ARC

Asphalt Research Consortium

ARC Update on Warm Mix Research

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Presented to

Manitoba, Infrastructure and Transportation

Materials Engineering Branch
Central Lab, 1181 Portage Avenue Annex
Winnipeg, Manitoba

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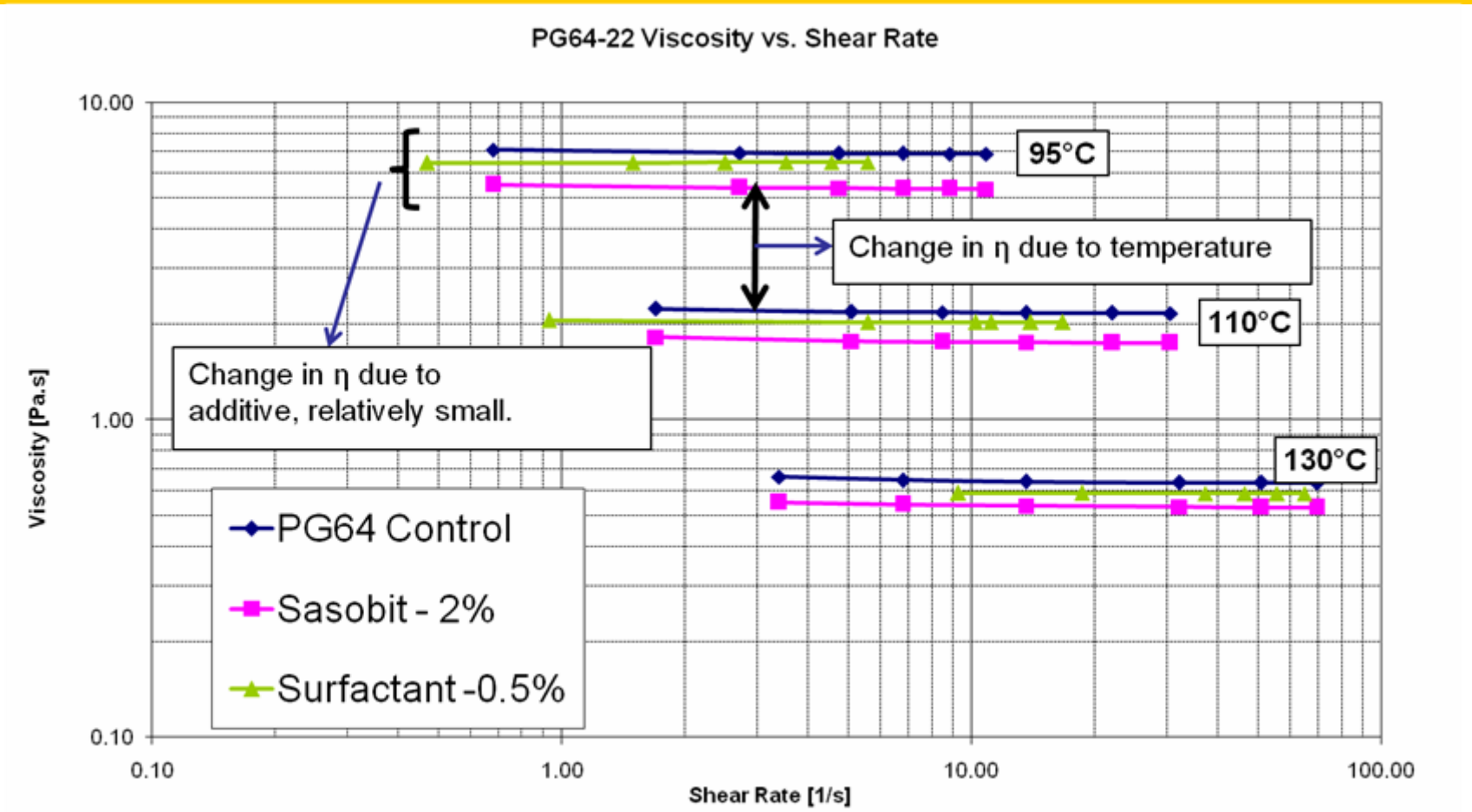
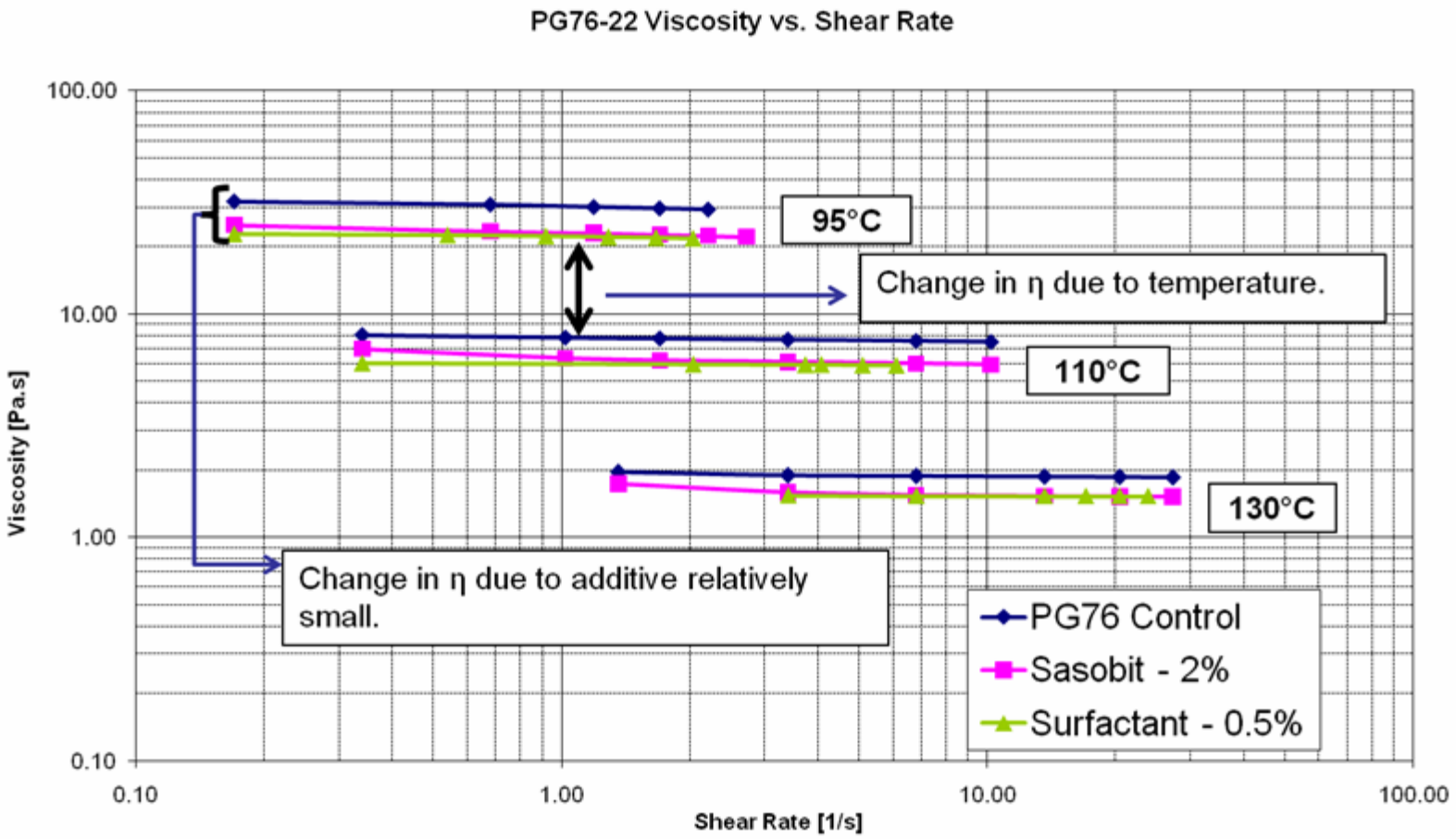
ARC Subtask E1c-1:
Effect of WMA Additives

