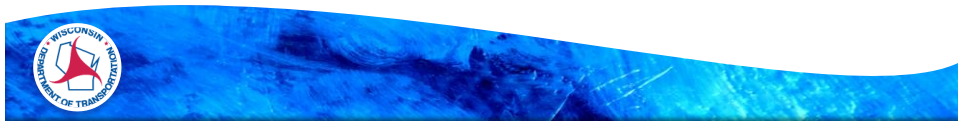


HMA Materials

Session 3



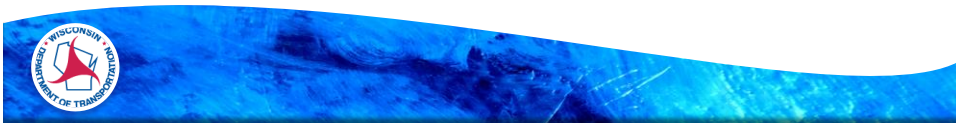
What are HMA pavements made out of?

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

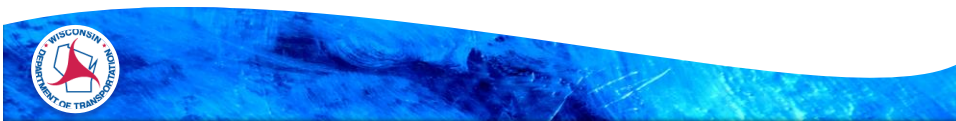


What is HMA made of

- ▶ Aggregates (93-96% by weight)
 - Load bearing components of the mix
 - Skid resistance, stability, workability
- ▶ PG binder (4-7% by weight)
 - Glue or muscle that holds everything together
 - Flexibility, durability
- ▶ Air
 - Allows proper compaction for the pavement to remain flexible



Aggregates



Aggregate Properties

- ▶ Aggregates have several physical properties that are of importance to the asphalt pavement designer:
 - Gradation & Size
 - Particle Shape
 - Toughness
 - Durability / Soundness
 - Cleanliness (deleterious materials)
 - Absorption
 - Specific Gravity
 - Adhesion
 - Surface Texture



Aggregate Properties



- ▶ Toughness:
 - Resist crushing, degradation and disintegration
- ▶ Durability / Soundness:
 - Resistance to breakdown from wetting and drying
- ▶ Freeze Thaw
 - Resistance to breakdown from freeze thaw cycles



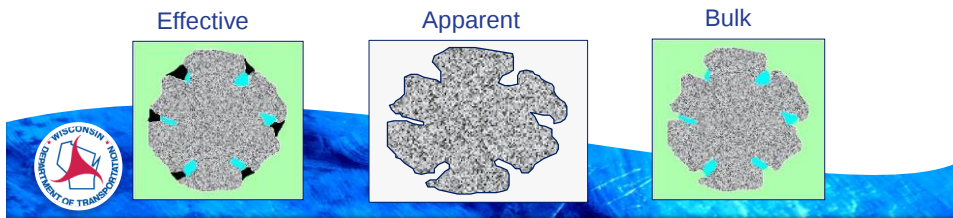
Aggregate Properties

► Absorption:

- Capacity to absorb water or Asphalt

► Specific Gravity

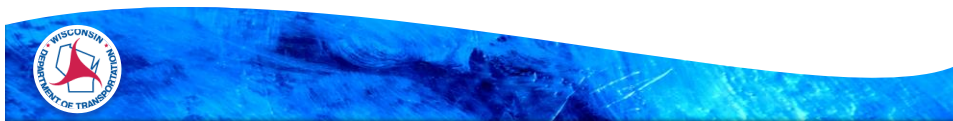
- Ratio between the weight of a given volume of the aggregate and the weight of an equal volume of water (@23°C).
- Means of expressing a weight – volume relationship



