Performance Graded Asphalt Cements for Airfield Pavements

by

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CAPTG Workshop SWIFT Annual Conference
Calgary Alberta, September 16, 2007

HUSKY ASPHALT

Black Max™
POLYMER MODIFIED ASPHALT

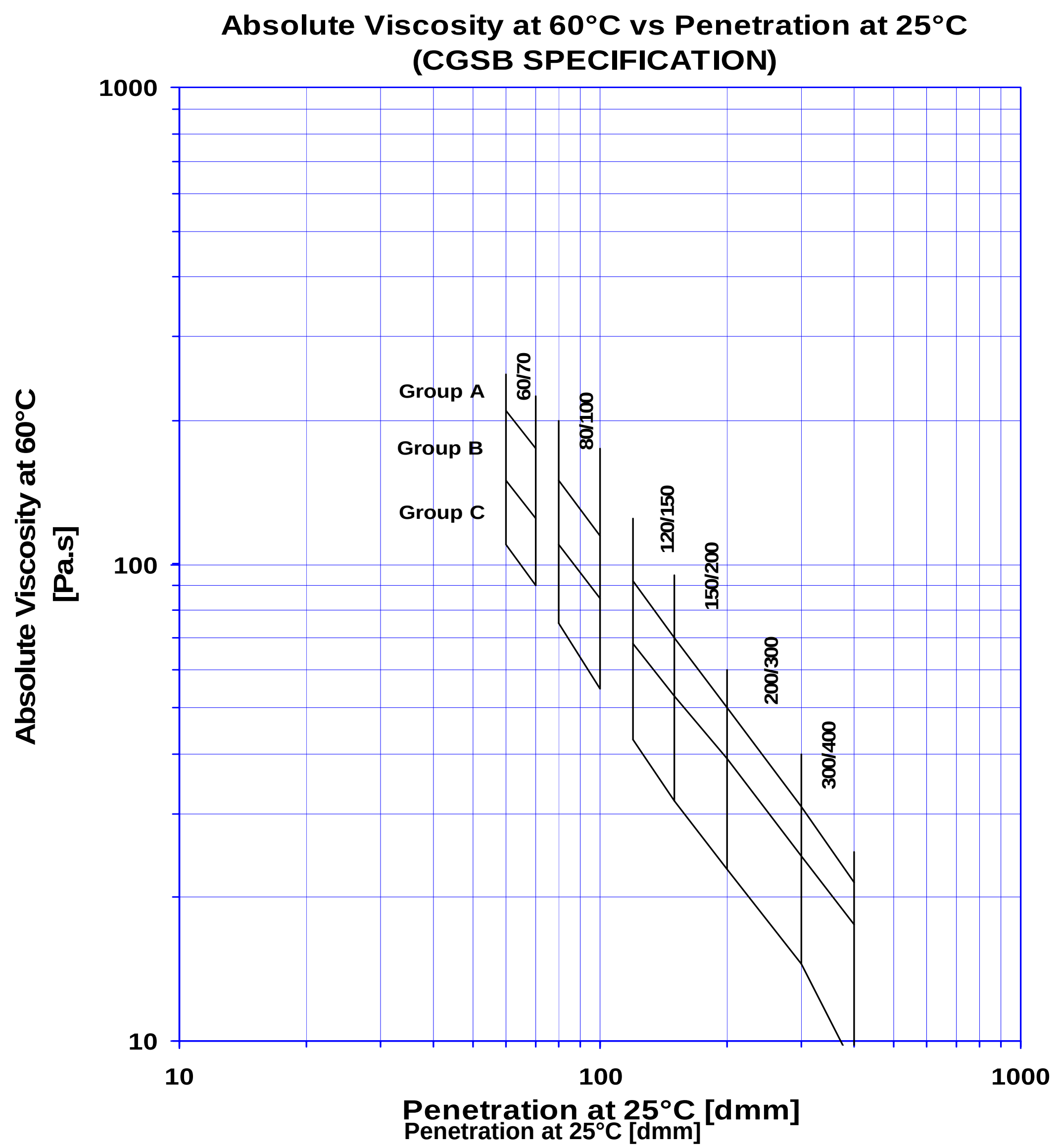
Properties of Asphalt

- Critical conditions during construction and service
  - Construction:
    - mixing
    - spreading ↓ appropriate viscosity
    - compacting
  - Service:
    - plastic deformation (rutting)
    - thermal cracking
    - fatigue cracking

Specifications of Paving Asphalts

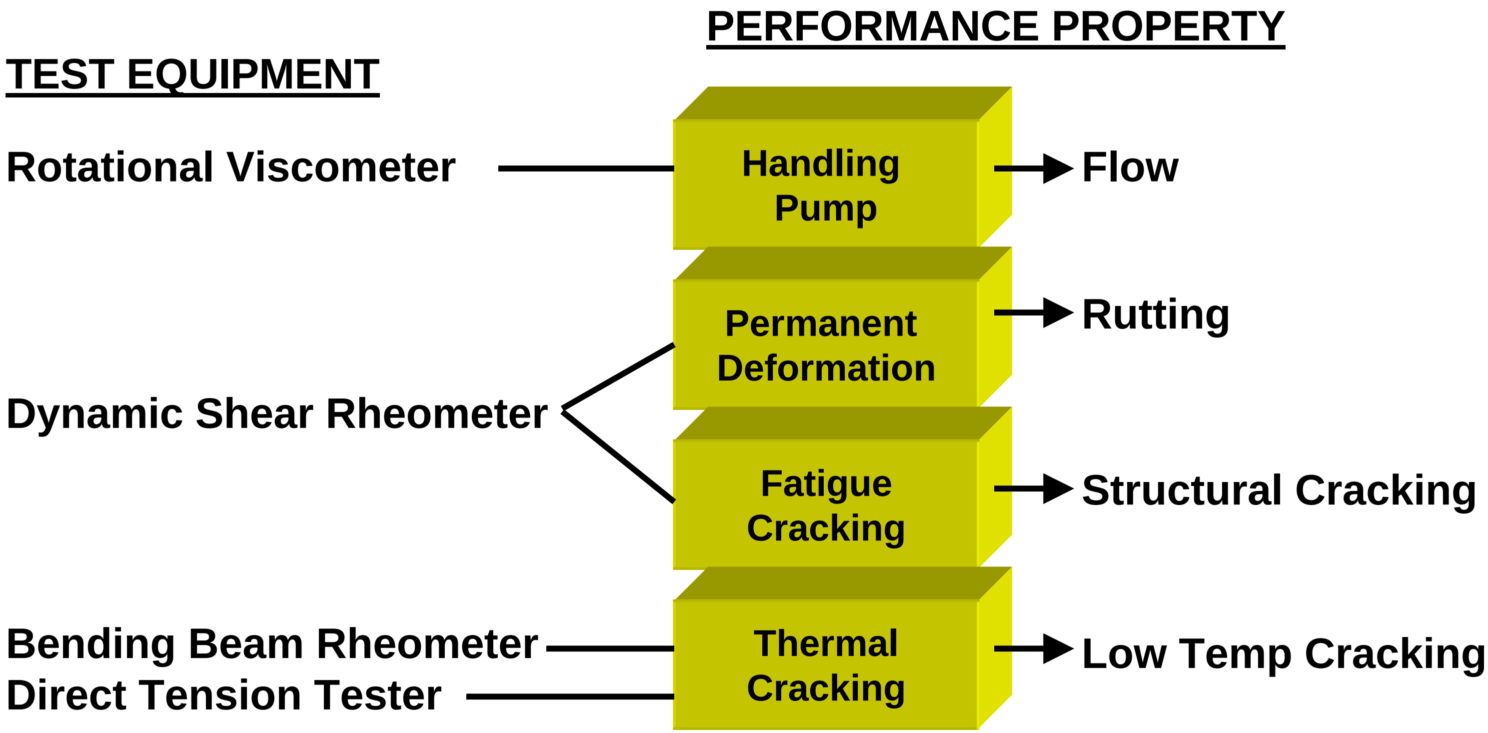
- The role of specifications:
  - specify properties that directly reflect asphalt behaviour
  - express these properties in physical units
  - provide information from which the service performance can be predicted
  - establish limits for those properties to exclude poor performing products

