SWIFT

SEPT 13th - 15th 2022

Montréal Aviation Events Group captg

ASPHALT BINDER AND MIXTURE TESTING TRENDS AND SPECIFICATIONS

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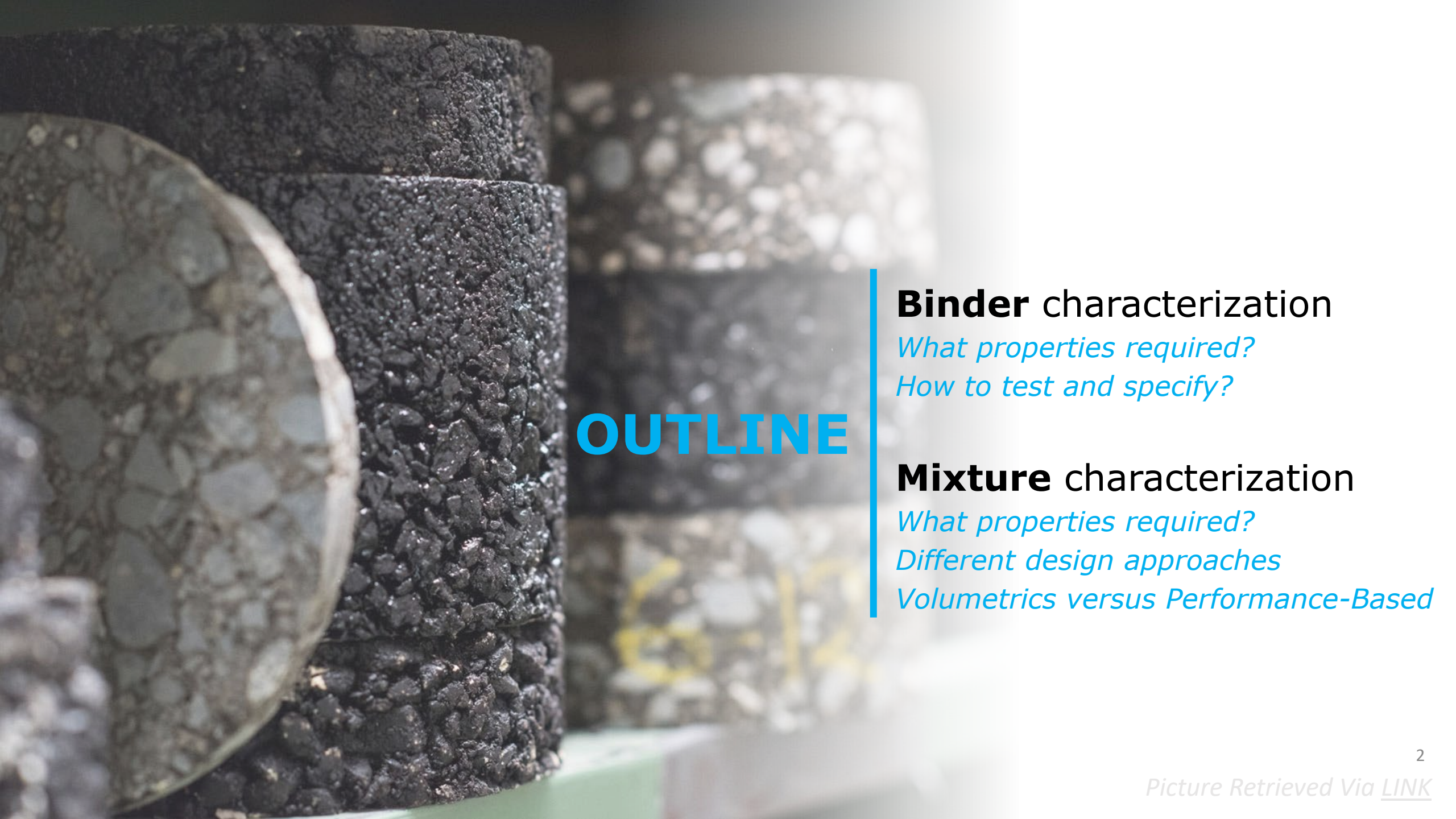


OUTLINE

Binder characterization

What properties required?

How to test and specify?

Mixture characterization

What properties required?

Different design approaches

Volumetrics versus Performance-Based

Picture Retrieved Via LINK

BINDING AGENT

*"A dark brown to black **CEMENTITIOUS** material in which the predominating constituents are bitumens which occur in nature or are obtained in **PETROLEUM PROCESSING**."*

(American Society for Testing and Materials - ASTM)

***BITUMEN** is the international nomenclature for asphalt cement*

Canada & United States - The term "asphalt" may be used to refer to the liquid asphalt

ASPHALT CEMENT
Unmodified, Straight-Run, Virgin

ASPHALT BINDER
Modified with Polymers and/or additives

ASPHALT BINDER

Desired Characteristics
(Stiffness vs. In-Service Temperature)

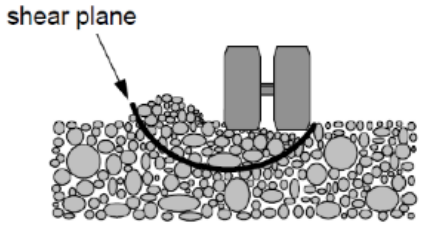
Aging due to Oxidation during production and after being in-service

