

# USE OF TEAR-OFF RECYCLED SHINGLES IN ASPHALT PAVEMENTS

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## Background

- 10 million tons of asphalt Shingles enter waste stream each year
  - 1 million tons manufacturer waste
  - 9 million tons tear-offs or used Shingles
  - Third largest construction material waste
- ARMA analyzed a number of recycling options and identified HMA as the best use
  - Volume of waste used
  - Ease of recycling since Shingles composed of materials routinely used in HMA

## Background

- Why use Shingles?
  - Economic benefits
    - Considerable cost savings per ton of HMA
    - Not all benefits accrue to all users
      - Tipping fees and handling costs vary
  - RAP sources are declining in some markets
  - It's the right thing to do
    - Process can be engineered to provide asphalt mixtures with equivalent performance

# Background

- Potential benefits from the use of Shingles in HMA include:
  - Improved resistance to pavement cracking
    - Due to reinforcement from fibers
  - Improved resistance to rutting
    - Due to fibers and increased stiffness of binder
  - Reduced costs for the production of HMA
    - Conservation of natural resources
  - Conservation of landfill space
    - Reduced costs for Shingle waste disposal
- Studies ongoing at this time
  - At this time consider impact as neutral

## Background

- Shingles typically contain:
  - Asphalt binder
    - Tear-offs contain 30 – 40% binder
    - Manufacturer waste 18 – 22% binder
  - 40 to 60% hard rock granules and fillers
  - 1 to 12 % fiber, felt, and miscellaneous materials

## Oldcastle Materials Shingles Use

- Began using shingles in 2002
  - 2009 OMG received 83K tons of shingles
  - 2010 OMG received 146K tons of shingles
    - Majority of shingles received were tear-offs
    - 87K tons used in the production of ~1.4 million tons of asphalt mixtures
  - 6 of 7 OMG Divisions used shingles in 2010, 14 different companies
  - Shingles were used in:
    - Texas
    - Missouri
    - Oregon
    - Iowa
    - Massachusetts
    - Oklahoma
    - Pennsylvania
    - North Carolina
    - Alabama
    - Ohio

# AASHTO Standard Practice

- PP 53-09 Design Considerations when Using Reclaimed Asphalt Shingles in New HMA
  - Provides guidance on:
    - Design considerations
      - “the size of the RAS can be expected to affect the fraction of RAS binder that contribute to the final blended binder”
      - “Particles of undissolved asphalt binder may act like aggregate particles that require more virgin asphalt binder to accomplish coating”
      - “fibrous material present in RAS may also require additional virgin asphalt binder to accomplish coating”