Canadian Federal Specification



Superpave PG Specification

- Superpave specification attempts to measure properties that are directly related to pavement field performance



Superpave PG Specification

- Strategic Highway Research Program (SHRP)
  - $50 million research 1987 through to 1993
  - Development of related products and technologies
    - Superpave continues to be administered by the FHWA today
- Federal Aviation Administration 1994
  - Evaluation began with a draft specification in December 1999 (NCAT review)
  - AASHTO provisional guidance for PG grade bumping was provided by AI

Superpave PG Specification

- ITEM P-401 Plant Mix Bituminous Pavements (Superpave) Interm specification)
  - Gross aircraft weights
  - Taxiways / aprons pavements
- Unified Facilities Guide Specification UFSG-02749 March 2002
  - Aircraft tire pressure

Superpave Asphalt Binder Specification

PG 58 - 31

Performance Grade

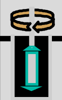
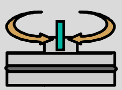
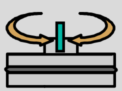
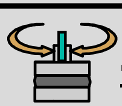
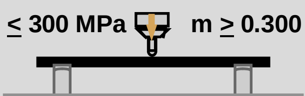
Maximum pavement temperature

Min pavement temperature

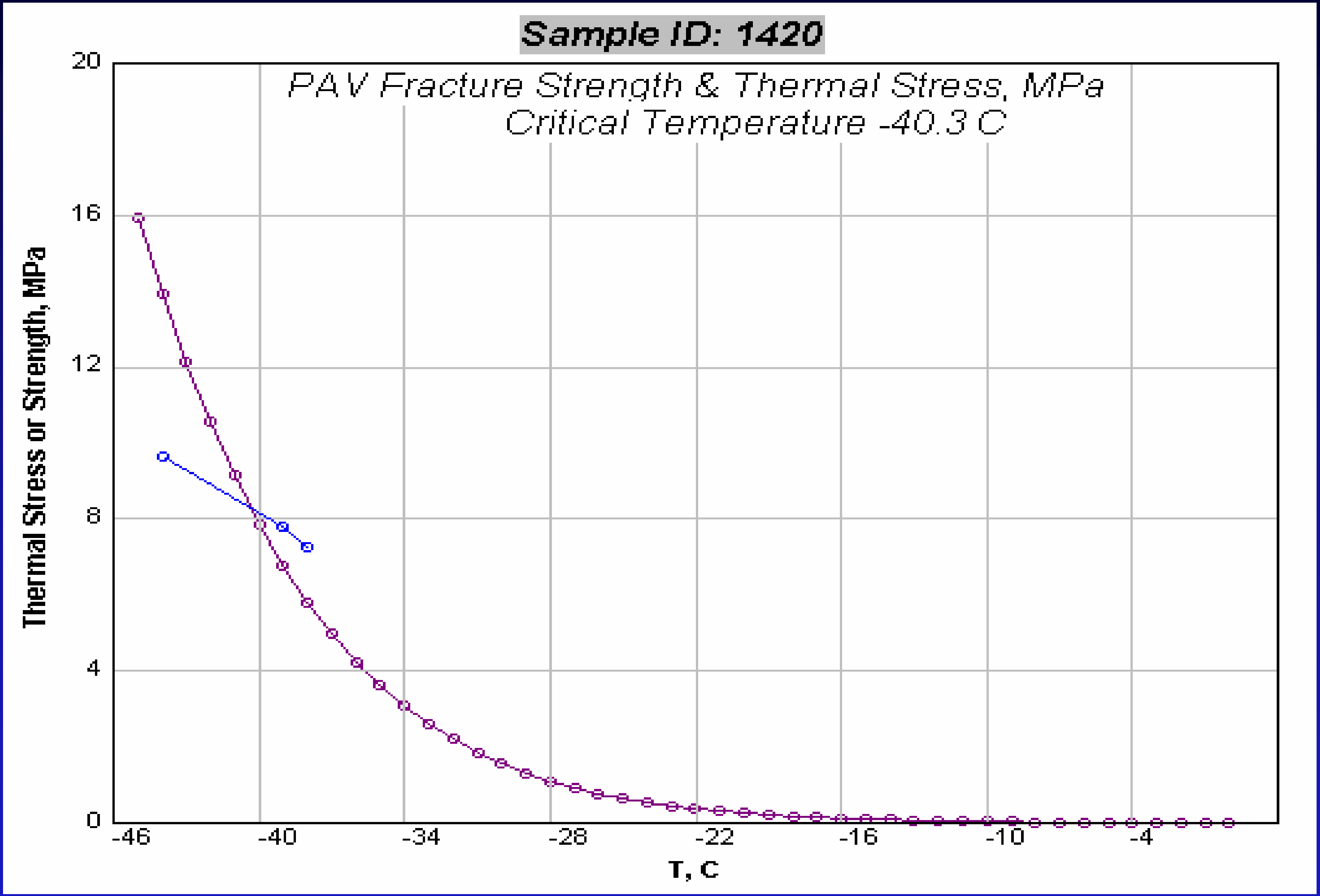
Performance Grade Specifications

– PGAC specifications explicitly quantify the binder performance at actual in-service pavement temperatures
– PGAC specifications explicitly consider the in-service aging characteristics of the binder once it is placed in the pavement
– PGAC specifications contain formal protocols for addressing in-service traffic conditions (+ FAA recommendations for airfield pavements)
– PGAC specifications explicitly accommodate the concept of reliability
– PGAC specifications can be used to specify (high performance) modified binder systems