Aggregate Production

Crushing Operation Overview

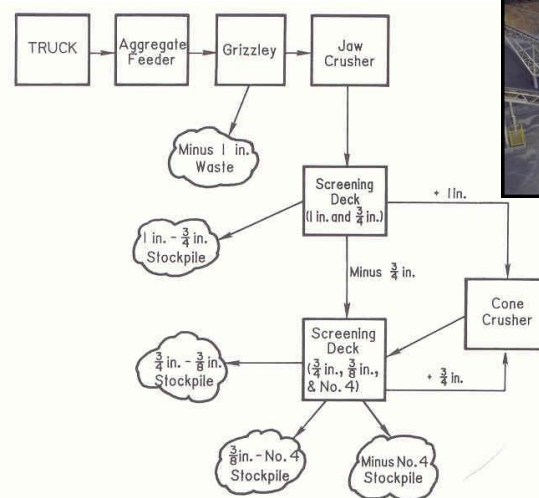
- Stripping overburden
- Drilling and blasting
- Primary Crushing
- Scalping off larger size – intermediate sizes to second and tertiary crushers for further reduction (when necessary)
- Washing to remove silt, clay and other tenacious coatings (when necessary)
- Stockpiling



Aggregate Production



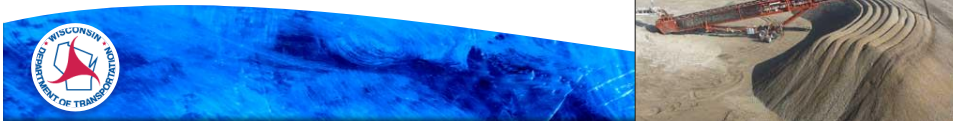
Aggregate Production Simplified Crusher Set-up



Aggregate Production

Potential sources of Segregation

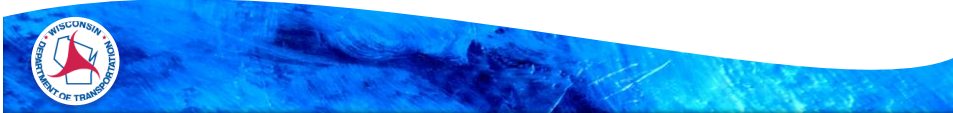
- ▶ Aggregate falling great distances from the conveyor belt to stockpile
- ▶ Travelling long distances on conveyor belts
- ▶ Dozers pushing/working stockpiles
- ▶ Improper loading of trucks/bins by loader operator



WisDOT Standard Specification 460

- ▶ Aggregates
 - Department-approved source
 - Gradation Master Range
 - Consensus/Volumetric Properties
 - Design limits may differ from production tolerances
 - Additives, antistripping, rejuvenators and stabilizing agents
 - Recycled Asphaltic Material
 - Production testing

Field Inspection: contact Materials personnel to verify source compliance



WisDOT Standard Specification 460

- ▶ RAM (Recycled Asphaltic Materials)
 - RAP-Reclaimed Asphaltic Pavements
 - May be fractionated into different sizes, then identified as FRAP
 - RAS-Recycled Asphalt Shingles (tear offs or manufacturer waste-limited to 5% total weight)
- Stockpile sampling/testing same as any other aggregate source
 - Extractions required to adjust asphalt contents
 - Controlled by binder replacement percentage and not by weight

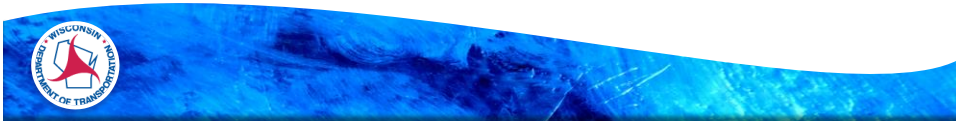
Field Inspection Handled by QMP requirements



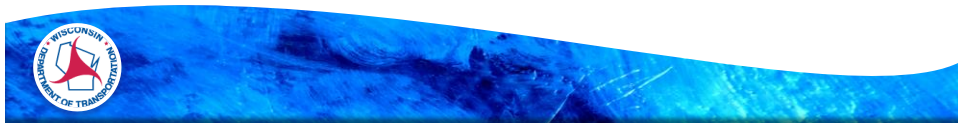


WisDOT Standard Specification 460

	Max. Allowable Lower Layer	%Binder Replacement Upper Layer
RAS	25	20
RAP & FRAP	40	25
RAS, RAP, & FRAP	35	25

