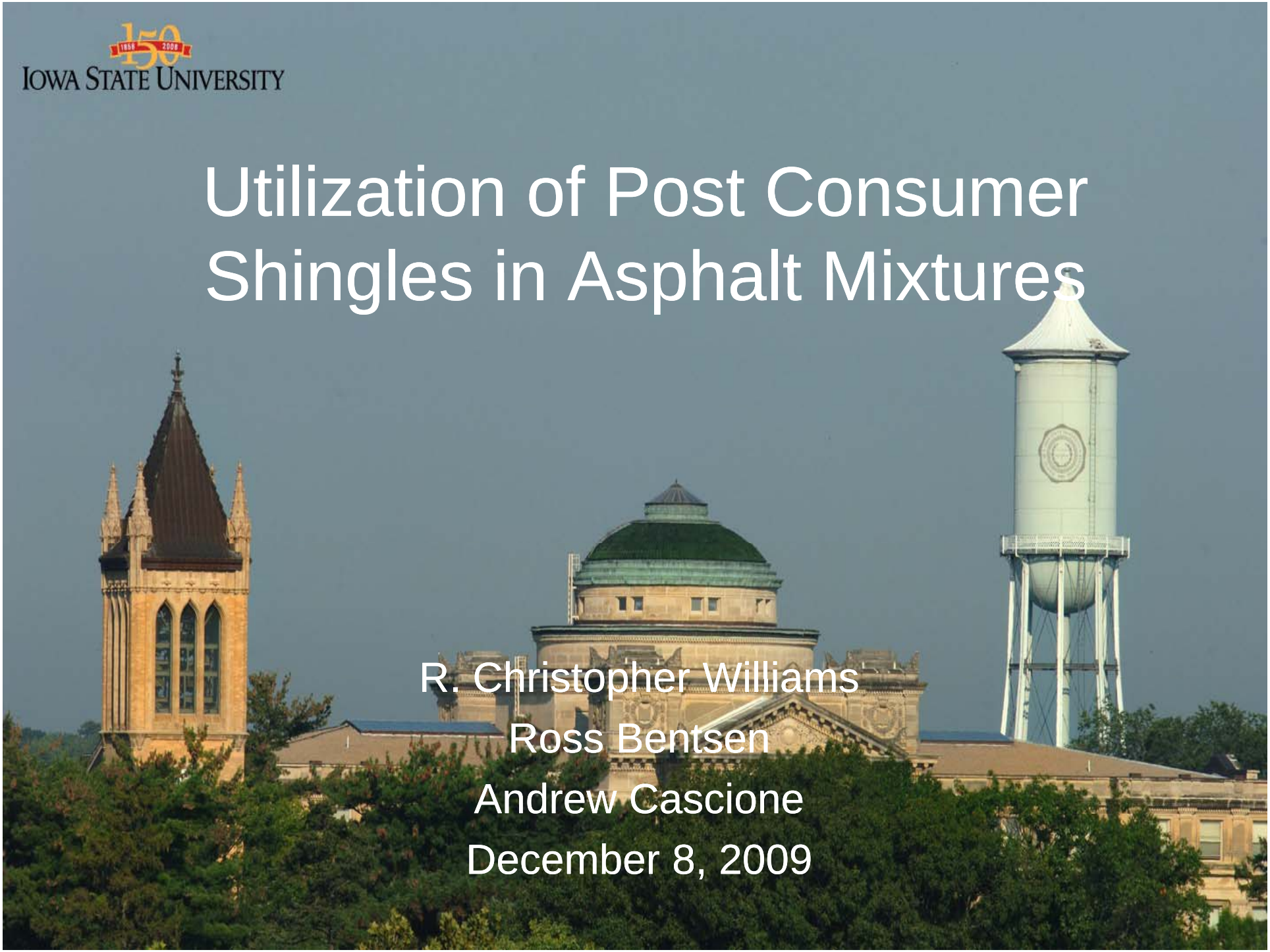

IOWA STATE UNIVERSITY
Utilization of Post Consumer Shingles in Asphalt Mixtures
R. Christopher Williams
Ross Bentsen
Andrew Cascione
December 8, 2009

Presentation Outline

- Introduction
- Federal requirements
- Source material properties
- Mix design & properties
- Ongoing Research
  - National Pooled Fund Study
  - Illinois Tollway
- Concluding thoughts

Introduction

- Asphalt shingles
  - Manufacturing scrap
  - Post consumer
- 60% of shingle sales are due to storm damage
- Asphalt shingles have multiple beneficial components for use in asphalt mixtures
  - Asphalt, Aggregate, Fibers, & Limestone filler

23 CFR Section 637B

Quality Assurance Procedures for Construction

- 637.201 Purpose.

To prescribe policies, procedures, and guidelines to assure the quality of materials and construction in all Federal-aid highway projects on the National Highway System

- 637.203 Definitions.
- 637.205 Policy.
- 637.207 Quality assurance program.
- 637.209 Laboratory and sampling and testing personnel qualifications.

Product Quality Characteristics

- Source material- recycled shingles
  - Limit loads of post-consumer shingles to residential buildings with four or fewer dwelling units *(these buildings are not "regulated facilities" according to state and federal **NESHAP 40 CFR Part 61, Subpart M**)*.
  - Asbestos free
  - Deleterious material
  - Grind size
  - Moisture content

