TPF – 5(153)
Optimal Timing of Preventive Maintenance for Addressing Environmental Aging

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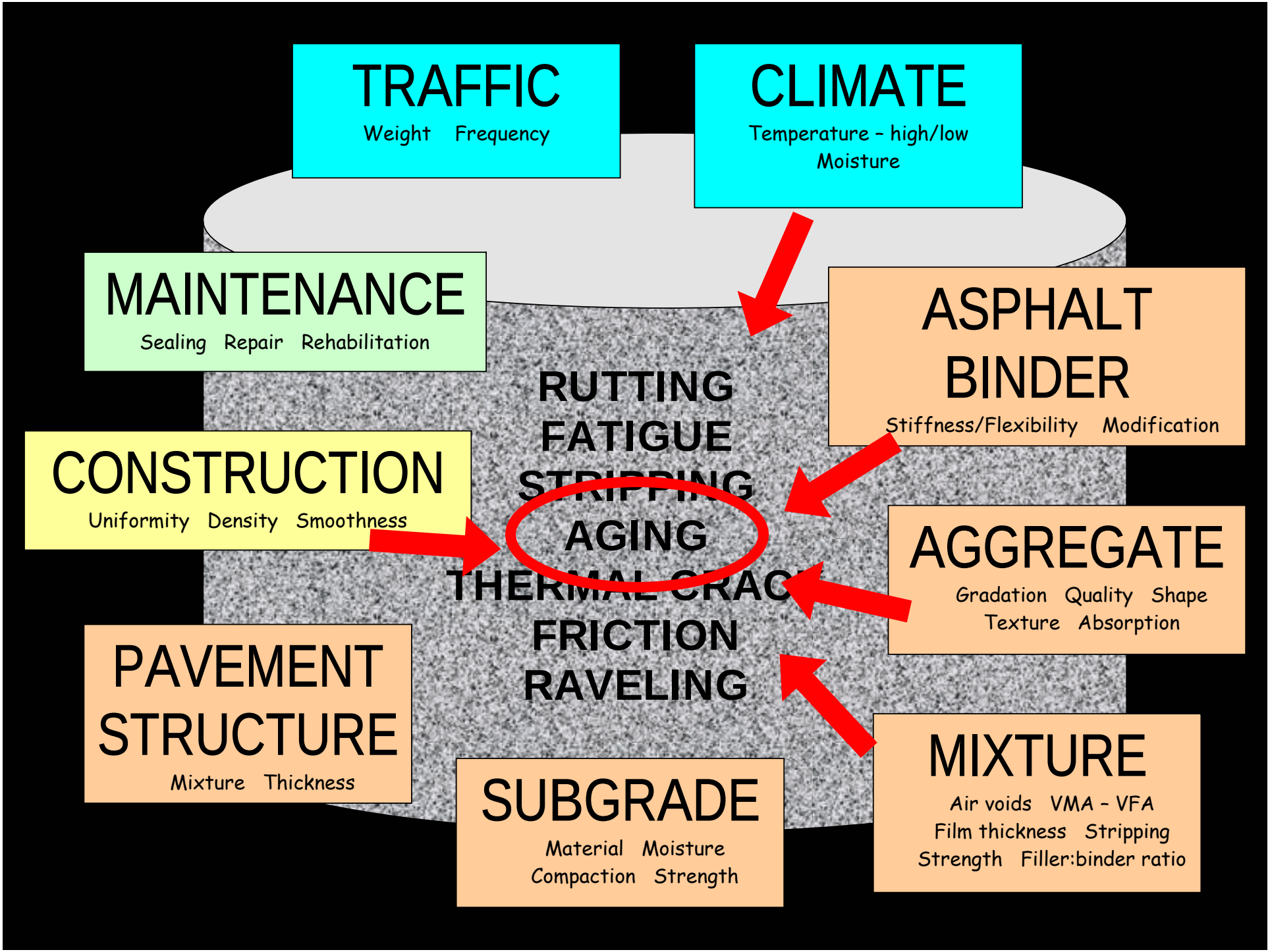
TRAFFIC
Weight Frequency
CLIMATE
Temperature – high/low
Moisture
MAINTENANCE
Sealing Repair Rehabilitation
ASPHALT BINDER
Stiffness/Flexibility Modification
RUTTING
FATIGUE
STRIPPING
AGING
THERMAL CRAC
FRICTION
RAVELING
CONSTRUCTION
Uniformity Density Smoothness
AGGREGATE
Gradation Quality Shape
Texture Absorption
PAVEMENT STRUCTURE
Mixture Thickness
SUBGRADE
Material Moisture
Compaction Strength
MIXTURE
Air voids VMA – VFA
Film thickness Stripping
Strength Filler:binder ratio