# AASHTO Standard Practice

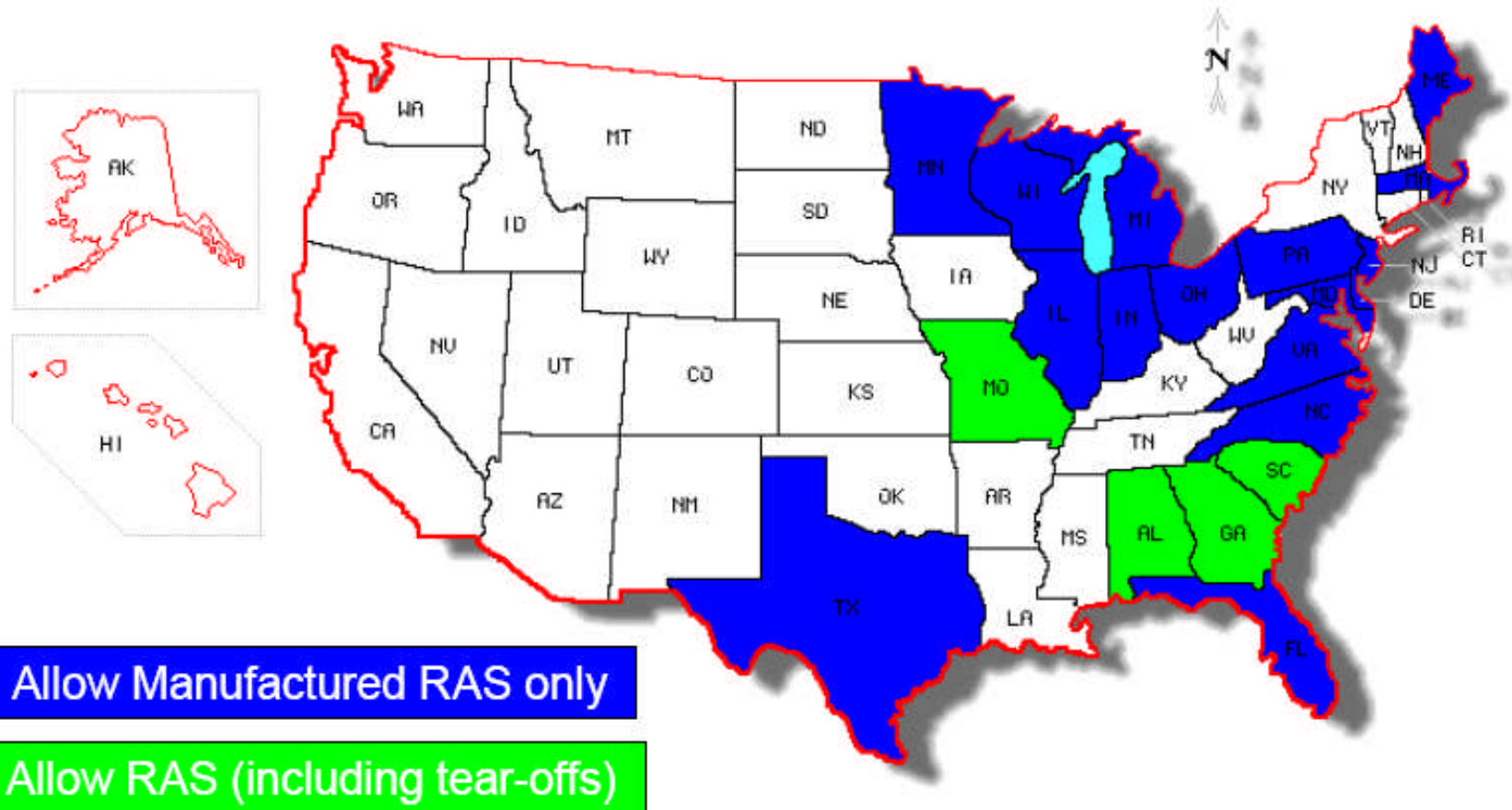
- PP 53-09 Design Considerations when Using Reclaimed Asphalt Shingles in New HMA
  - Provides guidance on:
    - How to determine the shingle aggregate gradation
      - “it is suggested the shingle fiber present in the shingle be removed prior to testing”
    - How to estimate the contribution of the RAS binder to the final binder blend
      - “finer the grind, the greater the amount of the contribution of binder from the reclaimed asphalt shingle to the final blended binder”
      - “Recognized limitations in procedure due to assumptions related to: the amount of shingle binder released into the mix, the additional absorption due to the RAS present in the mix, the additional existing coating requirements due to the RAS present in the mix”



# AASHTO Standard Practice

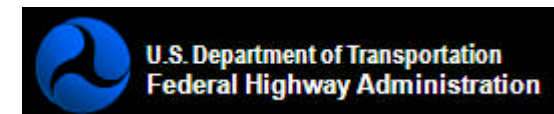
- MP 15-09 Use of Reclaimed Asphalt Shingle as an Additive in HMA
  - Provides standard definitions for RAS
  - Requires RAS to be processed so that 100% passes the 12.5-mm sieve
    - Allows the blending of RAS with fine aggregate to prevent agglomeration of RAS particles
  - Requires additional testing of the composite binder if the percentage of liquid contributed by the RAS and RAP exceeds 30 percent
  - Addresses deleterious materials present in the RAS

# Recycled Shingle Use in US



12-8-08

ODOT Supplemental specification 1116  
dated January 21, 2011.