Thermal Cracking
Non-load Associated

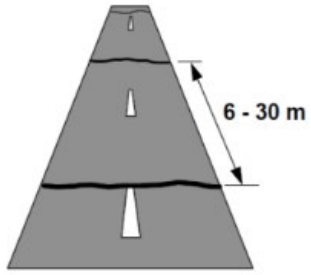
Fatigue Cracking
Load Associated

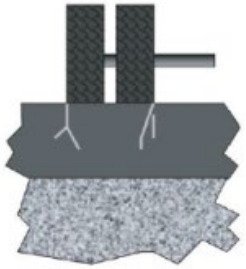
Rutting Shoving
Load Associated

Handling
Production Workability



Ideal – Desired





STIFFNESS

Temperature

Below -16°C

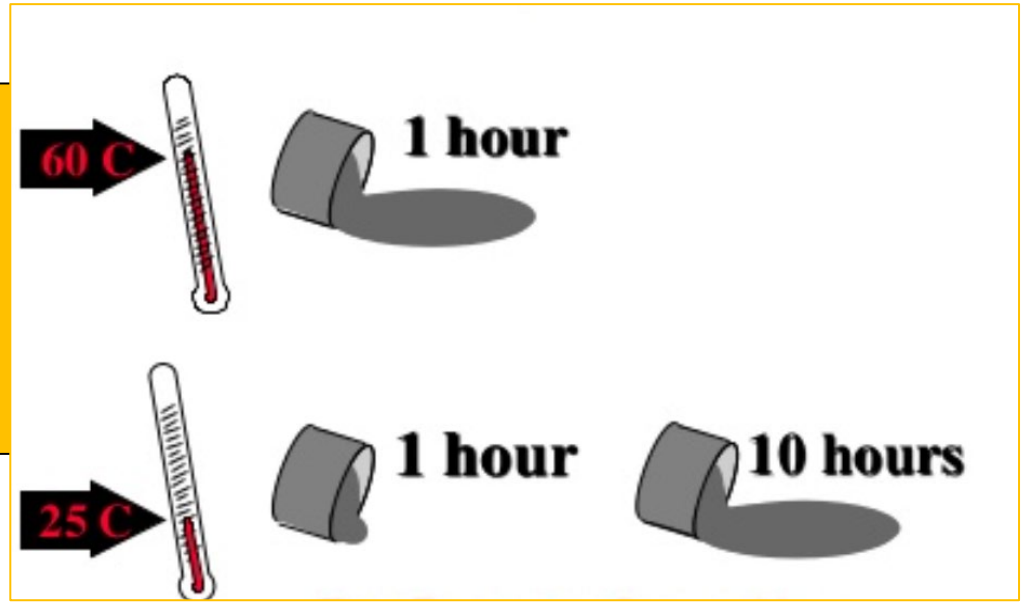
0°C to 25°C

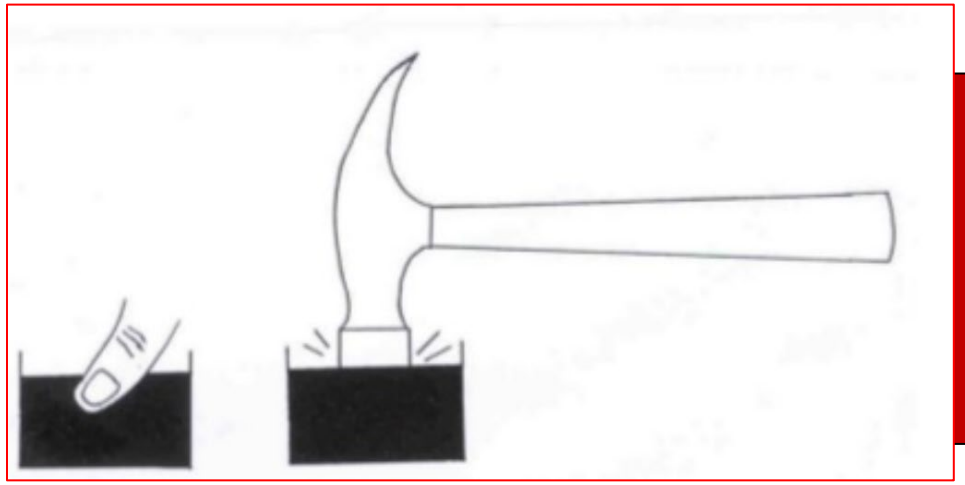
40°C - 60°C

120°C Above

ASPHALT BINDER

Temperature and Time Sensitivity





Rate of Loading

ASPHALT BINDER

Historical Trends in Testing Binders in Canada

Penetration Graded (i.e. 85/100)

Stiffness
Characterization
At 25°C

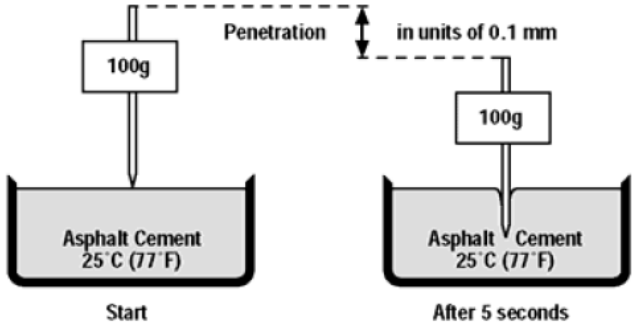
Viscosity Graded (i.e. AC-5)