Summary of Recent Projects

- Analysis method to better quantify film thickness
- Analysis method to measure binder aging without large extracted samples
- Better characterization of mineral filler

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Film Thickness

Development of new film thickness models for hot mix asphalt

Michael Heitzman
2005 dissertation
Iowa State University, Ames, Iowa

New Approaches for Computing Film Thickness

Michael Heitzman
Iowa Department of Transportation
2006 AAPT additional paper, not presented

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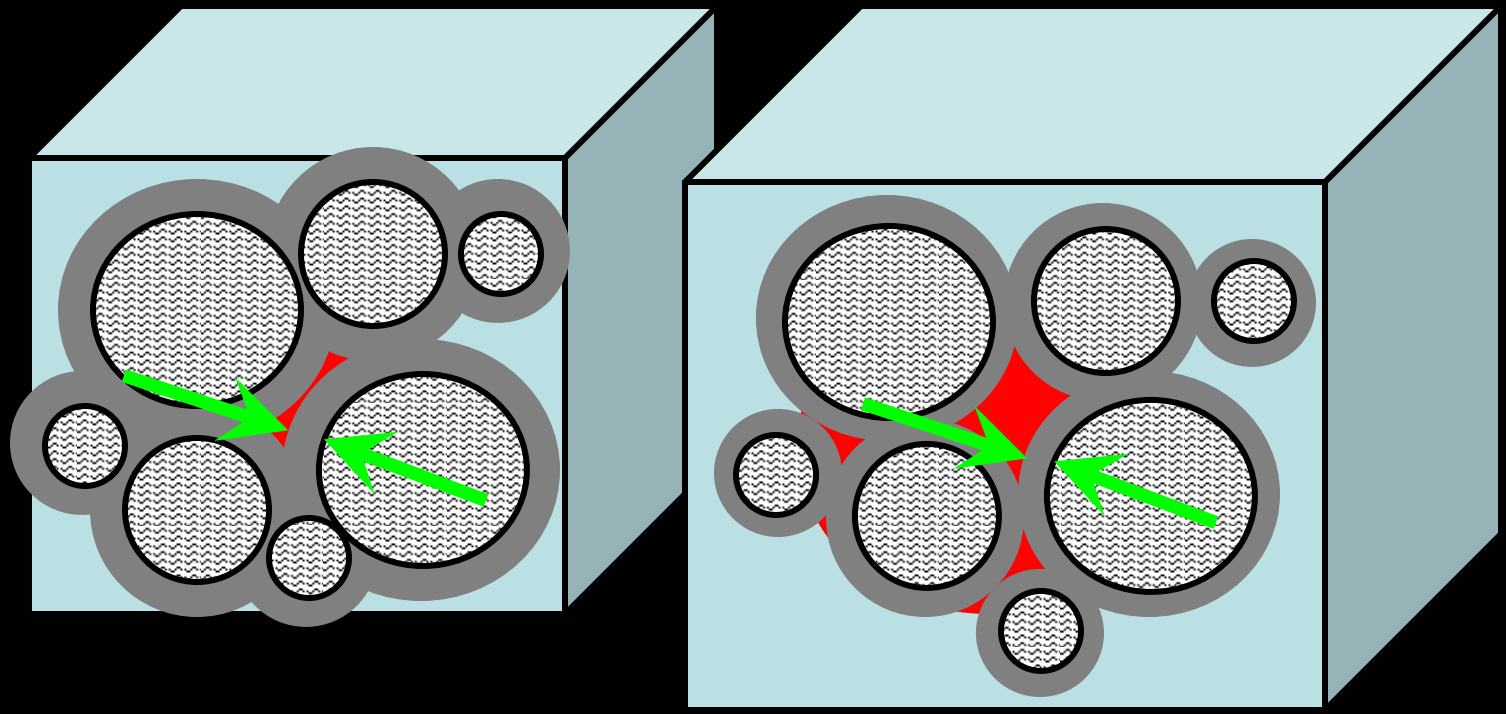
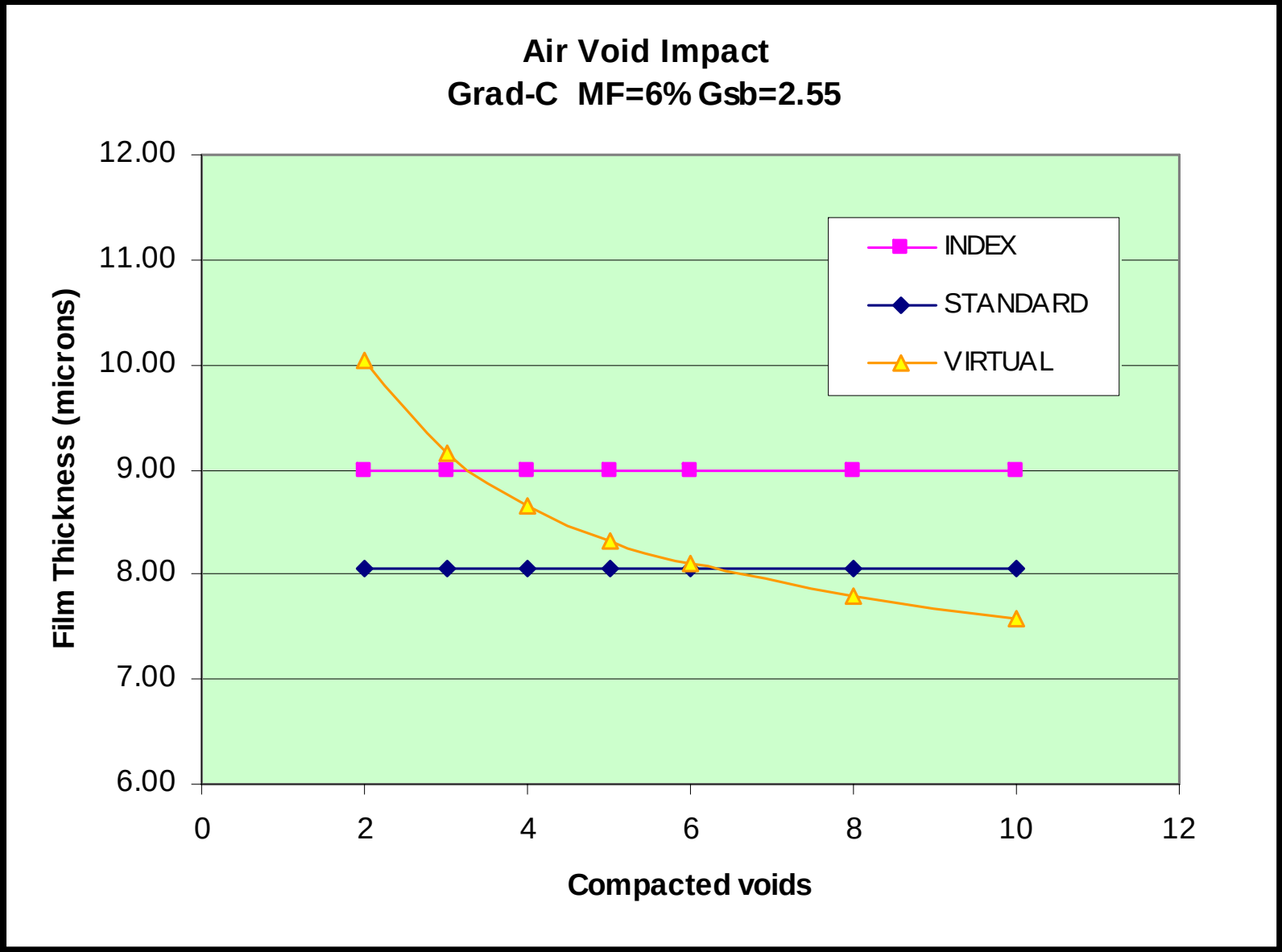
Film Thickness (VIRTUAL Model)

