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Overview of Warm-Mix Asphalt for Virgin and Reclaimed Asphalt Mixes

TRB Warm Mix

May 25, 2010

John Bartoszek
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Overview

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- Payne & Dolan Inc
- Driving factors for Warm Mix
- Warm Mix Asphalt Technology
- First Trial with Warm Mix
- Project Application
- Lessons Learned

Operations Aggregates-Asphalt

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Payne & Dolan Inc
Vertically Integrated Construction Company

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www.payneanddolan.com

European Scan Tour-Group

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- Eric Harm, chairman
- John D'Angelo, co-chairman
- Gaylon Baumgardner
- John Bartoszek
- Matthew Corrigan
- Jack Cowsert
- Tom Harman
- Mostafa (Moe) Jamshidi
- Wayne Jones
- Dave Newcomb
- Brian Prowell, reporter
- Ron Sines
- Bruce Yeaton

- Illinois DOT
- FHWA
- Paragon Technical Services
- Payne & Dolan
- FHWA
- North Carolina DOT
- FHWA
- Nebraska DOT
- Asphalt Institute
- NAPA
- Adv. Materials Services LLC
- P.J. Keating
- Maine DOT

Where the Group Visited

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Warm Mix Asphalt Benefits:
Reduced Worker Exposure

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Typical reductions:

- ✓ 30% to 50% asphalt fumes and poly-cyclic aromatic hydro-carbons (PAHs)

Warm Mix Asphalt Benefits:
Reduced Plant Emissions

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Typical reductions:

- ✓ 25% Co_2
- ✓ 25% SO_2
- ✓ 35% VOC
- ✓ 20% CO
- ✓ 40% NO_x

Payne & Dolan's Interest initially was emissions

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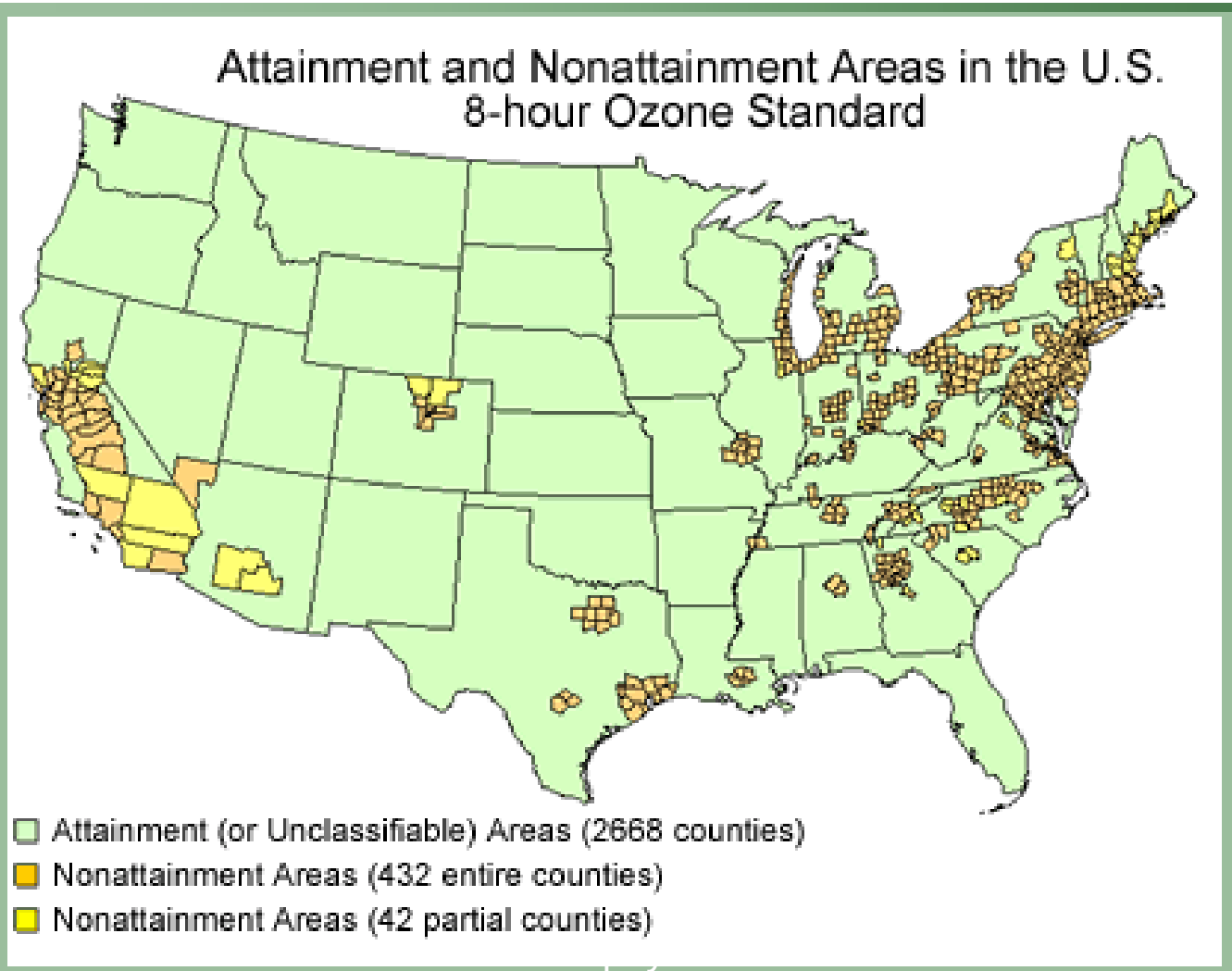

Warm Mix Asphalt Benefits:
Reduced Fuel Usage

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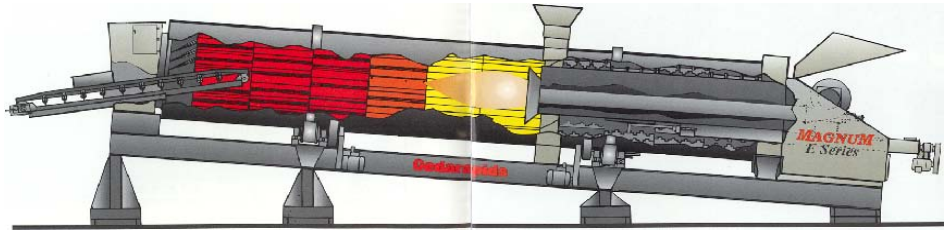

Burner Fuel Savings are typically 11% to 25%

Warm Mix Asphalt Benefits:
Paving Benefits

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- ✓ Improved workability
- ✓ Extend Paving Season
- ✓ Pave through cooler temperatures
- ✓ Haul longer distances
- ✓ Improved Compaction
- ✓ Better Ride IRI

Experiences

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- First Warm Mix Project In Wisconsin and Michigan 2006 -350K ton To Date
  - Sasobit-Wax
  - Evotherm-Emulsion Based and 3G
  - Advera-Zeolite-Additive “Foaming”
  - Gencor-Green Machine “Foaming”
  - Maxam-AquaBlack “Foaming”

Experiences

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- First Warm Mix Project in Wisconsin 2006
  - Sasobit-Wax-1500 ton
  - Evotherm-Emulsion Based Technology-1500 ton

Mix Design-First Trial

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- Used existing WisDOT approved mix design
- **14% RAP, 4.6% Added AC**
- **SUPERPAVE 12.5mm E-3**
- **BINDER PG 64-28**
- **SPECIFIED THICKNESS 1-3/4”**
- **NORMAL MIX TEMP. 320 F**