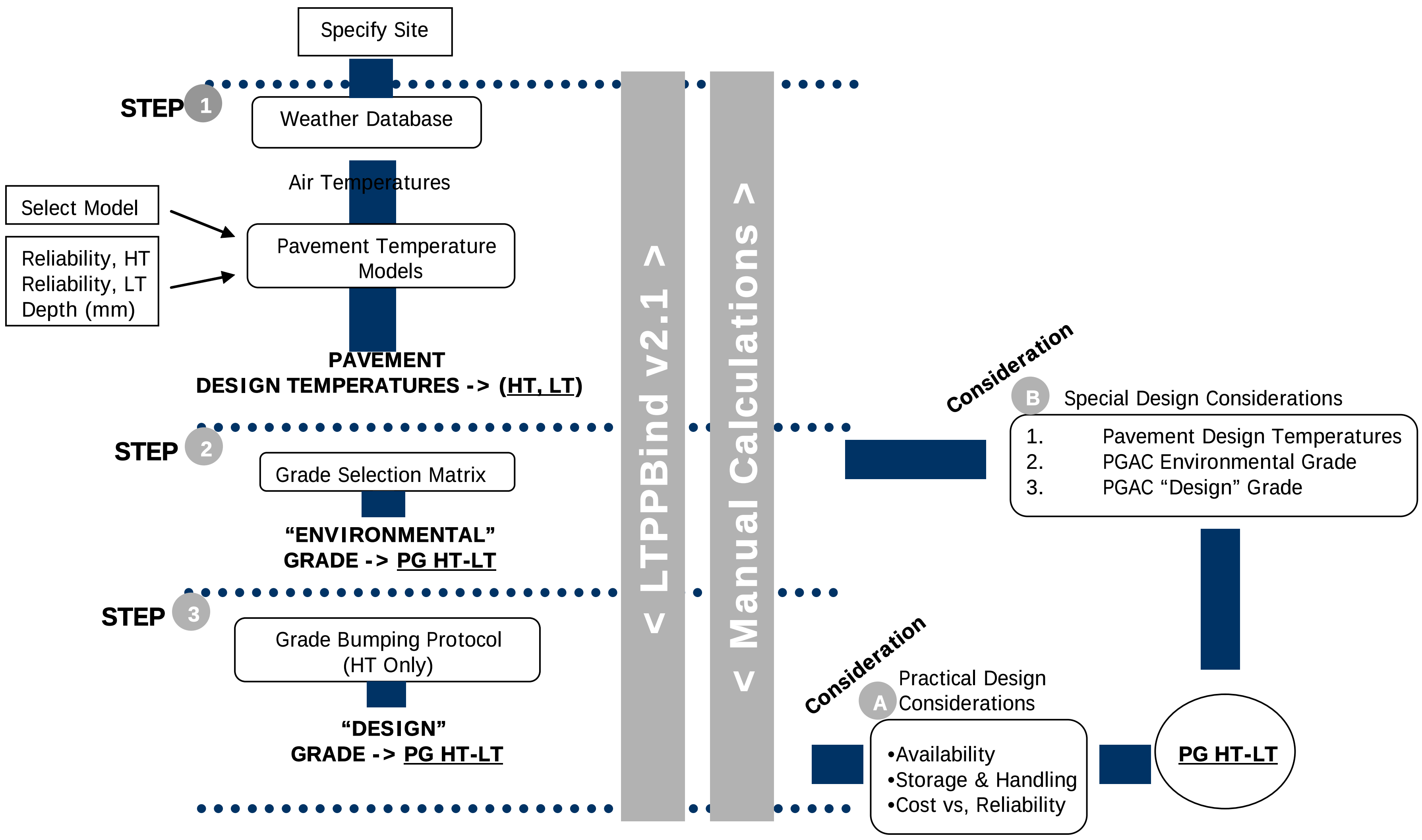
Performance Grades

Avg 7-day Max, °C	PG 46	PG 52	PG 58	PG 64	PG 70	PG 76	PG 82
1-day Min, °C	-34 -40 -46 (-28 -34)	-10 -16 -22 -28 -34 -40	-46 -16 -22 -28 -34	-40 -10 -16 -22 -28 -34	-40 -10 -16 -22 -28 -34	-40 -10 -16 -22 -28 -34	-10 -16 -22
ORIGINAL							
 $\geq$ 230 °C	(Flash Point) **FP**						
$\leq$ 3 Pa·s @ 135 °C	(Rotational Viscosity) **RV**						
 $\geq$ 1.00 kPa	(Dynamic Shear Rheometer) **DSR** G*/sin δ						
	46	52	58	64	70	76	82
(ROLLING THIN FILM OVEN) RTFO Mass Loss $\leq$ 1.00 %							
 $\geq$ 2.20 kPa	(Dynamic Shear Rheometer) **DSR** G*/sin δ						
	46	52	58	64	70	76	82
(PRESSURE AGING VESSEL) PAV							
20 Hours, 2.07 MPa	90	90 100	100	100 (110)	100 (110)	110 (110)	
 $\leq$ 5000 kPa	(Dynamic Shear Rheometer) **DSR** G* sin δ						
	10 7 4 25 22 19 16 13 10 7 25 22 19 16 13 31 28 25 22 19 16 34 31 28 25 22 19 37 34 31 28 25 40 37 34 28 31						
S $\leq$ 300 MPa  m $\geq$ 0.300	(Bending Beam Rheometer) **BBR** "S" Stiffness & "m"- value						
	-24 -30 -36 0 -6 -12 -18 -24 -30 -36 -6 -12 -18 -24 -30 0 -6 -12 -18 -24 -30 0 -6 -12 -18 -24 -30 0 -6 -12 -18 -24 0 -6 -12 - (-18 -24)						
Report Value	(Bending Beam Rheometer) **BBR** Physical Hardening						
$\geq$ 1.00 % 	(Direct Tension) **DT**						
	-24 -30 -36 0 -6 -12 -18 -24 -30 -36 -6 -12 -18 -24 -30 0 -6 -12 -18 -24 -30 0 -6 -12 -18 -24 -30 0 -6 -12 -18 -24 0 -6 -12 (-18 -24)						

Low Temperature Cracking M320-05
Table 2



PGAC Selection Process



Determining Pavement Design Temperatures

- Starting with the Climatic Data

- It is important for practitioners to:
- look at several sites near your design location,
- understand the nature of the weather data for each site, and
- apply proper engineering judgment as to which data set(s) are most applicable to your specific design situation.

"The best weather station may not necessarily be the closest weather station"

Determining Pavement Design Temperatures

- For each weather station
- LTPPBind 2.1:
  - the hottest seven-day period was identified and the average maximum air temperature (for this seven-day period) was computed and used to define the hot temperature design condition, and
  - the one-day minimum air temperature was used to define the cold temperature design condition.

Determining Pavement Design Temperatures

- For each weather station
- LTPPBind 3.1:
  - PG grade (high temperature) is based on rutting damage model
  - Based on a Degree-Days concept
    - Average yearly Degree-Days air temperature over 10 C (50% Reliability)
      - Average 7 Day Maximum Temperatures vs DD
  - PG variability with latitude
  - PG grade is adjusted for higher reliability

Determining Pavement Design Temperatures

	Temperature	Description	Overall Quality	Reference
SHRP Model	Low Temperature	The original low temperature algorithm encoded in the SHRPBind program (predecessor of LTPPBind). Surface pavement temperature was assumed to be equal to air temperature.	Poor	LTPPBind V2.1, July 1999
SHRP Model	High Temperature	The original low temperature algorithm encoded in the SHRPbind program (predecessor of LTPPBind). Pavement surface temperature is based upon net heat flow at the pavement surface. Net heat flow - [direct solar radiation] + [diffuse radiation]¤[convection]¤[conduction]-[black body radiation]	Better	LTPPBind V2.1, July 1999
LTPP Model	Low Temperature	Empirical derived from LTPP data and coded into the new LTTPBind program. Relates pavement temperature to air temperature, latitude, and depth.	Better	LTPPBind V2.1, July 1999
LTPP Model	High Temperature	Empirical derived from LTPP data and coded into the new LTTPBind program. Relates pavement temperature to air temperature, latitude, and depth.	Best	LTPPBind V2.1, July 1999
Revised TAC Model	Low Temperature	Developed by the Transportation Association of Canada (TAC). Empirical model based on detail regression analysis of insitu temperature data taken from eight Canadian sites.	Best	TAC, Technical Brief#15, October 1998