## ODOT specifications

- Supplemental Specification 800 1-21-2011 Section 401.04 refers to Supplemental Specification 1116 also dated 1-21-2011
- Job Mix Formula. The Contractor may use a blend of new materials in combination with RAP obtained from verifiable Department or Ohio Turnpike Commission projects and/or RAS obtained from un-used manufactured shingle waste or used roofing tear-off shingles as listed in Tables 401.04-1 and QCP for ongoing processing and testing of these piles. Ensure no foreign or deleterious material (703.04, 703.05) is present in RAP. All RAS suppliers must meet the requirements of Supplemental Specification 1116.

ODOT RAS specification

**SUPPLEMENTAL SPECIFICATION 1116**  
**Requirements for Suppliers of Reclaimed Asphalt**  
**Shingles**  
**Used in Asphalt Mixtures**  
**January 21, 2011**

**1116.01 Scope**

**1116.02 Reclaimed Asphalt Shingle Material**  
**Requirements**

**1116.03 Reclaimed Asphalt Shingle Supplier**  
**Approval Process**

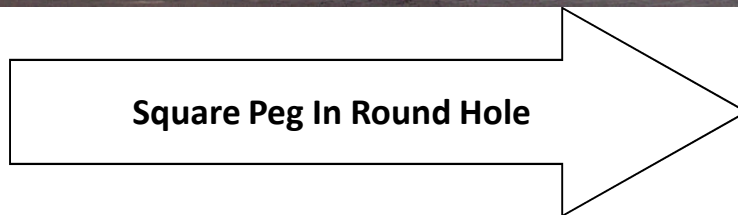
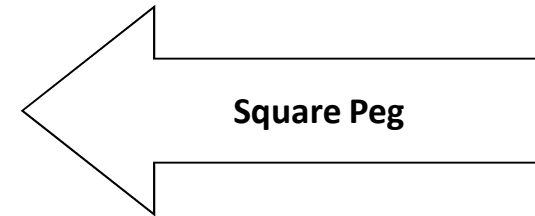
**1116.04 Quality Control Requirements for RAS**  
**Suppliers**

**1116.05 Quality Assurance**

**1116.01 Scope**

# Processing Shingles for Use in HMA

- The age old engineering question
  - How do you make a square peg fit into a round hole?





# Processing Shingles for Use in HMA

- Various equipment has been tried to grind the Shingles into a usable product
  - Shredding approach