Warm Mix Asphalt Trials

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- Sasobit – Sasol International
  - Fisher-Tropsch wax technology
  - Manufactured in South Africa
  - Added to bitumen at the Asphalt Cement plant or pneumatically fed through the fiber port of a drum plant.
  - Melting Temperature – 210F
  - Reduces the viscosity of the mix

Sasobit

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- Sasobit – Wax Additive

  Superpave E-1, E-3

  - Binder Type 64-22, 58-28,64-28
  - Used in Conjunction RAP(10-20%)
  - Average Mix Reduction Temp 55 F
  - Average Field Density Improvement .9 Percent

Evotherm

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- Manufactured by MeadWestvaco
- Three Products:
  - Evotherm - Emulsion Technology with Chemical Package.- 30% water
  - Evotherm DAT - Chemical Package – 10% water
  - Evotherm 3G M1 – Waterless technology.
  - Superpave E.3,E-1,E-3
  - Binder 64-22, 58-28,64-28
  - Average Temp Reduction 65 F
  - Average Field Density Improvement 1.1 Percent

Muskego Plant

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Asphalt Binder Testing Lab

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Muskego Plant Emissions Testing

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Field Emissions Testing

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Asphalt Fumes (at the paver)

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- Sasobit

  43% - 91% Lower than HMA

- Evotherm

  22% - 82% Lower than HMA

Field Testing

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Field Results (Mix-Overall)

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2006 Ryan Road - 12.5mm E3

	SAMPLE VOLUMETRIC PROPERTIES									
Property	JMF	HMA #1	HMA #2	HMA #3	SAS#1	SAS#2	SAS#3	EVO#1	EVO#2	EVO#3
G_{mm}	2.534	2.521	2.533	2.516	2.526	2.517	2.518	2.518	2.519	2.521
G_{mb}	2.433	2.441	2.428	2.424	2.437	2.427	2.434	2.436	2.441	2.431
V_a	4.0%	3.2%	4.1%	3.7%	3.5%	3.6%	3.3%	3.3%	3.1%	3.6%
VMA	14.2	13.8	14.2	14.4	13.9	14.3	14.0	14.0	13.8	14.1
VFB	71.8	76.8	71.1	74.3	74.8	74.8	76.4	76.4	77.6	74.5
P_b	5.30%	5.17%	5.16%	5.29%	5.20%	5.19%	5.17%	5.23%	5.23%	5.21%

Final Product

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Moving forward with WMA

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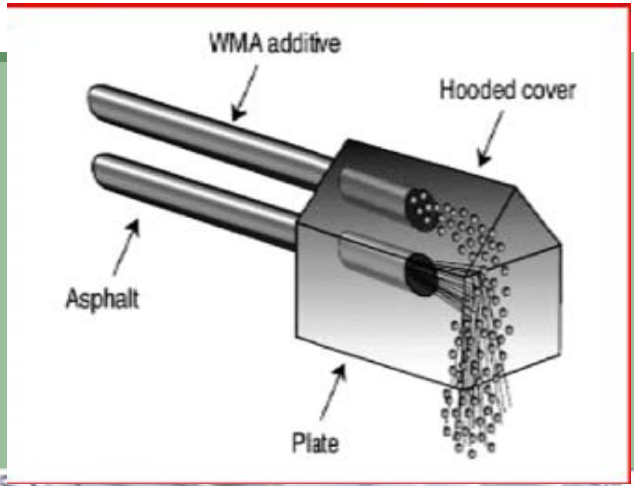
- Very successful first trials
- Several new technologies researched
- Advera
- Evotherm 3G
- Foaming Units
- All products very different but had similar results



Advera® WMA

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- Advera-Foaming
  - Added through fiber port
  - Superpave E-1, E-3, E-10, SMA, Commercial Mixes
  - Binder 58-28, 64-22, 70-28P
  - Mix Temperatures Reduced 10-50 F
  - Densities are always equal to or better than control mix

West Bend Airport

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West Bend Airport

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- City of West Bend Wisconsin
- Existing Runway severe distress cracking
- E3-12.5mm, 20% RAP, PG64-38 2 inch overlay
- Abundance of crack sealant
- Runway 75 feet wide
- Paved in echelon 37.5 feet wide
- Lay down temp 235 degrees or below

West Bend Airport

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Paving in Echelon

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Finished Product

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- Densities Average 93.2
- Little to no reflective bumps from crack sealant
- Mix volumetrics 100 percent pay
- Extremely happy owner

Key Factors for Good Plant Operations

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- Aggregate Moisture and Stockpiling
- Burner Optimization at reduced Temperatures
- Baghouse Operations
- Drum Operations and Flighting
- Liquid Storage and Handling at Lower Temperatures

Aggregate Moisture Critical

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- Keeping moisture out is a great way to start
- Keep track of temperature drop of material
- > 20°F from drum discharge to load out can indicate moisture

Baghouse Operations

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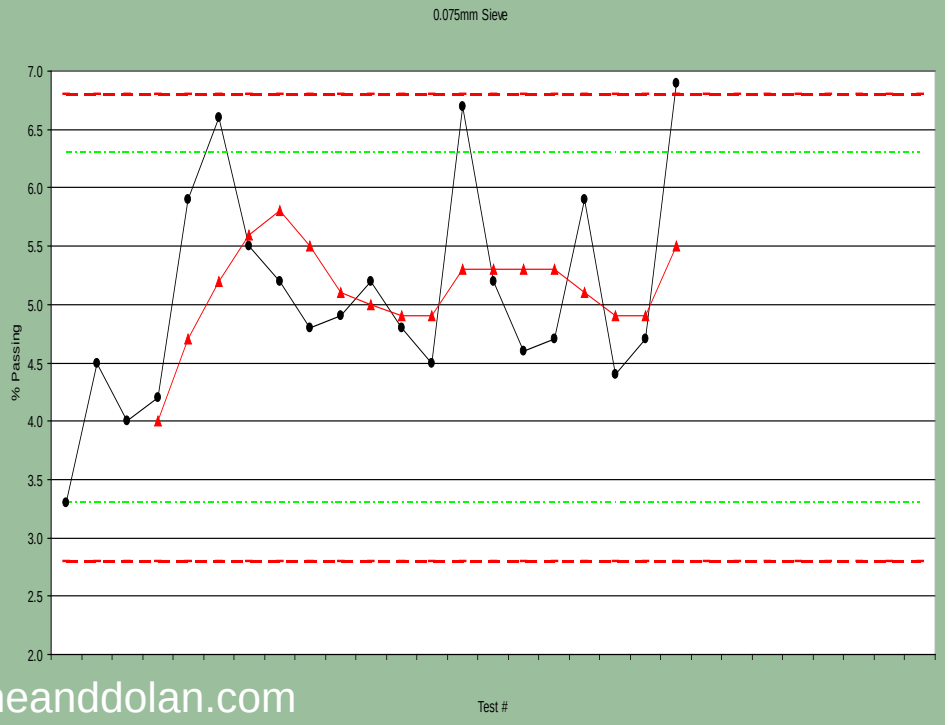
- Erratic air voids and dust can indicate Baghouse problems
- Keep an eye on pressure differential across the Baghouse
- Pressure should be consistent , if you have a large variance.

You can have problems.