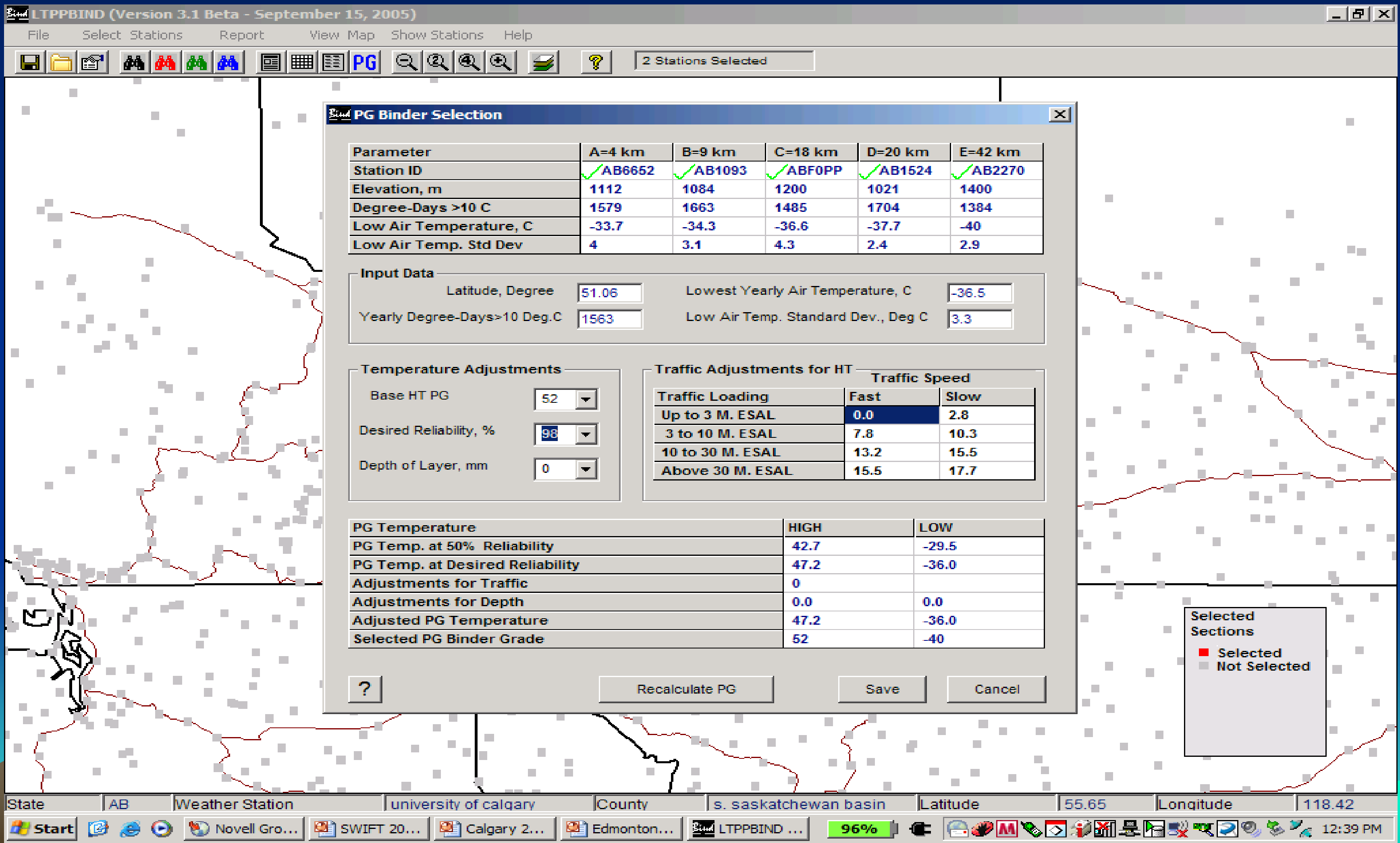
Determining Pavement Design Temperatures

- Converting Climate Data into Pavement Temperatures
  - Most practioners in Canada support the use of the LTPP High Pavement Temperature Model coded into LTPPBind V2.1, July 1999
    - More conservative than the SHRP High Pavement Temperature model
  - Most practioners in Canada support the use of the Revised Low Pavement Temperature Model in TAC Technical Brief #15, October 1998
    - Superior correlation to observed field measurements at select Canadian sites
  - LTPPBind 2.1 does not support the TAC model
  - LTPPBind 2.1 has aggressive grade bumping protocols (KMC,SHRP)

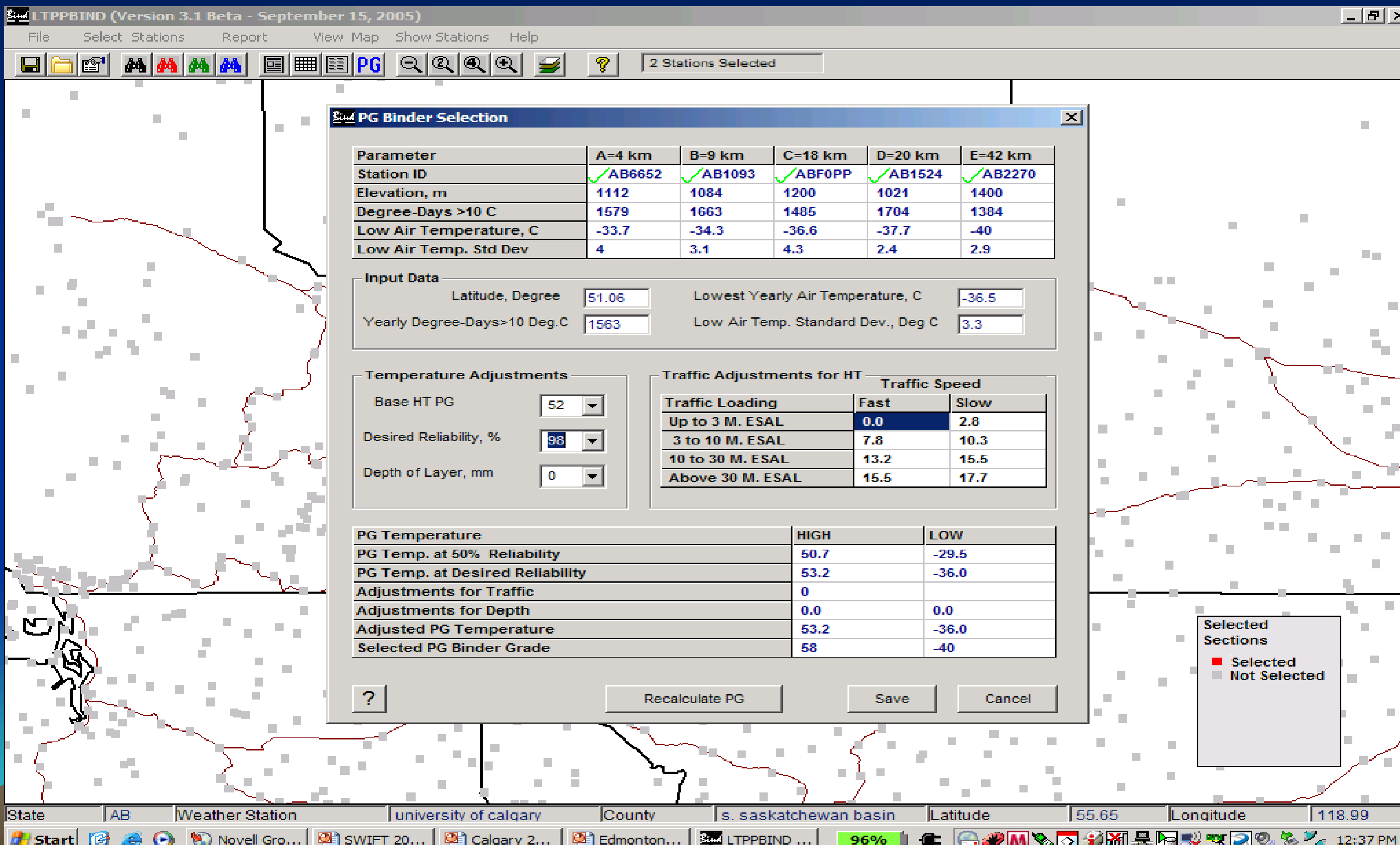
Determining Pavement Design Temperatures