# Processed Shingle Stockpile





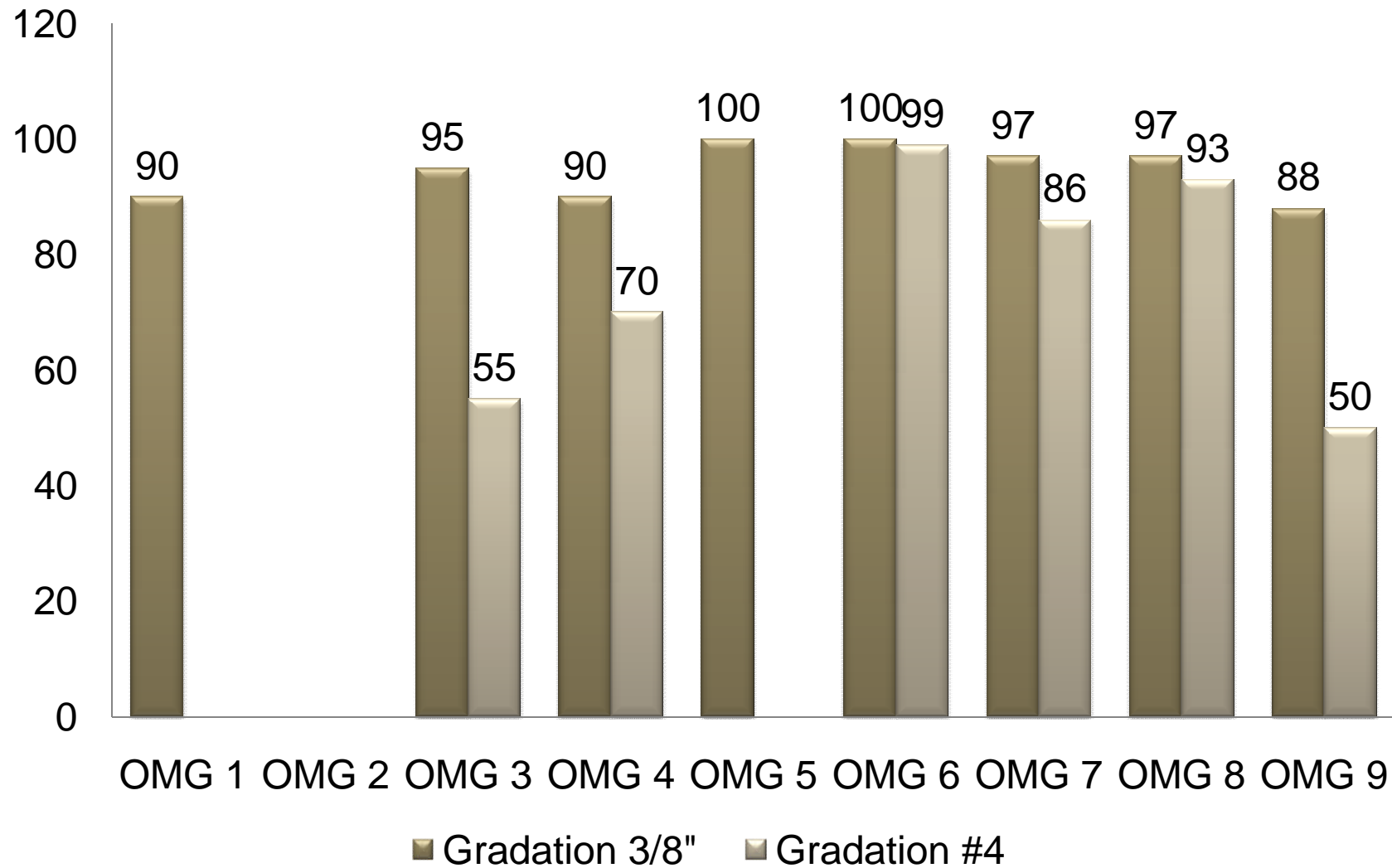
# Processing Shingles for Use in HMA

- Carrier aggregate used to keep Shingles from agglomerating and allow to flow through cold feed bin
  - RAP, 3/8" Stone, Washed stone screenings, Natural sand
  - ***Also have locations that have been successful with no carrier aggregate***
- Blending by volume / weight
- Blending methods
  - Dual bin blender
  - Ground blending with additional processing

