FHWA Expert Task Group RAP / RAS Update

SEAUPG
Southeastern Asphalt User/Producer Group

NOVEMBER 16, 2016
CORPUS CHRISTI, TEXAS

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Use of RAS

1. **FHWA Recycling Policy**
2. RAS Background and Use
3. ΔT_c: Definition
4. ΔT_c: Importance
5. AASHTO PP 78-14

FHWA Recycled Materials Policy

Updated September 8, 2015

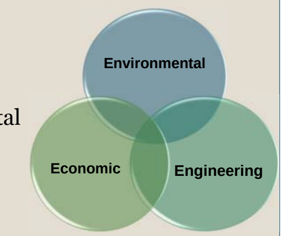
"Recycling presents environmental opportunities and challenges, which, when appropriately addressed, can maximize the benefits of re-use."


FHWA Recycled Materials Policy
Administrator's Message:

FHWA Recycled Materials Policy

3 Steps with the 3 E's

1. Review Engineering suitability
2. Review Environmental suitability
3. Conduct Economic assessment



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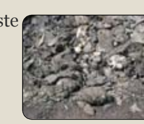
Asphalt Roofing Shingles

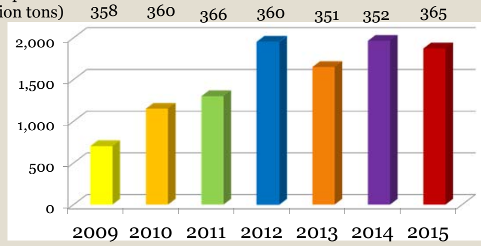
- ***11 million tons* of waste asphalt roofing shingles are generated in the US per year.**
  - Manufacturing Waste
    ~ 1 million tons
  - Roofing tear-offs
    ~ 10 million tons
- **Reclaimed Asphalt Shingles (RAS)**
  - Crushed/ground and screened
  - Used in hot mix asphalt
  - High beneficial reuse


RAS Usage in HMA/WMA

Total *RAS tons used for mix production in USA*

Total asphalt mix:
(million tons) 358 360 366 360 351 352 365



(year)

702 1,100 1,192 1,863 1,647 1,960 1,872
(thousands tons)

RAS Leading Users
(Based on Tonnage) (1,000's Tons)

State	2013	2014	2015	
Illinois	92	270	309	14%
Texas	341	309	301	3%
Pennsylvania	127	324	224	31%
North Carolina	18	33	137	315%
Alabama	176	167	124	26%
Oregon	19	63	106	68%
Missouri	193	81	97	20%
Wisconsin	83	*	93	*

RAS –South Eastern AUPG

State	2013	2014	2015	
Texas	341	309	301	3%
North Carolina	18	33	137	315%
Alabama	176	167	124	26%
Oklahoma	45	52	53	2%
Arkansas	25	43	47	9%
Kentucky	19	66	47	29%
Tennessee	26	65	29	55%
Virginia	63	20	10	50%
Georgia, Florida, Louisiana, Mississippi, South Carolina, West Virginia			<10	

Reclaimed Asphalt Shingles (RAS)

Benefits

- **Improved resistance to rutting**
  - Due to fibers and increased stiffness of binder
- **Reduced costs for HMA production**
  - Conservation of natural resources
- **Conservation of landfill space**
  - Reduced costs for Shingle waste disposal

Risks

- **Decreased resistance to cracking**
  - Due to extremely hard binder stiffness
  - Due to low effective binder content

Recent Publications

http://goaspha.lt/QIP129E

RAS Binder Characterization

http://www.trb.org/Pavements/Blurbs/173888.aspx

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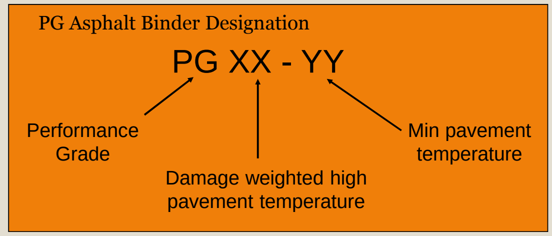
Type of Requirement

- Reclaimed Binder Ratio (RBR)?
- Mix Test?
- Binder Test?