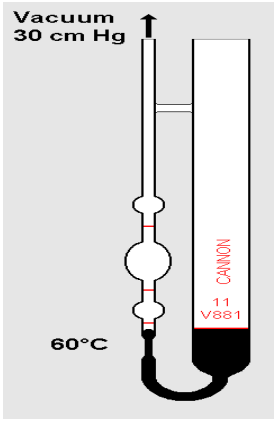
Stiffness & Workability
25°C
135 & 165°C

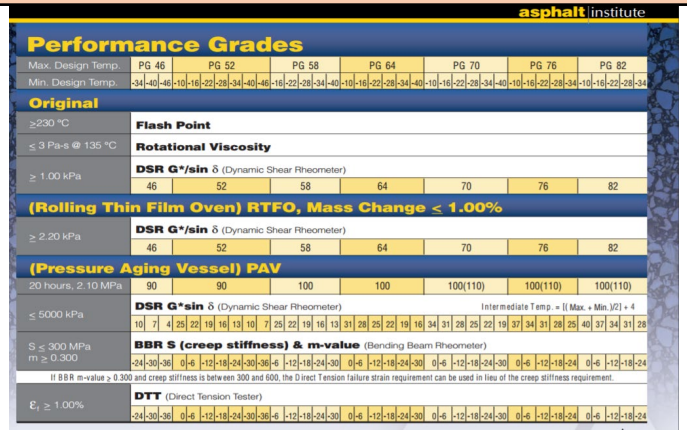
Performance Graded (i.e. PG 58-28)

Array of testing
Stiffness at Low, Intermediate and High
Workability
Aging susceptibility

1947 → 1970s → Early 1990s → Now?







Increasing Loadings

Changes in crude and refining practices
Changes in other raw material supply

Extreme Events
Structural Resiliency

ASPHALT BINDER

Modification

Objectives

Improve or alter **PHYSICAL** or **CHEMICAL** properties

Widen the viscoelastic **RANGE** (i.e. PG 58-28 vs. 64-28)

Improve binder's **RESPONSE** to a particular in-service condition

Common Techniques

POLYMERS - most commonly known as "PMA's"

- Elastomers – SBS, SB, SBR
- Plastomers – PE, EVA, EPDM

Extenders – sulphur, lignin

Fillers – CR*, HL, Fly Ash, baghouse fines, carbon black

Process based – air blowing, steam distillation

Chemical - Oxidants, antioxidants, acids, anhydrides

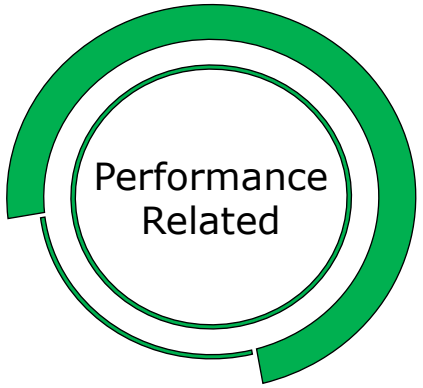
ANTISTRIPS – amines, imidazolines, phosphate esters, silanes

Acids (PPA) – could qualify into several categories

ASPHALT BINDER

Specification Types in Canada

Owner's full control over ingredients (specified and/or banned)



Empirical specifications (historical-based)
Fundamental-based specifications
Know as "PG-PLUS")

ASPHALT BINDER

Example of Owner's control over ingredients (OPSS 1101)

PGAC shall be homogeneous

- Free of water and any contamination, and shall not foam when heated to the temperatures specified by the manufacturer for the safe handling and use of the product.
- Silicone oils are allowed as anti-foaming agents at less than five parts per million. Zinc oxide and iron carboxylates may be used as hydrogen sulfide (H2S) scavengers.

PGAC **shall not contain**

- More than 0.3% polyphosphoric acid (PPA) or 0.3% elemental sulfur (S) in addition to the typical sulfur that is naturally presence in the asphalt cement, and these shall only be used as catalysts for the purpose of modification with epoxy(E)-type or styrene-butadiene (SB)-type polymer modifiers. PGAC shall not contain any orthophosphoric acid.
- PGAC shall not be air blown or catalytically oxidized in any manner.
- PGAC shall not contain any air blown or catalytically oxidized residues.

ASPHALT BINDER

Example of Owner's control over ingredients (OPSS 1101)

The asphalt cement **shall not contain**

- Any of the following additives added for PGAC modification:

  atactic polypropylene; carbon black; polyisobutylene; polyisoprene; natural rubber; alkaline bases; insoluble particulates or fibres; salts of iron, copper, manganese and/or cobalt; silicates; styrene-butadiene rubber (random copolymer latex); synthetic waxes (paraffin waxes, naphthenic waxes); synthetic and saturated oils (including but not limited to the following: vegetable oils or modified vegetable oils; (paraffin oils, polyalphaolefins (PAO), lube oils, and re-refined lube oils.); waste oils (including but not limited to the following: cracked residues, re-refined high vacuum distillate oils; tall oils, vacuum tower asphalt extenders; waste cooking oils, waste engine oils, waste engine oil residues).