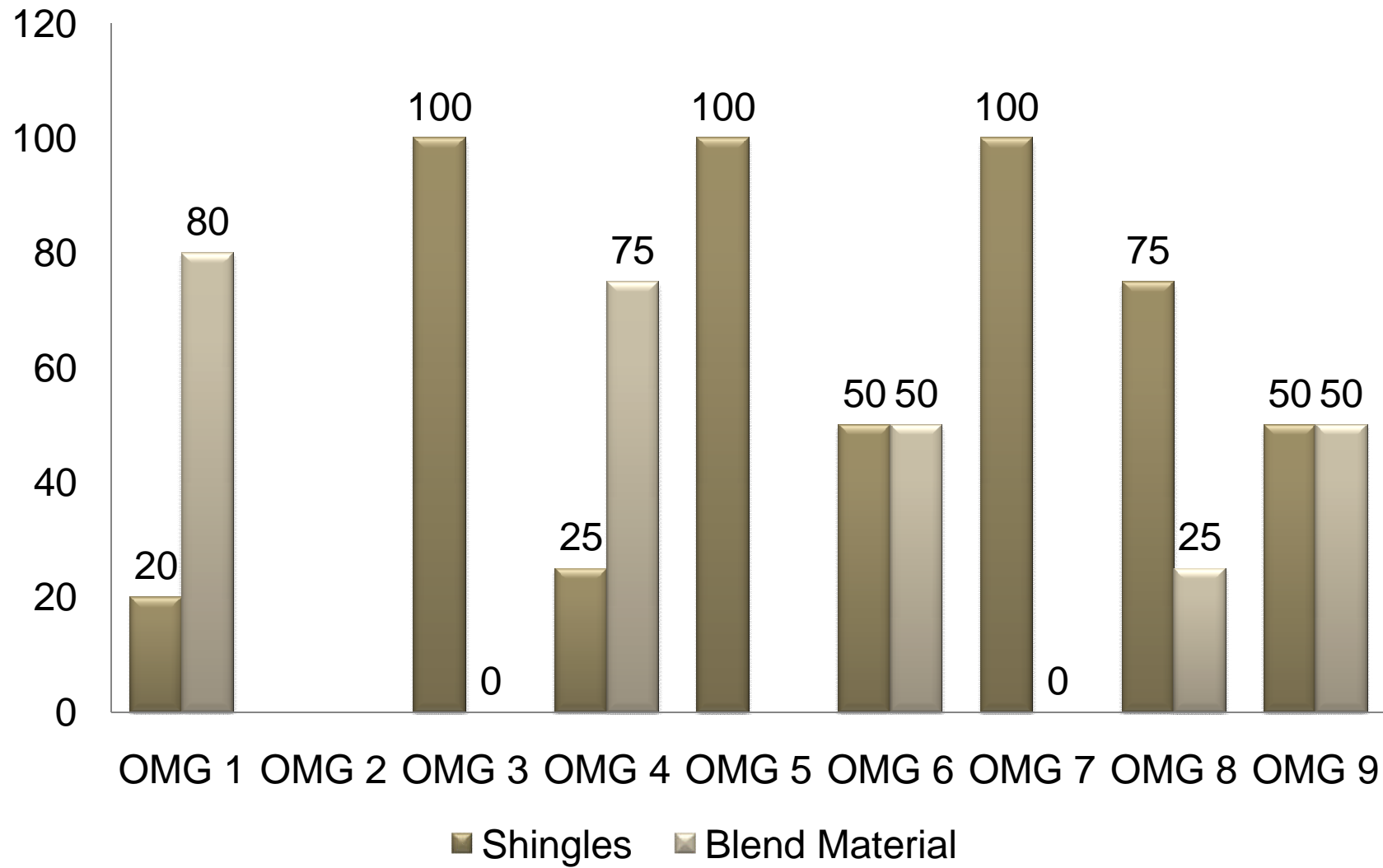




## Processed Shingle Gradations



## Shingle / Carrier Aggregate Blend Ratios



# Processing Shingles for Use in HMA



Grind is too coarse



Preferred Grind

- Most significant concern is proper sizing of the ground Shingle particle
  - Finer is better!
- Oversized Shingles particles impact:
  - Contribution to  $P_{be}$  (Effective asphalt content)
  - Mat texture
  - Consistency of blend with carrier aggregate

# Processing Shingles for Use in HMA



- Environmental concerns
  - Typical concerns for aggregate crushing and HMA production
  - HMA with Shingles is recyclable
  - Asbestos screening
    - Must comply with local agency requirements, which vary from state to state



# Typical Tear-off Shingle Composition

- Results shown below were obtained from processed tear-off Shingles
- Gradation and binder contents of manufacturer waste are significantly different
  - Gradation is finer with lower binder content

Sample Number	Asphalt Content (%)	Percent Passing Sieve Size (mm)							
		9.5	4.75	2.36	1.18	0.600	0.300	0.150	0.075
1	29.1	100	98.6	93.7	70.7	41.4	31.4	22.8	13.8
2	29.3	100	97.7	91.3	68.5	42.1	33.8	26.4	17.8
3	31.1	99.4	93.3	86.4	62.9	39.8	29.9	21.1	12.4
Avg.	29.8	99.8	96.5	90.4	67.3	41.1	31.7	23.4	14.7

