WisDOT/WAPA Asphalt Pavement Project Manager Training

June 2010

Topics

- HMA Materials and Mix Design
- HMA Plant Overview
- Hauling, Laydown and Compaction
- Quality Management Program
- Overlay Applications and Asphaltic Surfaces

Let's talk about

- What the specifications say
- Good construction practices
- Project Managers/Leaders roles and responsibilities

Hot Mix Asphalt Materials and Mix Design

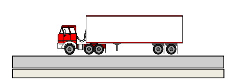
WisDOT/WAPA Asphalt Pavement Project Manager Training

June 2010

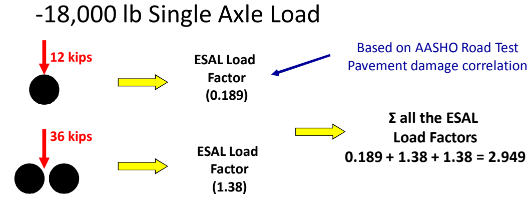
Definitions

- HMA = Hot Mix Asphalt
  - Homogeneous blend of aggregates and asphalt
- SMA = Stone Matrix Asphalt
  - Also homogeneous blend of aggs and asphalt
  - Gap-graded aggregate to allow room for asphalt mastic (asphalt and fines and often stabilizer)

Traffic Loading (ESALs)



- What is an ESAL?
  - -Equivalent Single Axle Load
  - -18,000 lb Single Axle Load



Components of HMA Pavements

- Aggregates (~95% by weight or ~85% by volume)
- Asphalt Cement (~5% by weight or ~15% by volume)

7

Topics

- General mix requirements
- Aggregate properties
- Asphaltic binders
- Recycled asphaltic materials
- HMA mix design

8

460.2 HMA Material Requirements

- Coarse aggregates from approved source
  - Verify approved sources
- Aggregates should be hard and durable particles with minimal deleterious material

  ≤1% total by weight of lumps, clay, loam, shale, soft particles, organic materials, adherent coatings, etc.

9

Aggregate Properties

- Aggregate physical properties that are of importance to asphalt mix/pavement design:
  - Gradation & Size
  - Particle Shape
  - Toughness
  - Durability / Soundness
  - Cleanliness (deleterious materials)
  - Absorption
  - Specific Gravity
  - Adhesion
  - Surface Texture

10

Aggregate Requirements

- Blend Requirements:
  - Percent fractured faces
  - Flat and elongated particles
  - Gradation
- Deposit/Source Requirements
  - LA wear loss
  - Freeze-thaw soundness

11

Source Approval (106.3.4.2.2)

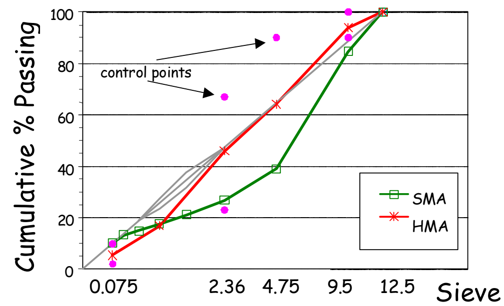
- Qualified personnel/ labs for sampling and testing
- Coarse aggregate sources tested every 5 years (pits) or 3 years (quarries)
- Aggregates tested for
  - LA Wear
  - Soundness (sodium sulfate)
  - Fracture
  - Specific gravity and absorption
  - Liquid limit and plasticity
  - Freeze/Thaw for sources in specific counties or from out of state

12

Aggregate Gradation

- Distribution of particle sizes expressed as percent of total weight
- Determined by sieve analysis

Example Gradations



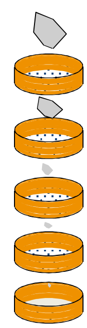
Gradation Definitions

- **Maximum Aggregate Size**:
  the smallest sieve through which 100% of the particles will pass
- **Nominal Maximum Aggregate Size (NMAS)**:
  one sieve size larger than the first sieve size to retain more than 10% by weight of the particles

Asphalt mixture designations use the NMAS.