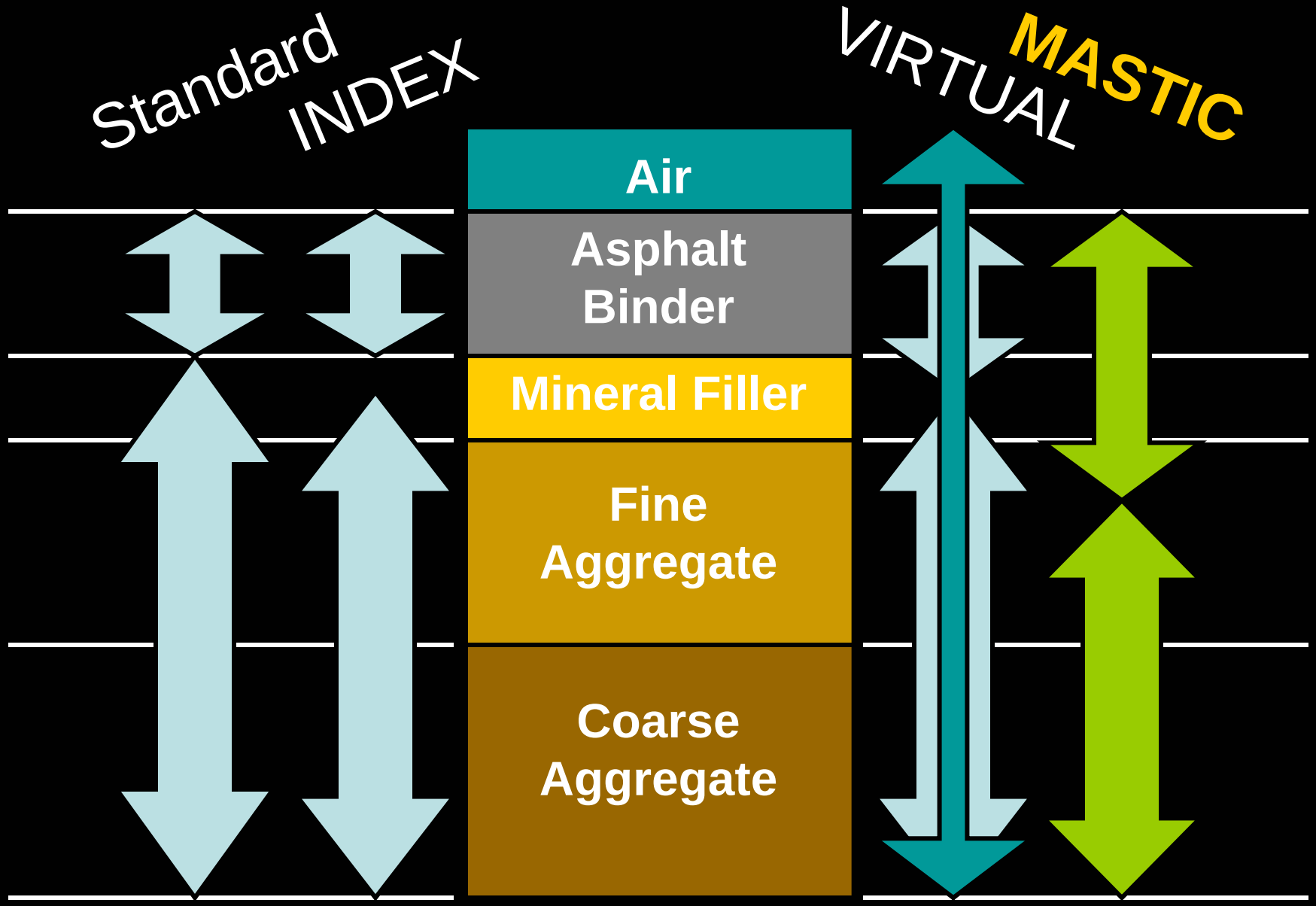
$$a_1 t + a_2 t^2 + a_3 t^3 = \ln(1 - Vs / Va)$$



Random Spatial Distribution


Air Void Impact
Grad-C MF=6% Gsb=2.55
Film Thickness (microns)
12.00
11.00
10.00
9.00
8.00
7.00
6.00
0
2
4
6
8
10
12
Compacted voids
INDEX
STANDARD
VIRTUAL

Research Beyond Film Thickness??