# Shingle Impact on Binder Grade - Phase III

- Complete performance grading of PG 64-28 blended with RAP and Shingles
  - Two mixes: Binder 5.1% AC, Top 5.5% AC
  - Tested various combinations of mix components

Test	Criteria	Sample			
		PG 64-28 VRS - B	PG 64-28 VR - T	PG 64-28 VRS - T	PG 64-28 VS - T
Original Binder					
Rotational Viscosity	3.0 Pa-s	1.165 Pa-s	0.526 Pa-s	1.203 Pa-s	0.863 Pa-s
Dynamic Shear	1.0 kPa	1.954 kPa	2.021 kPa	1.717 kPa	1.141 kPa
RTFO Binder Residue					
Mass Loss	1.0%	0.89%	0.80%	0.97%	0.90%
Dynamic Shear	2.2 kPa	7.094 kPa	7.544 kPa	7.39 kPa	5.069 kPa
PAV Binder Residue					
Dynamic Shear	5000 kPa	4793 kPa	3356 kPa	4822 kPa	3867 kPa
Creep Stiffness	300 MPa	48 MPa	168 MPa	50 MPa	85 MPa
Creep Stiffness Slope	0.300	0.334	0.314	0.334	0.309
Resulting Binder Grade					
		PG 76-16	PG 64-28	PG 76-16	PG 76-22

# Shingle Impact on Binder Grade - Observations

- Addition of up to 20% recovered RAP binder has little impact on blended binder's high temperature grade
- Addition of recovered Shingle binder has significant impact on binder's high temperature grade
- Black rock (paper) vs. homogenous blend?
  - Some Shingle binder bound in discrete Shingle particles and does not contribute to the mixture's effective binder content
  - Test procedures used do not account for reduced binder contribution from Shingles

# Shingle Paving Projects – TX Bitulithic





# Oldcastle Materials Shingles Use

- No significant production or placement problems
- Mix design considerations
  - Typical use is 5 - 7% of mix
  - Percentage use is based on mix type, surface vs. binder
  - Marshall and Superpave designs developed
- Shingles used in batch and drum facilities
- Concerns regarding the control of the addition of small amounts of shingle materials
  - Belt scale, belt speed, or use of carrier aggregate to address
- Have not encountered serious problems with shingles stored over the winter

# Oldcastle Materials Observations

- Issues and concerns noted:
  - Shingle sand and Shingle RAP blends tend to retain moisture
  - Mix working time reduced
  - Material handling
  - Shingle tabs can get through grinder
  - Lack of general acceptance of this recycling practice
    - Necessitates ability to use multiple recycled products at the same time

# Oldcastle Materials Observations

- Issues and concerns noted (continued):
  - Shingle contribution to the mixture's effective binder content
  - Increased wear on equipment due to Shingle use
  - Consistency of Shingle supply
    - Tear-offs
    - Manufacturers
  - Uniformity of Shingle grind supplied
    - Oversized particles may require screening after grinding
    - Binder content consistency

# Best Practices





# Best Practices



# Summary

- Shingles can be effectively used in HMA to produce a mix of equal or better quality
  - Binder savings in excess of those obtained from RAP use alone appear realistically achievable
- Practical issues need to be addressed
  - Use of multiple recycled products at the same facility at the same time
  - Material storage concerns
  - Consistency of Shingles and carrier aggregate blends
  - Required environmental testing

# Summary

- Additional research required
  - Development of mix design protocol and standard specifications
    - Considering contribution of Shingles to the mixture's effective binder content
    - Must be volumetrically based
  - Determine amount of binder blending and the resulting binder's low temperature performance
    - When are different virgin binders necessary?
  - Develop database of Shingle mix performance
  - Identify hurdles to general acceptance of this type of recycled product