Drum Operations

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- Due to lower temperatures and addition of RAP, buildup on the flights and in the drum can occur more rapidly

- Frequent starts and stops can be more of a problem with warm mix in cooler temperatures
- Excessive buildup will affect mix quality

Liquid Binder

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- Cooler Asphalt Production temperatures doesn't necessary mean cooler liquid binder temperatures
- Cooler liquid binder can affect pumping and meter accuracy
- Produce and pump liquid binder at the temperature you are calibrated for
- Modified binders have a steeper viscosity curves and dramatically increase the problems with meter accuracy if you try to pump at too cool of temperatures

Things to Watch

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- Production
  - Make sure aggregates are dried properly
  - Monitor by watching TSR values
  - Don’t go too cold too fast
  - Double check procedures
  - BMP’s for adding modifiers
- Laydown
  - Cold weather make sure to warm up equipment
  - Start hotter and cool down slowly
  - Longitudinal joints - Joint Heater?
  - Listen to the field crew
- Testing
  - Have a procedure for repeatability
  - Reheated samples - not the same as fresh samples

Benefits

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- **Production**
  - Quality/consistent mix (Rap/Shingles)
  - Fuel Savings
  - Ability to sell Superpave mix to FOB customers
  - Higher production rates late season
  - Longer haul distances
- **Laydown**
  - More consistent mat temperature
  - Better densities
  - Better ride (Less bumps paving over crack sealant)
  - Less shadowing/segregation
  - Aesthetics better handwork
- **Profitability**
  - Work later in season
  - Customer base-FOB customers
  - Lower operational costs (fuel usage/ rollers)?

Advera® WMA

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- Advera-Attributes
  - Handwork segregation much improved at higher temperatures
  - Can be stored for 8 plus hours in silo and maintain properties
  - Improved ride with harsh mixes
  - Very consistent volumetrics
  - No change in TSR ratios
  - Very versatile in being used as compaction aid or warm mix
  - Paved in December in Wisconsin E-10 with 70-28P oil
  - Extends the paving season
  - Cost $1.25-$2.00 ton

Sasobit

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- Sasobit –Benefits
  - Field Crews - Slightly better hand work
  - Mix Tests and Volumetrics consistent
  - Very good densities at lower temperatures
  - No change in TSR values noticed
  - Mix costs associated with material $2.25-$3.00 ton
  - May give slightly stiffer binder grade
  - Plant modification costs $60K

Evotherm

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- Evotherm Attributes-3G
  - Improved Workability and Handwork
  - Probably the most diverse product used to date
  - Mix Tests and Volumetrics consistent but not as repeatable when reheated samples taken
  - TSR ratios slightly better
  - Mix costs associated with material $2.00-$2.75 ton
  - New chemical package very easy to use at plant
  - Can be added directly to the tank at the plant
  - Plant modification costs $10-$15K

Gencor Green Machine

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- Gencor-Foaming Water
  - Installed directly on AC Line
  - Superpave E-1,E-3
  - Binder 58-28, 64-22
  - Mix Temp Average Reduction 35F
  - Densities equal to or better than control
  - Workability and handwork Improved
  - Material laydown behind screed improved less dragging

Gencor Green Machine

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INCORPORATED

- Gencor-Foaming Water
  - Mix Volumetrics slightly harder to control - not as consistent as with control
  - Mix cools faster in cold temperatures than control at same temperature
  - Ideal for use during the summer and on commercial mixes
  - Unit cost $45-$55k
  - Water costs minimal
  - Very economical

Maxam AquaBlack

PAYNE & DOLAN INCORPORATED

- Maxam-Foaming Water
  - Installed directly on AC Line
  - Superpave E-1,E-3
  - Binder 58-28, 64-22
  - Mix Temp average reduction 35F
  - Densities equal to or better than control
  - Workability and handwork Improved
  - Material laydown behind screed improved – less dragging

Maxam AquaBlack

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INCORPORATED

- Maxam
  - Mix Volumetrics slightly harder to control - not as consistent as with control
  - Mix cools faster in cold temperatures than control at same temperature
  - Ideal for use during the summer and on commercial mixes
  - Unit cost $45-$55k
  - Water costs minimal
  - Very economical

Questions?

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Virginia's Warm Mix Experience

Stacey Diefenderfer, PhD., P.E.
Research Scientist
Virginia Transportation Research Council

May 24, 2010

VA's Road to Implementation

- Evaluate warm mix asphalt
  - Field evaluation during construction
  - Lab evaluation of plant mix
    - Specimens compacted on-site
    - Reheated specimens
  - Lab evaluation of lab-produced mix
  - Long-term performance monitoring
- Long-term goals of studies
  - Verify performance
  - Specification

Research Program

- Monitored Field Installations - 2006
  - Sasobit – US Rt. 211, Rappahannock County
  - Sasobit – US Rt. 220, Highland County
  - Evotherm ET – State Rt. 234, Williamsburg
- Lab Evaluation
  - Sasobit
  - Did not proceed with Evotherm ET
- Pending Work
  - Foam processes

Field Evaluation

- HMA and WMA sections
  - Same paving procedures
- Three trials / three contractors
- Evaluation
  - In-place density
  - Cores
    - Density & Permeability
  - Visual inspection
  - Returned at 3-months, 6-months, 1-year, 2-years
  - Plan to return at 5-years (2011)

Expectations

- Equal (or improved) properties
- Equal (or improved) paving
- Equal (or improved) performance

- Except for temperature, no changes were made to plant or paving operations

Keys to Success

- Communication, Cooperation, and Planning
  - Agency
  - Contractor
  - Technology manufacturer/representative
- Minimized “interference”
  - No changes to typical operations
- Document successes and any reasons for lack of success

Trial A – Aug. 11, 2006

- Rappahannock County, VA
- AADT: 1,100 vehicles, 2% trucks
- Haul distance: 30 mi
- 1.5 in overlay
- 9.5mm NMAS surface mix, PG 64-22
- 5.5% AC
- 20% RAP
- Sasobit

Field Testing Summary

- No significant differences
  - Nuclear density at construction
  - Core air voids at construction, 3mo, 1yr, 2yr
  - Permeability at all ages
- Significant difference
  - Core air voids at 6mo (HMA: 6.2; WMA: 7.8)
  - Due to random variability in coring
- QC results within acceptable limits
  - No penalties assessed
- Visual assessment – no difference

Trial B – Aug. 14-15, 2006

- Highland County, VA
- AADT: 780 vehicles, 9% trucks
- Haul distance: 45 miles, 1 hr 45 mins
- 1.5 inch overlay
- 12.5mm NMAS surface mix, PG 64-22
- 5.3% AC
- 10% RAP
- Sasobit

Field Testing Summary

- No significant differences
  - Nuclear density at construction, 3mo, 6mo, 1yr, 2yr
  - Core air voids at construction, 3mo, 6mo, 1yr
- Significant difference
  - Core air voids at 2yr (HMA: 9.5; WMA:7.4)
  - Due to random variability in coring
- QC results within acceptable limits
  - No penalties assessed
- Visual assessment – no differences

Trial C – Oct. 26 & Nov. 2, 2006

- York County, VA
- Haul distance: 10 miles
- 1.5 inch overlay
- 9.5mm NMAS surface mix, PG 70-22
- 5.7% AC
- 20% RAP
- Evotherm ET