- Progress Update
  - Binder Properties
    - Viscosity
    - Performance Grade
  - Mixture Workability
    - Compaction Curves
    - Workability Indices

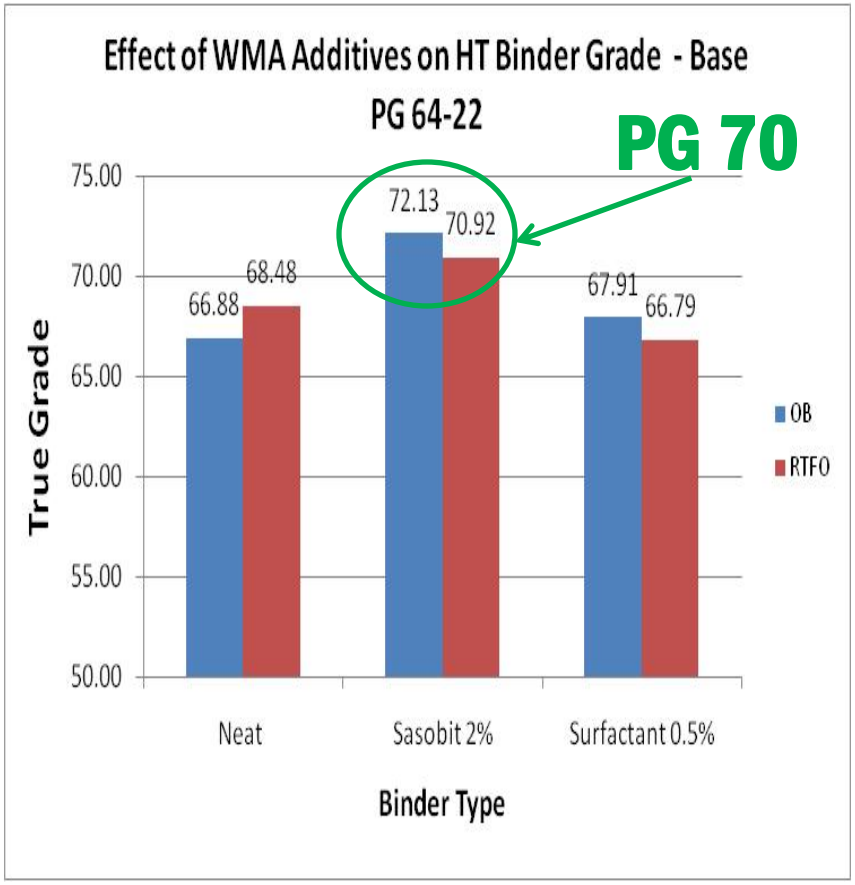
Effect on Viscosity: PG64-22



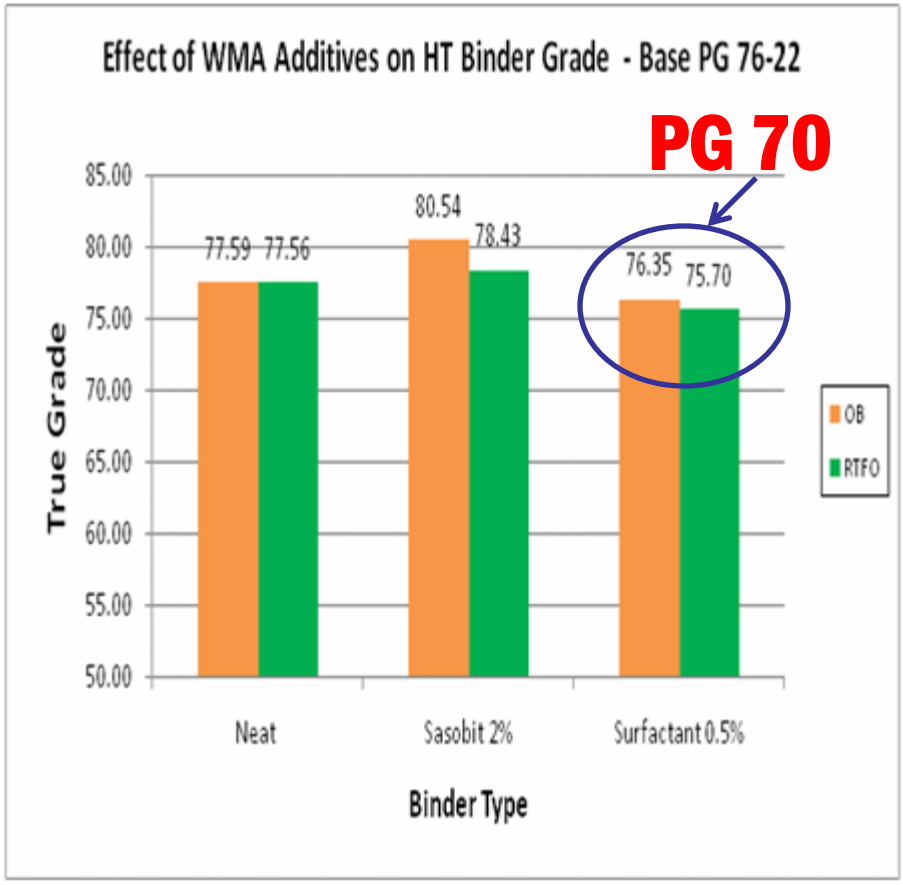
Effect on Viscosity: PG76-22



Effects of WMA Additives:
HT PG Grade (G*/sinδ)