Measuring Binder Aging

Reducing Stiffness of Oxidized Binder in Recycled Asphalt Mixture by Stage Mixing

Kwang W. Kim, Jaehun Jung, and Young S. Doh
Kangwon National University, Chuncheon, Korea

Serji N. Amirkhanian
Clemson University, Clemson, SC

AAPT 2007

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Measuring Binder Aging

The Test Method

"Since the oxidation is a process that changes molecular size distribution of the binder, … it is possible to utilize gel-permeation chromatography (GPC) to detect this delicate change of molecular size distribution. Many studies have already shown that a relatively high correlation exists between viscosity and corresponding large molecular size (LMS) distribution in the GPC profile."

"In this GPC method, a small amount of mixture particle was dissolved into a solvent (tetrahydrofuran: THF) and a GPC sample was collected from the filtered dissolution."

AAPT paper

Measuring Binder Aging

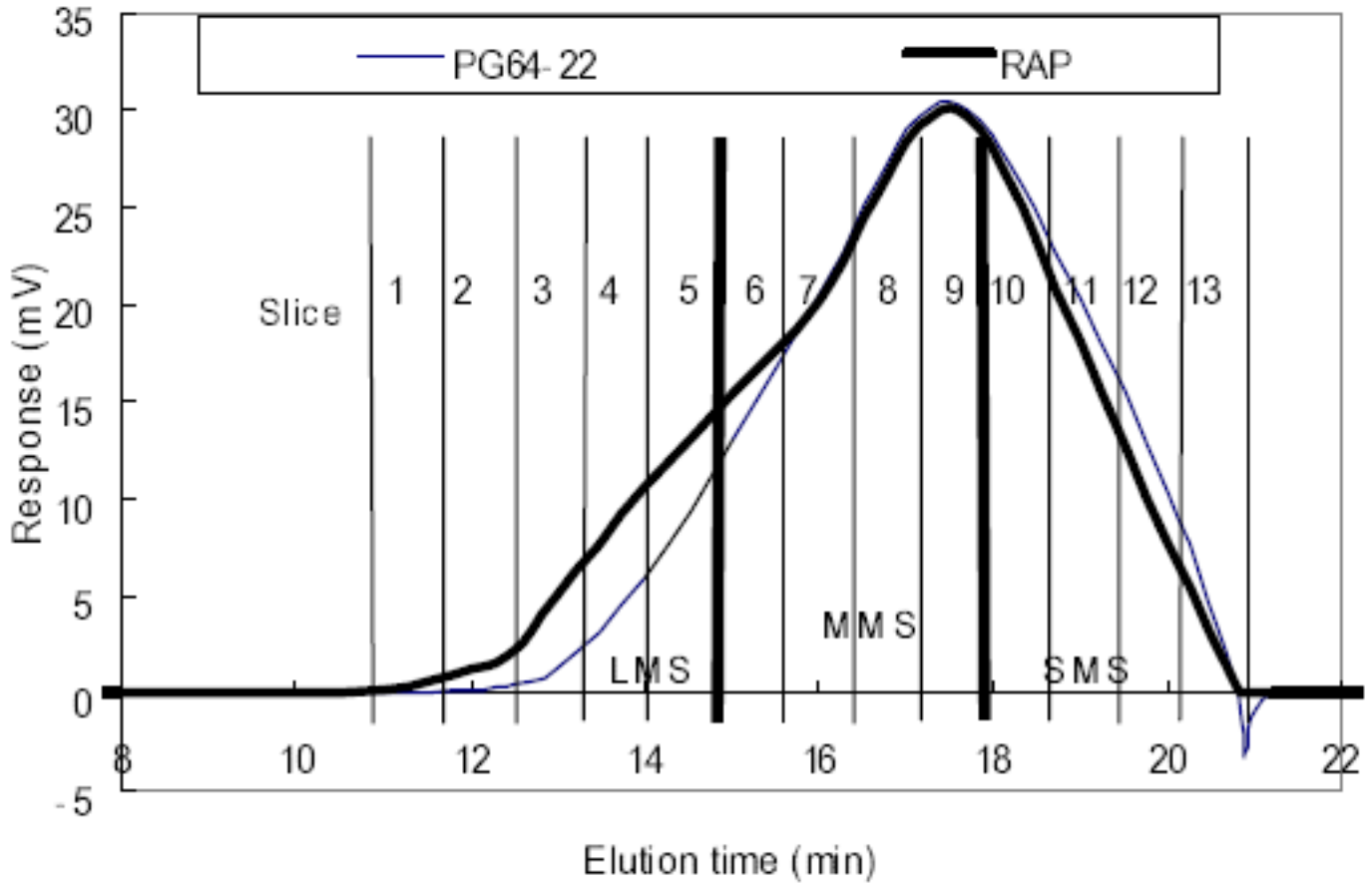
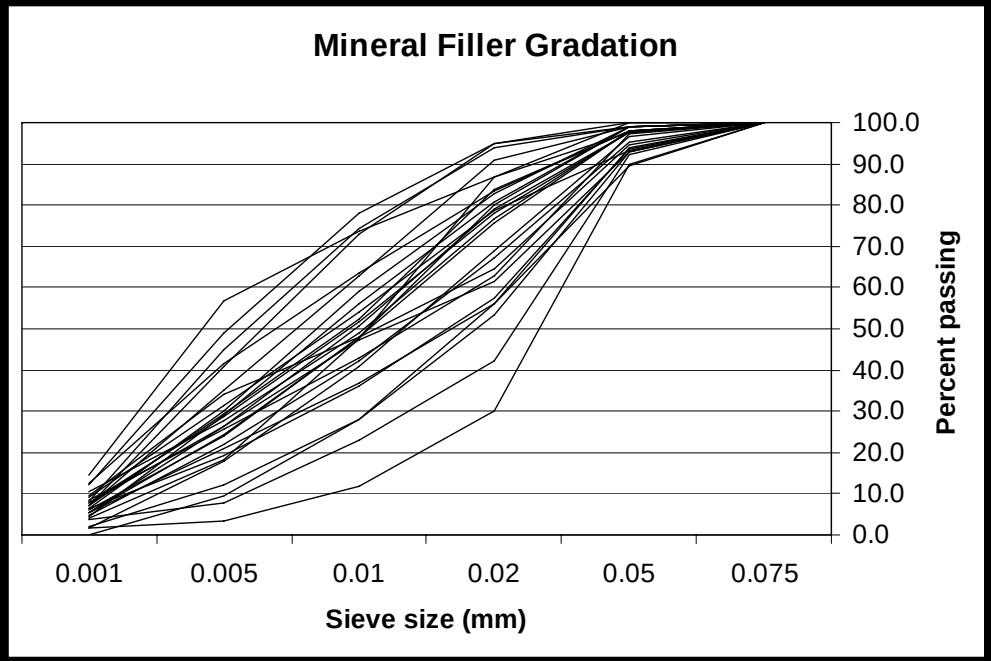


