Field Validation of Wisconsin Modified Binder Selection Guidelines (0092-03-13)

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Four Sections

- Mixing and Compaction Temparatures
  - Zero Shear Viscosity Temperatures
- Low Temperature Cracking
  - Critical Cracking Temperatures
- Rutting
  - Gv parameter obtained by creep and recovery test with DSR
- Fatigue
  - Np20 parameter obtained by time sweep testing with DSR

(BINDER GUIDELINES FROM 0092-01-01)

Mixing and Compaction Temparatures

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Project Name	Project ID	Layer	Binder	PMA	Mixture	Date Sampled
STH 17 Rhinelander Bypass	9040-09-70	Base	58 - 34	YES	E-3 19mm	Sep-03
I – 94 Baldwin	1020-01-74	Surface	70 - 28	YES	E-30 12.5mm	Oct-03
STH 95 Arcadia - Fountain City	7132-04-61	Surface	58 - 28	NO	E-1 12.5mm	May-04
STH 95, Arcadia – Fountain City (Intersection)	7132-04-61	Surface	64 - 28	YES	E-1 12.5mm	May-04
USH 51, Iron County	1170-13-70	Surface	64 - 34	YES	E-10 12.5mm	Jun-05
Hanley Rd. Intersection Hudson	7200-05-70	Surface	70 - 28	YES	E-10 19mm	Sep-05
Lindale Dr. Appleton	20050412025 (contract #)	Surface	64 - 28	YES	E-30 12.5mm	Sep-05
Madison Beltline (Midvale-Gammon)	5300-04-74	Surface	64 - 28	YES	E-10 12.5mm	Oct-05

ZSV and Superpave Mix. & Comp. Temps.

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Project ID	Binder	Mixing Temperatures ºC		Compaction Temp. ºC	
		Superpave	ZSV	Superpave	ZSV
9040-09-70	58 - 34	158	153	144	138
1020-01-74	70 - 28	173	164	163	150
7132-04-61	58 - 28	145	136	131	123
7132-04-61 (Int.)	64 - 28	160	154	148	140
1170-13-70	64 - 34	169	187	158	164
7200-05-70	70 - 28	181	161	170	150
20050412025	64 - 28	170	151	156	138
5300-04-74	64 - 28	167	154	154	138