Aggregate Properties

Gradation Definitions Example:



Sieve Size	% Passing	
50.0 mm (2 in.)	100	
37.5 mm (1 ½ in.)	100	Max. Size
25.0 mm (1 in.)	99	Nominal Max. Size
19.0 mm (3/4 in.)	89	
12.5 mm (1/2 in.)	72	
9.5 mm (3/8 in.)	65	
4.75 mm (No.4)	48	
2.36 mm (No. 8)	36	
75 µm (No. 200)	4	

Gradation / Size Considerations

Larger Maximum Size
- Increases strength
- Improves rut resistance
- Increases skid resistance
- Decreases asphalt content

But …
- Increases chances of segregation

Smaller Maximum Size
- Reduces segregation
- Reduces road noise
- Decreases tire wear
- Aesthetics

But…
- Requires higher binder content (greater surface area per unit volume)

Gradation Master Ranges (460.2.2.3)

Sieve	37.5 mm	25.0 mm	19.0 mm	12.5 mm	9.5 mm
50.0 mm	100				
37.5 mm	90-100	100			
25.0 mm	90 max	90-100	100		
19.0 mm		90 max	90-100	100	
12.5 mm			90 max	90-100	100
9.5 mm				90 max	90-100
4.75 mm					90 max
2.36 mm	15-41	19-45	23-49	28-58	20-65
0.075 mm	0-6.0	1.0-7.0	2.0-8.0	2.0-10.0	2.0-10.0

SMA Gradation Requirements

Sieve	SMA 12.5 mm	SMA 9.5 mm
19.0 mm	100	
12.5 mm	90-97	100
9.5 mm	58-72	90-100
4.75 mm	25-35	35-45
2.36 mm	15-25	18-28
0.075 mm	8.0-12.0	10.0-14.0

19

Nominal Sizes for Layers

- Lower pavement level 19.0 mm
- Upper pavement level 12.5 mm
- SMA layer 12.5 mm

Unless otherwise specified in contract.

20

Toughness

- Los Angeles Abrasion Test (AASHTO T96)
  - Resistance of coarse aggregate to abrasion
  - Aggregate subjected to damage from rolling with steel balls in a drum
  - Aggregates must resist damage during production, placement and compaction and under traffic
- Value is expressed as % loss

4-8

21

LA Abrasion Test

- Approx.. 10% loss for extremely hard igneous rocks
- Approx.. 60% loss for soft limestones and sandstones

4-9

22

LA Wear Loss (Table 460-2)

Mixture	E-0.3	E-1	E-3	E-10	E-30	E-30x	SMA
ESALs x 10^6	<0.3	0.3-<1	1-<3	3-<10	10-<30	≥30	---
LA Wear – max % loss							
100 revs	13	13	13	13	13	13	13
500 revs	50	50	45	45	45	45	40

Higher traffic levels require tougher aggregate.
All need to withstand production/construction wear.

Applies to each deposit or source in the blend.

23

Soundness

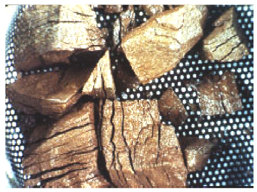
- Sodium sulfate soundness (AASHTO T104)
- Estimates resistance to weathering
- Simulates freeze/thaw action
- Result is total percent loss

4-11

24

Soundness

Before



After

4-12

25

Freeze-Thaw Durability

- AASHTO T 103
- Similar to soundness test but with alcohol-water solution
- Required for limestone/dolomite sources and gravel sources in specific counties or from out of state (106.3.4.2.2.2)

26

Soundness and Freeze-Thaw

Mixture	E-0.3	E-1	E-3	E-10	E-30	E-30x	SMA
ESALs x 10^6	<0.3	0.3-<1	1-<3	3-<10	10-<30	≥30	---
Soundness	12	12	12	12	12	12	12
Freeze-Thaw	18	18	18	18	18	18	18

Applies to each source or deposit used in blend.