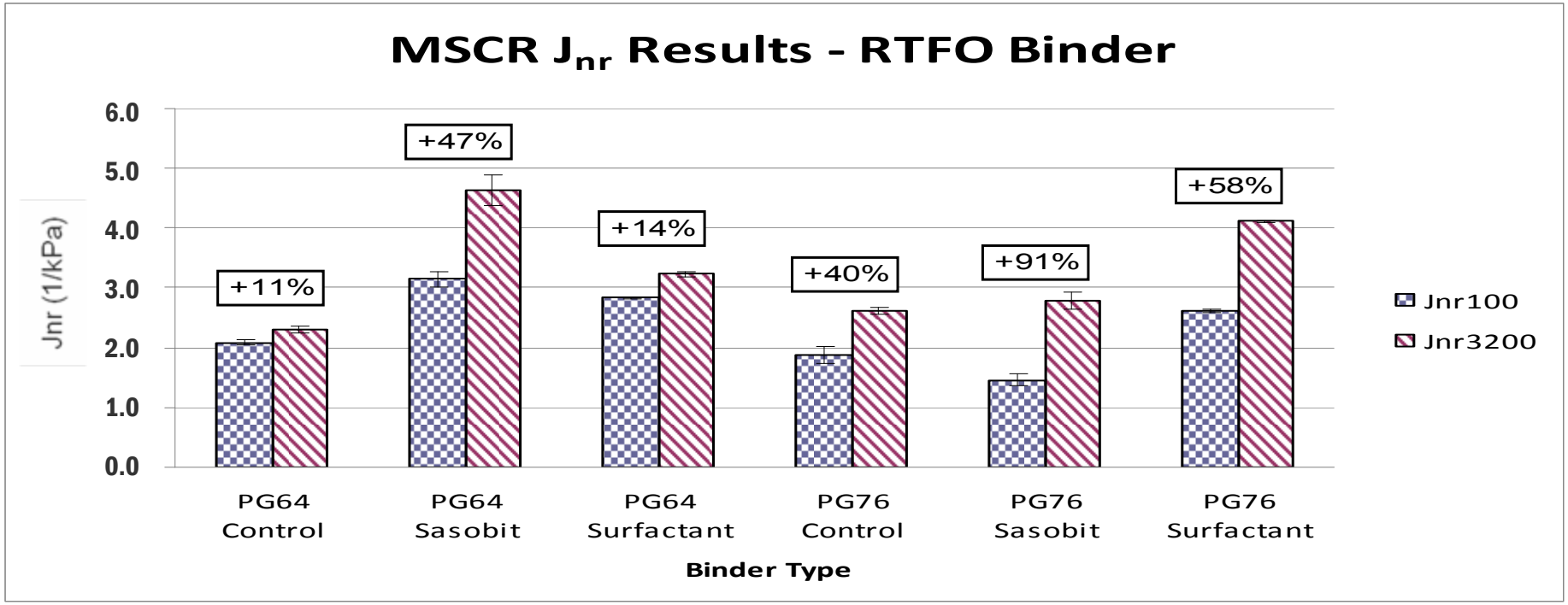


2% Sasobit - One Grade Bump



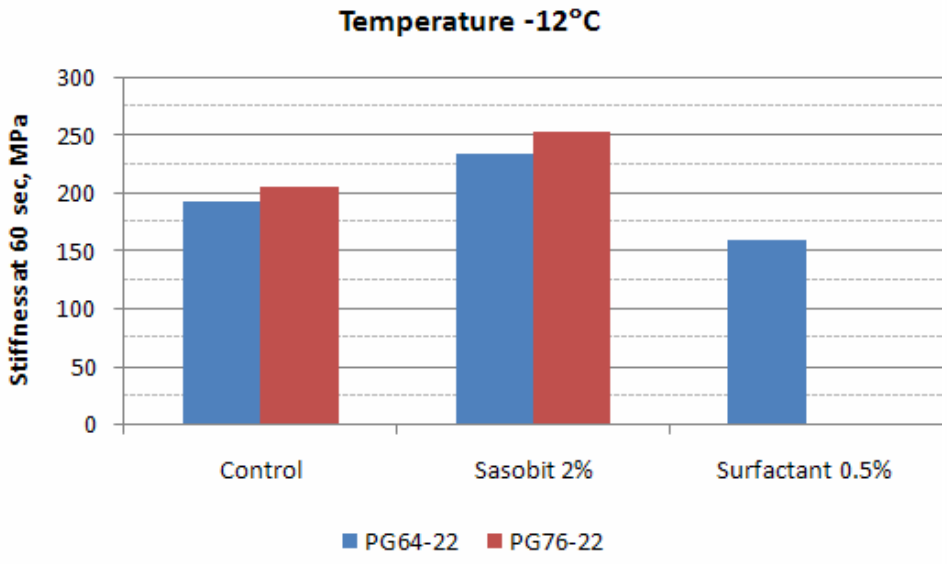
0.5% Surfactant - One Grade Lower

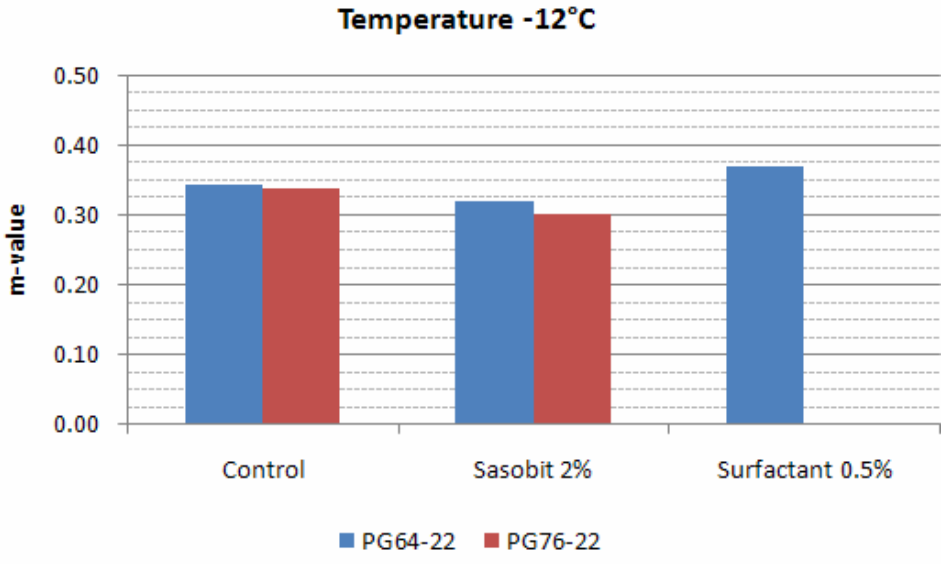
Effects of WMA Additives:
HT PG Grade (MSCR)