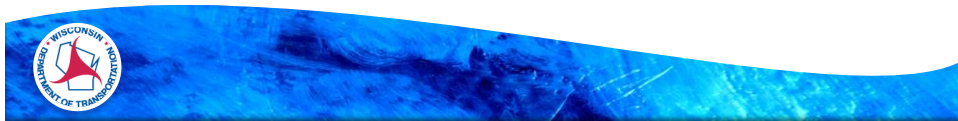


Asphalt Binder



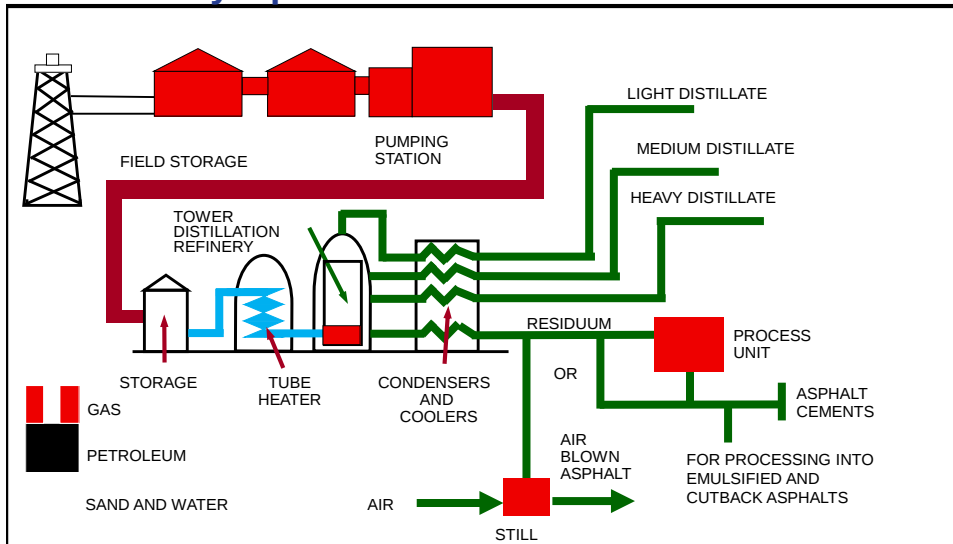
Asphalt

- ▶ Sweet vs. Sour
 - Amount of Sulfur
- ▶ Light vs. Heavy
 - Light-Middle East & North America
 - Heavy-Venezuela & Canada



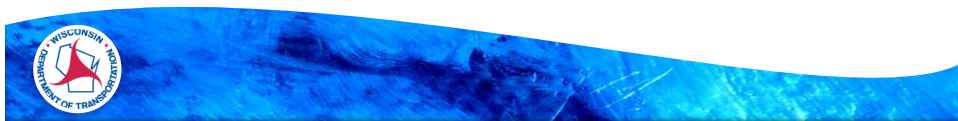
Background

Refinery Operation



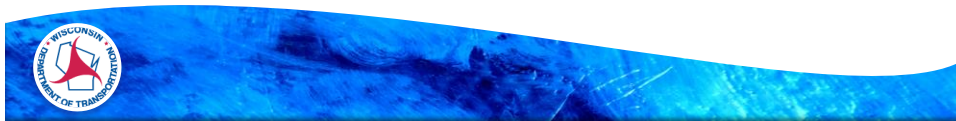
Asphalt

- ▶ Asphalt cement is a *viscoelastic* material (viscous properties at high temperatures and elastic properties at low temperatures)
- ▶ Asphalt is a *thermoplastic* material that softens as it is heated and hardens when cooled