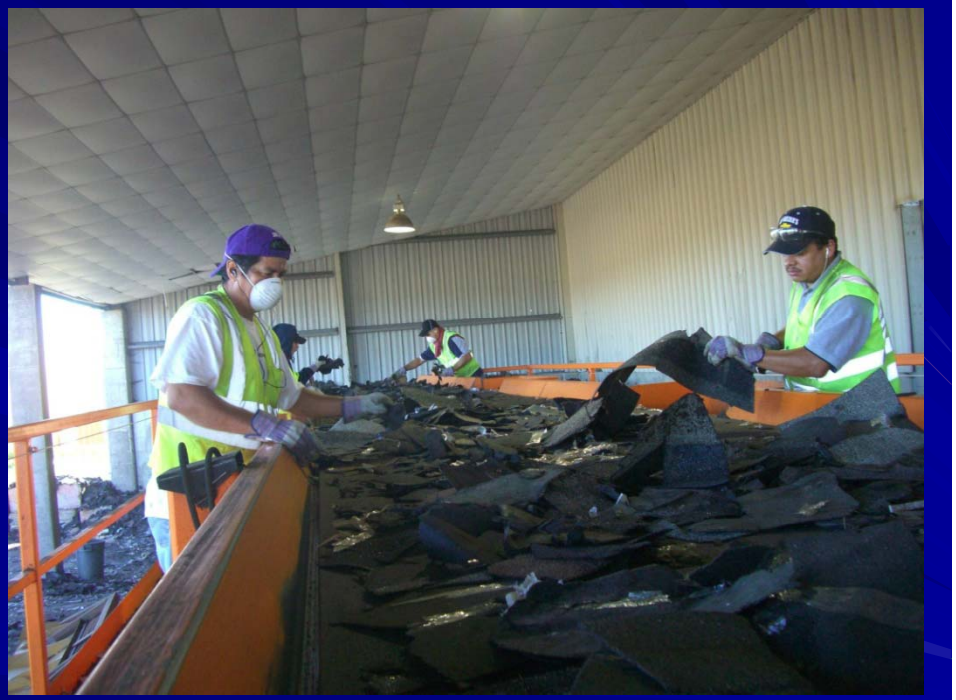
Product Quality Characteristics

- Asphalt mixture (hot mix or warm mix)
  - Limiting recycled asphalt binder content
  - Binder content
  - Voids criteria (lab air voids, field air voids, VMA , etc)
  - Smoothness

Quality Assurance

- Must be a statistically based approach
- FHWA has promoted percent within limit
  - Achieving product targets
  - Product consistency