- Converting Climate Data into Pavement Temperatures
  - LTPPBind 3.1
  - PG high temperature grade
  - Based on acceptable rut depth (12.5 mm standard)
  - Decreasing acceptable rut depth increases high temperature grade
  - Compare acceptable rut depth from 12.5 mm to 8.5 mm

Determining Pavement Design Temperatures



Determining Pavement Design Temperatures



Determining Pavement Design Temperatures

- Specifying Reliability– Explicitly Considering Risk
  - Reliability is defined as the percent probability, in a single year, that the actual temperature (one day low or high temperature) will not exceed the design temperature

"A higher level of reliability means a lower level of risk"

Determining Pavement Design Temperatures

- Specifying Reliability – Explicitly Considering Risk
  - Level of reliability is a function of the application
    - Is this a major highway or low volume road?
    - Is this a runway or taxiway/apron?
    - What is the implication of a failure?
      - Not good for a runway
    - Reliability must be consistent with Owner Agency policy.
  - Reliability of the high temperature grade can be different for the low temperature
  - Consider a high level of reliability (99%) on the high temperature
    - Rutting leading to safety issues i.e. Hydroplaning

Determining Pavement Design Temperatures

- Specifying Reliability – Explicitly Considering Risk
  - Consider support for a moderate level (90%) for low pavement temperature (overlays)
    - Failure modes like cracking are a performance cost/ issue and therefore must be set within the context of life cycle cost considerations.
  - Consider using 99% reliability on the high temperature and 90% reliability for the low temperature then adjust your reliability thresholds to be consistent with Owner/Agency policy and suit your site specific design requirements and project economics

Determining PGAC Environmental Grade

Typical Environmental Performance Grades for various cities across western Canada

Station ID	Prov	Weather Station Name	LTPP High Temp (°C)	TAC Low Temp (°C)	Environment Performance Grade	
		Reliability =	99%	90%		
5050960	MB	FLIN FLON A	51.1	-34.1	PG 52-34	a
5040680	MB	DAUPHIN A	53.5	-31.4	PG 58-31	a
5023222	MB	WINNIPEG INT'L A	54.6	-31.0	PG 58-31	
5020880	MB	EMERSON	55.3	-31.1	PG 58-31	a
5020320	MB	BOISSEVAIN	54.1	-31.3	PG 58-31	a
5010485	MB	BRANDON CDA	55.1	-33.9	PG 58-34	
4057120	SK	SASKATOON A	53.9	-34.5	PG 58-34	a
4056240	SK	PRINCE ALBERT A	52.5	-35.9	PG 52-37	b
4045600	SK	NORTH BATTLEFORD A	52.8	-33.5	PG 58-34	
4028040	SK	SWIFT CURRENT A	54.5	-31.4	PG 58-31	a
4016560	SK	REGINA A	55.2	-34.4	PG 58-34	a
3072920	AB	GRANDE PRAIRIE A	50.4	-36.3	PG 52-37	
3050520	AB	BANFF	52.0	-33.9	PG 52-34	
3034480	AB	MEDICINE HAT A	56.8	-33.3	PG 58-34	
3033880	AB	LETHBRIDGE A	54.9	-31.0	PG 58-31	
3031100	AB	CALGARY INT'L A	53.0	-31.1	PG 58-31	a
3012208	AB	EDMONTON MUNICIPAL A	51.3	-31.7	PG 52-34	
1123970	BC	KELOWNA A	56.9	-24.6	PG 58-28	c
1108447	BC	VANCOUVER INT'L A	50.3	-12.1	PG 58-22	c
1096450	BC	PRINCE GEORGE A	51.2	-34.8	PG 52-37	
1066481	BC	PRINCE RUPERT A	44.2	-17.4	PG 58-22	c
1025370	BC	NANAIMO A	54.3	-13.7	PG 58-22	c
1018655	BC	VICTORIA INT'L A	51.3	-10.7	PG 58-22	c

a - Low temperature rounded up slightly (less than 0.5 °C)
b - High temperature rounded down slightly (less than 0.5 °C)
c - PGAC grade rounded up to a PG 58-22 (i.e. use at least the equivalent of an 80/100C, which is the poorest quality asphalt cement currently available in this market)

Determining Pavement Design Grade

AASHTO MP-2 Grade Bumping Protocol

Design ESAL[1] (millions)	Adjustment to PGAC High Temperature Grade[2]		
	Traffic Loading Rate		
	Standing[2]	Slow[3]	Standard[4]
< 0.3	See note 6	No change	No change
0.3 to < 3	2	1	No change
3 to < 10	2	1	No change
10 to < 30	2	1	See note 6
> 30	2	1	1

1. Design ESALs are the anticipated project traffic level expected on the design lane over a 20-year period. Regardless of the actual d roadway, determine the design ESALs for 20 years and choose the appropriate N design level.
2. Standing Traffic - where the average traffic speed is less than 20 km/h.
3. Slow traffic - where the average traffic speed ranges from 20 to 70 km/h.
4. Standard traffic - where the average traffic speed is greater than 70 km/h.
5. Increase the high temperature grade by the number of grade equivalents indicated (1 grade equivalent to 6 degrees C). Use the lo as determined in Section 5.
6. Consideration should be given to increasing the high temperature grade by 1 grade equivalent

Determining Pavement Design Grade

- PG Grade Bumping for High Temperature

LTPPBind 3.1

Adj = PGn – PGS

Where:

Adj = PG Adjustments for a site.
PGn = PG at a specific traffic loading and speed.
PGS = PG at standard loading (3 million axles) and high speed

Determining Pavement Design Grade

Speed	Base Grade	Traffic Loading ESAL, Millions			
		< 3	3-10	10-30	> 30
Fast	52	0	10.3	16.8	19.3
	58	0	8.7	14.5	16.8
	64	0	7.4	12.7	14.9
	70	0	6.1	10.8	12.9
Slow	52	3.1	13	19.2	21.6
	58	2.9	11.2	16.8	19
	64	2.7	9.8	14.9	17
	70	2.5	8.4	12.9	14.9

Binder Grade Selection and Grade Bumping Based on Gross Aircraft Weight

FAA P-401 Interm Specification for Superpave

Determine binder requirements from LTTP Bind version 2.1 using 98 percent reliability with no traffic or speed adjustments. Increase the high temperature grade by the number of grade equivalents indicated (1 grade is equivalent to 6 degrees C) below. Use the low temperature grade as determined from LTTP Bind version 2.1. (see NOTES)

Aircraft Gross Weight (pounds)	High Temperature Adjustment to Binder Grade	
	Pavement Type	
	Runway	Taxiway/Apron
Less than 12,500	--	--
Less than 60,000	--	1
Less than 100,000	NA	1
Greater than 100,000	NA	2

NOTES:

1. PG grades above a –22 on the low end (e.g. 64–16) are not recommended. Limited experience has shown this to be a poor performer.
2. PG grades below a 64 on the high end (e.g. 58-22) are not recommended. These binders often provide tender tendencies.
3. PG grades above a 76 on the high end (e.g. 82-22) are not recommended. These binders anr very stiff and difficult to work and compact.