Field Testing Summary

- No significant differences
  - Core air voids at construction, 3mo, 6mo, 1yr, and 2 yr
- Significant difference
  - Nuclear density at construction
- WMA density not within acceptable limits
  - Penalties were assessed
- Visual assessment
  - WMA appears more open
  - Similar performance to date

Laboratory Testing

- Plant-compacted and lab-compacted plant mix specimens
- Lab production at different temps
- Testing plan
  - Volumetrics
  - Binder content and gradation
  - Moisture susceptibility
    - TSR, Hamburg
  - Rutting potential - APA
  - Fatigue

Trial A Laboratory Summary

- Similar results - volumetric properties, gradations
- Permeability
  - Similar performance, acceptable <9.5% air voids
- TSR
  - HMA passed, WMA failed even after reheating
- Hamburg – similar performance
- APA Rutting - acceptable, similar performance
- Fatigue – similar performance

Trial B Laboratory Summary

- Volumetric properties, gradations
  - Similar results
- Permeability
  - Similar performance, acceptable <8.0% air voids
- TSR
  - Acceptable, WMA indicated lower strengths
- Hamburg
  - WMA indicated slightly better performance
- APA Rutting - acceptable, similar performance
- Fatigue – similar performance

Path to Specification

- Trial sections (2006)
- Special Provision (July 1, 2008)
  - Allowed technologies from Approved List
  - Limited initial production of 500T or one day production
  - Superpave properties will be determined after cooling to 100ºF and reheating
  - Minimum TSR requirement ≥ 0.60
- Special Provision Copied Note (Aug. 1, 2009)
  - Minimum TSR requirement ≥ 0.80

Path to Specification

- Supplemental Specification (Dec. 3, 2010)
  - Addendum to Road & Bridge Specifications
  - Allows technologies from Approved List
  - Limited initial production of 500T or one day production
  - Superpave properties will be determined after cooling to 100ºF and reheating
  - TSR requirement ≥ 0.80

Approved Products List

- Requires cooperation
  - Manufacturer and Contractor
- Submittals to Agency
  - Documentation and independent test data
  - Mix design
  - Trial section or limited production
- Review by committee
- Addition to Approved Products List

Challenges Within Agency

- Risk-aversion
- “I don’t want to be a guinea pig.”

- Education
  - What is WMA?
  - What are benefits to Agency?
  - What are the risks to Agency?
  - What is the cost of WMA?
  - How to we specify WMA as a bid item?
  - Should we expect a reduction in bid price?
  - Should Value Engineering proposals be required for WMA?

Summary

- Field trials were generally successful
  - Production, construction
- WMA field performance to date has been comparable to HMA
- Lab performance was comparable

- Specification
  - Evolved over three years
  - WMA allowed under Supplemental Specification

More Information

- For additional information please visit our website: www.vtrc.net
- Reports available on website:
  - Diefenderfer, McGhee, and Donaldson. (2007) Installation of Warm Mix Asphalt Projects in Virginia, VTRC 07-R25.
  - Diefenderfer and Hearon. (2008) Laboratory Evaluation of Warm Asphalt for Use in Virginia, VTRC 09-R11.
  - Diefenderfer and Hearon. (2010) Performance of Virginia's Warm Mix Asphalt Trial Projects, VTRC 10-R17.


VTRC
Virginia Transportation
Research Council

Virgin and RAP WMA

Andrea Kvasnak

National Center for Asphalt Technology
NCAT
at Auburn University

Benefits of WMA for Binders

- Lower temperature reduces oxidation of binder
- Less oxidation results in a softer binder
- Potential for improved fatigue and low temperature cracking resistance
  - Jury is still out

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However….

- WMA tends to have lower indirect tensile strengths than HMA
- Often results in lower tensile strength ratios
- Adding RAP to mix will typically increase indirect tensile strengths
  - Also partially offsets the additional cost of WMA