Field Data
Project 1020-01-74

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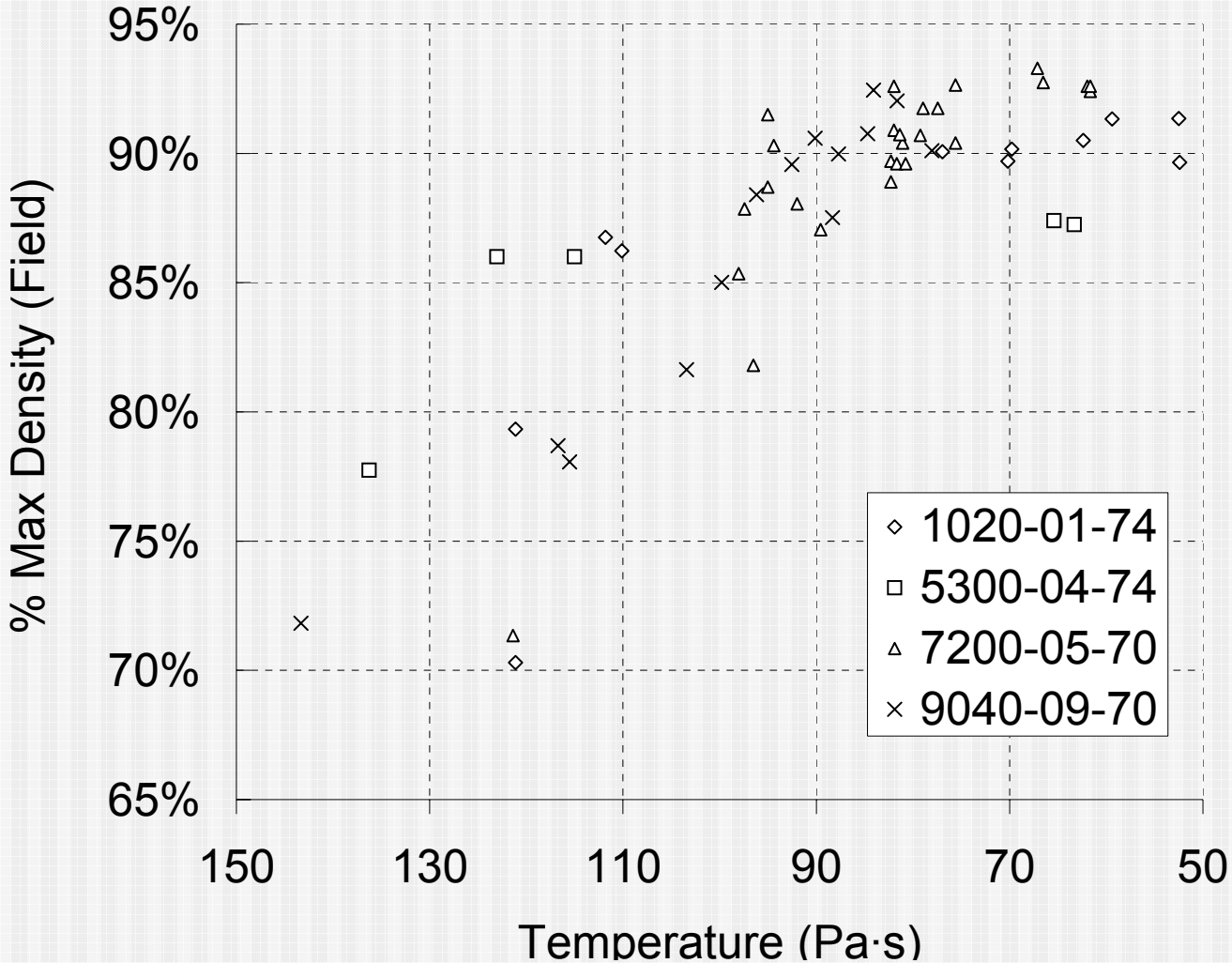
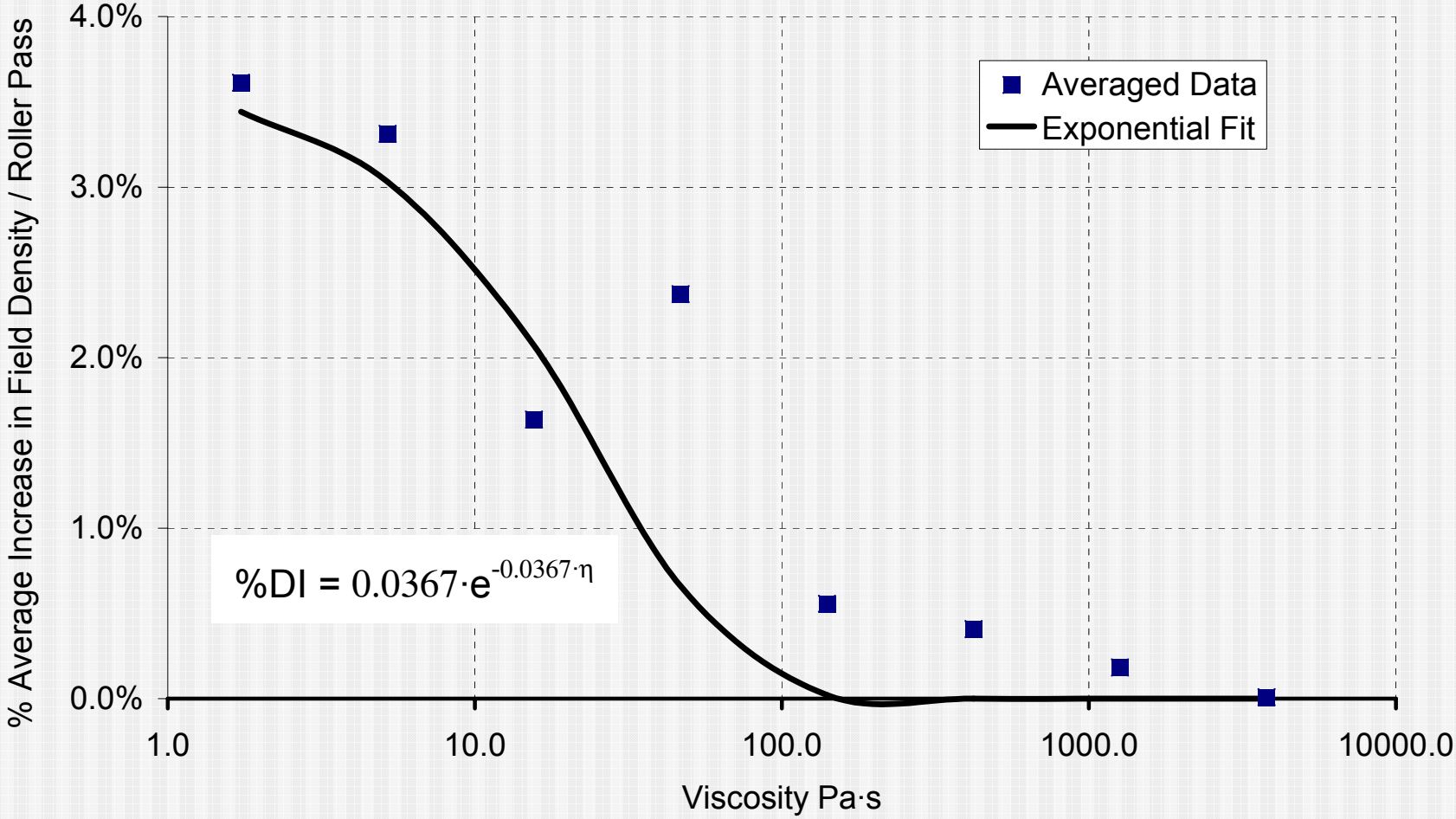
Roller Type	Pass #	Spot 1		Spot 2 (Center)		Spot 3	
		% Max. Density	Surface Temp. ºC	% Max. Density	Surface Temp. ºC	% Max. Density	Surface Temp. ºC
Paver	1	70.3%	106	N/A	N/A	N/A	N/A
Neumatic	1	77.0%	108	83.0%	106	78.0%	104
Breakdown	1	85.6%	99	87.9%	96	N/A	N/A
(Vibratory)	2	84.8%	96	87.1%	97	86.8%	95
Steel Roller	1	88.9%	66	90.2%	64	91.1%	65
(Vibratory)	2	88.4%	61	91.7%	55	90.4%	59
	3	89.7%	59	N/A	N/A	N/A	N/A
Cold	1	88.1%	52	92.9%	51	90.5%	52
(Vibratory)	2	90.1%	48	92.6%	48	91.3%	51
	3	87.5%	39	90.7%	43	90.8%	46
(Static) =>	4	N/A	N/A	90.8%	43	91.9%	42