27

Particle Shape

- Cubical preferred over flat, thin, elongated or round.
- Greater interlock and internal friction → stable mix.
- Coarse and fine aggregate angularity
- Influences workability and compaction

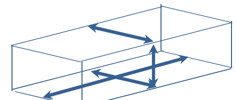
28

Shape – Fractured Faces

- Determined by visual inspection and count
- Percent of particles with one or more crushed faces and with two or more crushed faces.
- Stability, rut resistance

29

Shape – Flat and Elongated Particles

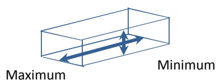


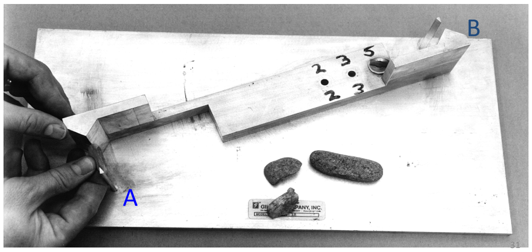
- ASTM D4791
  - Total flat and elongated
  - Maximum to minimum dimension
    - 5:1 (3:1 for SMA)
- "Flaky" particles can break under rollers or make mix harsh and hard to compact

4-26

30

Flat and Elongated





Shape – Fine Aggregate Angularity

- AASHTO T304, method A
- Fine aggregate at a specified gradation is allowed to flow freely into a 100 cm^3 cylinder
- Calculate the voids between particles
- The more angular the aggregate, the higher the void content
- Angular fine agg improves rut resistance, stability

32

Fine Aggregate Angularity

Natural sands:
typically < 45

Manufactured sands:
typically > 44

33

Particle Shape Requirements (Table 460-2)

Mixture	E-0.3	E-1	E-3	E-10	E-30	E-30x	SMA
ESALs x 10^6	<0.3	0.3-<1	1-<3	3-<10	10-<30	≥30	---
Fractured Faces*	60/--	65/--	75/60	85/80	98/90	100/100	100/90
Flat and Elongated**	5	5	5	5	5	5	20
Fine Agg Angularity	40	40	43	45	45	45	45

•Apply to the blend of aggregates (coarse or fine).
•Higher traffic requires higher angularity. All must be compacted. SMAs have higher requirements.

*One or more crushed faces/two or more crushed faces
** 5:1 ratio except 3:1 for SMA

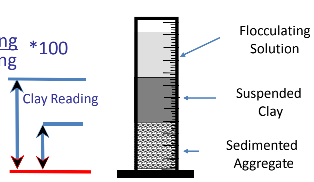
34

Sand Equivalent

* AASHTO T176

Used to estimate the relative proportions of sand. and clay-like or plastic fines and dust.

$$SE = \frac{\text{Sand Reading}}{\text{Clay Reading}} * 100$$



35

Sand Equivalency

Mixture	E-0.3	E-1	E-3	E-10	E-30	E-30x	SMA
ESALs x 10^6	<0.3	0.3-<1	1-<3	3-<10	10-<30	≥30	---
SE, %	40	40	40	45	45	50	50

SE value relates to aggregate cleanliness.
Clay and dust can interfere with bond of binder to aggregate.
Cleaner aggregate has higher SE value.

36

Aggregate Properties

- All aggregates are porous to varying degrees, which affects the amount of asphalt needed to coat the aggregate particles and the percentage of air voids in the final mixture.
- Some absorption is good – improves bond with binder.
- Too much is uneconomical and makes mix design tricky.

37

Asphaltic Binders

38

Binder Grades

- Specified in contract.
- Contractor option to use virgin, modified or blend with recovered (RAP) binder
- Resultant blend must meet specified grade.

39

PG Binder Grading

PG+ Designation

PG 58-28 P

Performance Grade

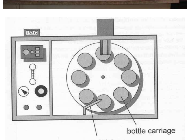
Average 7-day max pavement design temp
(58 ºC / 136 ºF)

Min pavement design temp
(- 28 ºC / - 18 ºF)

40

Rolling Thin Film Oven (RTFO)

- Simulates plant/ construction aging
- Oven is heated to 325 °F (163°C)
- Carousel is rotated at 15 RPM for 85 minutes
- Rotation continuously exposes new binder to the heat



41

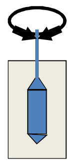
Pressure Aging Vessel (PAV)

- Simulates aging in service
- Uses RTFO samples to make the PAV samples
- Samples placed in pans
- "Aged" for 20 hours
- Temperature at 100°C
- Pressure 2.07 MPa (300 psi)