Binder Grade Selection and Grade Bumping Based on Tire Pressure Unified Facilities Guide Specification

FAA Guidelines

Aircraft Tire Pressures (psi)	High Temperature Grade Adjustment(s) for Binders
	Pavement Type
	Runways, Taxiways and Parking Aprons
Less than 100	0
100 - 200	0 – 1
Greater than 200	1 – 2

Unified Facilities Guide Specification
Section 02749 HMA for Airfields

Determining Pavement Design Grade

- Specifying Design Depth
  - LTPP Models include depth as an independent variable.
  - SHRP Models computes pavement temperature at surface only
  - TAC Low Temperature Model computes pavement temperature at the surface only
  - LTPPBind 3.1 uses the LTPPBind 2.1 high temperature model only

Special Design Considerations

PGAC in Recycle Applications

NCHRP Recommend guidelines for using PGAC in RAP

	RAP Percentage Recovered RAP Grade PG XX-22 or lower	PG xx-16	PG xx-10 or higher
No change in binder selection	< 20%	< 15%	< 10%
Select a virgin binder one grade softer	20-30%	15-25%	10-15%
Follow the recommendation produced from blending charts	> 30%	> 25%	> 15%

The complete text of the NCHRP Research Results Digest 253 may be downloaded from the following web address:

http://gulliver.trb.org/publications/nchrp/nchrp_rrd_253.pdf

Further information is also available from the NCHRP Publication entitled: Report 452 Recommended Use of Reclaimed Asphalt Pavement in the SuperPave Mix Design Method: Technician's Manual which may be downloaded from web address:

http://gulliver.trb.org/publications/nchrp/nchrp_rpt_452.pdf

Determining Pavement Design Temperatures

Pavement PG design grade is determined by:

1) climatic statistics of the design site,
2) the pavement temperature model selected,
3) the design reliability,
4) high temperature grade bumping protocol,
5) specified depth within pavement structure,
6) percentage of recycled asphalt pavement

Special Design Considerations

- Overlays on Previously Cracked Pavements
  - Practitioners have stated that “modified PGAC grades will only be used for new construction or overlays on un-cracked pavements”.
    - Highly modified PGAC will not prevent reflective cracking
  - This protocol may restrict the use of modified PGAC’s in applications that they have potential to improve the performance of the overlay.

Special Design Considerations

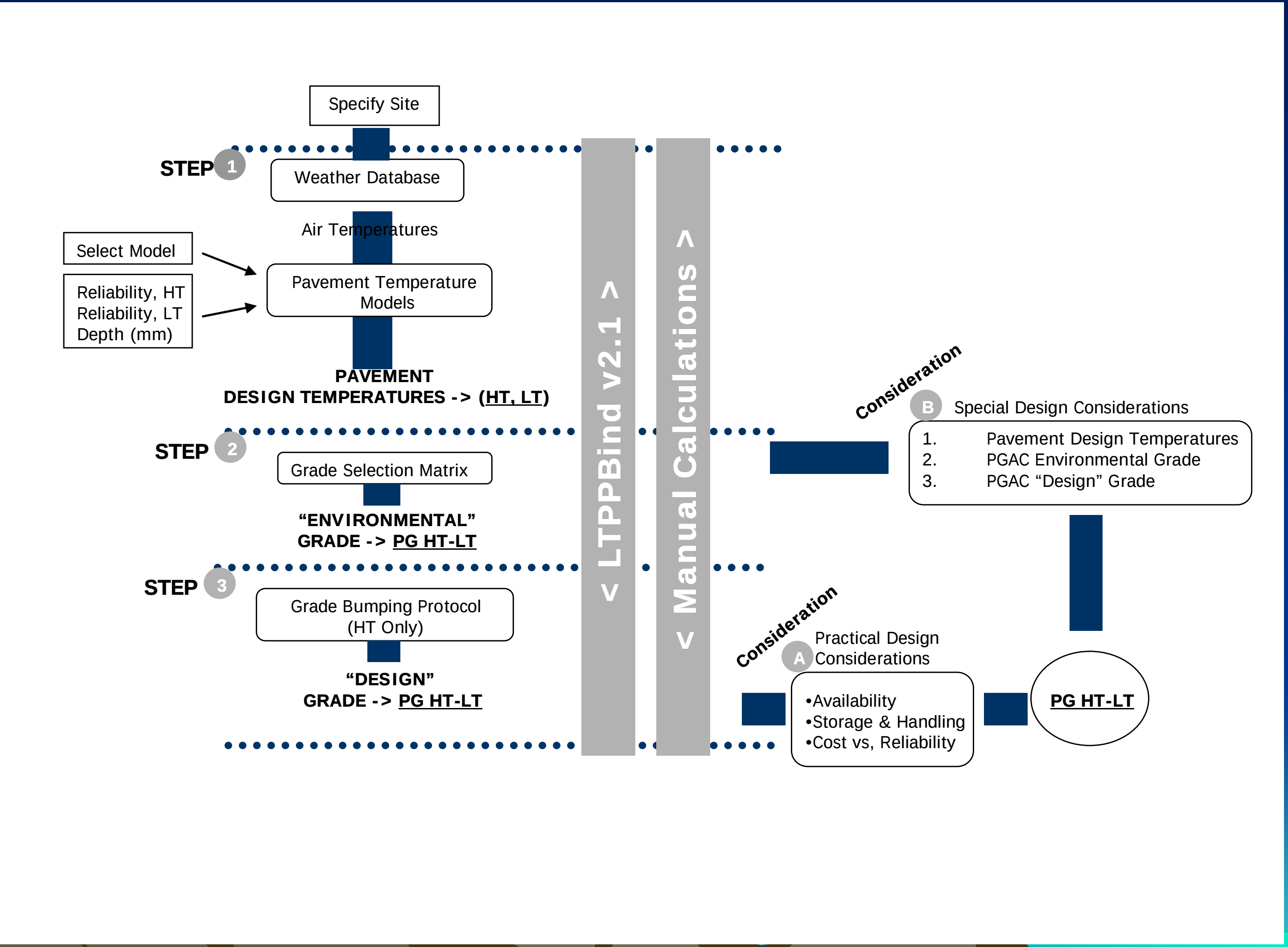
- Overlays on Previously Cracked Pavements
  - Accept a lower level of reliability (80%) as a function of the degree of thermal cracking of the existing pavement when selecting the low design temperature for the overlay PGAC.
  - Increased strength of some modified PGAC's (in particular elastommeric PMA's) will provide increased resistance to reflective cracking and surface degradation (including crack degradation, raveling etc)
  - Life cycle cost implications of using these grades must be integral in the design decision.