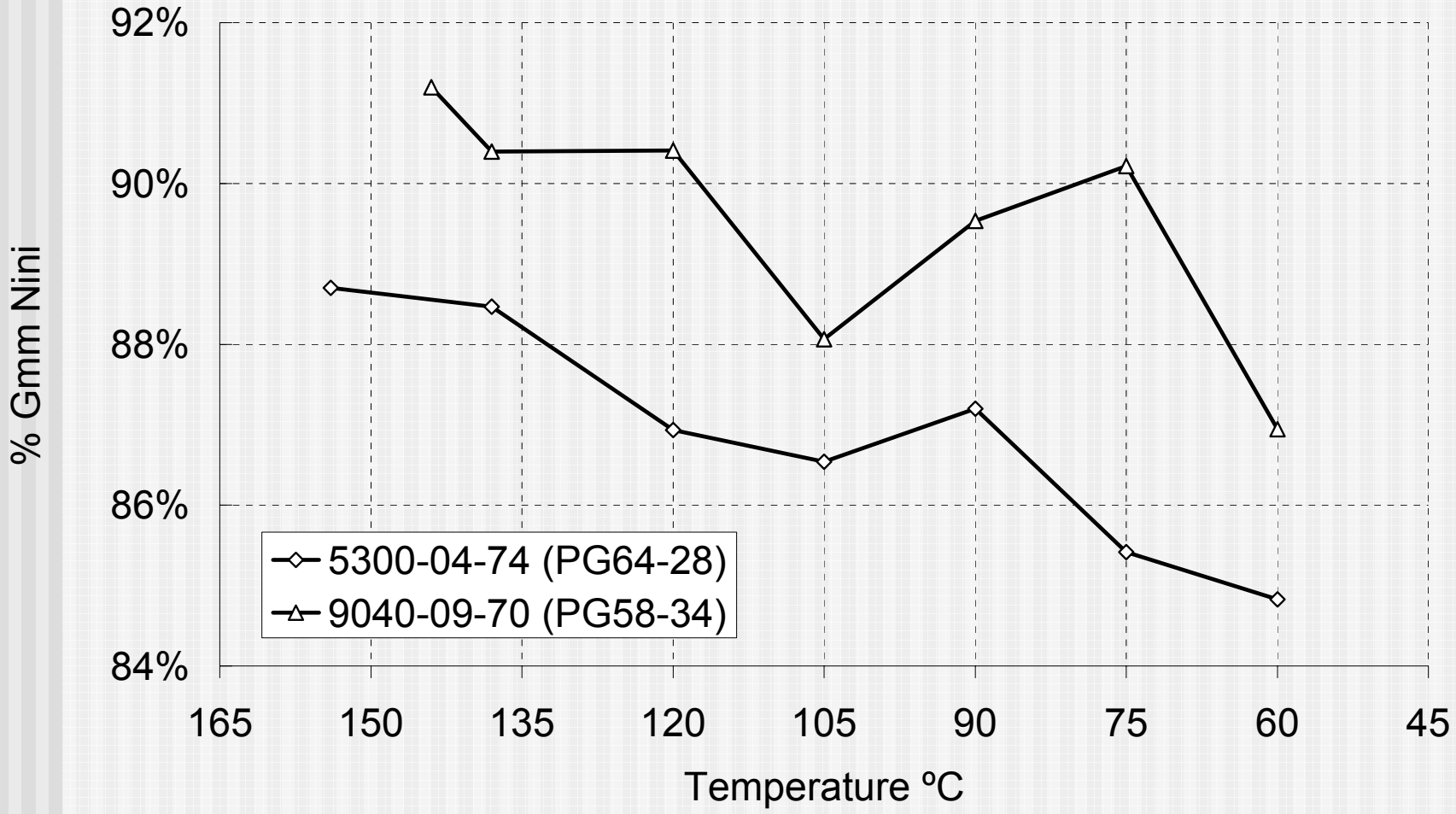
Field Data


95%
90%
85%
80%
75%
70%
65%
% Max Density (Field)
150
130
110
90
70
50
Temperature (Pa·s)
1020-01-74
5300-04-74
7200-05-70
9040-09-70