- Sasobit shows much higher stress sensitivity

Effects of WMA Additives: LT PG Grade

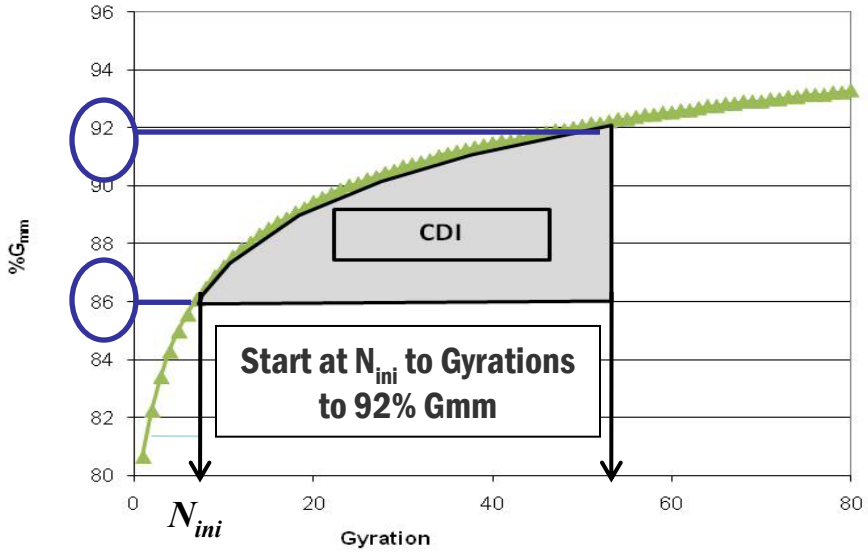




Mixture Workability

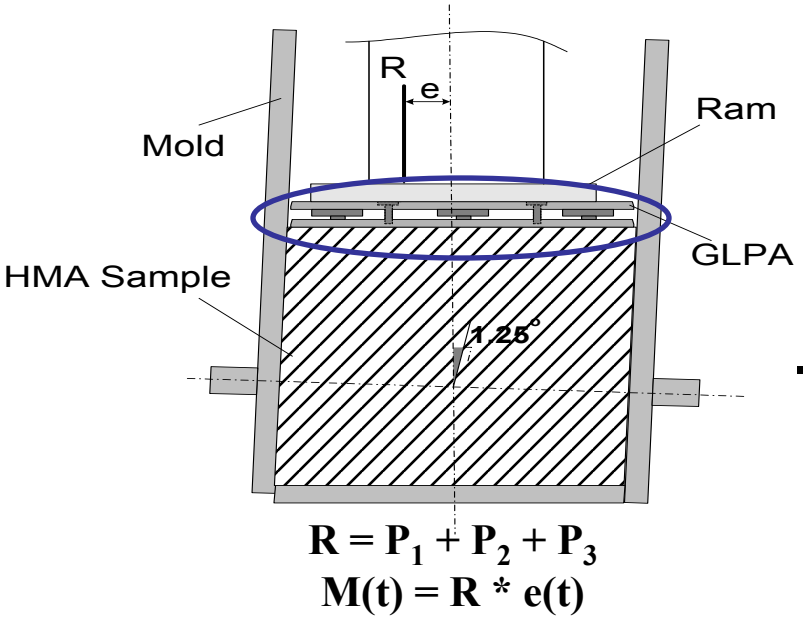
- Mix Design
  - NMAS: 19.0 mm/Gradation: Fine /AC: 5.4%
- Binder Grades
  - PG64-22-and polymer-modified PG76-22
- Evaluation Criteria
  - Compaction Curves and Air Voids
  - Workability indices
    - > Construction Densification Index (CDI)
    - > Construction Force Index (CFI)

Mixture Workability - CDI



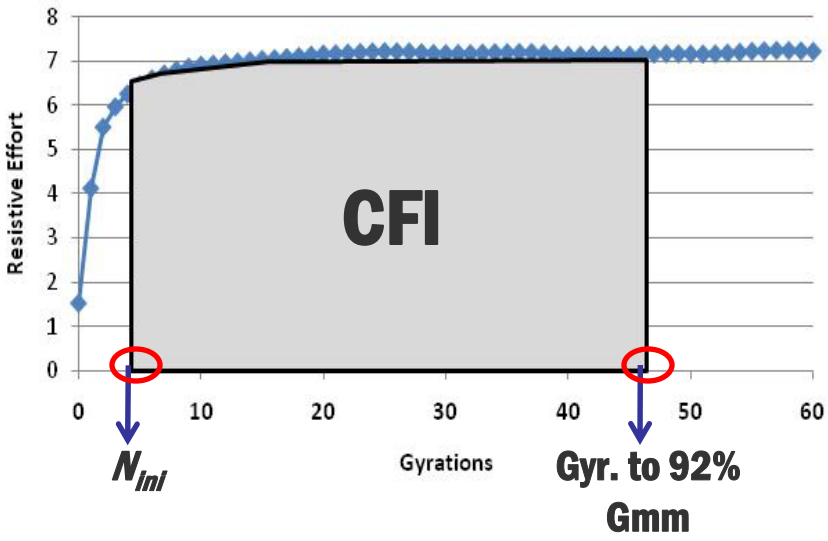
- CDI Based on Compaction Curves:
  - Area under the %Gmm vs. Gyration Curve from Nini – 92% Gmm. Densification after paver to field compaction.
  - Lower CDI relates to better workability.

