

# Development of a Framework to Evaluate Asphalt Properties in Plant Produced Asphalt Mixes

Amma Wakefield, PhD Candidate, PEng

Supervisor: Prof. Susan L. Tighe, PhD, PEng



**UNIVERSITY OF WATERLOO**  
FACULTY OF ENGINEERING

# PRESENTATION OUTLINE

- WHY: Background & Research Gaps
- WHAT: Research Objectives
- HOW: Sampling & Testing
- WHEN: Timeline and Current Status
- WHO: Acknowledgements



# 1990s to 2000s: SUPERPAVE PERFORMANCE GRADING

- Classifies asphalt properties for the given environment.
- Measure properties related to field performance:
  - Rutting
  - Fatigue Cracking
  - Low Temperature Cracking
- Measure asphalt flow properties under different:
  - Temperatures
  - Stages of aging



WHY



## Asphalt Cement Properties

- Asphalt is composed of extremely large number of organic molecules
  - Saturates; Aromatics; Resins; Asphaltenes
- Reacts with oxygen from environment
- Oxidation process changes the concentrations of these fractions



WHY



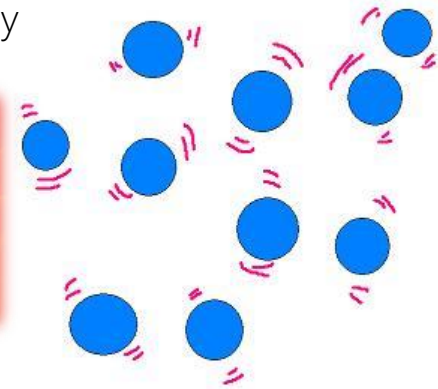
## Asphalt Cement Properties

- Oxidative Aging
  - Asphalt becomes stiff with increase in asphaltenes concentration



Oxidative aging occurs faster during asphalt mix production

- High surface area to volume ratio
- More molecular activity

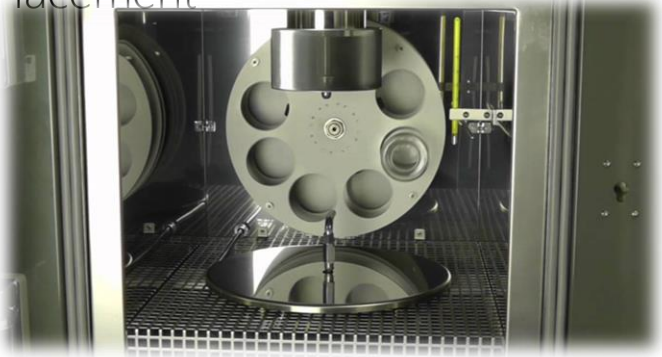


WHY

# SIMULATING OXIDATIVE AGING

## Rolling Thin Film Oven (RTFO) Test

- Hot jet air blows AC in a rotating carriage
- Short Term - Production and Placement



## Pressure Aging Vessel (PAV)

- High temperatures and Pressure
- Accelerated aging
- Long Term – In service



WHY



# 2003 to 2008: HWY 655 Research

MTO investigates premature cracking

- 2003 – Construct test sections with various PG grades
- 2008 - Pavement condition assessment and testing of virgin and recovered AC

Section	PG True Grade
Section A	PG 65-36
Section B	PG 65-36
Section C	PG 65-36
Section D	PG 67-35
Section E	PG 66-35
Section F	PG 59-35
Section G	PG 52-34

WHY



# 2003 to 2008: HWY 655 Research Findings

Tank AC - Laboratory Aged

Test Method	Property Measured	Correlation ( $r^2$ ) to Transverse Cracking
PG Grading	Low Temperature Grade	0.001
ExBBR	Grade Loss	0.55
DENT	Ductility	0.17

Recovered AC - Field Aged

Test Method	Property Measured	Correlation ( $r^2$ ) to Transverse Cracking
PG Grading	Low Temperature Grade	0.81
ExBBR	Grade Loss	0.83
DENT	Ductility	0.39

PG Grading properties relate to cracking performance, if lab aging can match field aging.

Huber et al., 2012

WHY





# 2016: RECOVERED ASPHALT CEMENT SPECIFICATION

## Why Recovered AC Specification?

- Correct AC is used
- Promote responsible use of Reclaimed Asphalt Pavement (RAP)
- AC is not excessively aged during production

## Challenges with Recovered AC Specification

- Physical properties of AC can be affected by solvent extraction
- Testing variability between labs is high
- Experience level of labs – AC recovery process