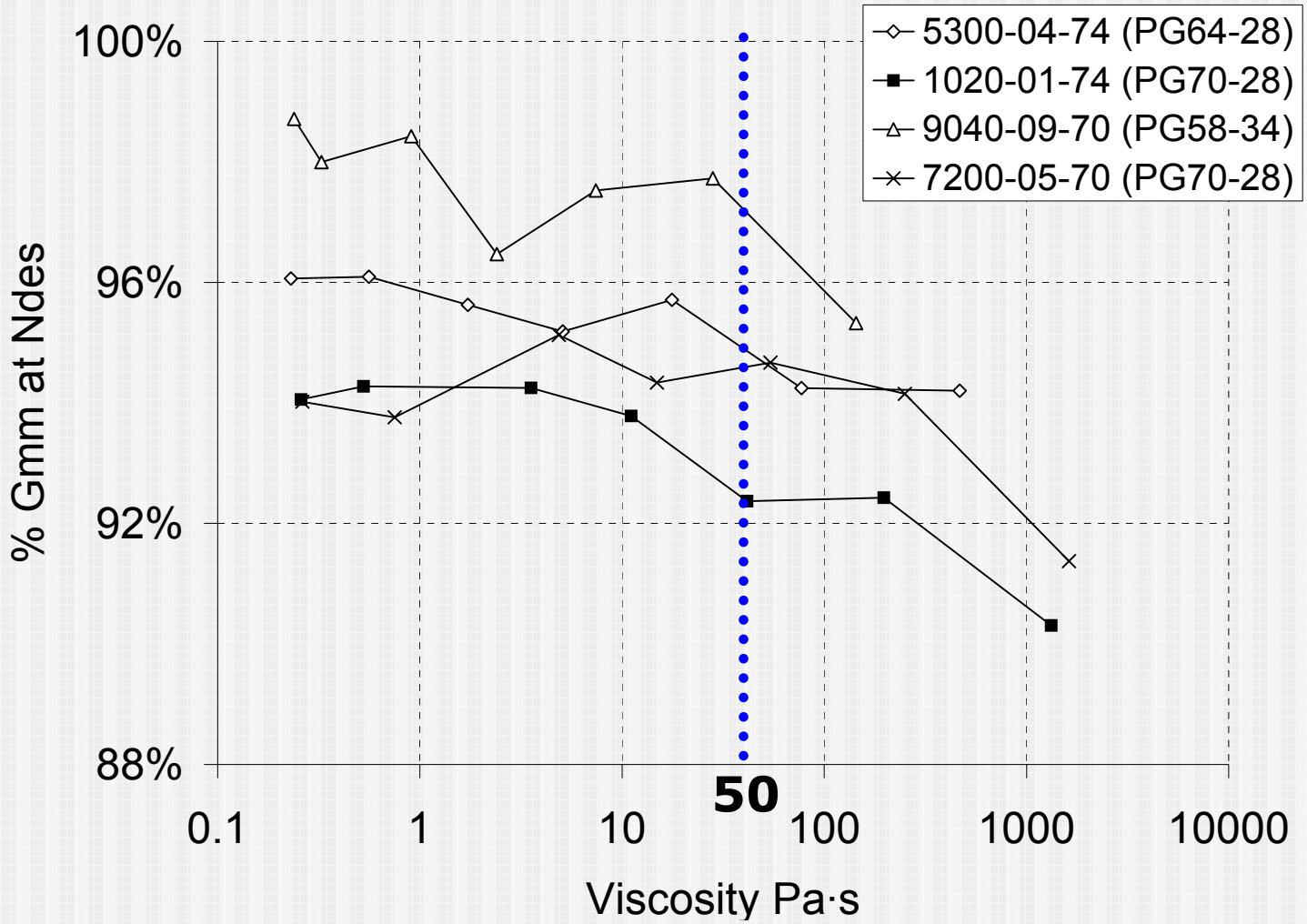
% Density Increase v/s Binder Viscosity (Field Data)



Lab Compaction



%Gmm at Ndes v/s Binder Viscosity (Lab Data)



Limiting Compaction Temperatures

Project	Temperature Limit for Compaction		
	Visc. Limit = 100 Pa·s	Visc. Limit = 50 Pa·s	Visc. Limit = 10 Pa·s
9040-09-70 (PG58-34)	63 ºC	69 ºC	86
5300-04-74 (PG64-28)	73 ºC	79 ºC	97
1020-01-74 (PG70-28)	81 ºC	88 ºC	106
7200-05-70 (PG70-28)	84 ºC	91 ºC	110

Recommendation:

Change Specification to "Minimum Temperature for Compaction", based on binder viscosity of 50 Pa·s

Fatigue

- Background
  - NP20 parameter: determined by time sweep testing with DSR
  - Input energy for testing depends on pavement structure

Input Energy in Pa

Temp. ºC	Major Highway	Médium Highway	Minor Road	Major Urban	Medium Urban	Minor Urban
8	800	4000	13000	800	3000	10000
13	500	2500	6500	500	2000	5000