Asphalt Binder Grading System

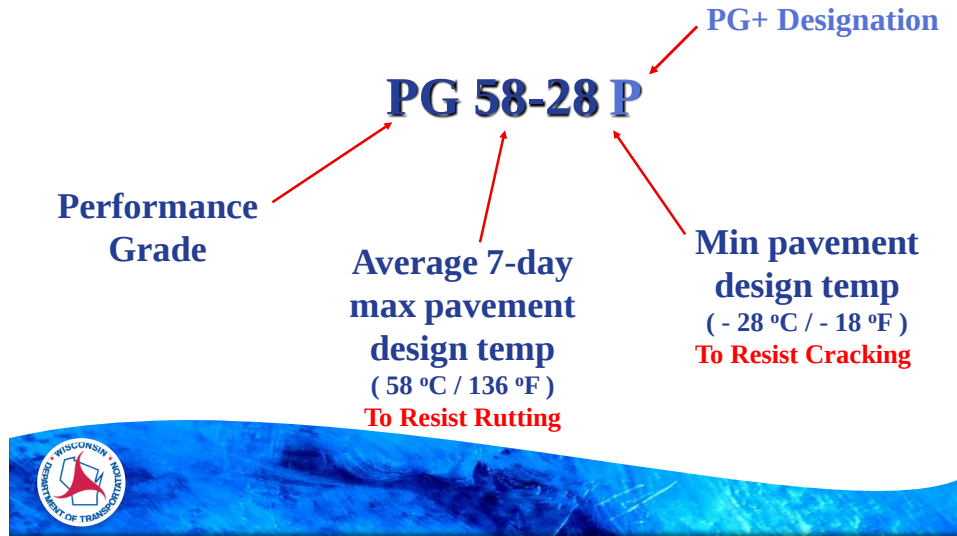
- Performance Graded Binders uses measured physical properties that can be directly related to field performance by engineering principles



PG Binder Grading Spec

PG 46PG 52PG 58PG 64PG 70PG 76PG 82																										
Avg 7-day Max, °C																										
1-day Min, °C	-34	-40	46	10	-6	-22	-38	-44	-40	-16	-22	-28	-34	-40	10	16	-22	-38	-44	-10	-16	-22	-28	34		
ORIGINAL																										
 ≥ 230 °C	(Flash Point) FP Safety																									
 ≤ 3 Pa·s @ 135 °C	(Rotational Viscosity) RV High Temp Handling																									
 ≥ 1.00 kPa	(Dynamic Shear Rheometer) DSR G*/sin δ Workability																									
	46	52	58	64	70	76	82																			
(ROLLING THIN FILM OVEN) RTFO Mass Loss ≤ 1.00 %																										
 ≥ 2.20 kPa	(Dynamic Shear Rheometer) DSR G*/sin δ Rutting Resistance																									
	46	52	58	64	70	76	82																			
(PRESSURE AGING VESSEL) PAV																										
20 Hours, 2.07 MPa	90	90	100	100	100 (110)	100 (110)	110 (110)																			
 ≤ 5000 kPa	(Dynamic Shear Rheometer) DSR G* sin δ Fatigue Cracking																									
	10	7	4	25	22	19	16	11	10	7	25	22	19	16	11	10	7	25	22	19	16	11	10	7	25	28
S ≤ 300 MPa  m ≥ 0.300	(Bending Beam Rheometer) BBR "S" Stiffness & "m"-value Thermal Cracking																									
	-24	-30	-36	0	5	-2	-8	-14	-20	-26	-32	-38	-44	-50	-56	-62	-68	-74	-80	-86	-92	-98	-104	-110	-116	-122
Report Value	(Bending Beam Rheometer) BBR Physical Hardening																									
≥ 1.00 %	(Direct Tension) DT Thermal Cracking																									
	-24	-30	-36	0	5	-2	-8	-14	-20	-26	-32	-38	-44	-50	-56	-62	-68	-74	-80	-86	-92	-98	-104	-110	-116	-122

PG Binder Grading

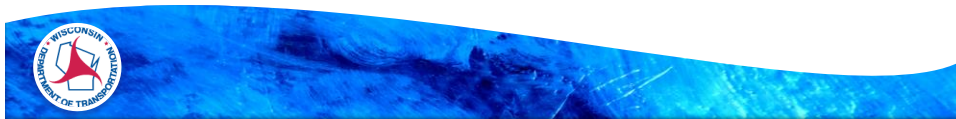


PG Binder Grading

Common Grades:

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

6°C Increments



New MSCR Binder Protocols

Current Grade

New Grade Comparison

58-28
64-28P
70-28P

58-28 S
58-28 H
58-28 V

58-34
64-34P
70-34

58-34 S
58-34 H
58-34 V



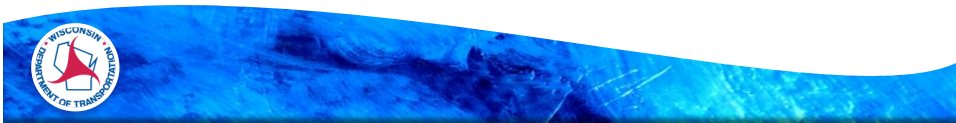
WisDOT Standard Specification 455

► General

- Furnish (and sample) asphaltic material conforming to the department's "Combined State Binder Group Certification Method of Acceptance for Asphalt Binders."
 - Field Inspection Sample Accordingly (Get copy of BOL)
- Do not change the grade of PG materials
 - Field Inspection Visual (Document Findings)
- Use only clean, dry sample containers free from cleaning oil or other contamination. Tightly seal, identify and submit. The Bureau of Technical Services tests the material.
 - Field Inspection Sample Accordingly (Get copy of BOL)



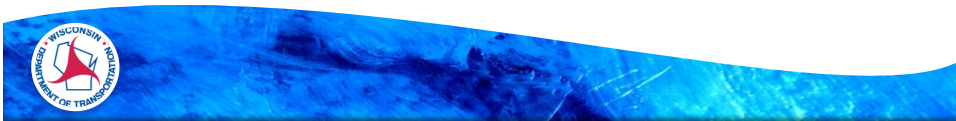
HMA Mix Design



Superpave

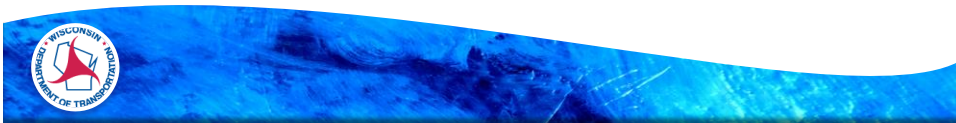
Superpave Design Looks at Pavement Performance:

- ▶ Asphalt Binder Grades related to temperature
- ▶ Aggregates are looked at more closely
- ▶ Mix Designs better simulate field conditions
- ▶ All aspects are based on traffic loading (ESALs)
 - Equivalent Single Axle Loads
 - Based off of 20 years

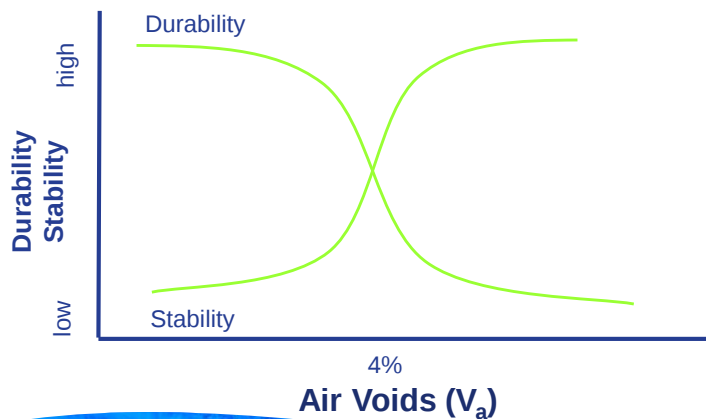


HMA Mix Design

- ▶ 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%



Air Voids Relationships

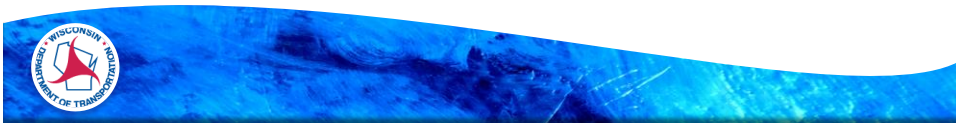


(For a given aggregate structure)