Sorting is manual

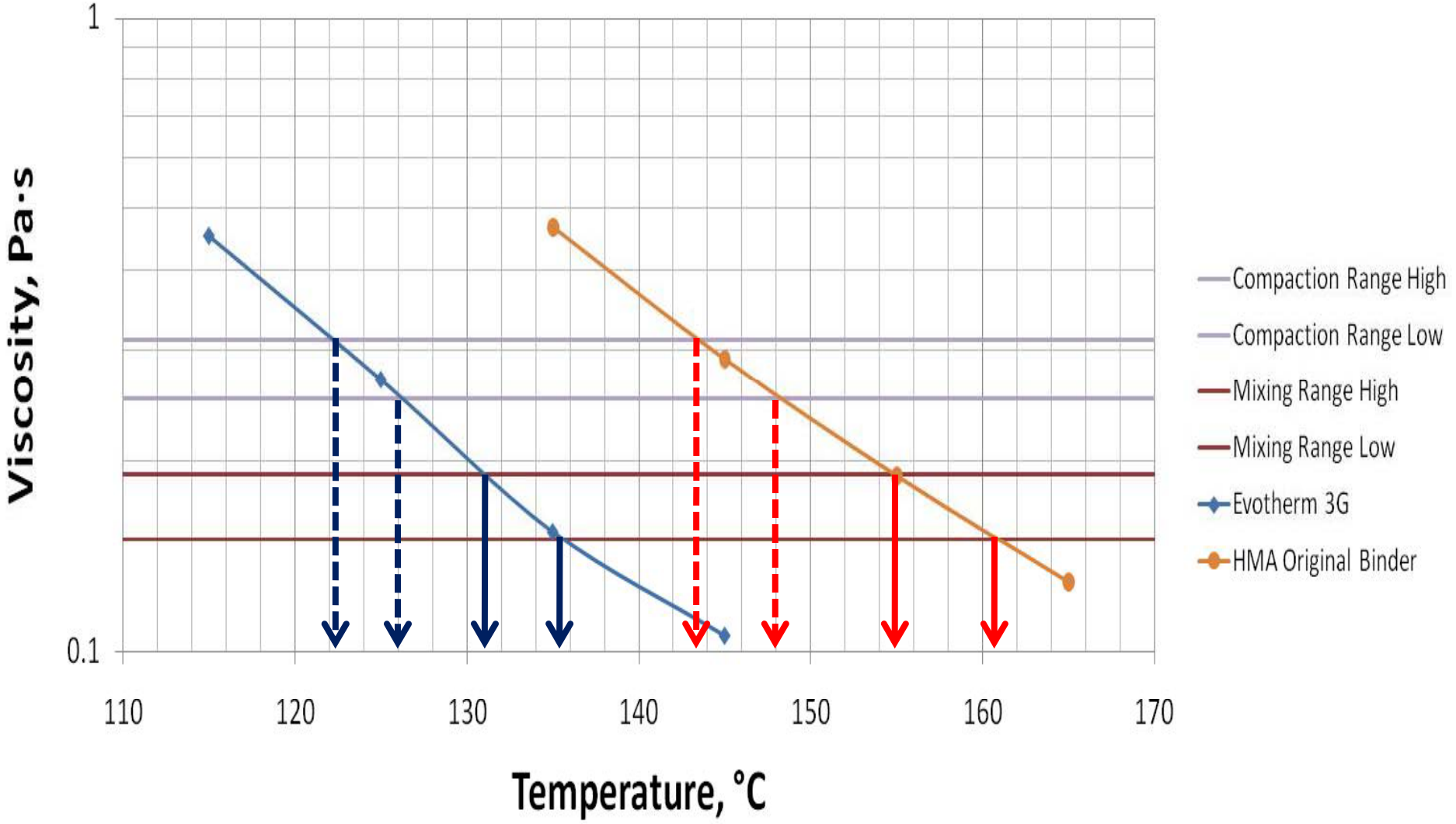



KOMATSU

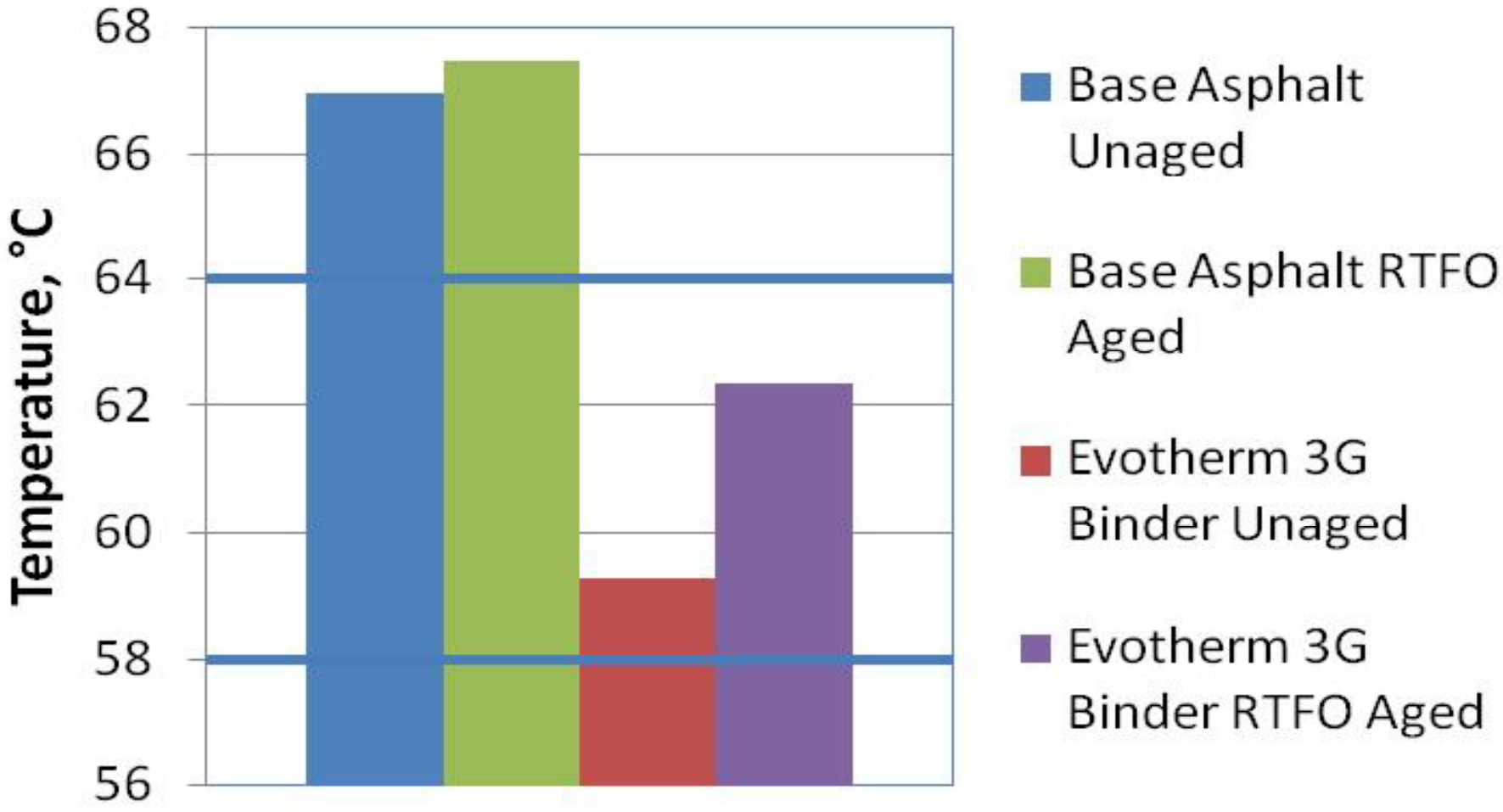
Challenge- Many new technologies in the asphalt industry

- Recycled shingles
- High RAP mixes
- Fractionated RAP
- Warm Mix Asphalt
  - Foaming Technologies
  - Organic Additives
  - Chemical Additives
- Bio Asphalt (non-petroleum)

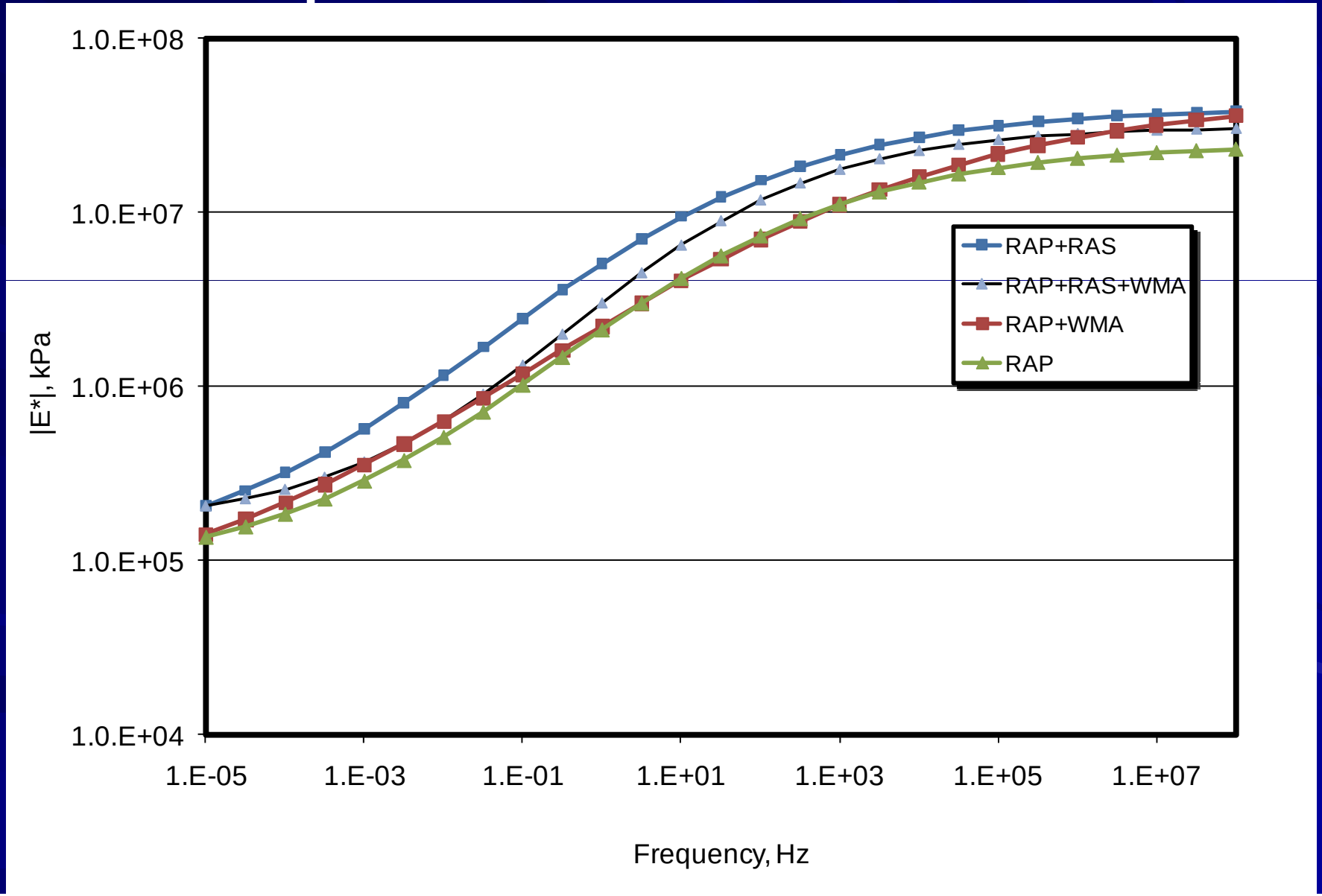
Viscosity Comparison of Evotherm 3G & Original HMA Binder



High Temperature Comparison



Comparison of Field vs. Lab



What are our expectations?