Fatigue

- Another parameter was added to the testing: surrogate stress sweep testing currently under study by the FHWA
- $G^* \cdot \sin\delta$ was also included in analysis

Projects for Fatigue Study

Project Name	DOT Project ID*	Binder	Polymer Modified	Construction Year
STH 17 Rhinelander Bypass	9040-09-70	58 - 34	YES	2003
Charlotte Court - Clover Road (STH 64)	9140-07-70	58 - 34	YES	2003
South County Line - CTH M (USH 51)	1177-10-70	58 - 34	YES	2003
Pine, Main & Mill Streets City of Weyauwega (STH 110)	6590-00-70	64 - 28	YES	2003
De Pere-Green Bay-Lombardi Ave - IH 43 (USH 41)	1130-12-71	64 - 28	YES	2003
STH67 – Walworth County	3120-06-70	64 - 28	YES	2003
Calumet Ave., City of Manitowoc (USH 151)	4100-10-71	64 – 22	NO	2003
Airport Freeway (IH 894)	1090-14-70	70 – 28	YES	2003

Traffic Data and Design Life

Project ID	Design ESALs	Growing Rate (Linear)	Design Life (years)	Design Speed (mph)	Category
9040-09-70	2029400	2.4%	20	60	Medium Highway
9140-07-70	1511101	1.5%	20	55	Medium Highway
1177-10-70	1898000 (1423500)	1.5%	20	55 (30-45)	Medium Highway (Medium Urban)
6590-00-70	861000	2.0%	20	30 - 40	Minor Urban
1130-12-71	19388800	2.1%	20	70	Mayor Highway
3120-06-70	> 1000000	1.7%	N/A	(rural)	Minor Highway
4100-10-71	4600000	1.5%	20	35	Medium Urban
1090-14-70	15972400	1.6%	20	60	Mayor Highway