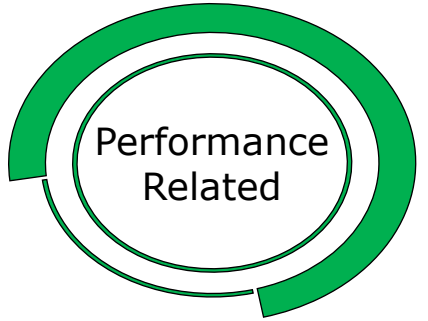
  Asphalt cement supplier shall declare in writing that they have not added the PGAC additives listed above.

- If modifiers or additives other than styrene-butadiene (e.g., SB diblock, SBS triblock, SBS radial, SBS high vinyl, SB tapered, etc.) or epoxy-type (e.g. reactive elastomeric terpolymers) polymers are used for the modification of neat asphalt cement, **pre-approval from the Owner is required.**

- Organic bases may be contained in the PGAC provided they are used as anti-stripping or warm mix additives or both. If any of the above additives are present in anti-stripping and/or warm mix asphalt additives, they shall be declared at the time of mix submission.

ASPHALT BINDER

PG-Plus Testing



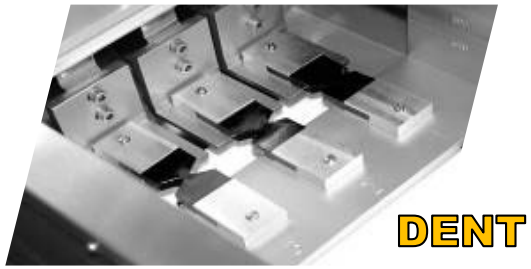
Ash Test - Contamination

Multiple Stress Creep Recovery (MSCR) – Elasticity

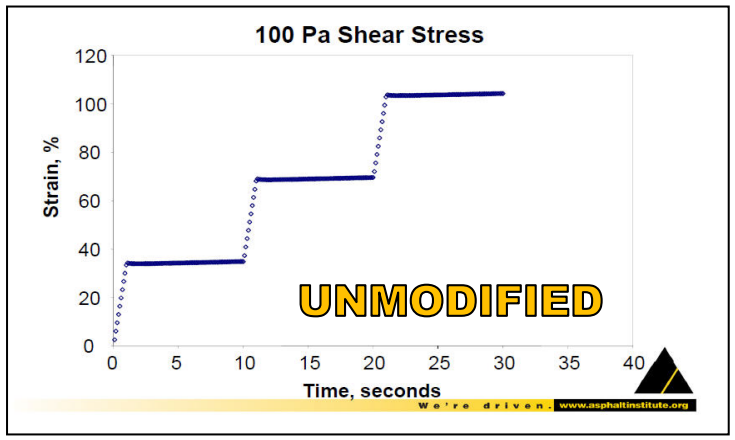
DENT – Double Edge Notch Tension - Fatigue

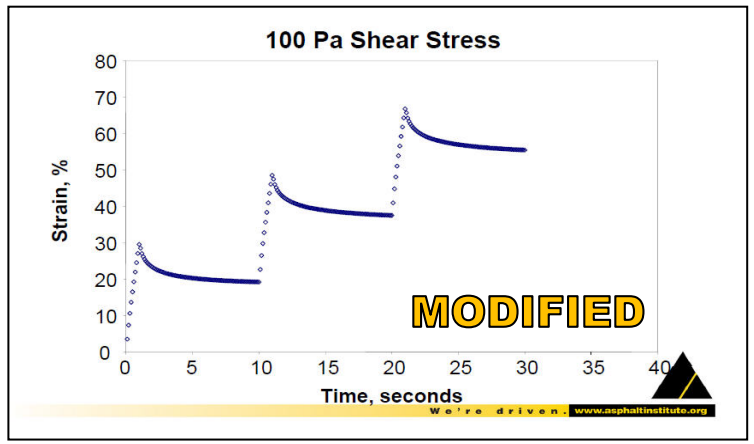
Delta TC - Low Temperature Relaxation

Extended BBR (ExBBR) – Low Temperature



MSCR





ASPHALT MIXTURE

Mixture of aggregate and binder agent

Provide a **hard-top**, while being **waterproof** to a level to prevent the support layers from becoming saturated and loosing support

Stiffness and Behaviour at different in-service temperatures controlled by aggregate skeleton and/or binder properties.

ASPHALT MIXTURE

Desired Mix Design = Optimized **Ratio of A/B** Based on **Cost Durability**

%BW= 4 to 6%
$/MT = 40 to 55%

%BW= 94 to 96%
$/MT = 5 to 50%

PRODUCTION

ENERGY
$/MT = 10 to 20%

RECYCLED ASPHALT PAVEMENT (RAP) (Aggregate/Binder)

ASPHALT MIXTURE

Mix Design Historical Trends

Barber Asphalt Paving Company
Mix of AC with Sand and Pulverized carbonite Lime

Hubbard-Field Method
Sand asphalt design
30 blow, 6" diameter with compression test

Bruce Marshall (Mississippi DOT)
Refined Hubbard Field Method – standardization of compaction energy with drop hammer
Used only air voids (3 to 5%)
VFA and VMA added in 1962
Stability and flow utilized

1890 → 1905 → 1920s → 1927 → 1943 → 1993 → NOW?