WHY



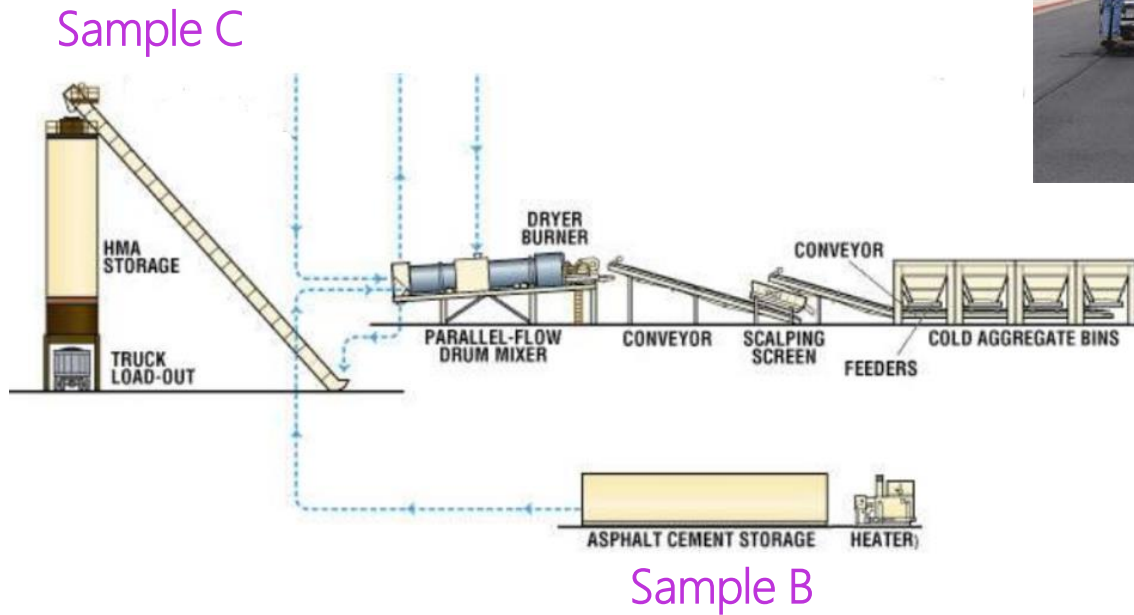
# RESEARCH OBJECTIVES

1. Compare chemical and physical properties of laboratory- and field-aged asphalt
  - RTFO
  - RTFO + 20hr PAV
  - RTFO + 40hr PAV (MTO LS 228)
2. Evaluate testing variability for recovered AC properties
3. Evaluate plant produced mixes by performance testing

WHAT



# MATERIALS SAMPLING



HOW



# MATERIALS SAMPLING

	HMA Mix Class	PG Grade	RAP Content	Owner Agency	Specification Year
1	HL1	70-28	0	Region of York	2016
2	12.5FC2	70-28	15	MTO	2016
3	12.5	58-34	15	MTO	2016
4	12.5	58-34	0	MTO	2016
5	12.5FC2	70-28	15	MTO	2014
6	12.5	58-28	0	Region of Waterloo	2017
7	12.5FC2	64-28	0	MTO	2016
8	12.5FC1	58-34	0	MTO	2016

HOW



# MATERIALS SAMPLING

	Sample Type	Quantity
Sample A	1-L of AC – Supplier Terminal	24
Sample B	1-L of HMA Plant Tank AC	24
Sample C (RAP)	For RAP Mix - Bags of RAP	25
Sample C	Boxes of Plant Mix	43
Sample D	Boxes of Site Mix	17
Sample D (Cores)	6 inch Cores	12

HOW



# AME

Materials Engineering



Sample Storage



HOW

# MATERIALS TESTING – PHASE I

## Object #1 – Laboratory Aging vs. Field Aging

- Asphalt cement properties
- Carbonyl Index
- SARA analysis

## Objective #2 – Testing Variability

- Interlaboratory correlation
- CCIL certified PGAC testing labs

HOW



# MATERIALS TESTING – PHASE II

## Objective #3: Performance Testing

### Asphalt Mix Performance Tester (AMPT)

- Performance prediction of rutting
- Flow Number



AMPT Set Up

HOW





# MATERIALS TESTING – PHASE II

## Objective #3: Performance Testing

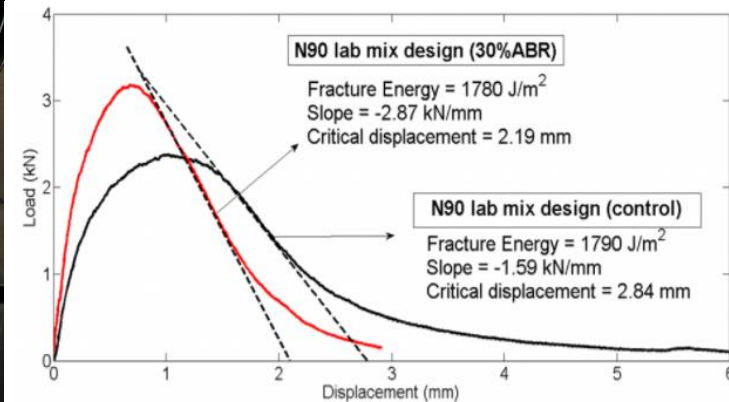
### Illinois Flexibility Index Test (I-FIT)

Fracture Energy

Flexibility Index

Test temperature: 25°C

Fatigue Cracking Performance



Typical Results adopted from: Imad Al-Qadi, David Lippert, Hasan Ozer, and Marshall Thompson,

# HOW



# STUDY TIMELINE

	Activity	2016			2017			2018			2019		
		W	S	F	W	S	F	W	S	F	W	S	F
1	Literature Review				In Progress	In Progress	In Progress	In Progress					
2	Definition of Problem				Completed	Completed							
3	Objectives and Hypothesis definition				Completed	Completed							
4	Engage instrustry for study participation					Completed	Completed						
5	Materials Sampling					Completed	Completed						
6	Engage testing labs for for mateiral testing					In Progress	In Progress	In Progress					
7	Phase I Testing							Not Started					
8	Phase I Technical Report							Not Started	Not Started				
9	Phase II Testing								Not Started	Not Started			
10	Phase II Technical Report									Not Started	Not Started		

Completed      W = Winter Term  
 In Progress      S = Spring Term  
 Not Started      F = Fall Term

WHEN



# ACKNOWLEDGEMENTS



[amma.wakefield@uwaterloo.ca](mailto:amma.wakefield@uwaterloo.ca)

WHO