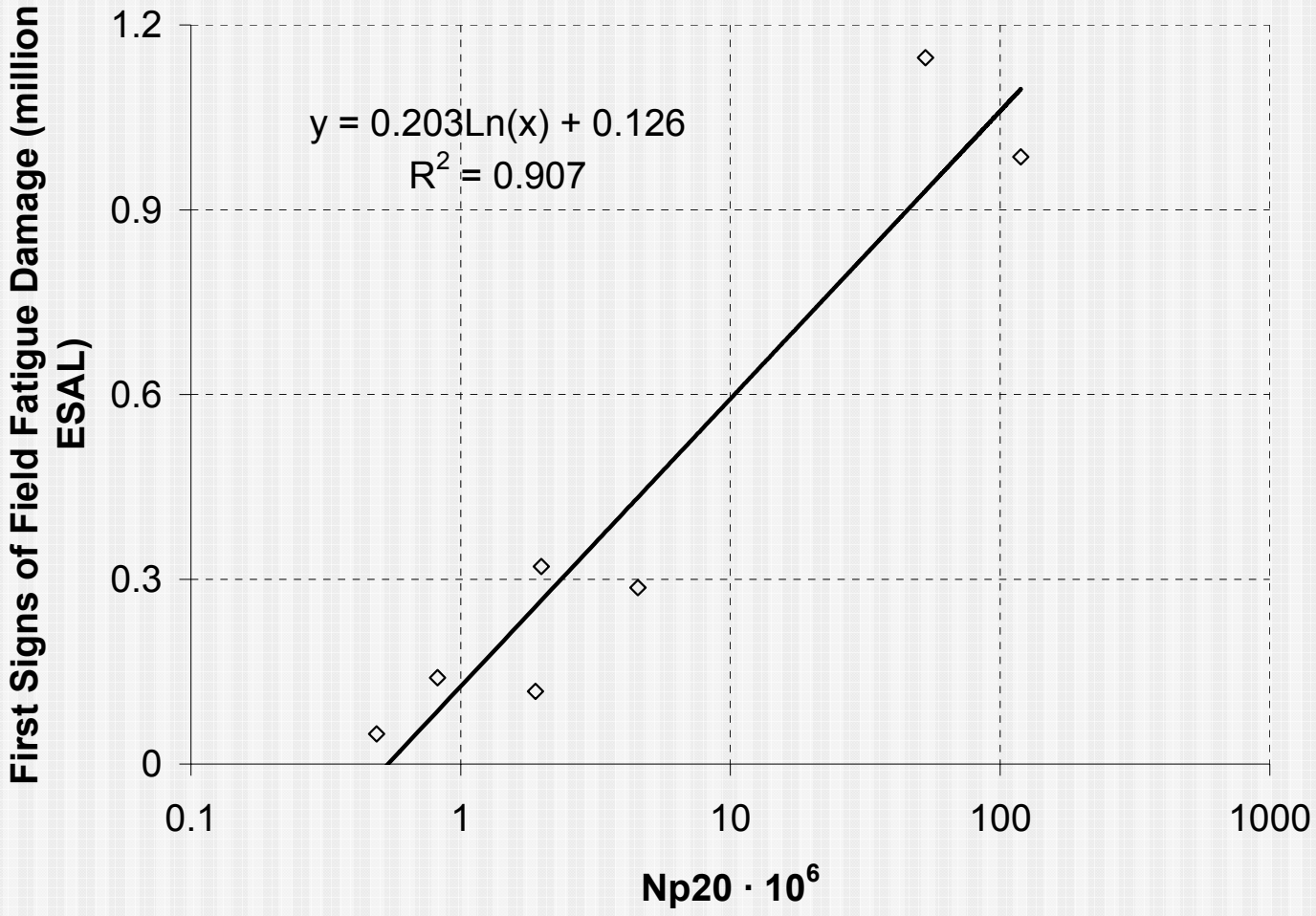
Sections with Longitudinal Cracking

Project ID	Winter 2004	Summer 2004	2006
9040-09-70	0%	0%	14%
9140-07-70	0%	0%	0%
1177-10-70	0%	14%	29%
6590-00-70	0%	0%	50%
1130-12-71	0%	70%	100%
3120-06-70	0%	67%	100%
4100-10-71	0%	100%	100%
1090-14-70	0%	22%	67%

Traffic at First Signs of Longitudinal Cracking

Project ID	Cumulated ESALs
9040-09-70	320838
9140-07-70	--
1177-10-70	118098
6590-00-70	140139
1130-12-71	1146768
3120-06-70	48889
4100-10-71	286622
1090-14-70	986099

Np20 v/s Field Performance

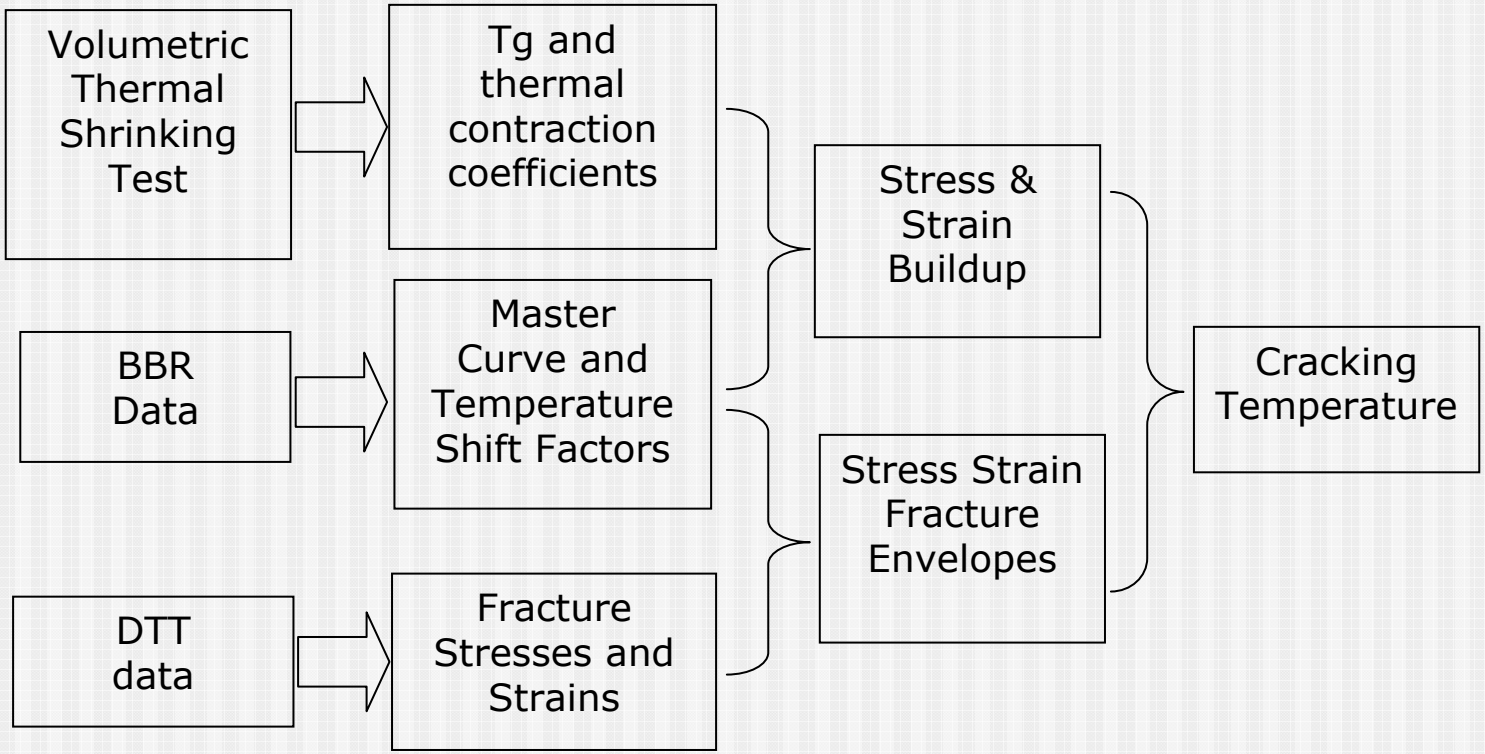


Other Parameters

- No correlation was found between field performance and surrogate stress sweep test
- No correlation was found between $G^* \cdot \sin\delta$ and field performance
- Results are not conclusive since only initials signs of longitudinal cracking were observed and fatigue life has not been reached for any of the projects