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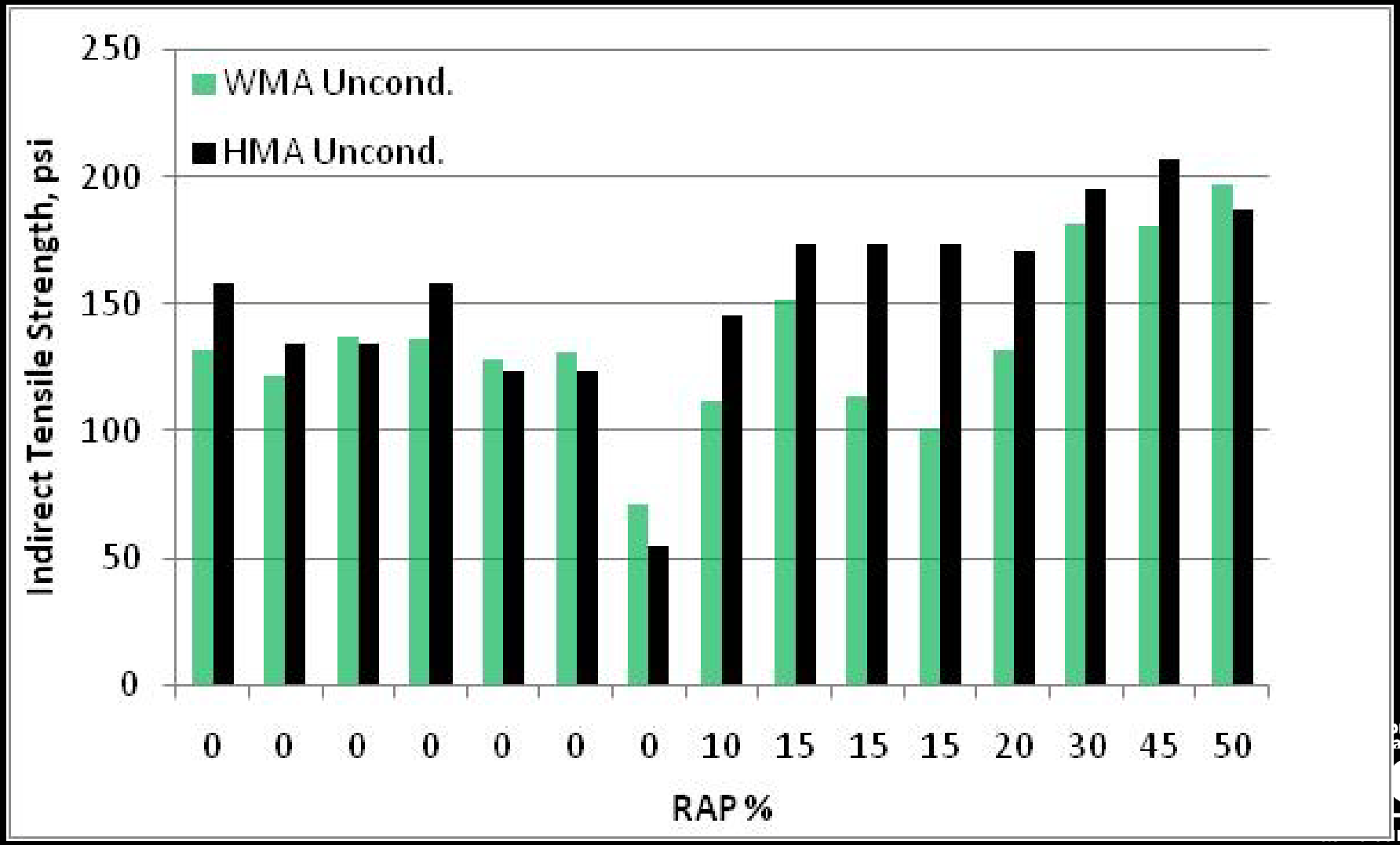
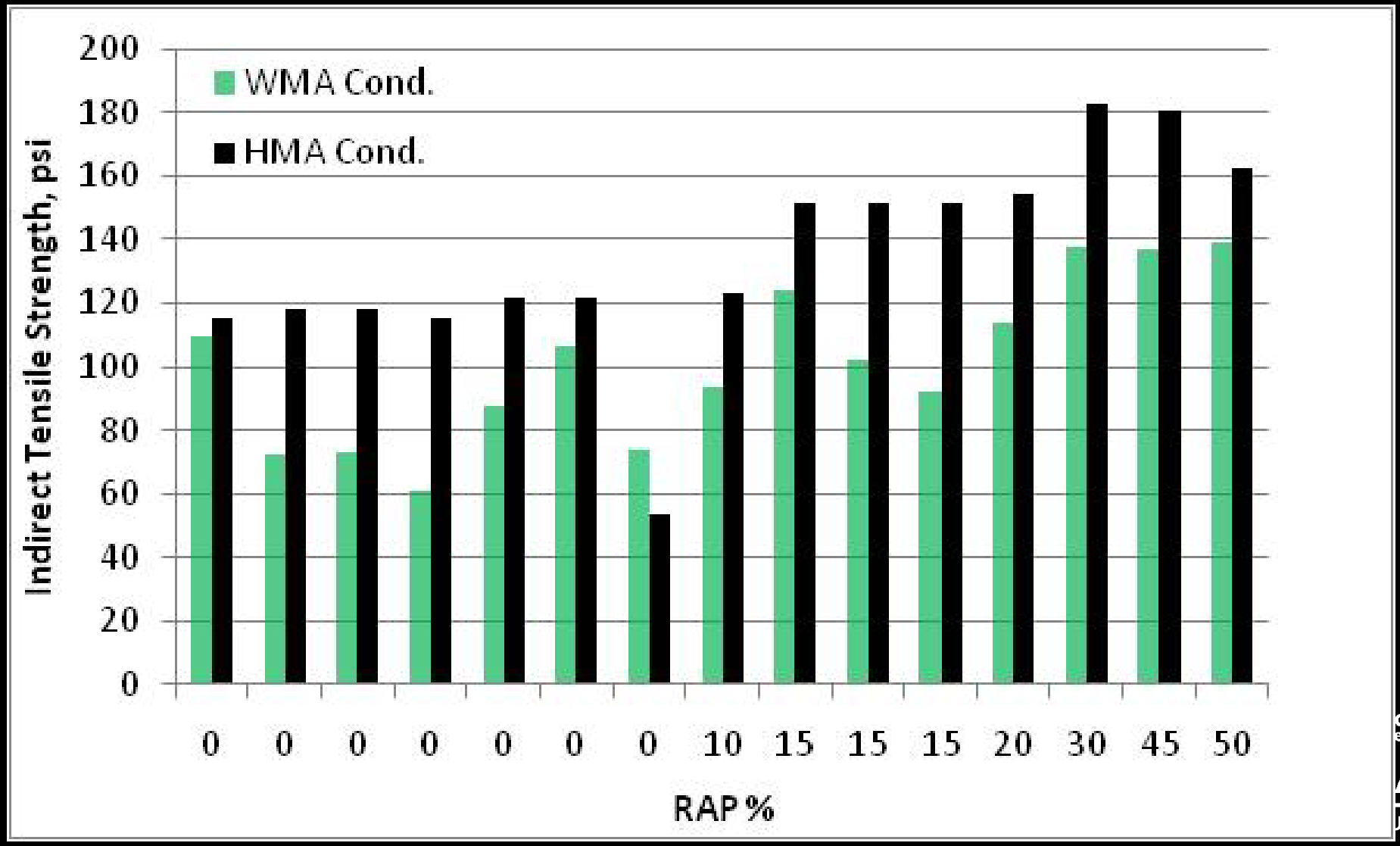
Unconditioned Indirect Tensile



Conditioned Indirect Tensile



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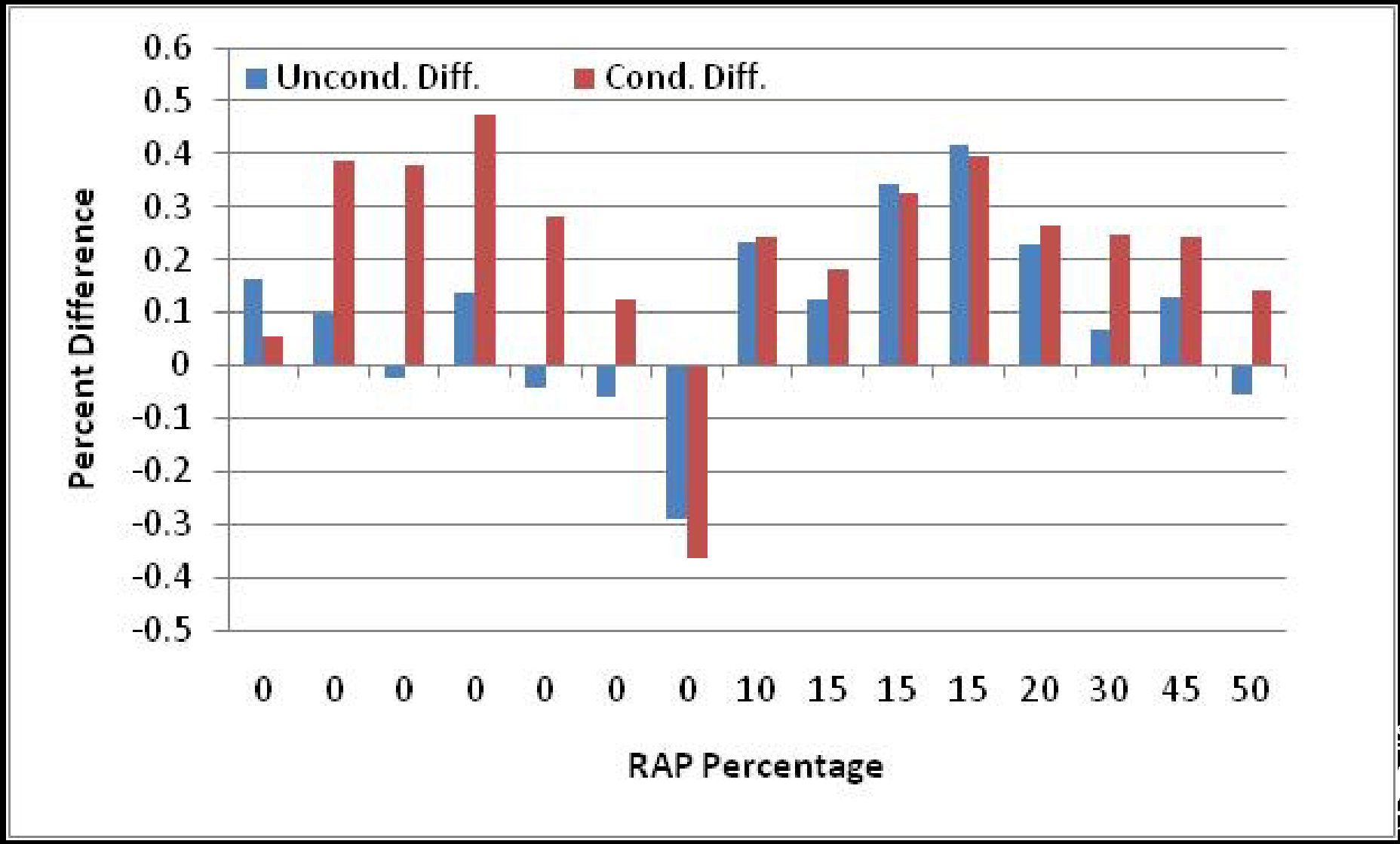
Percent Difference



Does Adding RAP Always Help?