How to Measure ΔT_c

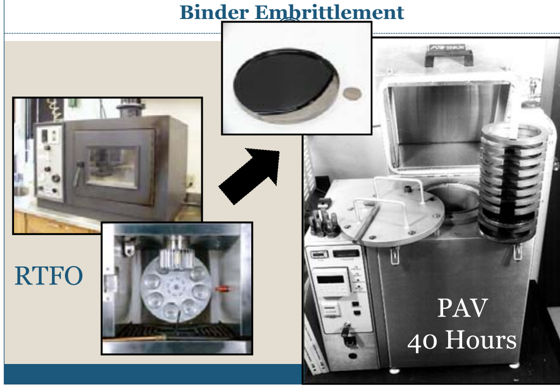
Binder Embrittlement

- The grading system is based on climate:
  - In-service pavement temperatures



How to Measure ΔT_c

Binder Embrittlement



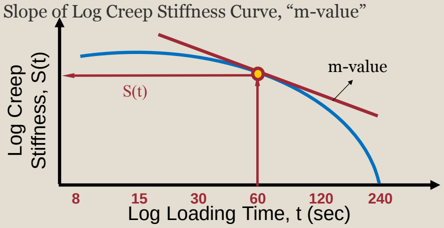
How to Measure ΔT_c

Binder Embrittlement

How to Measure ΔT_c

Binder Embrittlement

- Low temperature specification parameters required in AASHTO M320
  - Creep Stiffness, S(t)
  - Slope of Log Creep Stiffness Curve, "m-value"



How to Measure ΔT_c

Binder Embrittlement

ΔT_c = Stiffness critical temp (S) –
Relaxation critical temp (m-value)

Previous work by:
- Mike Anderson (Asphalt Institute) and
- Tom Bennert (Rutgers University)

When ΔT_c is less than -5.0°C (e.g. -10.0°C) there is a significant loss of cracking resistance.

Evaluate material aged in PAV for 40 hours.

Example 1: PG 64-22

Test	Temperature	Result	Criteria
RTFO and PAV Residue – Aged Binder			
Dynamic Shear Rheometer G*sin(δ)	19°C	NR	≤ 5000 kPa
	25°C	4100 kPa	
	28°C	NR	
Bending Beam Rheometer, Stiffness, S	-24°C	NR	≤ 300 MPa
	-18°C	368 MPa	
	-12°C	187 MPa	
Bending Beam Rheometer, m-value	-24°C	NR	≥ 0.300
	-18°C	0.270	
	-12°C	0.330	

ΔT_c = -15.7 – (-15.0) = -0.7°C

Tim Aschenbrener, FHWA

Example 2: PG 70-22

Test	Temperature	Result	Criteria
RTFO and PAV Residue – Aged Binder			
Dynamic Shear Rheometer G*sin(δ)	19°C	NR	≤ 5000 kPa
	25°C	NR	
	28°C	1870 kPa	
Bending Beam Rheometer, Stiffness, S	**-24°C**	313 MPa	≤ 300 MPa
	-18°C	110 MPa	
	-12°C	60 MPa	
Bending Beam Rheometer, m-value	-24°C	NR	≥ 0.300
	-18°C	0.266	
	-12°C	0.309	

ΔT_c = -23.6 – (-13.3) = -10.3°C

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Critical Temperature Difference (ΔT_c)

ΔT_c = Stiffness critical temp (S) – Relaxation critical temp (m-value)

= $T_{c(S)} - T_{c(m\text{-value})}$

= -15.7 – (-15.0) = -0.7°C > -5°C

= -23.6 – (-13.3) = -10.3°C < -5°C

Critical temperature (T_c) also know as "continuous grade"

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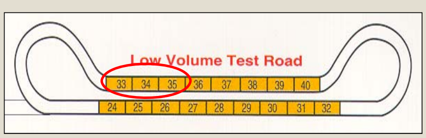
Importance of ΔT_c

Binder Embrittlement

MTE: MnROAD Study



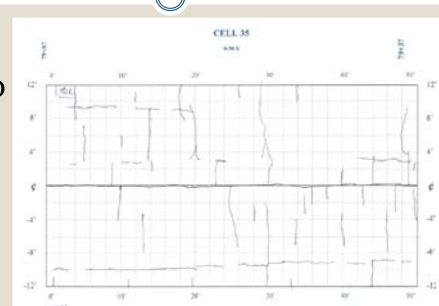
1999 SuperPave Cells
Cell 33 – PG 58-28
Cell 34 – PG 58-34
Cell 35 – PG 58-40