42

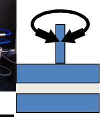
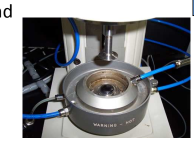
Rotational Viscometer (RV)

- *For pumping and mixing at the plant.*
- Measures the required torque to maintain a constant rotational speed (20 RPM)
- Converts the torque to viscosity at high temperature (135°C)

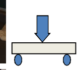

Dynamic Shear Rheometer (DSR)

- *Relates to resistance to rutting and fatigue.*
- Test sandwiches the sample between two circular plates
- Upper plate oscillates back and forth at a specified rate (Hz)
- Quantifies both the elastic and viscous properties
- *Measures phase angle (elasticity)*

Bending Beam Rheometer (BBR)

- *Tests for resistance to low temperature cracking.*
- A load is applied to beam of asphalt and its deflection is measured against time
- Stiffness is calculated based on measured deflection and standard beam properties
- Direct tension test can also be used for thermal cracking

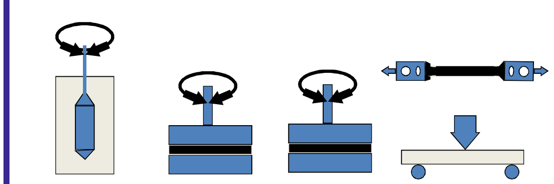




Elastic Recovery

- Stretch binder sample at low temperature
- Cut the thread of binder
- Allow thread to recover (retract)
- Put ends together and determine how much the thread “snapped back”
- Want elastic binders to resist rutting.

Putting It All Together

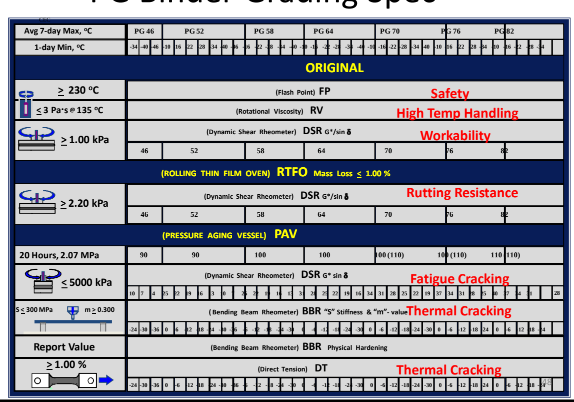
Workability (Mix & Compact)	*Permanent Deformation*	*Fatigue Cracking*	*Thermal Cracking*
Unaged Sample	RTFO Sample	RTFO & PAV Sample	RTFO & PAV Sample



135 60 20 -20

Pavement Temperature, C

PG Binder Grading Spec



PG + (PGXX-XXP)

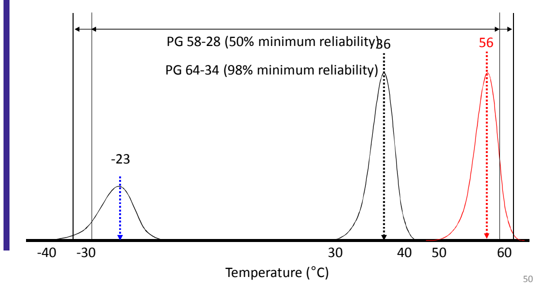
For Temperature Spread:

- 92° - ER ≥ 65%, δ ≤ 77.0
- 98° - ER ≥ 65%, δ ≤ 75.0
- 104° - ER ≥ 65%, δ ≤ 73.0

δ measured on original binder.