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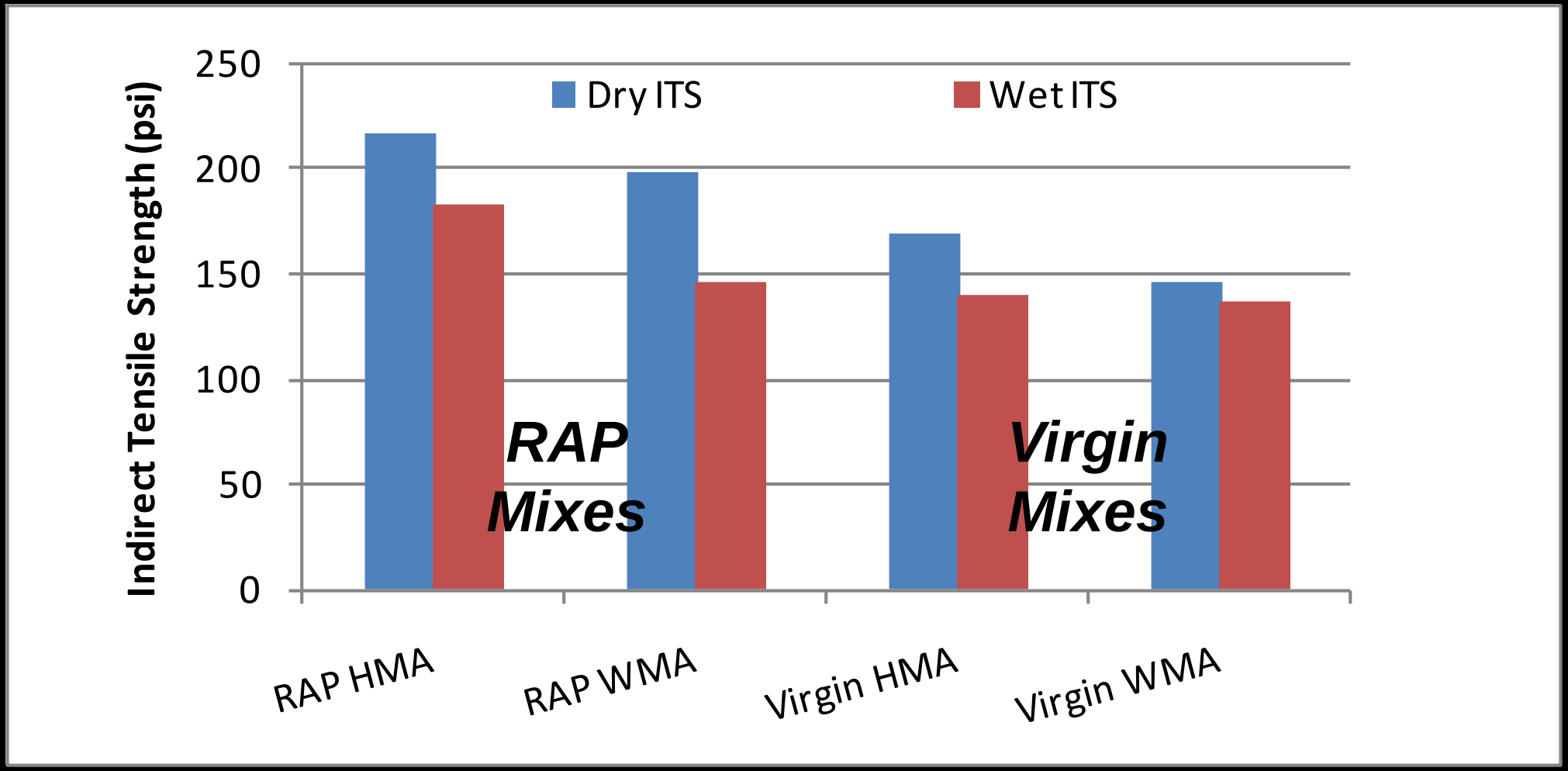
Plant Produced Mix ITS



What Are The Binder Performance Grade Differences?

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Binder Grade Differences

- Typically, at the time of construction WMA is softer than HMA
- However, after about 2 years the WMA binder grade is often similar to the HMA