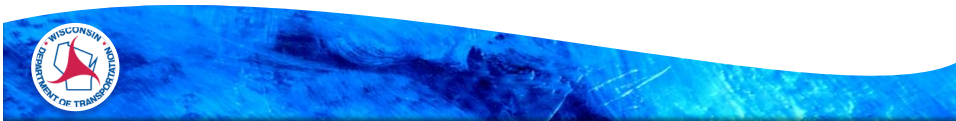
WisDOT Mix Designation

- ▶ E-0.3
- ▶ E-1
- ▶ E-3
- ▶ E-10
- ▶ E-30
- ▶ E-30X
- ▶ SMA
- ▶ Nominal Aggregate Size
 - 9.5 mm
 - **12.5 mm (upper layer)**
 - **19.0 mm (lower layer)**
 - 25.0 mm
 - 37.5 mm



New WisDOT Mix Designations

- ▶ LT <2 Million ESALs
- ▶ MT 2-8 Million ESALs
- ▶ HT >8 Million ESALs
- ▶ SMA >5 Million ESALs
 - Applies to surface mixes only





9.5 mm



12.5 mm

Superpave Mix Sizes

19.0 mm



25.0 mm



37.5 mm



9.5 mm (#5)



12.5 mm (#4)

New Mix Designations

19.0 mm (#3)



25.0 mm (#2)



37.5 mm (#1)







MATHY CONSTRUCTION CO.
GENERAL CONTRACTORS
920 10TH AVE N POST OFFICE BOX 189 ONALASKA, WI 54650
PHONE 608-781-4683 FAX 608-781-4694

Report of Bituminous Mix Design

Project Name	Necedah - Coloma STH 21
Date	July 3, 2014
Project #	6168-03-32
Test #	15-14-596-E1-12.5(R)
County	Adams
Specifications	12.5mm E1 Mix
Counsel Layer	



Aggregate Sources				
Percent	Material	Location / Source	G _{mm}	
1	25 3/4" x 3/8" Bit Gravel(5214)	Manthey East P6/26/35, 17.7E Adams	2.748	
2	15 3/8" Bit Gravel (5225)	Manthey East P6/26/35, 17.7E Adams	2.740	
3	15 1/8" Washed Man Sand(3404)	Tork/1, 22.5E Wood	2.719	
4	25 5/8" Screened Sand(5501)	Manthey East P6/26/35, 17.7E Adams	2.685	
5	20 RAP(5.7%AC)(7206)	Manthey Stockpile	2.733	
6				
7				
8				
Total	100.0			2.718
Virgin Agg Blend	31.25	18.75 31.25	6 7 8	Comb G _{mm} 2.756

Aggregate Gradations													
Sieve		Material								Job Mix		Spec	
(Std)	(mm)	1	2	3	4	5	6	7	8		High	Low	
2	100.0	100.0	100.0	100.0	100.0	100.0					100.0		
15"	37.5	100.0	100.0	100.0	100.0	100.0					100.0		
1"	25	100.0	100.0	100.0	100.0	100.0					100.0		
3/4"	19	100.0	100.0	100.0	100.0	100.0					100.0		
1/2"	12.5	93.0	100.0	100.0	98.0	99.0					95.1		
3/8"	9.5	41.0	100.0	100.0	94.0	94.0					82.6		
#4	4.75	5.2	76.0	99.0	84.0	79.0					64.4		
#8	2.36	3.0	52.0	84.0	76.0	60.0					52.2		
#16	1.18	2.7	37.0	55.0	71.0	46.0					41.4		
#30	0.6	2.6	29.0	37.0	55.0	36.0					31.5		
#50	0.3	2.4	22.0	21.0	22.0	22.0					17.2		
#100	0.15	2.0	15.0	7.6	6.0	14.0					8.2		
#200	0.075	1.6	10.4	1.8	2.5	9.0					4.7		
Soundness	225-215	225-215	225-20	225-215									
LAR 100/500 Ret	2011	2011	2014	2011							12 Max		
Crush 1 Face (%)	97.0	100.0	100.0	35.0		91.0					13 & 50 Max		
Crush 2 Face (%)	96.0	100.0	100.0	33.0		89.0					65 Min		
Sand Equiv.											80	40 Min	
Flat & Elong (%)	1.8	4.0	1.0	0.4	1.6						1.6	5 Max	
Water Abs.	1.1	1.0	0.1	0.6	1.0						0.8	40 Min	
Water Abs.	1.1	1.0	0.1	0.6	1.0						0.8	40 Min	