Clifford Richardson, New York Testing Company
Surface Sand Mix
Asphalt mix for lower layers
VMA terminology used

Francis Hveem (Caltrans)
Surface Area factors to determine binder content (Hveem stabilometer and cohesionmeter)

Air voids not used initially, mixes generally drier relative to others

Issues with fatigue cracking

Superpave
- Level 1 (volumetric-based approach) using 4% air voids, VFA, VMA, DP
- Introduction of gyratory compactor
- Level 2 (performance-based approach) – **Never implemented**

First trial in Ontario placed in 1996

Timeline prepared by Sina.V after reviewing "History of asphalt mix design in North America" published by Asphalt Magazine, Asphalt Institute Link:
http://asphaltmagazine.com/history-of-asphalt-mix-design-in-north-america-part-1/

ASPHALT MIXTURE

The Bigger Issue – *"Asphalt Mix Iceberg"*

*Navigating using **PAST EXPERIENCE** by seeing*

- *Asphalt Binder Physical & Chemical Properties*
- *Aggregate Properties*
- AGG-Binder Volumetrics (ABV) Relationship

NO MIX PERFORMANCE

under laboratory conditions

=

***HIGH RISK** in Extreme Events*

REDUCED** Structural **RESILIENCY

ASPHALT MIXTURE

Considering Performance in Mixture Design

1 Recipe & Volumetric Selection

2 Performance-Verified Volumetric Design

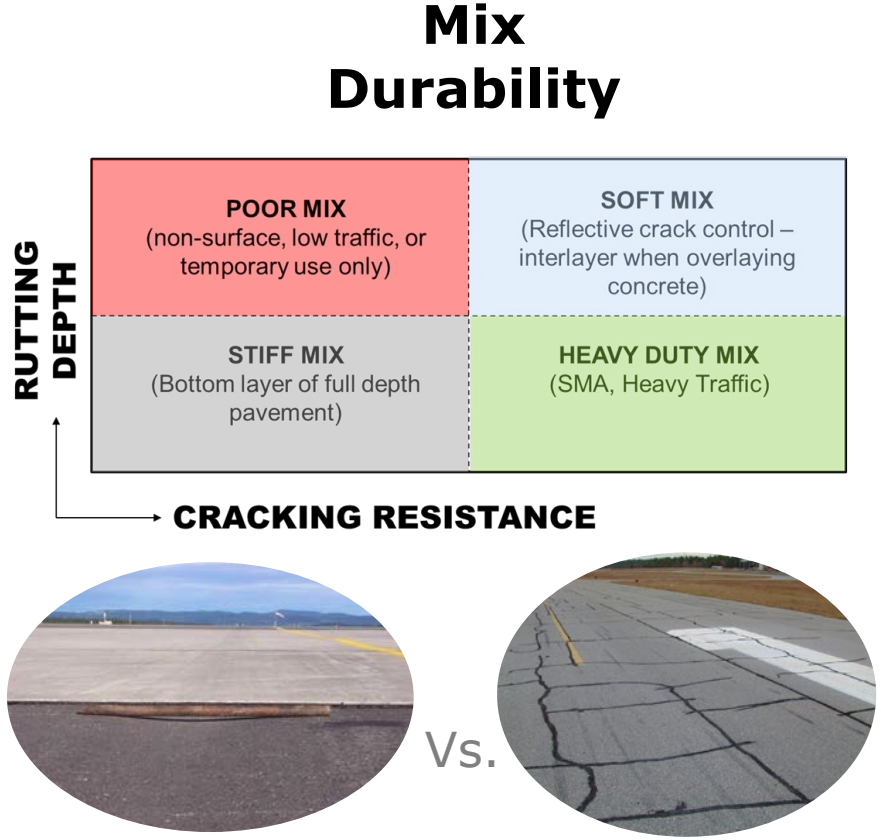
Verification of resistant to a specific distress
Example: Asphalt Cement (AC) modification to resist fatigue cracking

3 Performance-Modified Volumetric Design

Adjustment of mix proportions to resist a specific distress
Example:

4 Performance-Based Design

Durability
Performance testing for **Pavement design input**
Conduct volumetric for QA