Gerry Reinke, Mathy Construction Company

Importance of ΔT_c

Binder Embrittlement

MTE: MnROAD Study



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Binder Embrittlement

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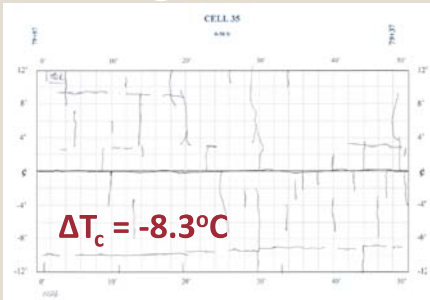

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Importance of ΔT_c

Binder Embrittlement

MTE: MnROAD Study

Binder grade	BBR Data from 20 hr. PAV tests performed in 2000			20 hr. PAV	20 hr. PAV	20 hr. PAV
	S critical from BBR	m critical from BBR	ΔTc (S grade - m grade)	S_critical from 4 mm DSR	m_critical_temp from 4 mm DSR	ΔTc (S grade - m grade)
58-28	-30.9	-30.3	-0.6	-31.3	-30.5	-0.8
58-34	-34.8	-35.98	1.2	-35.6	-35.4	-0.2
58-40	-44.3	-42.9	[illegible]	-44.4	-42.0	-2.4

Binder grade	40 hr. PAV	40 hr. PAV	40 hr. PAV	60 hr. PAV	60 hr. PAV	60 hr. PAV
	S_critical from 4 mm DSR	m_critical_temp from 4 mm DSR	ΔTc (S grade - m grade)	S_critical from 4 mm DSR	m_critical_temp from 4 mm DSR	ΔTc (S grade - m grade)
58-28	-29.5	-26.7	-2.8	[illegible]	-22.7	-5.8
58-34	-34.9	[illegible]	-2.5	-33.1	-27.6	-5.5
58-40	-42.9	-34.6	-8.3	-42.9	-30.5	-12.4

Binder grade	sulfur, %	phosphorus, %	molybdenum, ppm	zinc, ppm
58-28	4.896	0.001	9	19
58-34	4.374	0.001	8	10
58-40	3.969	0.059	18	925

Mathy Technology & Engineering

Gerry Reinke, Mathy Construction Company

Importance of ΔT_c

Binder Embrittlement

Rutgers: Airfield Study

- No rutting
- Longitudinal and transverse cracking observed
- Cracking top-down
  - Stops approximately 0.5″ to 0.75″ below surface

Tom Bennert, Rutgers University

Importance of ΔT_c

Binder Embrittlement

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Importance of ΔT_c

Binder Embrittlement

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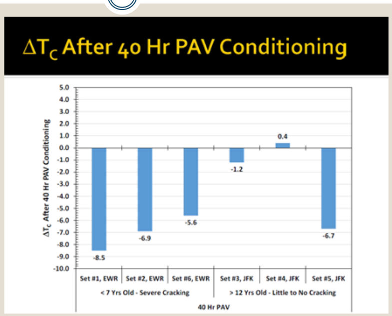

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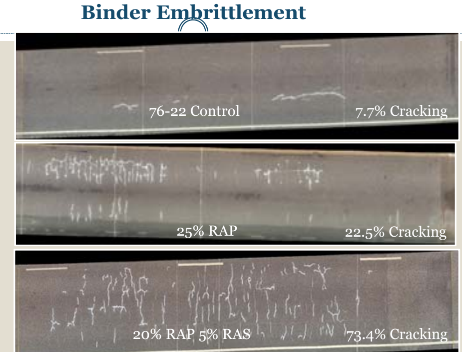
Importance of ΔT_c