Mixture Workability - CFI



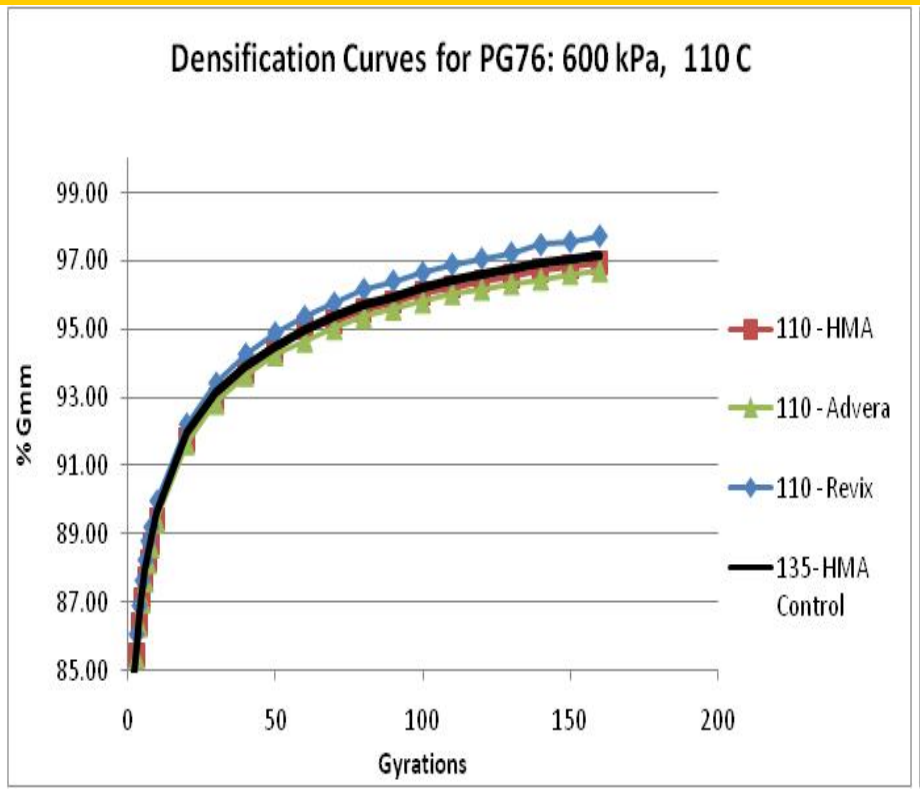
$$R = P_1 + P_2 + P_3$$
$$M(t) = R * e(t)$$

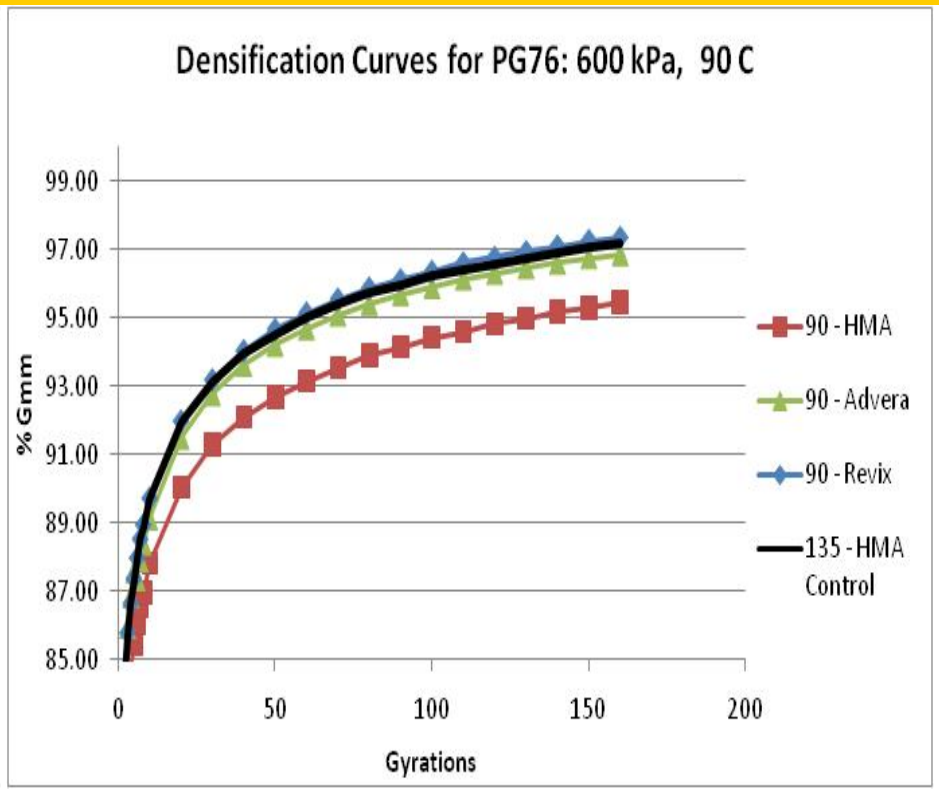
PDA Plate



- **CFI Based on Force Measured by PDA Plate:**
  - Pressure Distribution Analyzer (PDA) allow for calculation of resistive forces in the mix during compaction (*w*)
  - CFI calculated as the area under the Resistive Force (*w*) vs. Gyration curve