- Performance expectations are met
- Materials and production/construction processes are economical
- Integration of sustainability
  - Recycling
  - Reduction of emissions
  - Carbon credits

Performance Expectations

- Source materials
- Performance testing
  - Permanent deformation
  - Fatigue cracking
  - Thermal cracking

Mix Design Approaches for Integration of RAS into HMA

Development of Mixture Design

- Process is no different than current methods of asphalt mix design development.
- Need to pay attention to integration of RAS into batching materials
  - Proportioned materials should be pre-blended prior to placement into oven.
  - Ensures even distribution of RAS throughout aggregate structure.

Outcomes of Mix Design

- Virgin binder content will be lower when RAS is utilized.
- 60-80% of RAS binder will be integrated into HMA mix.
- Voids in the Mineral Aggregate will increase with RAS utilization.
- Contribution of RAS binder to overall binder grade will not be known……but!

Challenges

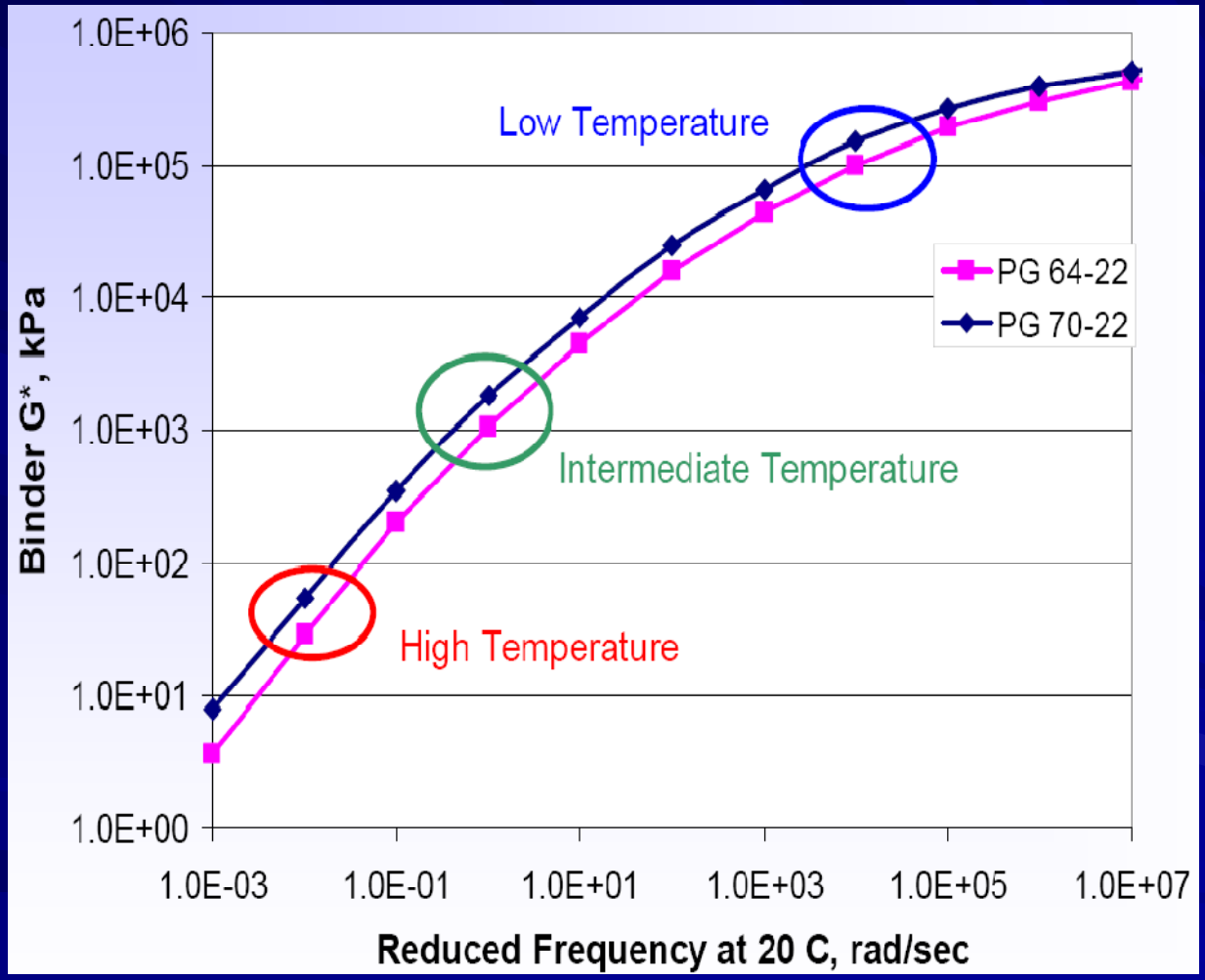
- AASHTO M323 binder recommendations assume complete mixing of new and recycled binder
- AASHTO M323 does not address RAS binders
- RAS rheology is different than paving binders

RAS Contribution to Performance Grade

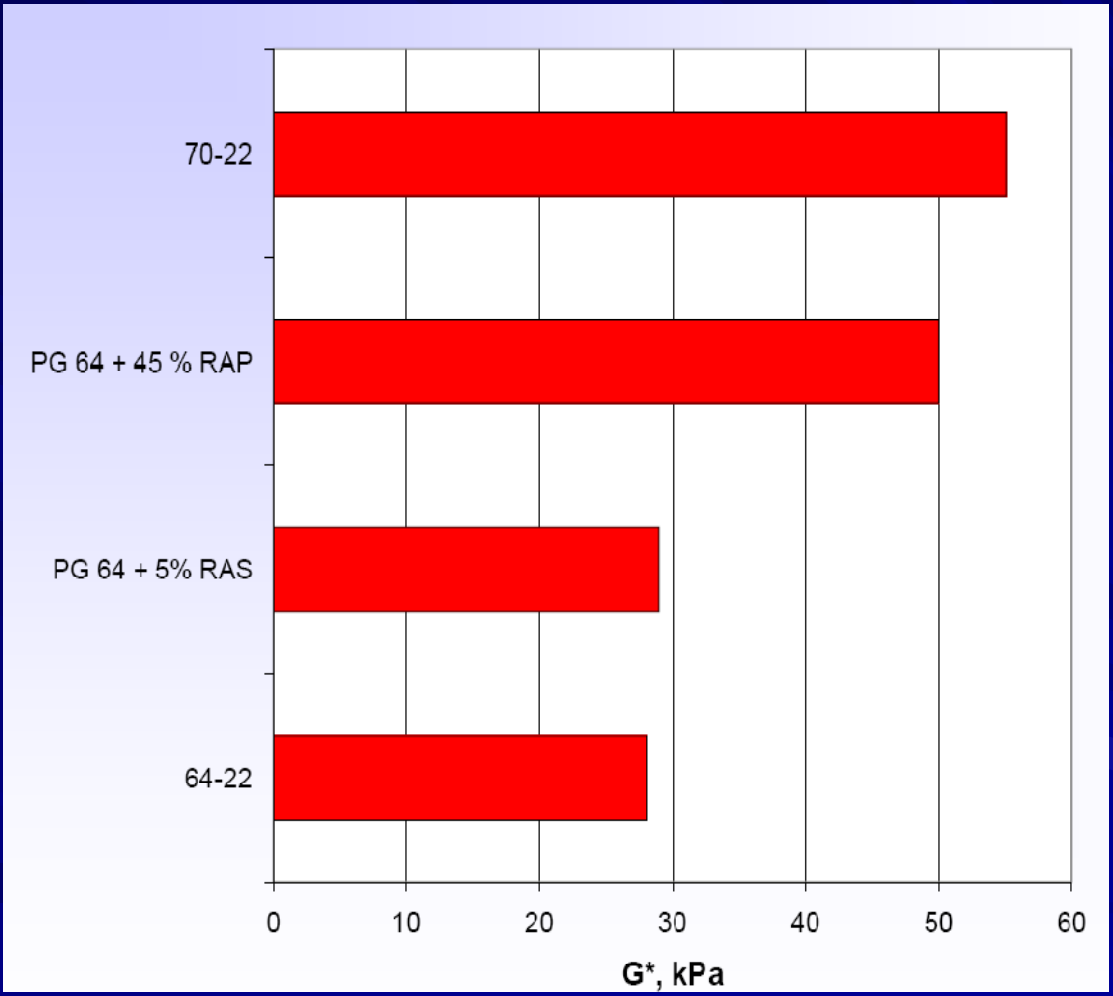
- Recovered binder properties
- Estimated binder properties through mix testing
  - Dynamic modulus testing
  - Very sensitive to binder properties
  - Estimate effective performance grade
  - Hirsch and Witzcak Models
  - Mix Modulus = f(Binder modulus, VMA, & VFA)

