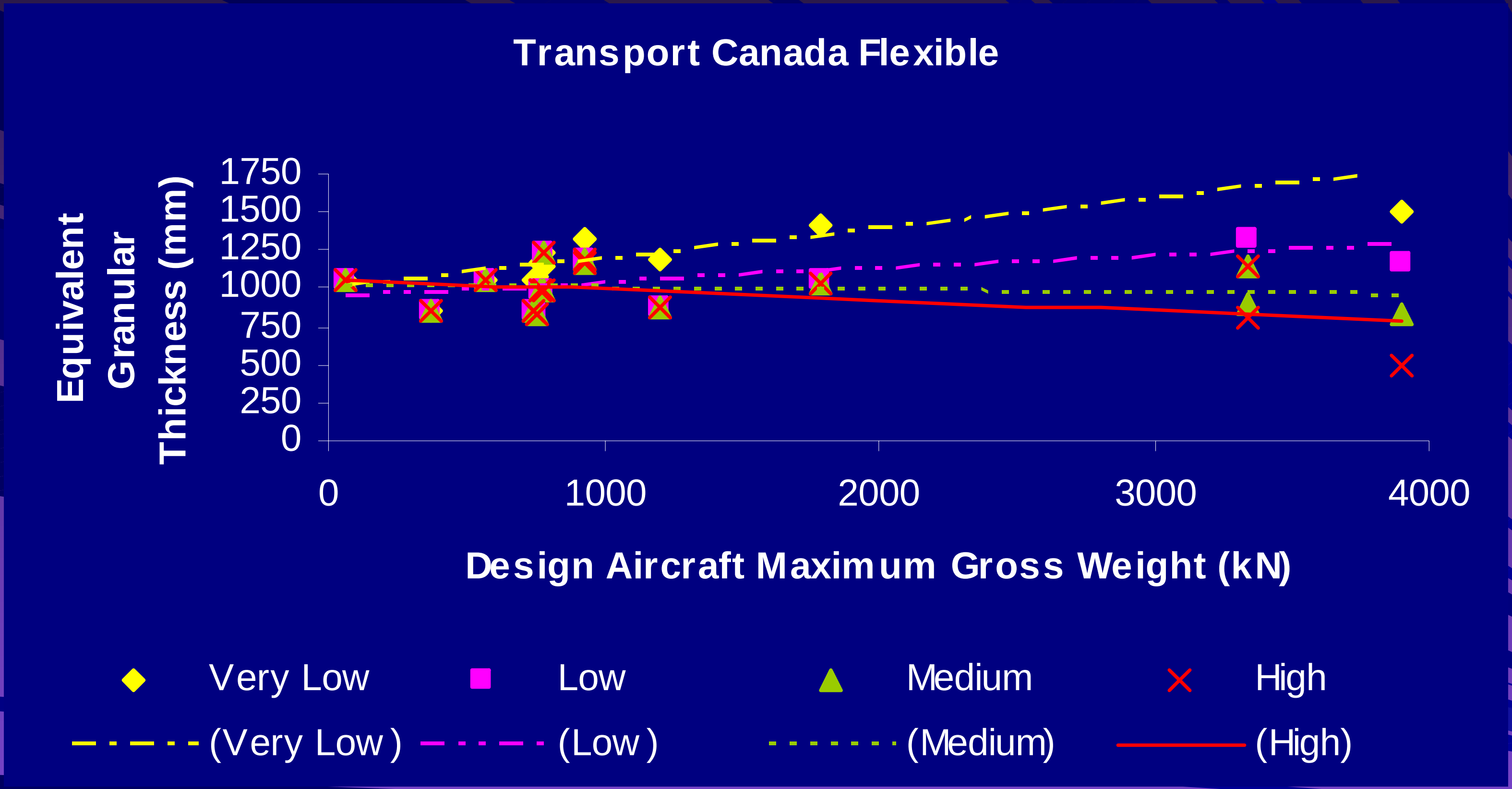
Airport Type

Within Program Sensitivity Analysis

- Subgrade Strength
  - California Bearing Strength (CBR)
- Climate
  - Freezing Index (FI)
  - Mean Annual Average Temperature (MAAT)
- Traffic
  - Aircraft Characteristics
    - Maximum Gross Weight (MGW)
    - Maximum Take-Off Weight (MTOW)
    - Wheel Load
    - Tire Contact Area
  - Aircraft Volume (% annual growth)



Sample sensitivity analysis EGT vs. MGW for TC flexible



Asphalt Cement = 2 GBE Granular Base = 1 GBE

GBE=Granular Base Equivalency

Between Program Data Analysis

- Variation significance
- Airport specific thickness vs. design method analysis
- Airport specific design method relative comparison