PERFORMANCE INDEX TESTING

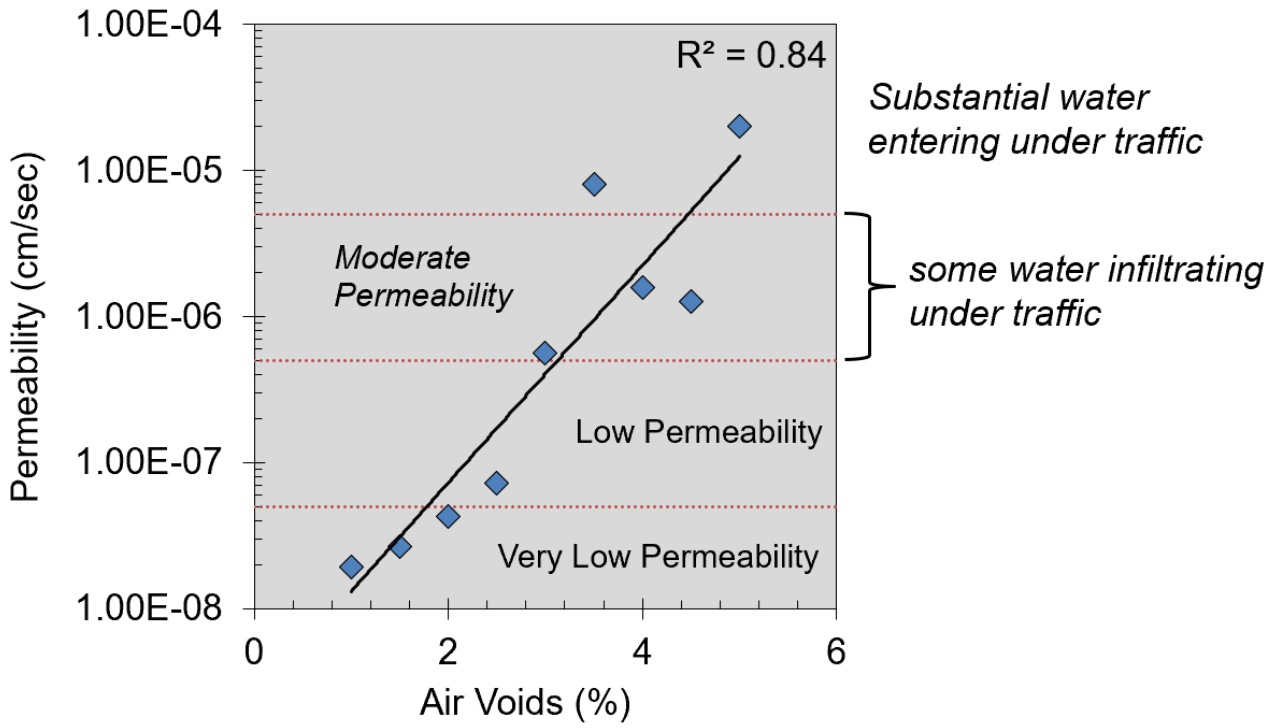
(Laboratory Torture Testing)

Critical tools for the owner including current technology Status and Some Critical Tests related to Performance

ASPHALT MIXTURE

Test Methods

Permeability – In-Place Density Related to Durability

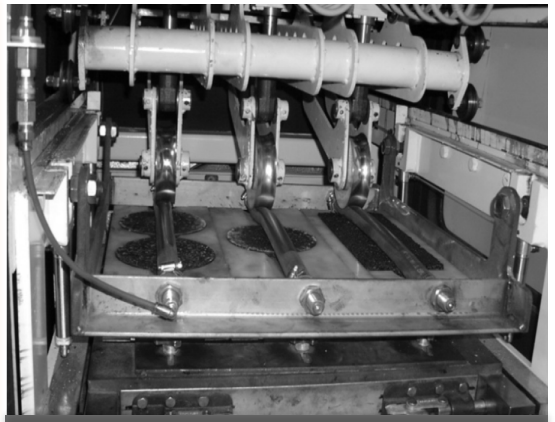


Research work Done by Dr. Varamini – CTAA 2019 "Development of Low Permeability Asphalt Mix"
Permeability ranges corresponding to those listed in Vardanega P, Waters T. "Analysis of Asphalt Concrete Permeability Data Using Representative Pore Size", Journal of Materials in Civil Engineering, American Society of Civil Engineers (ASCE), Reston, Virginia, Volume 23, Issue 2 (February 2011).

ASPHALT MIXTURE

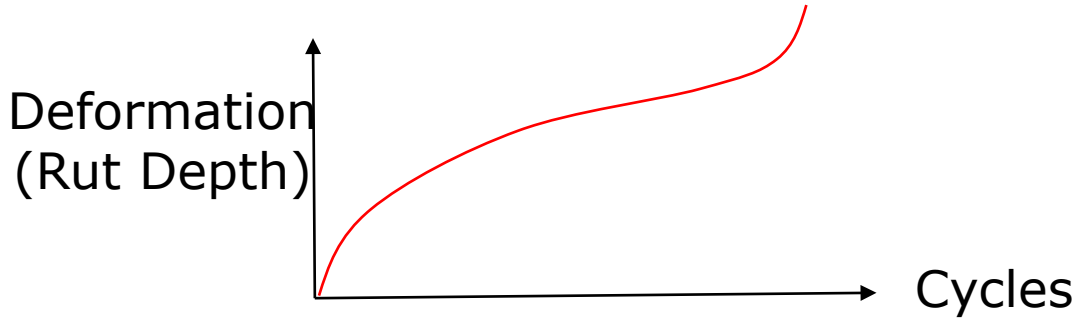
Test Methods – Permanent Deformation/Rutting