## Appendix

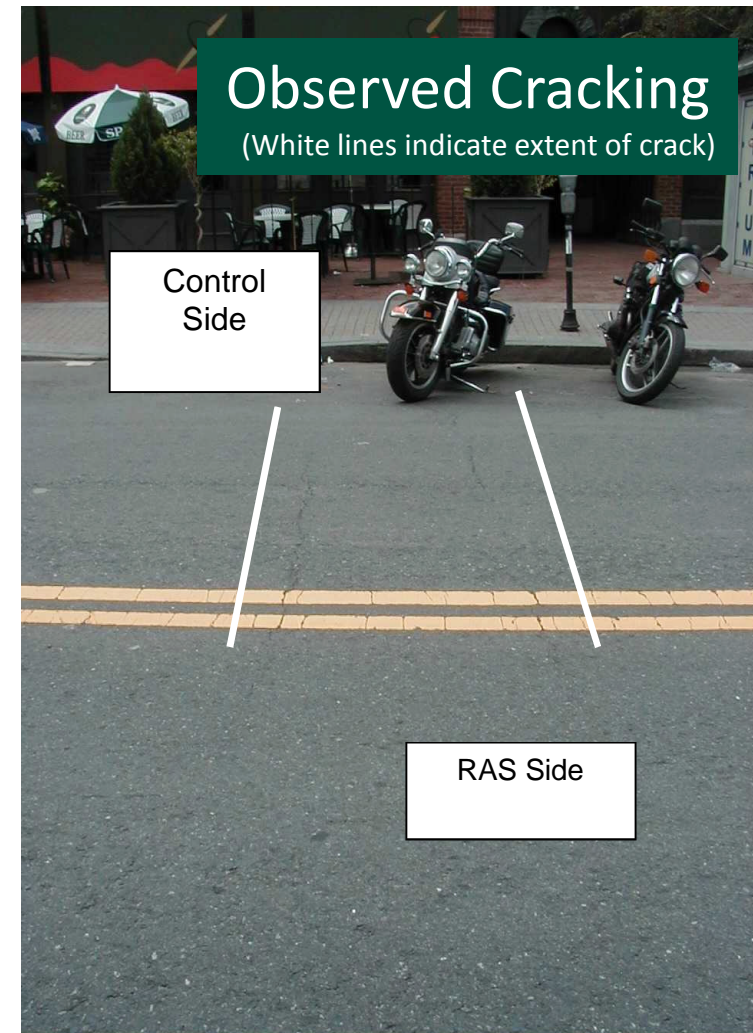
- Following slides are from some of the first projects to use shingles in North America



# Worcester, MA Demonstration Project 2000

## Site Description:

- Commercial Street, Worcester, MA
- 1 3/4-inch of surface mix placed over existing roadway
- 5-Percent, 1/2-inch RAS
- Manufacturer's Off-Spec Shingles
- Constructed September 21, 2000
- Standard Paving Equipment and Procedures
- Photos Taken June 28, 2002



# Saint Paul, MN Recreational Trail 1990



(Courtesy of Roger Olson / MnDOT)

- MnDOT's 1<sup>st</sup> test section containing shingle pavement
- Subbase: old railroad track-bed
- Base: 4-inch crushed concrete
- Wearing Course: 2.5-inch thick,
- 12-foot wide HMA containing 6% & 9% shingles
- 1995: Performing well
- 2003: Performing well
- Result of project: Move forward with roadway demonstration projects.
- See MnDOT Report No. 96-34 for more details



# Mayer, MN TH25 Overlay 1991

1995

- Shingle sections performing as well as control
- Transverse reflective cracking evident in both control and shingle test sections.

2003

- Shingle sections performing as well as control



**2002: 11-Years Later**  
(Courtesy of Roger Olson / MnDOT)

# Waterloo, Ontario, Canada Highway 86 1996

- 2-Lane road expanded to 4-lane highway
- Lower Binder: 1.5"
- Upper Binder: 2" with 3% shingles
- Wearing Course: 1.5" with 3% shingles
- See Yonke, *et.al.* Report for testing details

## Control mix, 1999

- Fine aggregate raveling
- Longitudinal joint raveling and opening
- Fatigue cracking in wheelpath

## Shingle mix, 1999

- No fine aggregate raveling
- No longitudinal joint raveling or opening
- No fatigue cracking in wheelpath



(Courtesy Paul Lum, LaFarge, 2001)