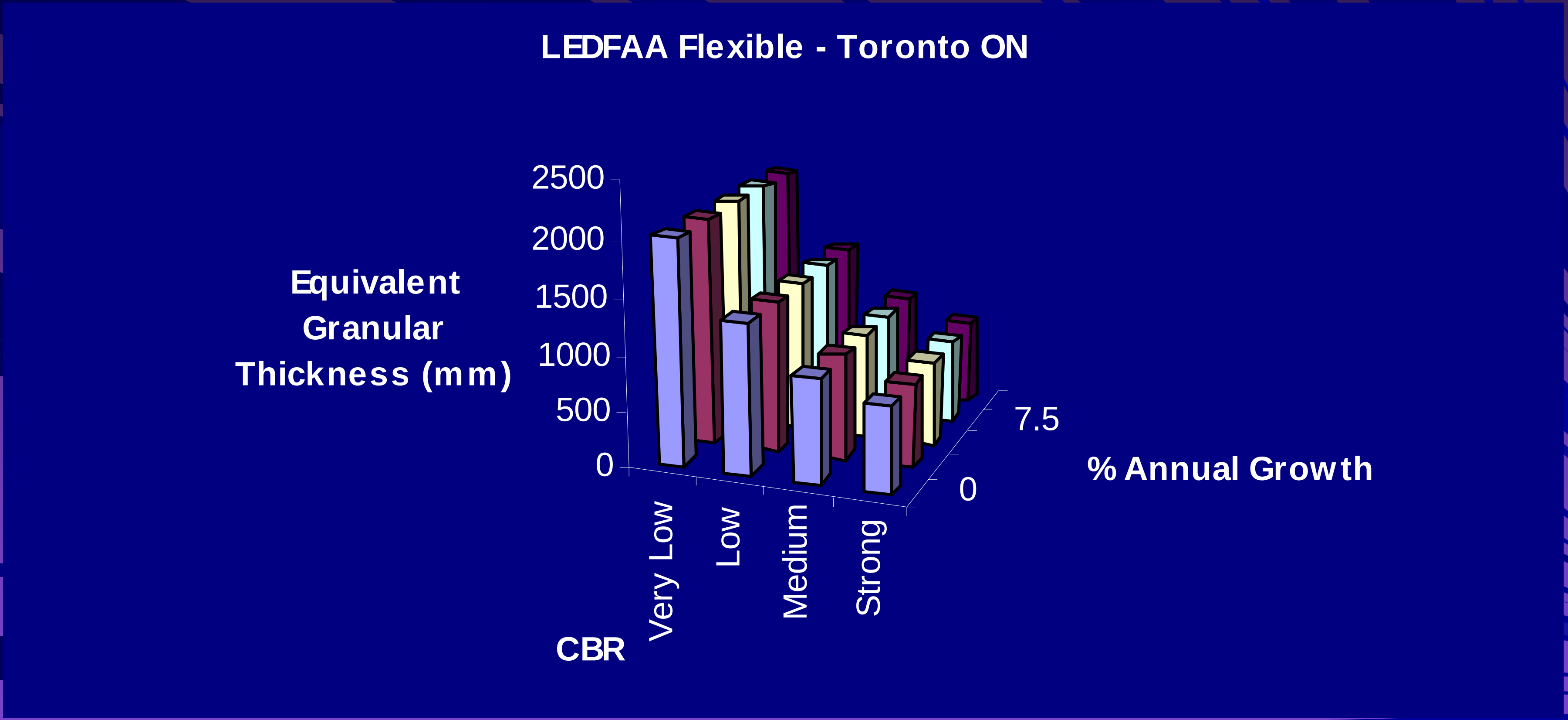
Sample – Variation Significance

Flexible EGT TC vs.	Method Variability Significance
TCNF	✓
FAA	✗
LEDFAA	✓
FEDFAA	✓
SW-1	✓
APSDS	✗

✓ denotes significant variability at a 95% confidence level

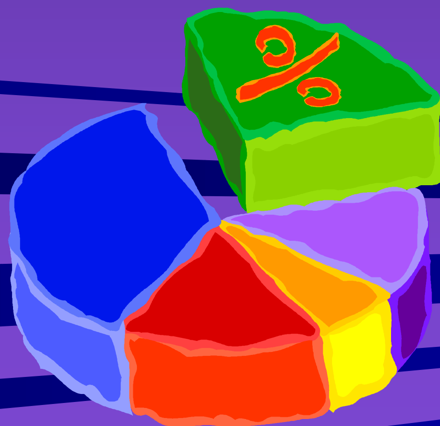
✗ denotes no significant variability at a 95% confidence level

Sample – Airport vs. Design Method



Between Program Flexible Results

- Subgrade strength & annual growth
  ➔ statistically significant
- Change in subgrade strength more significant than an ⬆ in traffic of up to 10%
- TC with frost protection & FAA with stabilized base
  ➔ most conservative flexible pavement structure
- LEDFAA & FAA with stabilized base most closely relate to TC flexible design output



Conclusions

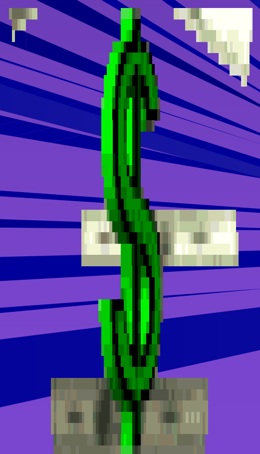
- Layer thicknesses increase as CBR values decrease
- SW-1 & APSDS are generally more conservative for large airports than TC/PW
- SW-1 & APSDS are less conservative for small airports than TC/PW

Conclusions

- The FAA flexible pavement thickness increases dramatically once the subgrade is reduced to a CBR of 6 (weak subgrade strength)
- FAA flexible = f (design aircraft maximum gross weight)
- LEDFAA, FEDFAA, SW-1, APSDS more sensitive to subgrade (vs. traffic)

Recommendations

- Geometric design analysis
  - impact on pavement design and performance
- Comparison new design methods (FAARFIELD)
- New state-of-the art designs do not necessarily account for the climatic conditions experienced in Canada
- Incorporate economic analysis into the design and planning stage



Thank you/ Merci

Questions?

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