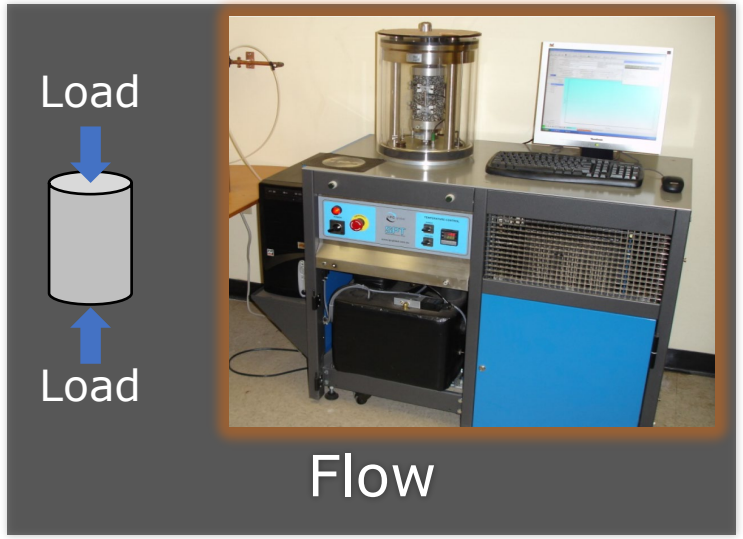
Hamburg Wheel Tracking



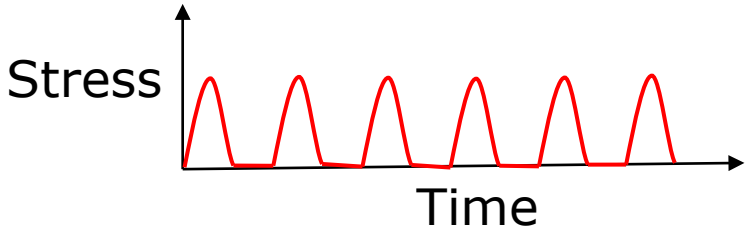
Asphalt Pavement Analyzer

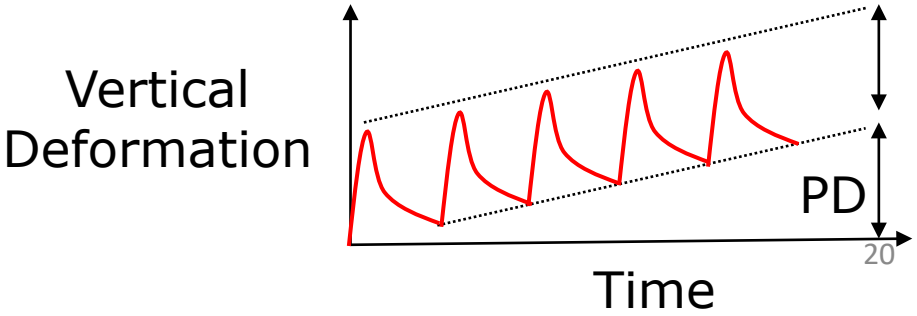
Simulative





Flow





ASPHALT MIXTURE

Test Methods – Fatigue & Low Temperature

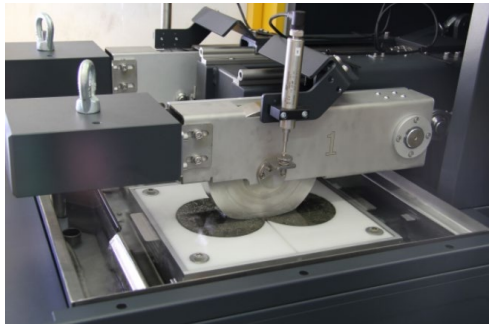
Semi Circular Bend (SCB)
Test
Fatigue Index at 25°C

Disk Shape Tension
(DCT)
Test
Low Temperature
Relaxation Index at
Temperature
Below -18°C

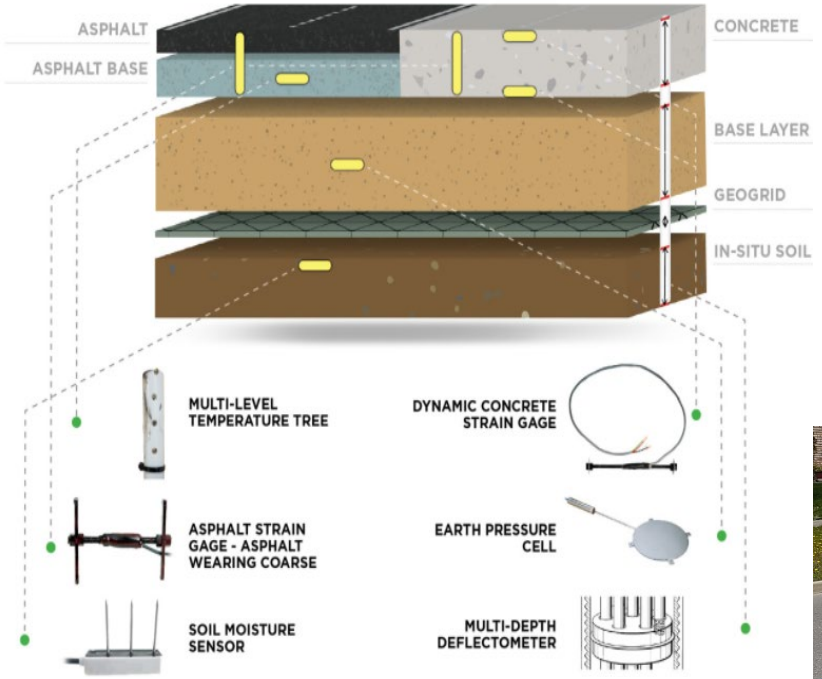
STRUCTURAL RESILIENCY

Need to Consider All Around Approach

Accelerated Loading Facilities (ALFs)