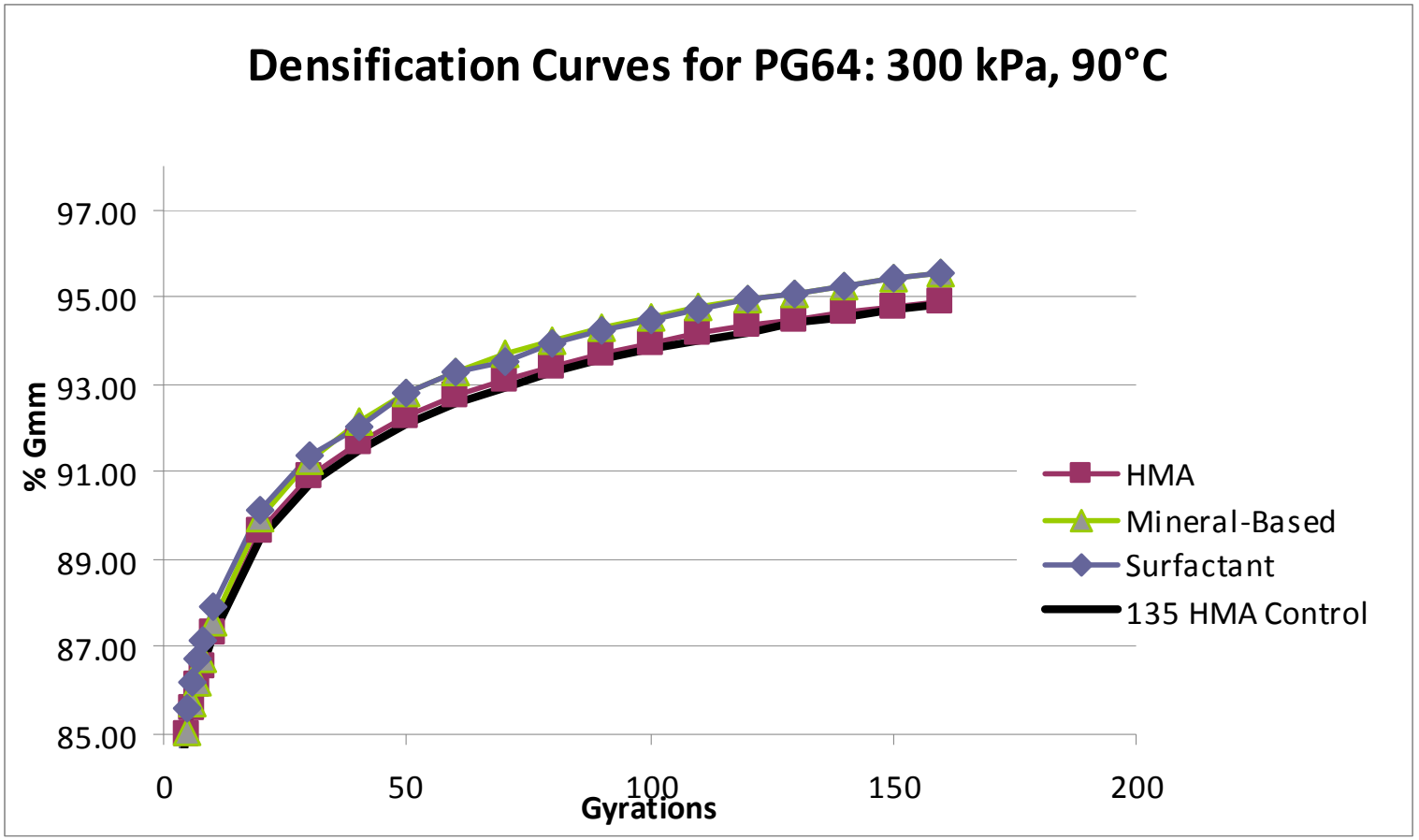
Mixture Workability – 600KPa



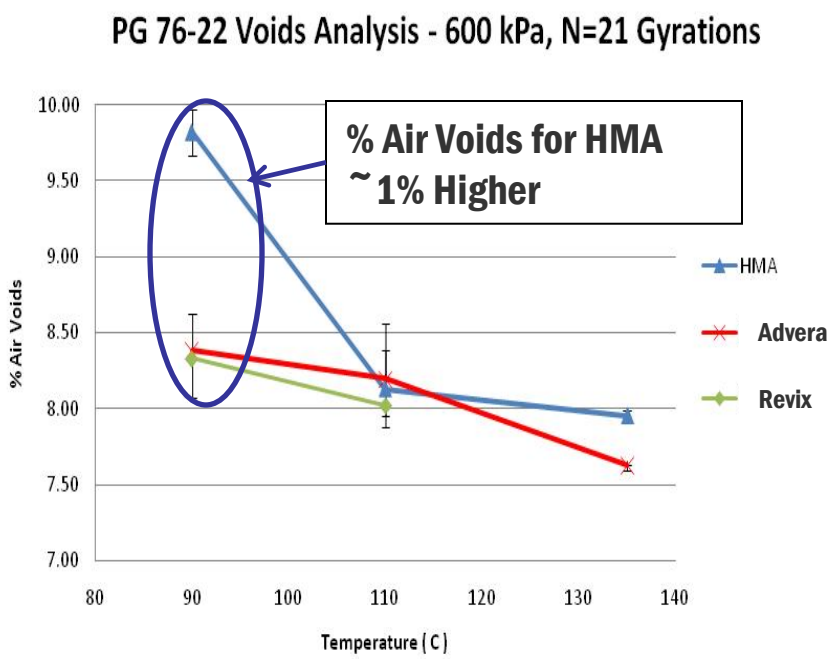


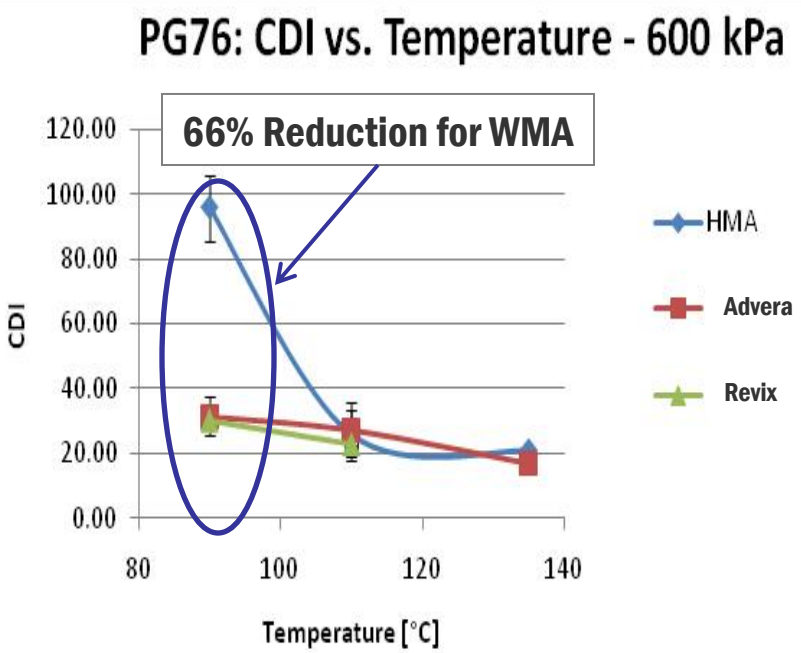
- No noticeable effects of WMA Additives.
- Additives allow mixes at 90°C to attain density of control mix at 135°C.