Simple Performance Test

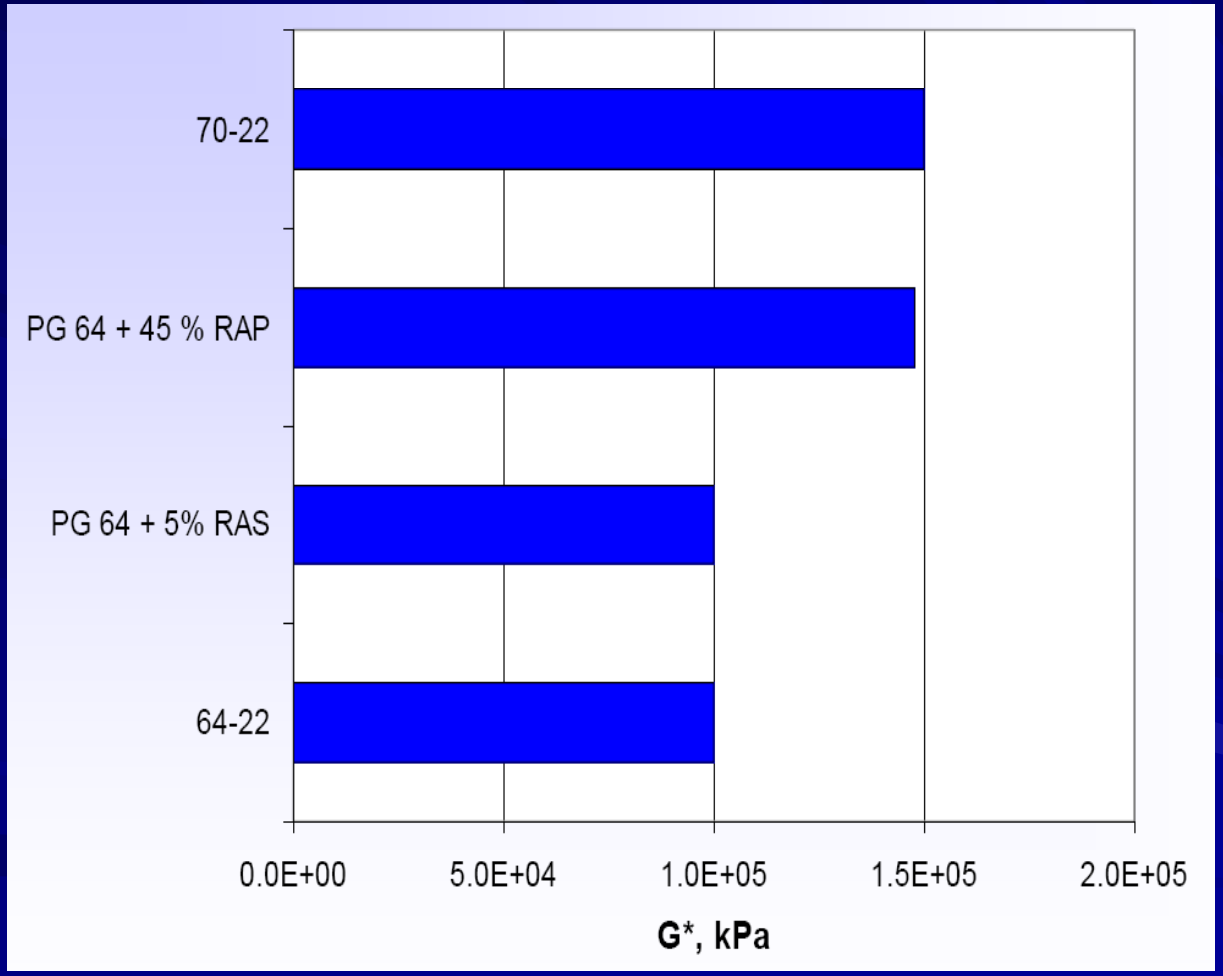
Graphical Representation



High Temperature



Low Temperature



Ongoing Research Work

- National Pooled Fund Study
- Illinois Tollway
- Region 5 EPA
- Headquarters EPA

National Pooled Fund Study

- MO DOT is the lead state (Joe Schroer, JD Wenzlick, Karmen Stockman)
- Participants: FHWA, MO, IA, IN, MN, WI
- Research Team: IA State, Deb Haugen, MN/DOT, Univ. of MN

Work Plan

- Literature Review
  - Nationwide Reports
  - Case Studies
    - Past
    - Current
    - Scheduled
  - Publications
  - Updated review of state specifications and environmental white papers on asbestos and PAH's in RAS

Made available on study website

Work Plan

- Review and Implementation of Quality Control/Quality Assurance for Processing and Sourcing Shingles
  - Working with environmental agencies on standard operating plans to ensure final product meets environmental requirements
    - Asbestos
    - Deleterious content
    - Sizing
- Working with HMA producers to ensure final product meets agency specifications
    - Sizing
    - Deleterious content
    - Moisture content
    - Asphalt content
    - Aggregate specific gravity
    - Aggregate absorption

Work Plan

- Development of Mix Design and Construction Specification Criteria for RAS in HMA
  - Specifications for demonstration projects
    - Mix type
      - RAS content
      - RAS and RAP content
      - RAS and FRAP content
      - Virgin binder content

Work Plan

- Demonstration Projects
  - Sampling of materials
    - RAS
    - Virgin asphalt binders
    - Field produced mixes
  - Project descriptions
    - Location
    - Pavement structure
    - Pavement design parameters
  - Production and construction processes
  - Project conditions
    - Weather, tonnage etc.