49

PG Binder Grading



50

PG Binder Grading

Common Grades:

- PG 58-28
- PG 58-34
- PG 64-22
- PG 64-28
- PG 70-28

6°C Increments

51

WisDOT Binder Selection Guidance

Layers	Project Type	New Base	Overlay
Upper	Rural ≥ 4 million ESALs	PG 58-28	PG 58-28
Upper	Urban	PG64-28	PG 64-22
Upper	Intersections – Stopped	PG64-28	PG 64-22
High Traffic	Speed < 55 mph ≥4 million ESALs	PG 64-28	
	Speed < 55 mph ≥10 million ESALs	PG 70-28	
	Speed > 55 mph ≥10 million ESALs	PG 64-28	
Lower	PG 58-28 normal PG 64-22 if upper layer is PG64-xx or higher		

52

WisDOT Binder Selection Guidance

"P" designations

- Substitute equivalent "P" designation for ≥ 5 million ESALs
- PG58-34P
- PG64-28P
- PG64-34P
- PG70-28P

53

Combined State Binder Group

- Six states share testing and acceptance testing responsibilities (IA, MN, NE, ND, SD, WI)
- Producer or supplier demonstrates ability to produce binder meeting specifications
- Requirements for qualified personnel and labs, sampling and testing, documentation, round robin testing, handling non-complying material, etc.

54

Project Personnel

- Obtain samples to monitor quality at plant for alterations made to site storage, plant handling process or if modification is occurring at plant.

Recycled Asphaltic Materials

Definitions

- RAP = Reclaimed Asphalt Pavement
- FRAP = Fractionated Reclaimed Asphalt Pavement
  - RAP separated into different size fractions
  - Fine fraction contains higher binder content
  - Coarse fraction may be easier to incorporate and meet specs
- RAS = Recycled Asphalt Shingles

Recycled Asphaltic Materials

- Contractor option to use RAP, FRAP and RAS
- Stockpile recycled materials separately
- Treat as individual JMF components
- Allowable contents based on percent binder replacement
  - Ratio of recovered binder to total binder

Maximum Binder Replacement

Recycled Asphaltic Material	Lower Layers	Upper Layer
RAS only	20	15
RAP only	35	20
FRAP only	35	25
RAS and RAP	30	20
RAS and FRAP	30	25
RAS, RAP and FRAP	30	25

May replace virgin binder with recovered binder up to max without changing virgin binder grade. If using more than max, furnish test results documenting that blend meets contract-specified grade.

HMA Mix Design

- The principle objective of a HMA mix design is to determine a unique asphalt content in conjunction with a specific blend of aggregates to produce an economical asphaltic mixture which meets the specified mix type specification

HMA Mix Design

- Factors related to durability
  - Sufficient asphalt binder in the mixture
  - Sufficient compactive effort
  - Sufficient air voids
  - Quality of aggregates

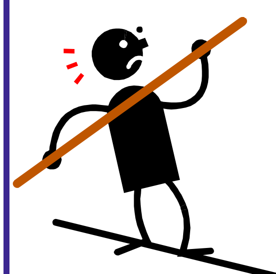
61

HMA Mix Design

- The amount of air voids measured in the HMA mixture is the most important factor in predicting HMA pavement performance
  - 3-5% air voids has historically proven to provide the best pavement performance
  - Compaction specifications require ~10% air voids (or min. 89.5% density)
    - After 3 years of traffic loading, the pavement air voids reduce to ~4%

62

Mix Design



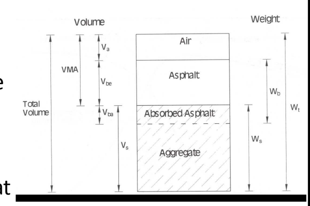
Balance

- Rut Resistance vs. Cracking Resistance
- Durability vs. Stability
- VMA, Air Voids, Binder Content

63

Volumetrics

- Designed Air Void (V_a) Target = 4%
- VMA Target based on nominal aggregate size
- Asphalt Content (P_b) dependent upon volumetrics with the required V_a and VMA at N_{design}



64

Air voids
VMA
VFB

Volumetric properties are interrelated – Changing one property affects others.

65

Voids too low?