Binder Embrittlement

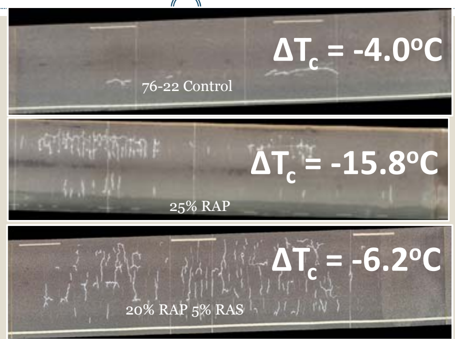
NCAT Test Track: FDOT Study



Pamela Turner, NCAT

Importance of ΔT_c
Binder Embrittlement

NCAT Test Track: FDOT Study



ΔT_c based on 20-hours PAV

Pamela Turner, NCAT

Importance of ΔT_c
Binder Embrittlement

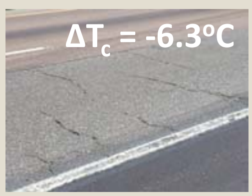
Wisconsin I-90/94

5-Year Old Pavement

Tim Aschenbrener, FHWA

Importance of ΔT_c
Binder Embrittlement

Wisconsin I-90/94



5-Year Old Pavement

Tim Aschenbrener, FHWA

Importance of ΔT_c
Binder Embrittlement

Wisconsin I-90/94

Aging	ΔT_c
No PAV	-3.0
20-hour PAV	-6.3
40-hour PAV	-7.3

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PP 78
Two Issues Addressed:

Design Considerations When Using Reclaimed Asphalt Shingles (RAS) in Asphalt Mixtures

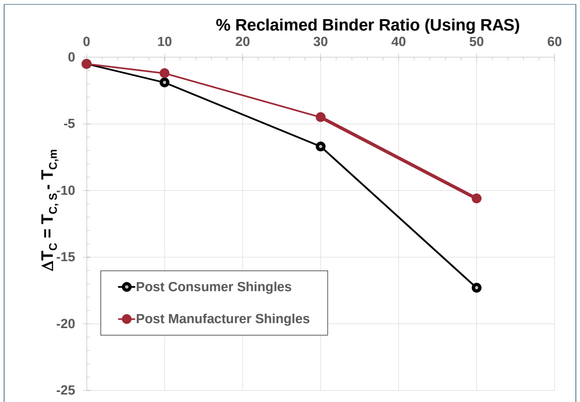
1. Quantity of Binder
   - How much of the RAS binder becomes effective asphalt binder? This impacts the effective asphalt content.
     - ***Potential Solution:*** VMA increased 0.1% for every 1% RAS
2. Quality of Binder – Binder Embrittlement
   - How to address the stiffness/brittleness of the RAS binder?
     - ***Potential Solution:*** ΔT_c greater than -5.0°C (e.g. -2°C)

Quantity of Binder

- Raise minimum VMA by 0.1% for every 1% RAS (by weight of total aggregate).
  - Based on assumption of 70% binder availability
  - Will increase effective binder in the mix to offset for the potential for non-effective binder on the RAS
- Simple way of addressing binder availability
  - More binder → Improved durability
  - Angular aggregate and stiffer binder in RAS → Minimal risk of rutting

Quality of Binder

- Comment #1:
  - Binder aging option - PAV aged for 40 hours
  - Mixture aging option – Loose mix conditioned at 135°C for 24 hours
- Comment#2:
  - Agency may default to mixture testing
  - Agency may default to RASBR ≤ 0.10
- Comment #3:
  - Agency may set allowable RAS tiers



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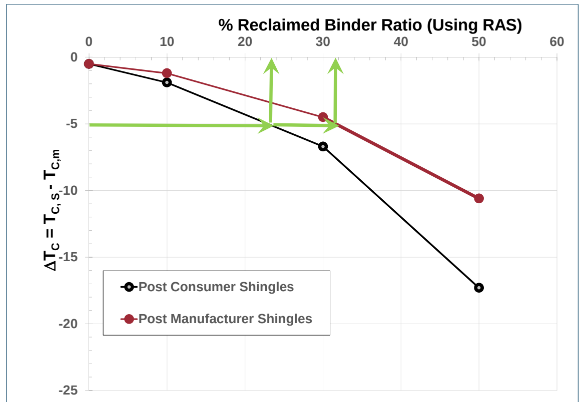

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Summary of Revised PP 78

- Binder quantity - increasing minimum VMA
  - Raise minimum VMA by 0.1% for every 1% RAS
- Binder quality – binder embrittlement using ΔT_c
  - Binder aging of recovered binder in PAV 40 hours
  - Criteria ≥ -5.0°C
- Alternate aging procedure (in appendix)
  - Loose mix aging 135°C for 24 hours then recover binder
  - Criteria ≥ -5.0°C
- Using RAP
  - Do not combine RASBR with RAPBR
  - Measure ΔT_c with RAS and RAP

Advantages

- Relatively simple approach
- End result
  - Base binders are different
- Setting RAS limits
  - Informed decision
  - Available base binders
  - Existing RAS materials

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Thank you

QUESTIONS / COMMENTS:

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