Test Methods: D312, D1762Q419, T11C117, T272-132, D4791, D5831, T304/C132, T96C131, T208Q2041, T1685Q2728

Test Methods: D312, T118/D3419, T111/C117, T27/C138, D4791, D5821, T304/C1252, T99/C131, T208/C2041, T166/C2278



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Report of Bituminous Mix Design

Project Name	Necedah - Coloma STH 21
Date	July 3, 2014
Project #	6168-03-32
Test #	15-14-596-E1-12.5(R)
County	Adams
Specifications	12.5mm E1 Mix
Counsel Layer	



Property	1	2	3	4	5	6
AC Content (% by Wt)	4.0	4.5	5.0	5.5		4.9
Compaction Level	Design	Design	Design	Design		Max
Air Voids V _a (%)	6.5	5.1	3.7	2.4		3.9
%G _{mm} @ N _{max}	88.7	90.2	91.5	92.7		91.2
%G _{mm} @ N _{max}	93.5	94.9	96.3	97.6		96.5
VMA (%)	14.7	14.5	14.4	14.4		14.0
VFA (%)	55.7	65.2	74.3	83.4		71.9
Density (kg/m ³)	2414	2433	2448	2463		2457
G _{mm}	2.414	2.433	2.448	2.463		2.457
G _{mm}	2.583	2.562	2.542	2.523		2.646

Gyrations	
N ₁	7
N ₂	60
N ₃	75

Antistrip	
None	

Property	Value	Specification
Design P _s	4.9	
Added P _s	3.9	
V _a	4.0	4.0
VMA	14.4	14.0 Min
VFA	72.3	65 - 78
G _{mm}	2.546	
G _{mm}	2.445	
P _{max}	4.4	
P _{max}	0.5	
Dust/Binder Ratio	1.1	0.6 - 1.2
%G _{mm} @ N ₁	91.2	< 90.5 Rec
%G _{mm} @ N ₂	96.1	~ 96.0
%G _{mm} @ N ₃	96.5	98.0 Max
TSR Ratio	74.0	70 Min
Rec. Mix Temp.	275-300	

Primary AC Source	AC Type	GB
MIA - LaCrosse	PG 58-28	1.023
Alternate Sources		
MIA - LaCrosse	PG 58-34	1.023
MIA - LaCrosse	PG 58-38	1.028
MIA - LaCrosse	PG 58-40	1.023
MIA - LaCrosse	PG 58-40P	1.024
MIA - LaCrosse	PG 58-42	1.028
MIA - LaCrosse	PG 64-38	1.030

% Binder Replacement
20.2%

Average # of Gyrations 12

Since this design is material specific, the conclusions and recommendations contained within are obtained from material submitted to and subjected to observations under laboratory conditions. Adjustments may become necessary when field laboratory data is obtained from plant produced mix. No guarantee or warranty is implied or offered.