Mixture Workability – 300KPa



Mixture Workability – CDI- 600KPa

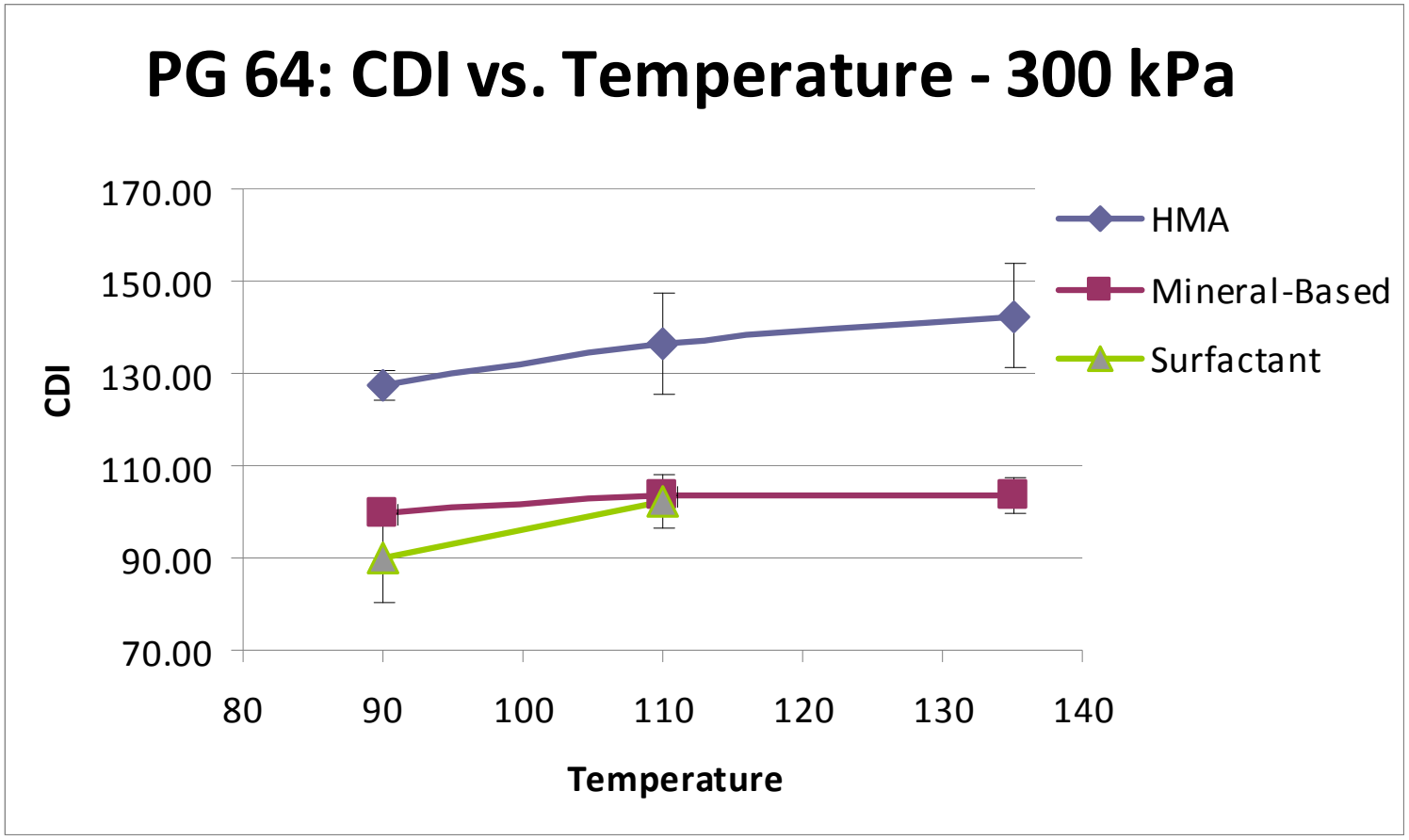




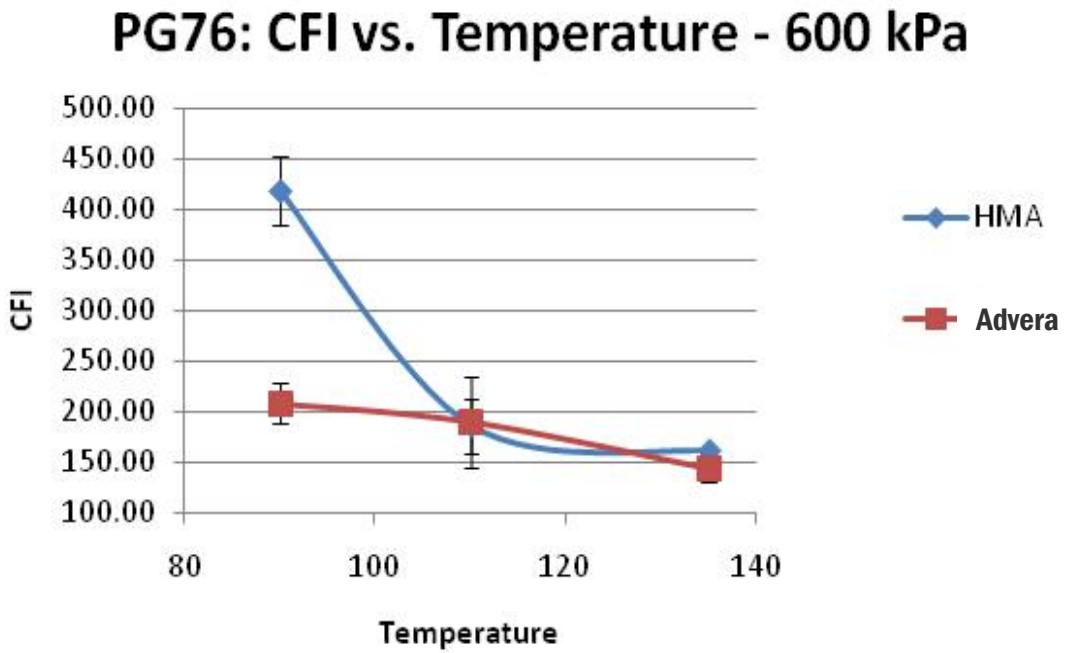
- Little difference between mixes until 90°C compaction temperatures.
- WMA has significantly lower % Air Voids.

- CDI shows similar trends. WMA much more workable at 90°C than HMA.
- CDI of WMA 66% lower.

Mixture Workability – CDI- 300KPa



Mixture Workability - CFI



- Construction Force Index
  - Force measurements are consistent – WMA additive requires less force to reach the same level of compaction.