Special Design Considerations

- Specifying (high performance) Modified Grades
  - Consideration to AASHTO M 320-05 Table 2 specification
  - The Rule of 100, If your design grade has a temperature range greater than 100 C consider using the M 320-05 Table 2 specification
    - M 320-05 Table 2 will yield more accurate low temperature grades
    - Asphalts from SGS or Cold Lake crudes will see these typical improvements:
      - **Straight run 1-3 c improvement**
      - **Air blown asphalts 2-3 C improvement**
      - **High quality SBS polymer modified up to 5 C improvement**

PGAC Calgary, Alberta

PGAC Calgary, Alberta



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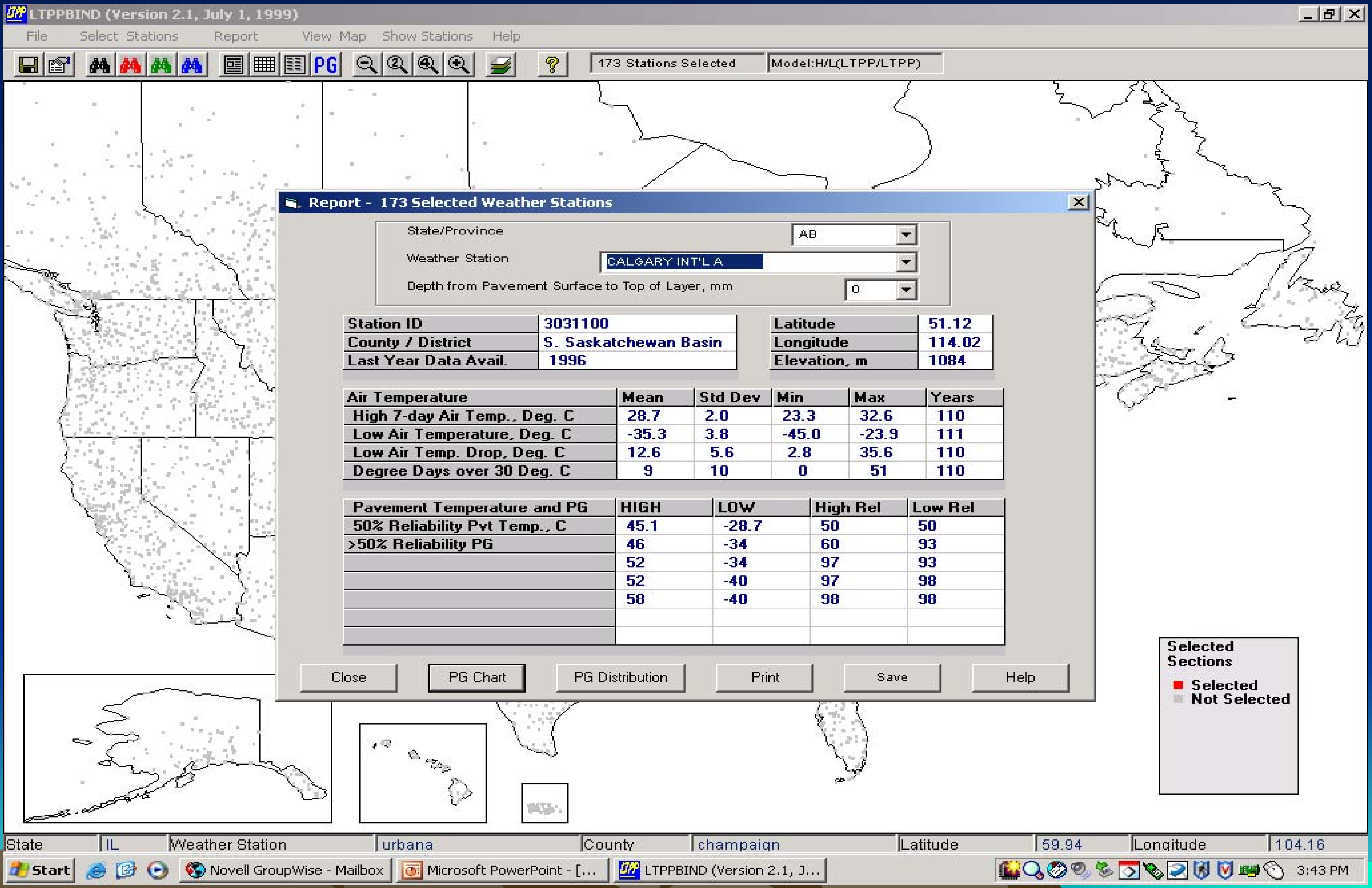