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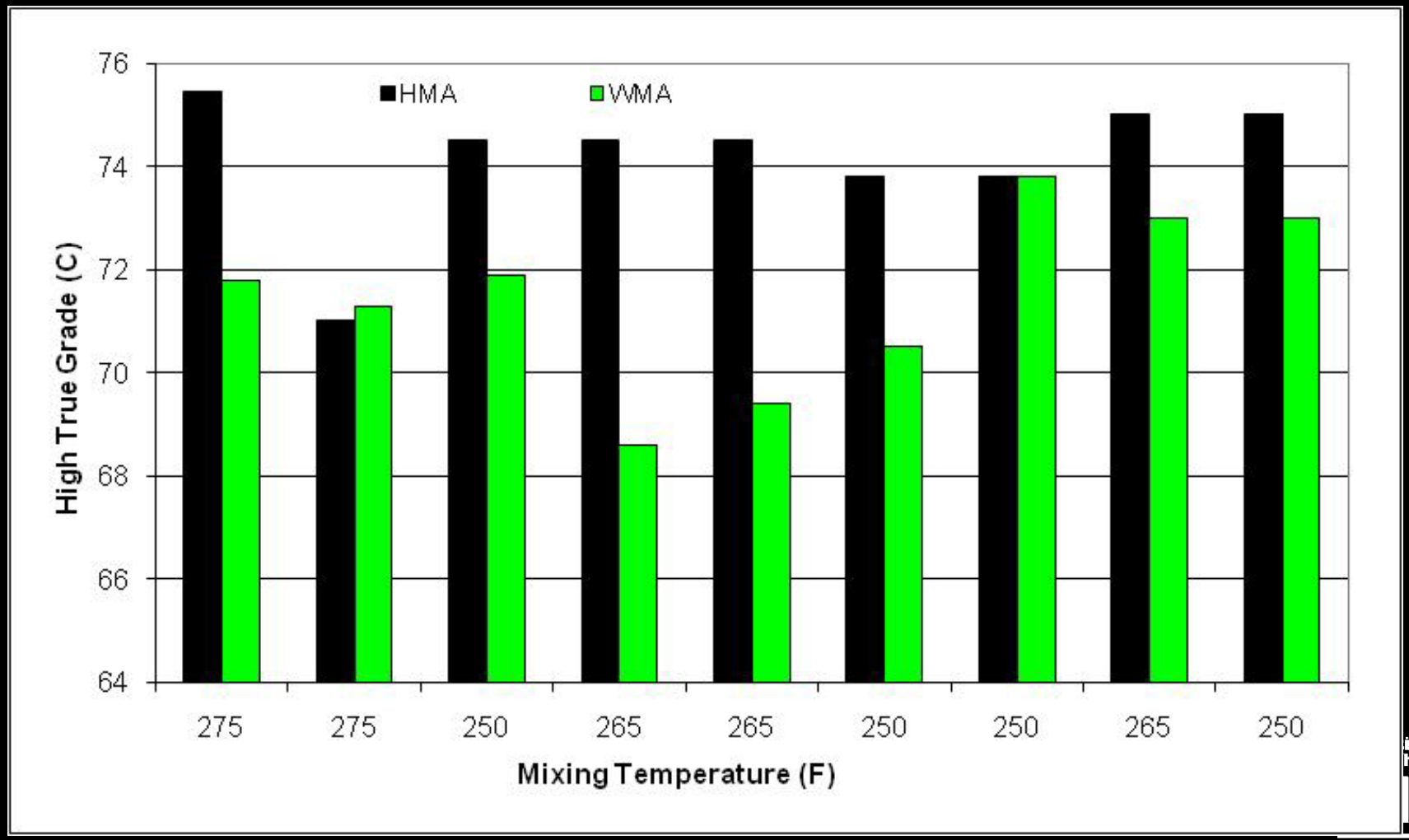
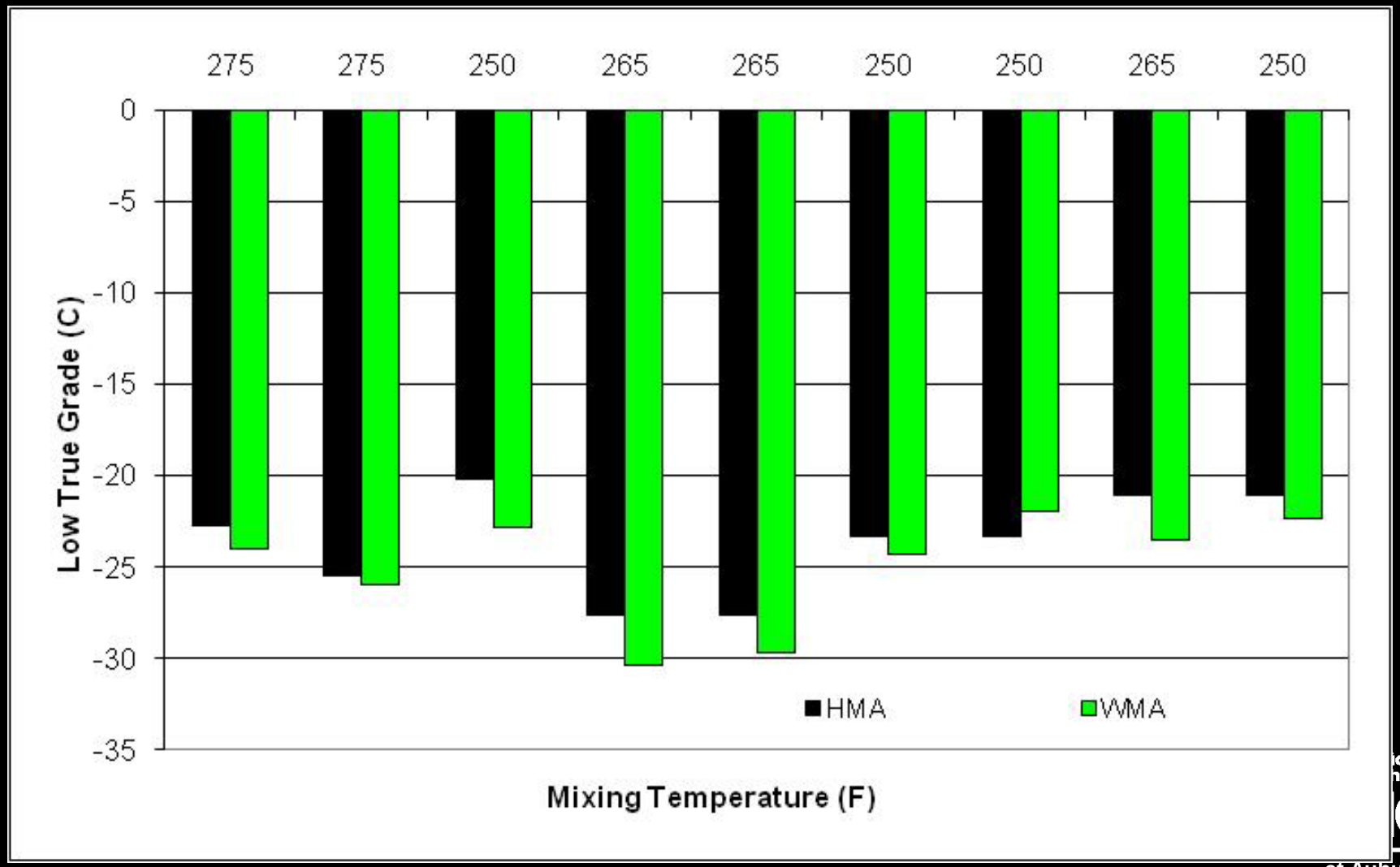
High Performance Grade



Low Performance Grade



Can a standard PG be used with high RAP WMA?

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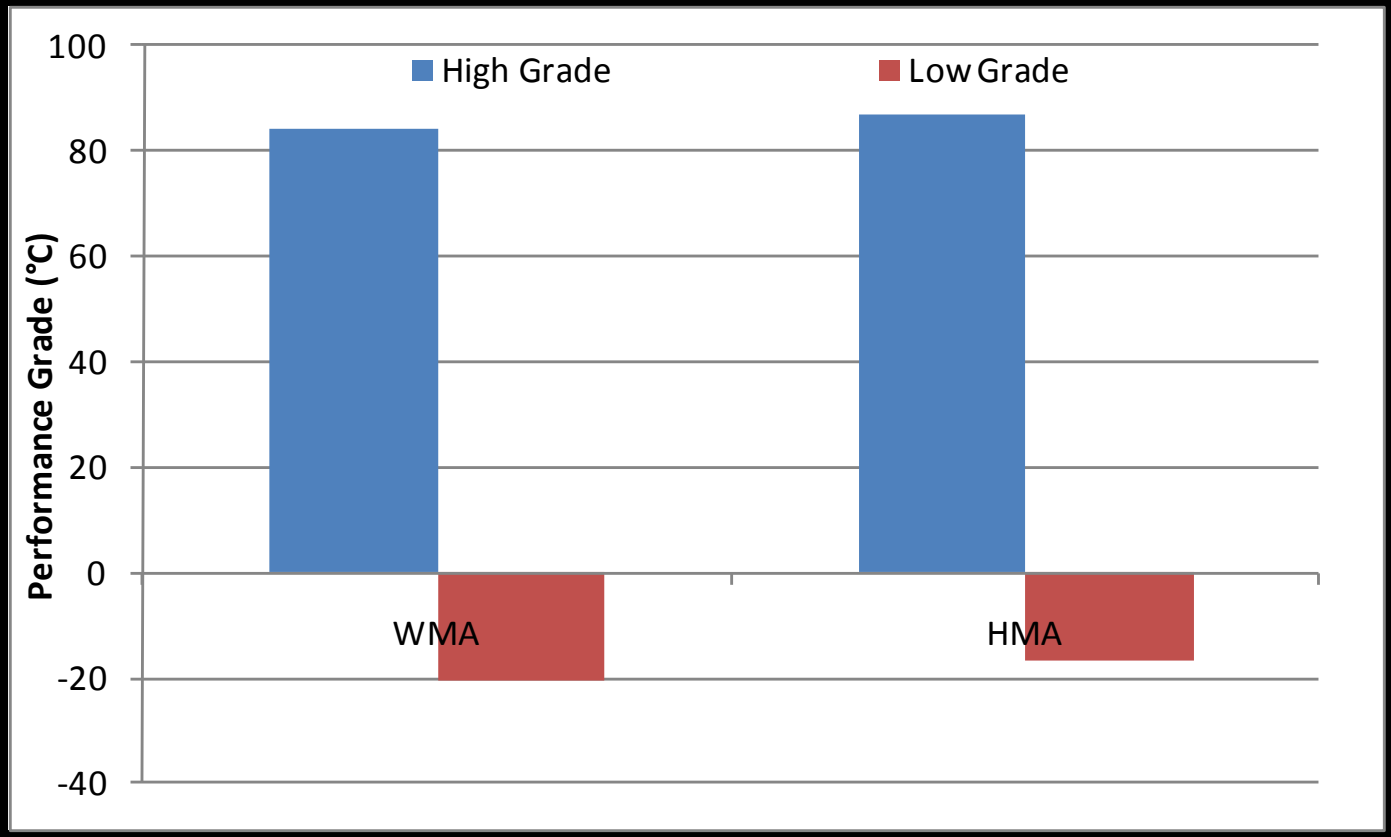
Use of Standard and Soft Binder