Work Plan

- Characterization of RAS, Recovered Mix and Virgin Binders
  - Dynamic shear rheometer
  - Bending beam rheometer
  - Aging tests
    - rolling thin film oven test
    - rolling thin film oven and pressure aging vessel
  - Asphalt recovered from RAS
    - AASHTO T170
    - Recovery of Asphalt from Solution by Abson Method
  - Create a blend chart

Work Plan

- Mix Performance Testing of Design Mixtures and Field Produced Mixtures
  - Prior to construction
  - Field produced mixes
  - Performance tests will be conducted at low, medium and high temperatures
  - Other ongoing research on RAS
    - Warm Mix Asphalt

Work Plan

- Field Performance Surveys of Constructed Demonstration Projects
  - Two field condition surveys
    - Distress Identification Manual for the Long-Term Pavement Performance Project
    - Digital Photo's

Work Plan

- Statistical Analysis
  - Develop sampling frequency for asbestos testing based upon Bayesian Statistics/Probability
  - Analysis of binder test data including blending charts to determine the percentage of allowable RAS
  - Analysis of mix performance data to determine the relative influence of RAS on mix performance which will include tests at low, intermediate and high temperatures
- Development of Final Report

Project Schedule

Task	2009		2010				2011	
	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sept	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sept
1. Literature Review								
2. QC/QA for Processing & Sourcing RAS								
3. & 6. Performance Testing of Design & Field Mixes								
4. Construction of Demonstration Projects								
5. Characterization of RAS, Recovered Mix & Binders								
7. Performance Surveys of Demonstration Projects								
8. Statistical Analysis								
9. Development of the Final Report								

2009 Tollway RAS Research

- Recycled asphalt shingles (tear-offs) into high FRAP mixes
- Shoulder Binder and Bases
  - 5% RAS with 3 levels of FRAP (25%, 35%, 45%)
- Shoulder Surface
  - 5% RAS with 20% FRAP
- SMA Surface (SBS PG 76-22)
  - 5% RAS with 15% Fine FRAP

2009 Tollway RAS Research

2009 Tollway RAS Research

- 3.5 mile length of Outside Shoulder: I-90
- Placement July-August 2009
- 8 Test Sections
- 4 Different RAS Shoulder Binder Mixes
  - 850 to 1300 tons each
- Standard (25% FRAP) and RAS Shoulder Surface placed over each
  - 1300 tons RAS Shoulder Surface

Tollway RAS Test Sections

Illinois Tollway Shingle Research Test Section Layout												
PROJECT	I-08-5543 – Jane Addams Memorial Tollway – I-90											
LOCATION	Westbound Outside Shoulders											
TEST SECTION	1	2	3	4	Bike Trail Bridge	4	5	Burr Oak Bridge	5	6	7	8	N/A
SECTION LENGTH, ft	2345	2214	1926	1990		826	1714		630	1388	2592	2150	
SURFACE MIX NUMBER	90BITRS05	90BIT0823		90BITRS05		90BITRS05				90BIT0823		90BITRS05	
SURFACE MIX TYPE	20% FRAP / 5% RAS N70 SCS	25% FRAP N70 SCS		20/5 RAS N70 SCS		20% FRAP / 5% RAS N70 SCS				25% FRAP N70 SCS		20% FRAP / 5% RAS N70 SCS	
STA #	363+25 MP 71 1/4 – 339+80	339+80 MP 71.7 – 298+40		[illegible] MP 72.5	278+50 – 276+00			250+60 – 248+60	242+30	[illegible] MP 73.5 – 202+50		[illegible] MP 74 1/4 – 168+80	
DATE PLACED	8/10/2009	8/10/2009		8/10/2009						8/10/2009		8/10/2009	
TONNAGE	256.41	616.6		556.51						633.09		532.69	