Low Temperature Cracking

- Determining the critical cracking temperature



Projects for Low Temperature Study

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Project Name	Project ID	Binder	PMA	Type of Base	Construct. Year
STH 17 Rhinelander Bypass	9040-09-70	58 - 34	YES	Pulverized HMA	2003
Charlotte Court - Clover Road (STH 64)	9140-07-70	58 - 34	YES	Pulverized HMA	2003
South County Line - CTH M (USH 51)	1177-10-70	58 - 34	YES	Existing AC	2003
Pine, Main & Mill Streets City of Weyauwega (STH 110)	6590-00-70	64 - 28	YES	Pulverized HMA	2003
De Pere-Green Bay-Lombardi Ave - IH 43 (USH 41)	1130-12-71	64 - 28	YES	Existing Concrete	2003
STH67 – Walworth County	3120-06-70	64 - 28	YES	N/A	2003
Calumet Ave., City of Manitowoc (USH 151)	4100-10-71	64 – 22	NO	Existing Concrete	2003
Airport Freeway (IH 894)	1090-14-70	70 – 28	YES	Rubblized Concrete	2003

Tranverse Cracking

Project ID	Transverse Cracks per Mile		
	Winter 2004	Summer 2004	2006
9040-09-70	0	0	11
9140-07-70	0	0	0
1177-10-70	0	121	143
6590-00-70	0	0	0
1130-12-71	0	195	259
3120-06-70	0	53	106
4100-10-71	0	290	422
1090-14-70	0	50	109

Field and Predicted Cracking Temperatures

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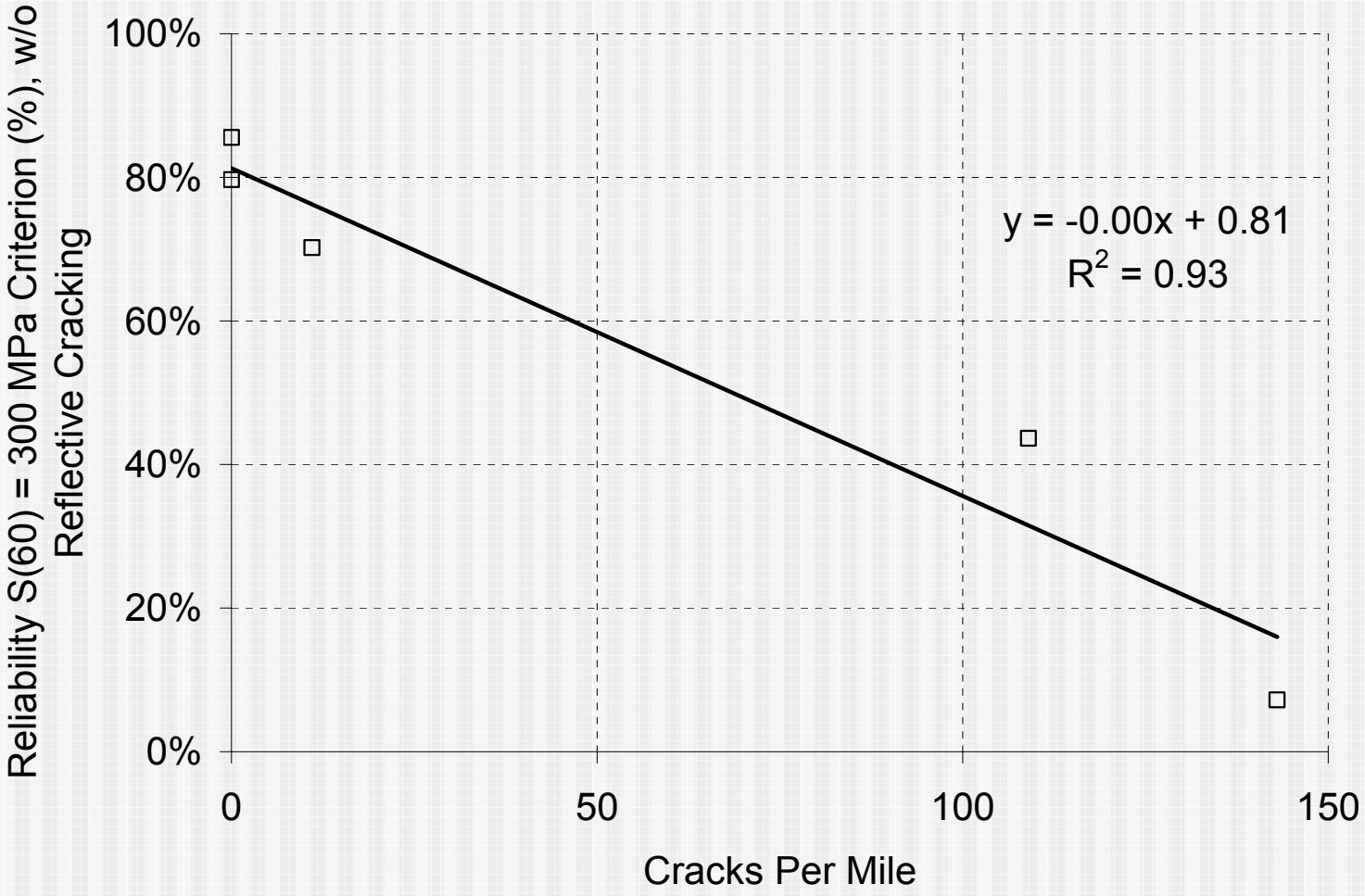
Project ID	PG Grade	Field Air Temp (Std) ºC	Temp ºC for S(60)=300 MPa (Reliab %)	Critical Cracking Temp ºC (Reliab %)		Cracks Per Mile (2006)	Type of Base
				Stress Crit	Strain Crit		
9140-07-70	PG58-34	-33.5 (3.3)	-37 (86%)	-37 (86%)	-45 (>99%)	0	Pulverized HMA
6590-00-70	PG64-28	-29 (3.6)	-32 (80%)	-31 (71%)	-58 (>99%)	0	Pulverized HMA
9040-09-70	PG58-34	-35.4 (3)	-37 (70%)	-35 (45%)	-41 (97%)	11	Pulverized HMA
3120-06-70	PG64-28	-26.4 (3.7)	-33 (96%)	-32 (93%)	-41 (>99%)	106	N/A
1090-14-70	PG70-28	-25.6 (3.7)	-25 (44%)	-24 (33%)	NR (>99%)	109	Rubblized Concrete
1177-10-70	PG58-34	-34.4 (3.7)	-29 (7%)	-35 (56%)	NR (>99%)	143	Existing AC
1130-12-71	PG64-28	-28.8 (3.4)	-33 (89%)	-32 (83%)	-58 (>99%)	259	Existing Concrete
4100-10-71	PG64-22	-26.7 (3.4)	-27 (54%)	-25 (31%)	-47 (>99%)	422	Existing Concrete