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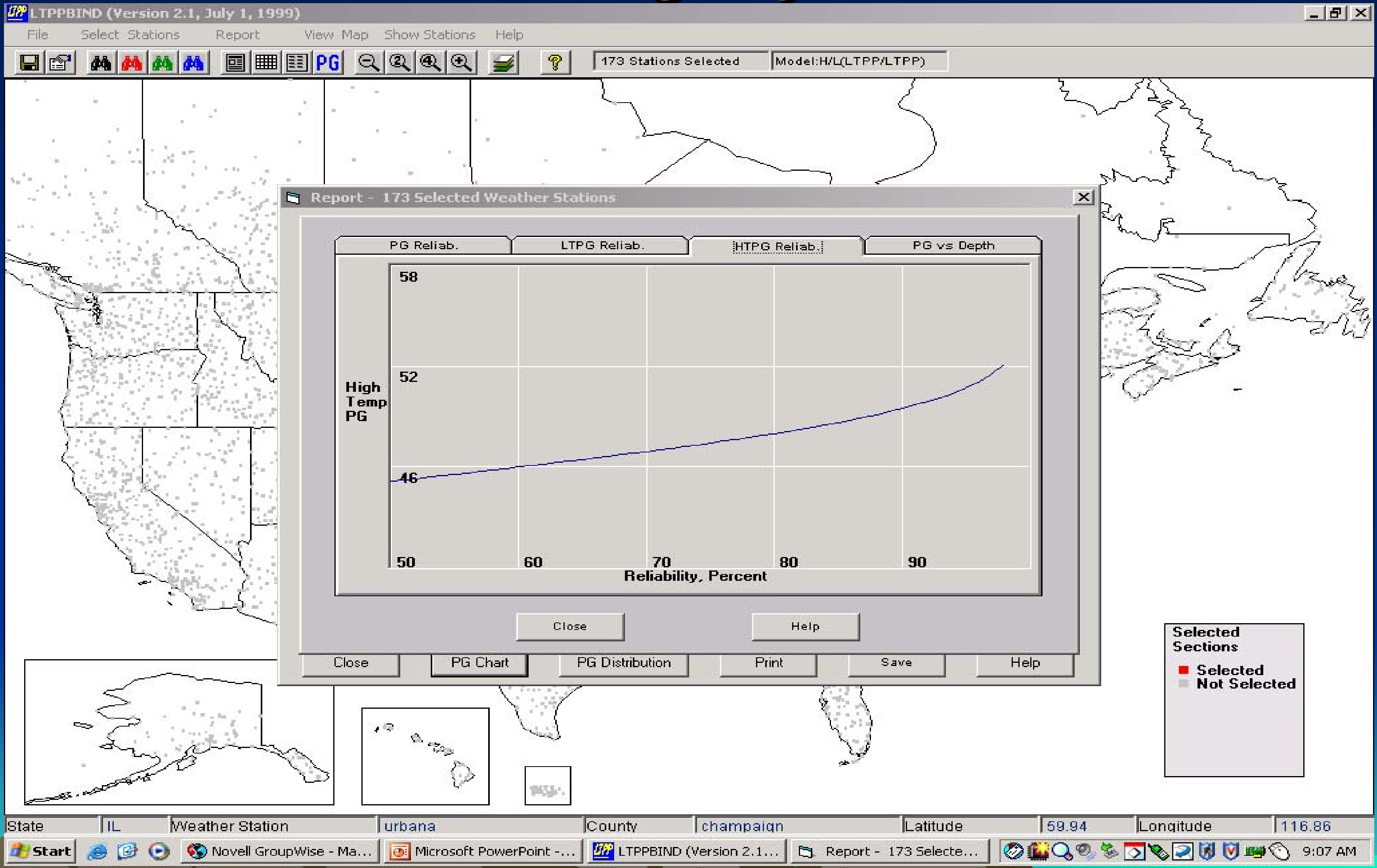
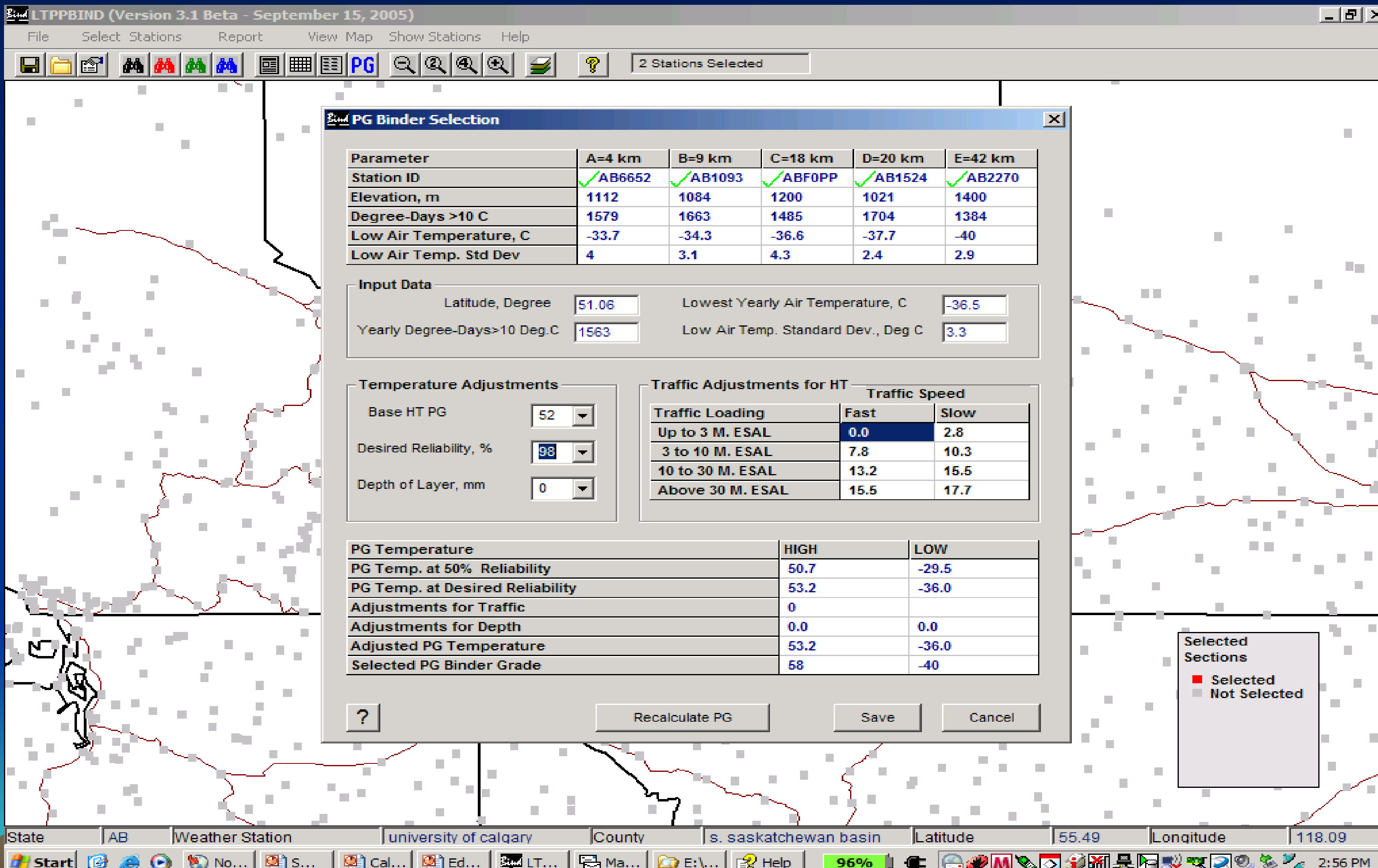


PGAC Calgary, Alberta

LTPP High Pavement Temperature Model										
Reliability (%) =	99%	98%	97%	96%	95%	90%	80%	70%	60%	50%
Reliability (z) =	2.327	2.054	1.881	1.751	1.645	1.282	0.842	0.524	0.253	0.000
Depth (mm) =	20	20	20	20	20	20	20	20	20	20
Depth (in) =	0.7874	0.7874	0.7874	0.7874	0.7874	0.7874	0.7874	0.7874	0.7874	0.7874
	53.0	52.1	51.5	51.1	50.7	49.5	48.0	46.9	46.0	45.1

PGAC Calgary, Alberta



PGAC Calgary, Alberta

TAC Revised Low Pavement Temperature Model

Reliability (%) =	99%	98%	97%	96%	95%	90%	80%	70%	60%	50%
Reliability (z) =	2.327	2.054	1.881	1.751	1.645	1.282	0.842	0.524	0.253	0.000
Depth (mm) =	0	0	0	0	0	0	0	0	0	0
Depth (in) =	0	0	0	0	0	0	0	0	0	0
	-34.9	-33.9	-33.2	-32.8	-32.4	-31.1	-29.5	-28.3	-27.4	-26.4

PGAC Calgary, Alberta

Environmental Grade PG 58-31

AASHTO MP-2 Grade Bumping Protocol

Design ESAL[1] (millions)	Adjustment to PGAC High Temperature Grade[2]		
	Traffic Loading Rate		
	Standing[2]	Slow[3]	Standard[4]
< 0.3	See note 6	No change	No change
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5. Increase the high temperature grade by the number of grade equivalents indicated (1 grade equivalent to 6 degrees C). Use the lo as determined in Section 5.
6. Consideration should be given to increasing the high temperature grade by 1 grade equivalent

PGAC Calgary, Alberta

– Environmental Grade PG 58-31

- PG 64-31
  - – Slow traffic where the average traffic speed is between 20 to 70 km/hr
  - – Design ESAL's over 0.3 million
- PG 70-31
  - – Standing traffic where the average traffic speed is less than 20 km/hr
  - – Design ESAL's over 0.3 million

PGAC Calgary, Alberta LTPPBIND 3.1

Speed	Base Grade	Traffic Loading ESAL, Millions < 3	3-10	10-30	> 30
Fast	52	0	10.3	16.8	19.3
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Binder Grade Selection and Grade Bumping Based on Tire Pressure
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	Pavement Type
	Runways, Taxiways and Parking Aprons
Less than 100	0
100 - 200	0 – 1
Greater than 200	1 – 2

Unified Facilities Guide Specification
Section 02749 HMA for Airfields

PGAC Calgary, Alberta

- Environmental Grade PG 58-31
  - PG 64-31
    - Less 100,000 lbs Aircraft Gross Weight (Taxiway/Apron)
    - Between 100-200 PSI (Runways/Taxiways/Aprons)
  - PG 70-31
    - Greater than 100,000 lbs Aircraft Gross Weight (Taxiway/Apron)
    - Greater than 200 PSI (Runways/Taxiways/Aprons)

Questions ?