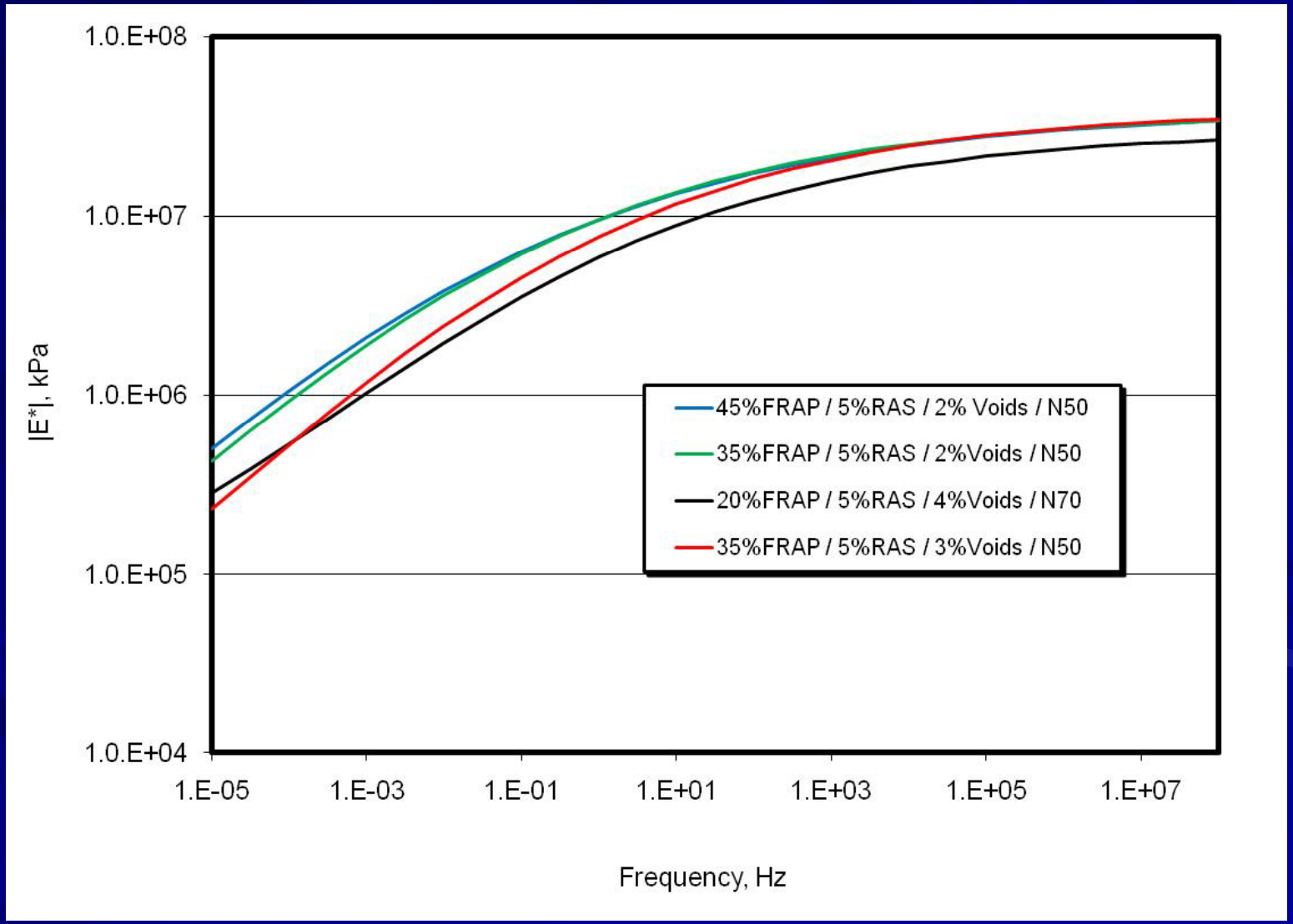
BASE MIX NUMBER	90BITRS04	90BITRS02	Bike Trail Bridge	90BITRS02	90BITRS03	Burr Oak Bridge	90BITRS03	90BITRS01		MILLED MATERIAL
BASE MIX TYPE	25% FRAP/5% RAS BIT BASE	35% FRAP/5% RAS BIT BASE		35% FRAP/ 5% RAS BIT BASE	45% FRAP/ 5% RAS BIT BASE		45% FRAP/ 5% RAS BIT BASE	35% FRAP/5% RAS N50 BCS		
STA #	363+25 – 317+66	317+66 MP 72.1	278+50 – 276+00	267+74	267+74 MP 73.1	250+60 – 248+60	228+42	228+42 73.8 – 181+00 MP 74.7		
DATE PLACED	7/29/2009	7/29/2009			7/29/2009			7/30/2009		
TONNAGE	1272.96	1295.86			846.23			1314.36		