Laboratory Torture Testing



Pavement Instrumentation

MATERIALS STRENGTH

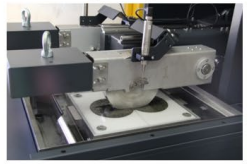
STRUCTURAL RESONSE/RESILIENCE

FIELD NON-DESTRUCTIVE EVALUATIONS

STRUCTURAL RESILIENCY

Need to Consider All Around Approach

Accelerated Loading Facilities (ALFs)



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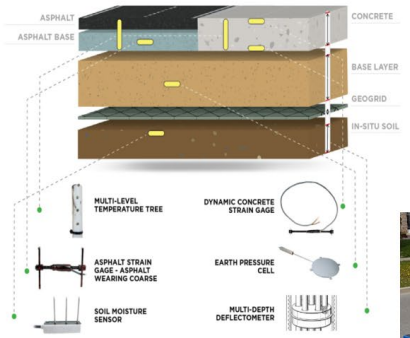

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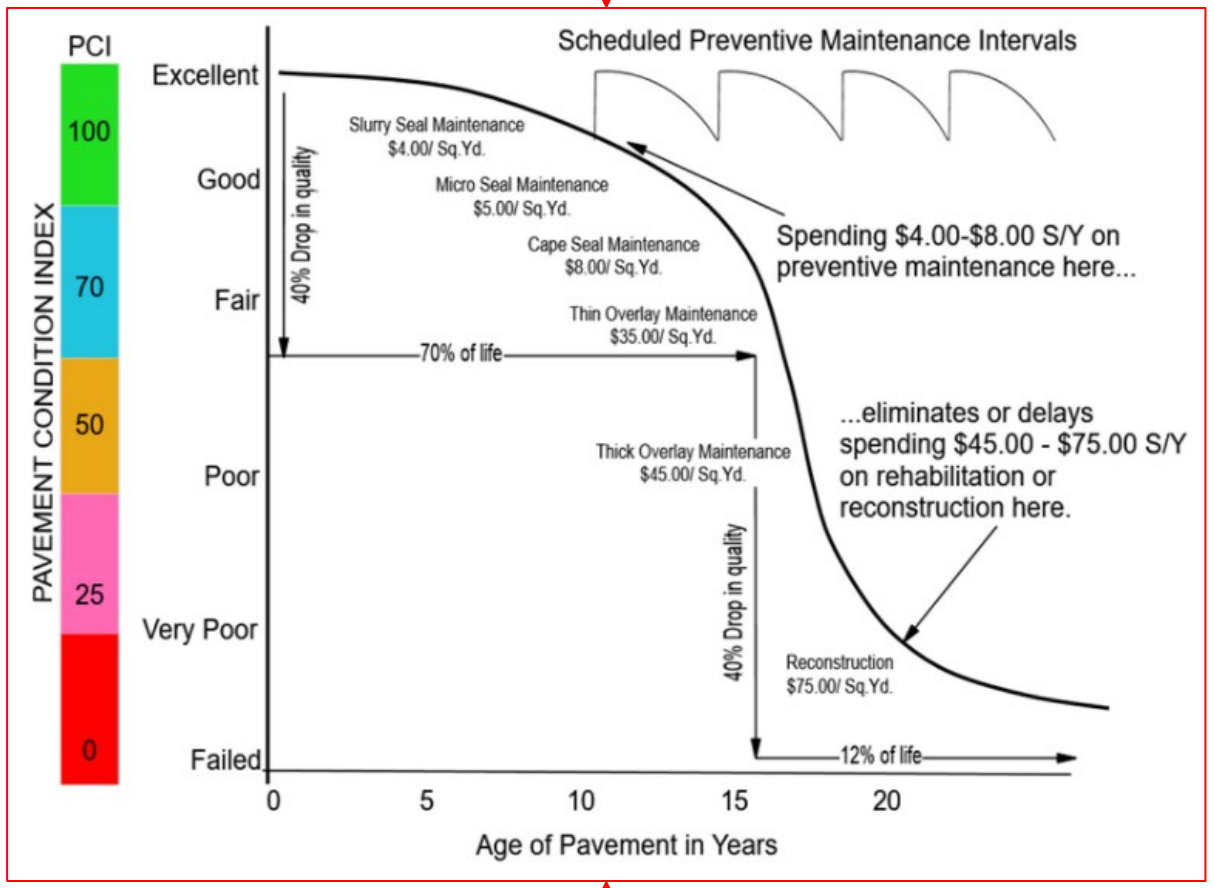

Questions and Discussions

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Vice-Chair, Soils and Materials Committee (Transportation Association of Canada, TAC)
Vice-Chair, CUPGA (Canadian Technical Asphalt Association, CTAA)

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