Figure 1. Typical chromatograms of two binders

Mineral Filler

We know very little about the mineral filler

- Physical properties (gradation, shape)
- Chemical properties
- Proportion in the mixture



Data from AAPT Vol 52, 1983

Mineral Filler

- NCHRP 09-45 Development of Specification Criteria for Mineral Fines Used in HMA
  - 3-year study started in 2007
  - PI is Dr. Hussian Bahia, University of Wisconsin - Madison
- Effect of Ultrafine Particles on Linear Viscoelastic Properties of Mastics and Asphalt Concretes
  - TRB 2008 paper 08-0865
  - Delaporte et al, France

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What is needed

- Comprehensive study of the mechanisms that influence MIXTURE aging

MIXTURE Aging = mixture performance change as the asphalt binder ages

Mixture performance = rutting, fatigue, low temperature cracking

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Nationally Combined Efforts

- FHWA directed research (ex: WRI, NCAT)
- NCHRP (2-3 year development period)
- Pooled fund (committed DOTs)

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Emphasis of this project

- Can we optimize the preventive maintenance, if we do not understand what we are measuring?
- Do we understand the aging process? Yes.
- Do we know what factors influences aging? Yes.

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Emphasis

- Do we know what factors are most important? No. We need a better understanding of the critical factors, then determine how to best control them.
- Do we know how the factors that influence aging impact other key performance criteria (rutting, fatigue, ...)? We cannot study aging without recognizing that HMA performance is complex.
- What is the best way to measure aging? Binder or mixture response? We cannot ignore mixture response. If binder ages, but mixture performance does not change … then aging is at acceptable levels.

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Closing comments

- There is no single magic bullet.
- Research must keep one eye focused on the practical application of the results.
- Do not narrow the research to binder only. Include mixture and mastic.

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