Not to Scale

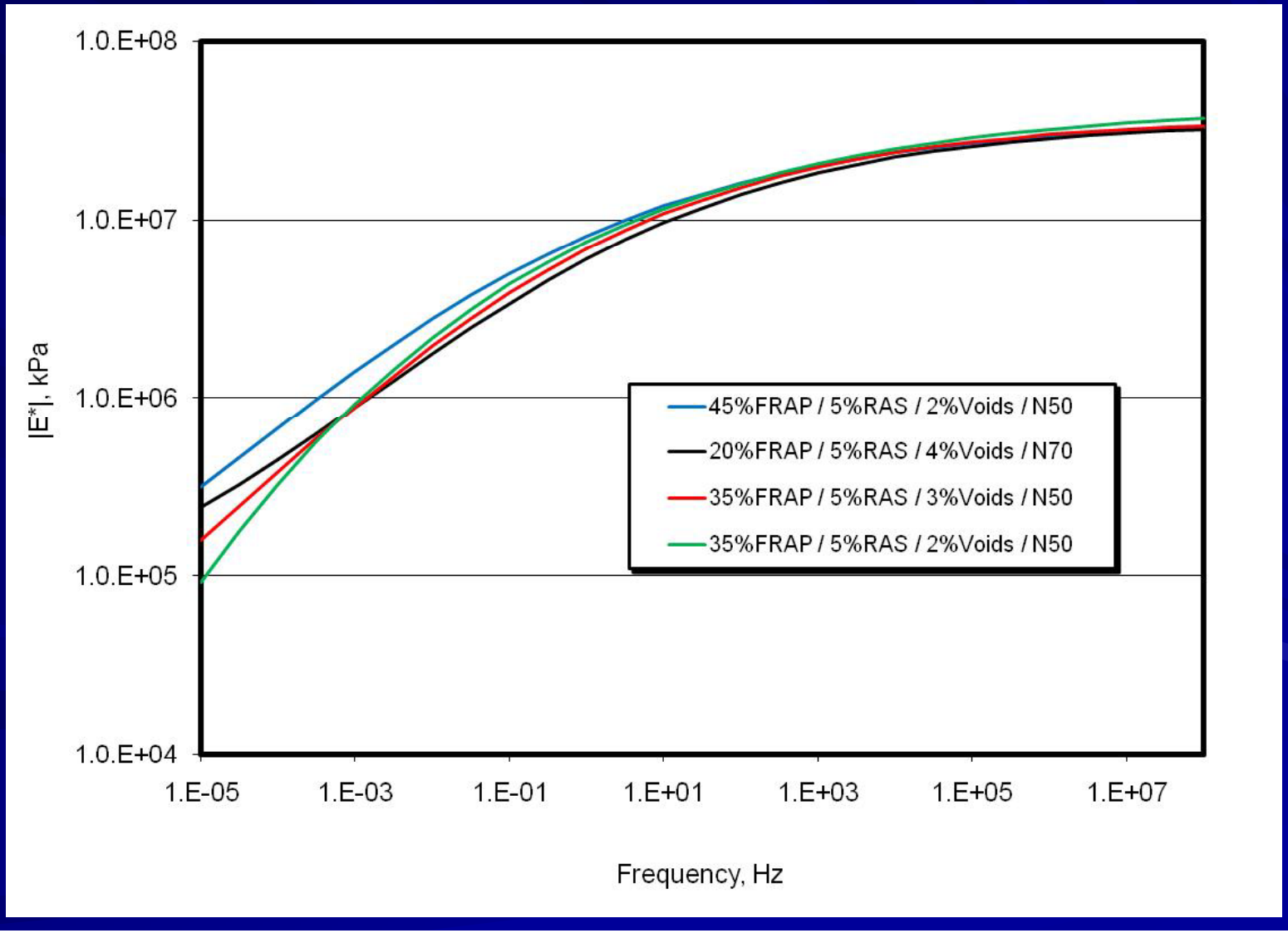
Lab Tests
Lab & Field Produced Mixes

- Dynamic modulus
- Beam fatigue
- Disc Compact Tension
- Recovered Binders

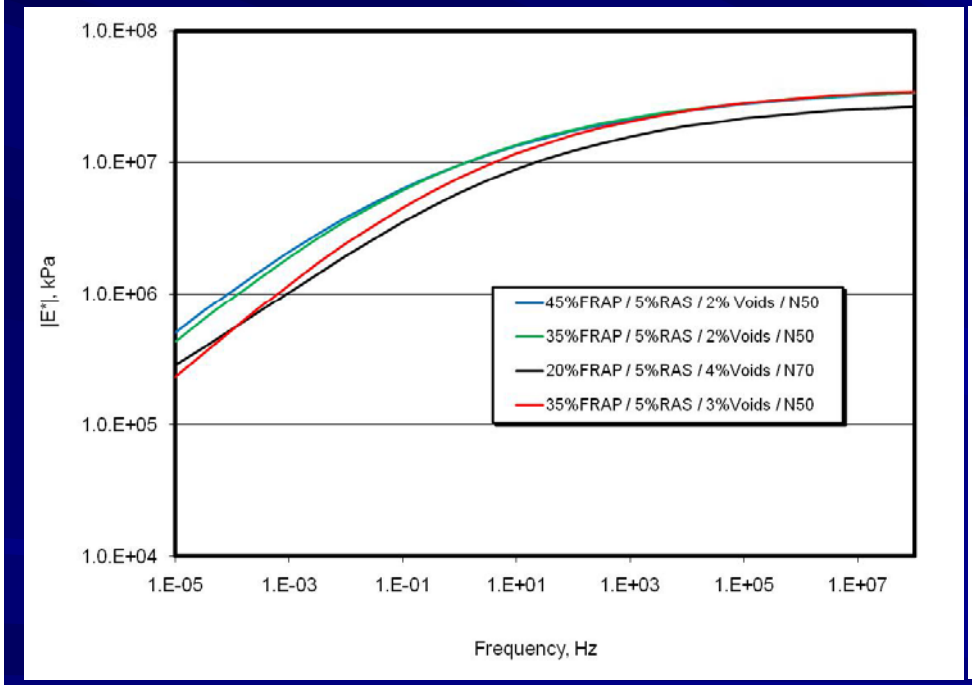
Laboratory Mixes



Field Mixes


1.0.E+08
1.0.E+07
1.0.E+06
1.0.E+05
1.0.E+04
|E*|, kPa
1.E-05
1.E-03
1.E-01
1.E+01
1.E+03
1.E+05
1.E+07
Frequency, Hz
45%FRAP / 5%RAS / 2%Voids / N50
20%FRAP / 5%RAS / 4%Voids / N70
35%FRAP / 5%RAS / 3%Voids / N50
35%FRAP / 5%RAS / 2%Voids / N50

Lab vs. Field


1.0.E+08
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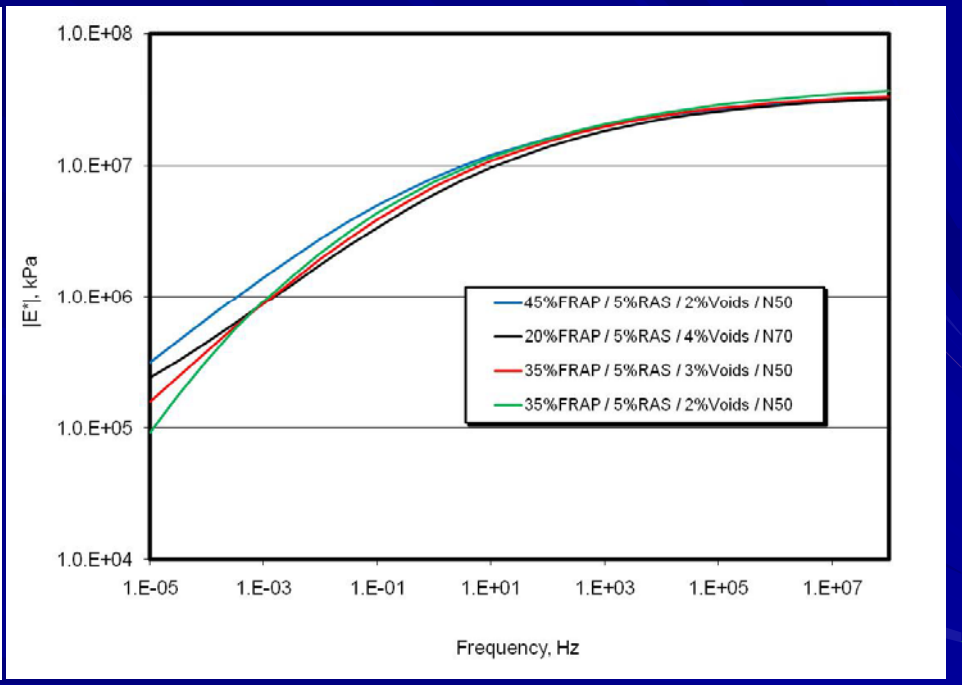
1.E+01
1.E+03
1.E+05
1.E+07
Frequency, Hz
45%FRAP / 5%RAS / 2% Voids / N50
35%FRAP / 5%RAS / 2%Voids / N50
20%FRAP / 5%RAS / 4%Voids / N70
35%FRAP / 5%RAS / 3%Voids / N50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Frequency, Hz
45%FRAP / 5%RAS / 2%Voids / N50
20%FRAP / 5%RAS / 4%Voids / N70
35%FRAP / 5%RAS / 3%Voids / N50
35%FRAP / 5%RAS / 2%Voids / N50

Summary

- The RAS binder contribution to the “mix” performance grade of combined binder can be reasonably estimated
- Warm mix asphalt technology is employing the same approach
- Warm mix asphalt & shingles are synergistic
- The approach is consistent with future mix performance testing

Concluding thoughts/questions

- Integrating shingles into asphalt mixture specifications is challenging.
  - New technologies
  - Composition of shingles is changing
- Are post consumer shingles a solid waste today, in 5 years, or 10 years?
- Two demonstration projects have been placed in Indiana- lab testing of materials will begin soon.

Acknowledgements

- Steven Gillen, Illinois Tollway
- Jay Behnke, STATE Testing
- Ray Bonaquist, AAT
- Chris Robinette, Granite Construction
- Jason Bausano, Navy
- Tamer Breakah, Iowa State University
- Andrea Kvasnak, NCAT


Thank You!
&
Questions?

HMA Production Considerations

Production Facilities

- Storage of RAS is for a limited time
  - 2-3 weeks
  - Can blend with a sand to extend storage time
- Counter Flow Drum is preferred
- 2nd Recycle Chute is preferred upstream of RAP
- How is liquid asphalt paid for?
  - Separate- need to be able to track added RAS