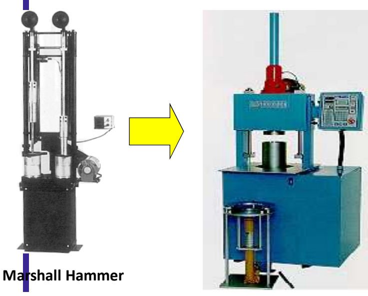
Steps in Mix Design

1. Materials Selection
   – Approved agg sources
   – Specified binder grade
2. Design Aggregate Structure
   – Mix trials and evaluate volumetrics
3. Design Asphalt Binder Content
   – For selected aggregate blend
4. Moisture Sensitivity Check

Based on 20 year traffic loading (ESALs)

67

Superpave Mix Design Equipment



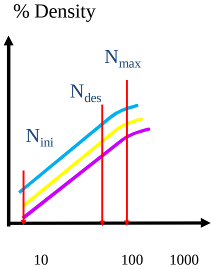
•Better simulates roller compactive effort

•Kneads material similar to traffic

•Indicates pavement performance at three stages of pavement life

68

SGC Analysis



- N_{des} - gyrations required to produce 4% air voids in the field after the indicated amount of traffic
- N_{ini} – measure of mixture compactibility (~ 11% Va)
- N_{max} – estimate of ultimate field density (rutting check ~ 2% Va)

69 Back

WisDOT Gyration Levels

Mixture	E-0.3	E-1	E-3	E-10	E-30	E-30x	SMA
ESALs x 10^6	<0.3	0.3-<1	1-<3	3-<10	10-<30	≥30	---
Nini*	6	7	7	8	8	9	8
Ndes	40	60	75	100	100	125	65
Nmax	60	75	115	160	160	205	160

* Guideline only.

70

Moisture Sensitivity

- Prepare specimens using selected mix design parameters
- Conduct Tensile Strength Ratio test
- Evaluate Results
  – TSR value > 0.70 without antistrip additive
  – > 0.75 with antistrip additive

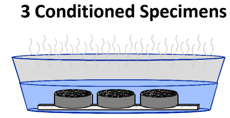
71

Moisture Sensitivity

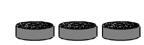
AASHTO T 283

- **Measured on proposed aggregate blend and asphalt content**
- **Reduced compactive effort to increase voids (6 to 8%)**

3 Conditioned Specimens



3 Dry Specimens



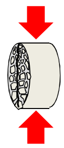
Vacuum saturate specimens
Soak at 60°C for 24 hours
Soak at 25°C for 2 hours

72

Moisture Sensitivity

AASHTO T 283

Determine the tensile strengths of both sets of 3 specimens



Calculate the Tensile Strength Ratio (TSR)

$$TSR = \frac{\text{Avg. wet tensile strength}}{\text{Avg. dry tensile strength}}$$

73

WisDOT Specification

Mixture	E-0.3	E-1	E-3	E-10	E-30	E-30x	SMA
ESALs x 10^6	<0.3	0.3-<1	1-<3	3-<10	10-<30	≥30	---
Air Voids	4.0	4.0	4.0	4.0	4.0	4.0	4.0
$\%G_{mm}$ at N_{ini}	≤91.5	≤90.5	≤89.0	≤89.0	≤89.0	≤89.0	---
$\%G_{mm}$ at N_{max}	≤98.0	≤98.0	≤98.0	≤98.0	≤98.0	≤98.0	---
Dust:Binder*	0.6-1.2	0.6-1.2	0.6-1.2	0.6-1.2	0.6-1.2	0.6-1.2	1.2-2.0
VFB	70-80	65-78	65-75	65-75	65-75	65-75	70-80

*0.6 – 1.6 for gradations passing below caution zone.
VFB for 9.5mm mixes is 73-76%
VFB lower limit for 25mm and 37.5mm mixes is 67%

74

Design Enhancement

Intersections: "Bump up" Mix & Binder

STSP 460.030

MAINLINE MIXTURE	INTERSECTION MIXTURE	BINDER
E-0.3 (PG 58-28)	**E-3**	**PG 64-28**
E-1 (PG 58-28)	**E-3**	**PG 64-28**
E-3 (PG 58-28)	**E-10**	**PG 64-28**
E-10 (PG 64-28)	**E-30**	**PG 70-28**
E-30 (PG 64-28)	**E-30X or SMA**	**PG 70-28**

Limit the number of different binders to ~2 for a project

Identify intersection limits

75

WisDOT Project Manager Perspective

- Project HMA Technician
  - HTCP Certified
- Project Manager
  - Documentation
    - Product Certifications
    - JMF Approval
  - Diary Notes
- Observe sampling at required frequency

76

Questions?

Comments?

Experiences?

77