- WMA at the standard grade and HMA at the softer grade



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On-Going Research

- NCAT Test Track
  - Evaluating WMA with and without RAP compared to HMA with and without RAP
- NCHRP 09-43
  - Mix Design for WMA – Final Report
- NCHRP 09-47A
  - Performance and Emissions of WMA
- WMA Certification

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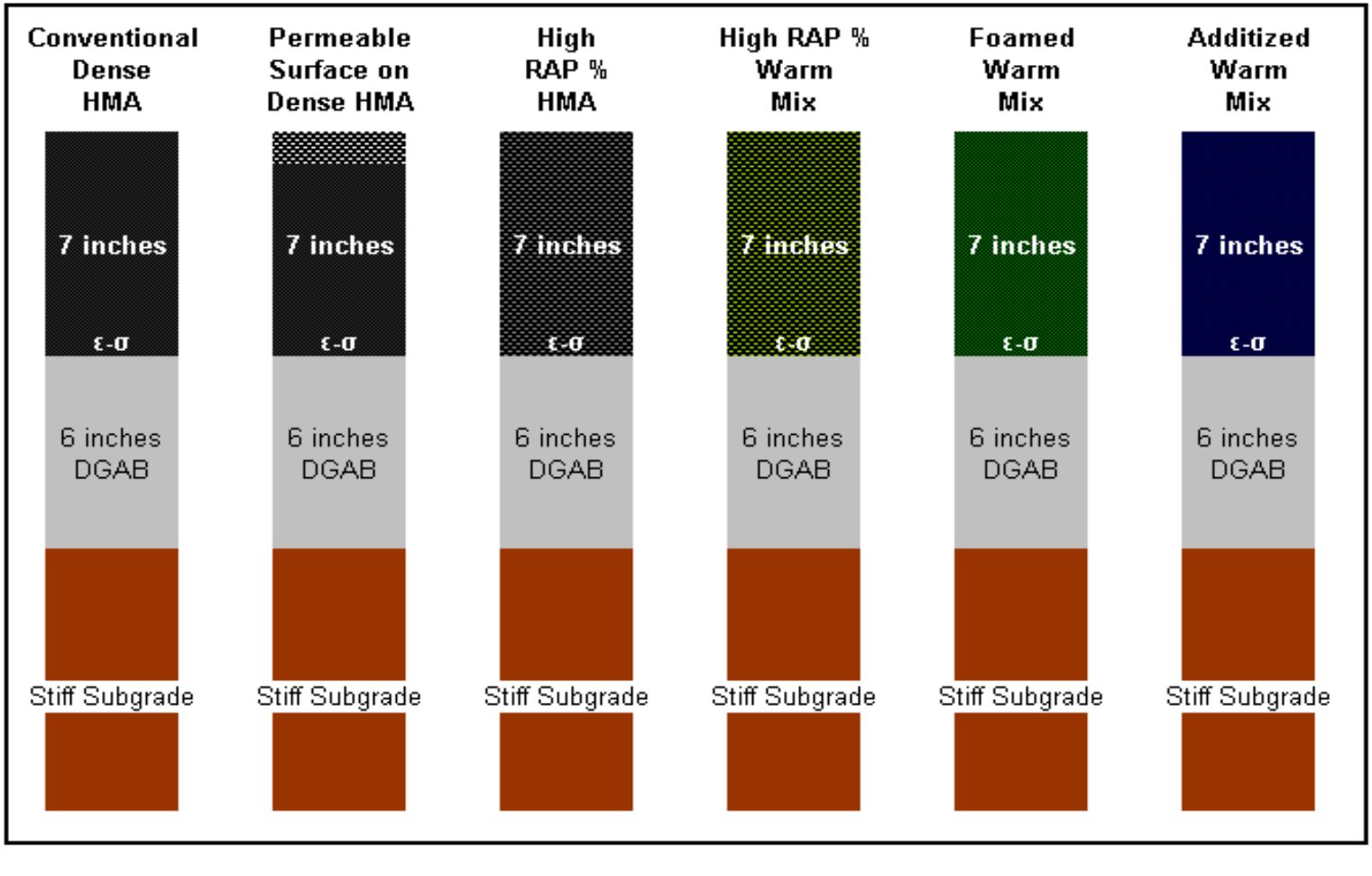
2009 Test Track Group Experiment



www.pavetrack.com

Virgin WMA

- S9
  - Control for group experiment
- S10
  - WMA Water Injection System
  - Same mix as S9
- S11
  - WMA Chemical Package
  - Same mix as S9

9.5mm PG 76-22
19.0mm PG 76-22
19.0mm PG 67-22

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High RAP and WMA

- N10:
  - Similar gradation and effective asphalt to S9
  - 50% RAP HMA
    - Fractionated RAP
- N11:
  - Same gradation as N10
  - 50% RAP WMA
  - Water injection system

9.5mm PG 67-22
19.0mm PG 67-22
19.0mm PG 67-22

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NCHRP 09-43

- Superpave Mix Design
  - Required Testing: Coating, Aging Index, Compactability, TSR, Flow Number
  - Optional: Indirect Tensile Creep Compliance and Strength, and AMPT Fatigue
- Evaluated Blending with RAP
  - Blending does occur at WMA temperatures

- *Final Report Under Review*

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NCHRP 09-47A

- Document the production and construction of WMA and HMA pavement sections
- Compare construction practices, field performance, laboratory performance, emissions, and fuel usage

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WMA Certification

- Evaluating WMA technologies in the field and in the laboratory
- Evaluating plant- and laboratory-produced mixes
- Will identify acceptable and unacceptable technologies

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WMA Resources

- http://www.warmmixasphalt.com
- NAPA documents (www.hotmix.org)
- Research Reports
  - NCAT (www.ncat.us)
  - VTRC
  - TTI
  - University of California – HVS

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QUESTIONS

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