S(60) v/s field performance



Findings

- Reliability of S(60) (probability of critical cracking temperature based on S(60) to be lower than minimal air temperature) correlated well with field transverse cracking
- None of the other parameters, including DTT and m(60), showed good correlation with thermal cracking on pavements.

RUTTING

- Gv paramter from creep and recovery
- Other paramters also verified
  - MSCR test
  - $G^*/\sin\delta$

Rutting Guidelines

Purpose	Testing Rate	Testing Stress	Testing Temperature	Traffic Level (Millions ESALs)					
				0 - 0.3	0.3 - 1	1 - 3	3 -10	10 - 30	> 30
Test on Original Binder									
Traffic Speed	Load / unload	Creep Stress		Minimum G_v at loading time (MPa)					
60 mph	0.01/0.09 s	25 Pa	58°C	1.0	5.0	15.0	50.0	150.0	> 200
15 mph	0.04/ 0.36 s	25 Pa	58°C	4.0	20.0	60.0	200.0	600.0	> 800
Test on RTFO Aged Binder									
Rutting Resistance	Load / unload	Creep Stress		Minimum G_v at loading time (MPa)					
60 mph	0.01/ 0.09 s	25 Pa	58°C	1.25	6.0	18.0	60.0	180.0	> 250
15 mph	0.04/ 0.36 s	25 Pa	58°C	5.0	24.0	72.0	240.0	720.0	> 1000

Projects for Rutting Study

Project Name	DOT Project ID*	Binder	Polymer Modified	Construction Year
STH 17 Rhinelander Bypass	9040-09-70	58 - 34	YES	2003
Charlotte Court - Clover Road (STH 64)	9140-07-70	58 - 34	YES	2003
I – 94 Baldwin	1020-01-74	70 - 28	YES	2003
STH 95 Arcadia - Fountain City	7132-04-61	58 - 28	NO	2004
USH 51, Iron County	1170-13-70	64 - 34	YES	2005
Whitewater Bypass (USH 12)	1080-00-72	58-28	NO	2003

Traffic Data and Design Life

Project ID	Design ESALs	Growing Rate (Linear)	Design Life (years)	Design Speed (mph)
9040-09-70	2029400	2.4%	20	60
9140-07-70	1511101	1.5%	20	55
1020-01-74	42350300	2.5%	20	70
7132-04-61	800000	1.5%	20	55
1170-13-70	2284900	1.5%	20	45
1080-00-72	1752000	1.5%	20	70

Findings are not definitive

- No rutting data has been observed in the field for the selected projects. Validation is not possible yet.
- Rutting life predicted using Gv indicates that the pavements should not have rutted yet, which agrees with field data

Aknowledgements

- WisDOT staff: Judy Ryan, Tom Brokaw, Nancy Busche, Richard Barden, Mike Malaney and Laura Finley