Moving Forward – Binder

		η	Adhesion / Cohesion	Rutting (OB & RTFO)		Fatigue (PAV)		Low Temperature (PAV)	
Binder	**PG Grade**	ZSV	UW-Madison Tack Test	G*/sinδ- (HT °C)	MSCR (HT°C)	G*sinδ (IT °C)	BYET (IT °C)	BBR (LT+10°C)	SENB (LT+ 10°C)
Neat L	64-22	✓	X	✓	✓	✓	✓	✓	X
Neat H	76-22	✓	X	✓	✓	✓	✓	✓	X
Neat L+ 2% Sasobit	70-22	✓	X	✓	✓	✓	✓	✓	X
Neat H+ 2% Sasobit	76-22	✓	X	✓	✓	✓	✓	✓	X
Neat L + Surfactant	X	✓	X	✓	✓	X	X	✓	X
Neat H + Surfactant	X	✓	X	✓	✓	X	X	✓	X
Neat L Foamed	X	X	X	X	X	X	X	X	X
Neat H Foamed	X	X	X	X	X	X	X	X	X

✓ = Test completed

X = Test is planned

Moving Forward – Workability

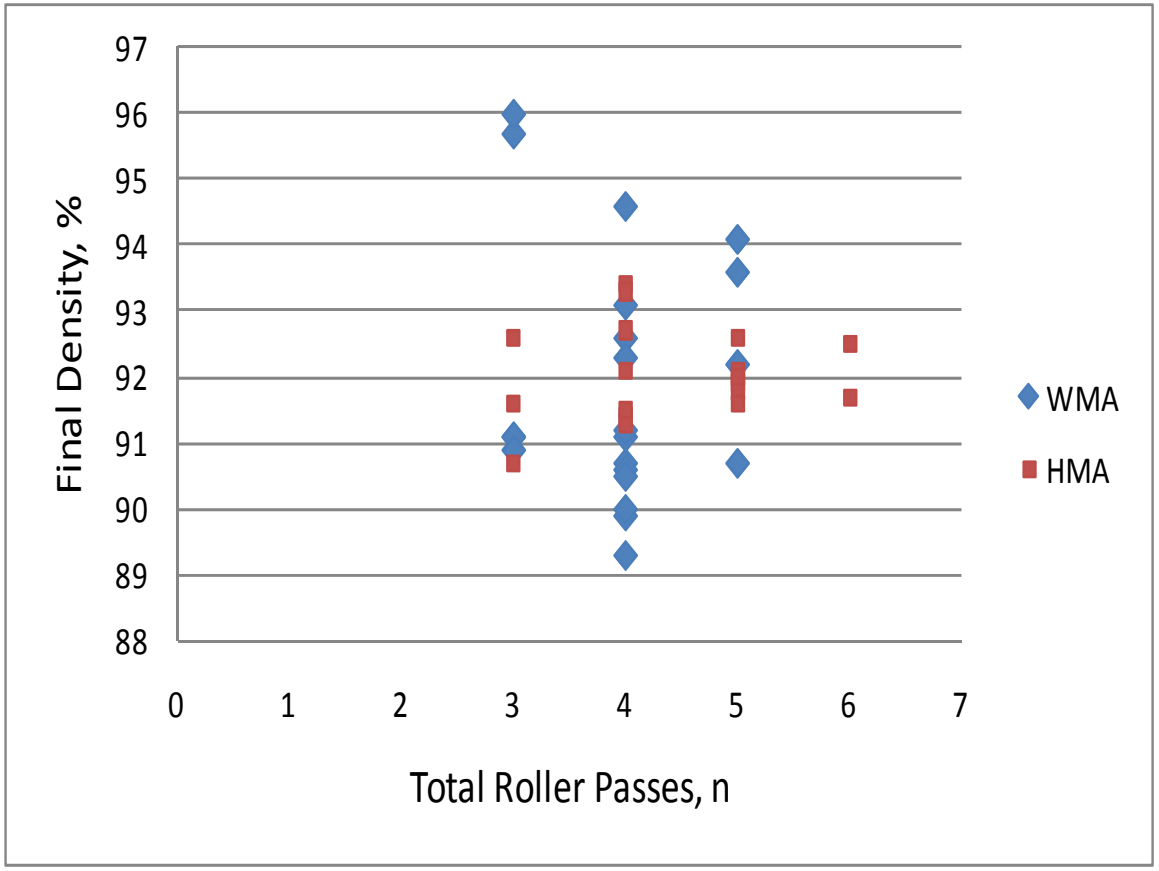
			Binder									
			PG64-22					PG76-22				
Gradation	Pressure [kPa]	Comp. Temp. [°C]	Control	Mineral Based Additive	Surfactant	Foaming	Sasobit	Control	Mineral-Based Additive	Surfactant	Foaming	Sasobit
19mm Fine	600	135	✓	✓	X	X	X	✓	✓	X	X	X
		110	✓	✓	✓	X	X	✓	✓	✓	X	X
		90	✓	✓	✓	X	X	✓	✓	✓	X	X
	300	135	✓	✓	X	X	X	✓	✓	X	X	X
		110	✓	✓	✓	X	X	✓	✓	✓	X	X
		90	✓	✓	✓	X	X	✓	✓	✓	X	X
19mm Coarse	600	135	X	X	X	X	X	X	X	X	X	X
		110	X	X	X	X	X	X	X	X	X	X
		90	X	X	X	X	X	X	X	X	X	X
	300	135	X	X	X	X	X	X	X	X	X	X
		110	X	X	X	X	X	X	X	X	X	X
		90	X	X	X	X	X	X	X	X	X	X

✓ = Test completed

X = Test is planned

Testing of Field Mixtures

Field Projects in WI – 2008



Field Mixes – with RAP

Aggregate	HMA - Design	HMA - UW	WMA - 30% QC	WMA-40%
Compaction Temp (F)	275	275	215	221
Nini - 7	91.2%	90.4%	92.0%	93.8%
Ndes - 60	96.1%	95.4%	97.0%	98.3%
Nmax- 75	96.6%	95.8%	N/A*	N/A*
VMA	14.10	12.86	12.30	11.00
*WMA QC samples were compacted to Ndes.				

Summary / Wish List

- WMA works at lower temps
  - Density is not a good measure
  - Better use densification indicators
- Project should include true control
  - HMA @ same temps as WMA
  - Enough materials
  - Good recording of temp, roller passes and sampling

Thank you !

- For giving us the opportunity
- For the warm reception to talk about warm asphalt
- Getting us to visit Winnipeg during our spring break!