Signature *J. C. Jagan* Cert. No. 361 Date: 7/3/2014



CRM
W134 N798 Bruce Road
Waukesha, WI 53072
(262) 524-4721

REPORT OF SUPERPAVE VOLUMETRIC MIX DESIGN
(AASHTO MP-2, PP-28, T312 & ASTM D 4867)

Issued Date: 8/6/2014
Amended Date: 8/6/2014

Design Number: 306214 Job: 1300-13-70
Plant: Waukesha Plant Mix Type: 5-3
Mix Size: 1/2" (12.5mm) Design ESAL Range (mil): 1 to <3
Mix Temperature: 125-140°C

Effort: NC: 7 NR: 75 Nm: 115

Binder Date: GRADE: PG 58-28 SOURCE: CRM Milwaukee GB: 1.030 Pcr: 24

AGGREGATE SOURCE DATA

AGG	AGGREGATE	SOURCE	TEST#	LOCATION	Pcb
Agg #1	2 1/2" Chips	Waukesha		526 TTN R18E Waukesha County	
Agg #2	3/8" Chips	Waukesha		526 TTN R18E Waukesha County	
Agg #3	MP2 D Sand	Waukesha		526 TTN R18E Waukesha County	
Agg #4	Natural Sand	Johnson		56 T6N R18E Waukesha County	
Agg #5	ISS	40002		40002	
Agg #6	FRAP	40002		40002	6.75

AGGREGATE GRADATION

	Agg #1	Agg #2	Agg #3	Agg #4	Agg #5	Agg #6	JMF	SPECIFICATIONS
%Blended	55.0	9.0	58.0	96.0	1.0	27.0		MIN MAX
2 30.0 mm	100.0	100.0	100.0	100.0	100.0	100.0	100.0	
1 1/2 37.5 mm	100.0	100.0	100.0	100.0	100.0	100.0	100.0	
1 25.0 mm	100.0	100.0	100.0	100.0	100.0	100.0	100.0	
3/4 19.0 mm	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100 100
1/2 12.5 mm	94.9	100.0	100.0	100.0	100.0	100.0	98.3	90 100
3/8 9.5 mm	16.0	92.6	100.0	100.0	100.0	96.3	88.1	90
#4 4.75 mm	2.1	5.8	88.9	96.5	100.0	72.6	70.2	
#5 3.94 mm	1.5	1.5	90.4	96.3	100.0	75.6	74.9	25 50
#10 1.9 mm	1.3	1.6	92.8	73.8	100.0	41.3	44.3	
#20 0.8 mm	1.2	1.4	15.7	61.7	100.0	29.2	33.9	
#40 0.4 mm	1.2	1.3	9.5	22.1	100.0	20.1	16.2	
#100 0.15 mm	1.1	1.1	2.4	3.9	100.0	14.9	7.3	
#200 0.075 mm	1.0	1.1	3.3	1.8	100.0	12.4	5.7	2.0 10.0

FAA 46.6 42.0 2.665 2.887 2.701

AGGREGATE DATA FOR BLENDED DESIGN JMF

CRUSH 10/20 100/100 Gmb: 2.707 Moist. Absorption: 0.9 L.A. WEAR: ELONGATED: 0.6(5%)

FAA: 49 Gmb: 2.775 Dust Proportion: 1.2

SE: 94 Gmb: 2.739 Soundness: Freeze-Thaw:

VOLUMETRIC DATA

Point	Added Pb	Total Pb	Gmm	Gmb	Va	VMA	VFB	Unit Weight	% Gmm N1	% Gmm Nm	TSM
A	3.6	4.8	2.553	2.405	3.8	15.4	62.3	2399			
B	4.1	5.3	2.534	2.433	4.0	14.9	73.2	2426			
C	4.6	5.8	2.516	2.428	2.4	14.6	83.6	2447			
JMF	4.1	5.3	2.534	2.433	4.0	14.9	73.2	2426	90.3	86.5	100

SPECIFICATION Comp Factor: >14.5 70-76 <89.0 <98.0

Comments: WisDOT Aggregate Test Number: 225-0028-2013 WisDOT Verification Number:

Under production eliminate Deg. Johnson Natural Sand to 97.2%.

A change in binder grade is recognized without the need for additional mix design laboratory testing as defined in the current WisDOT 2359.

Patrick J Timmer

Wisconsin Certified Hot Mix Asphalt Technician

THE TEST DATA SHOWN ON THIS REPORT PERTAIN ONLY TO THE MATERIAL SUBMITTED FOR DESIGN.

