NETC 18-2:

Framework of Asphalt Balanced Mix Design (BMD) for New England Transportation Agencies

Project Summary

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Project Objective

- Synthesize existing information and to develop recommendations for a rational BMD approach for use by New England transportation agencies.

Gaps in testing and performance data will be identified through this project and an experimental plan for required future work will be developed.

Overview of Tasks

- **Task 1** - Identify typical pavement distresses in each of the New England states.
- **Task 2** - Identify candidate performance tests for each identified common distress.
- **Task 3** - Collect existing performance test data, available from recent state/regional projects, and related historical field performance data on the representative pavements.
- **Task 4** - Analyze test and field performance data in order to develop preliminary recommendations for a BMD approach.
- **Task 5** - Identify gaps in the test and performance data, and develop an experimental plan for future research with the goal to further refine the development, validation, and implementation of a BMD approach for New England states.

Task 1 – Internet Survey

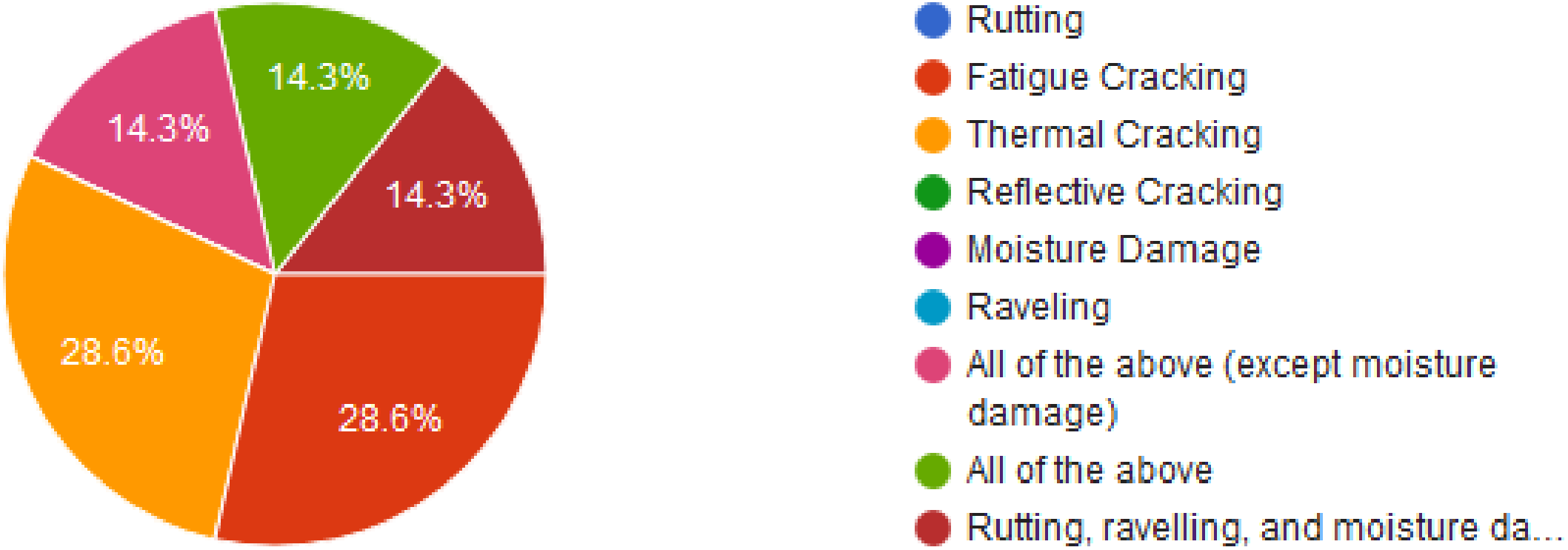
Survey & Response

- The total survey responses was seven.

- Each New England state transportation agency responded to the survey with Vermont responding twice.

Task 1: Survey Results

What are the predominant pavement distresses witnessed in your state?



Task 2 – Candidate Performance Tests

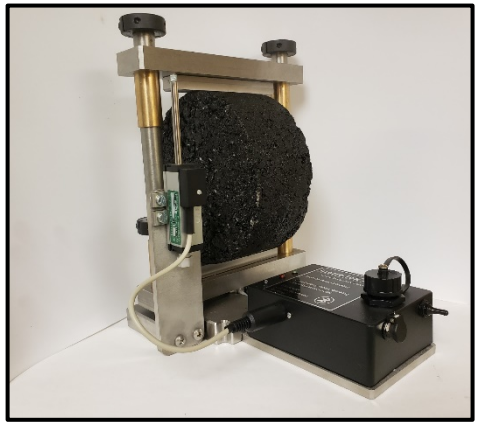
Task 2 - Identify Candidate Performance Tests for each Identified Common Distress

- Evaluate the pros and cons of different asphalt mixture performance tests and best match a performance test method to the state agency pavement distress(es) within a Balanced Mixture Design protocol.
  - Identification of Asphalt Mixture Performance Testing for Various Pavement Distress Types
  - Cost and Time Estimates within Balanced Mixture Design (BMD) Framework and Quality Control Implementation
  - Current Availability of Equipment for Regional Leveraging and Roadblocks to Purchase/Calibrate

Task 2 - Identify Candidate Performance Tests for each Identified Common Distress

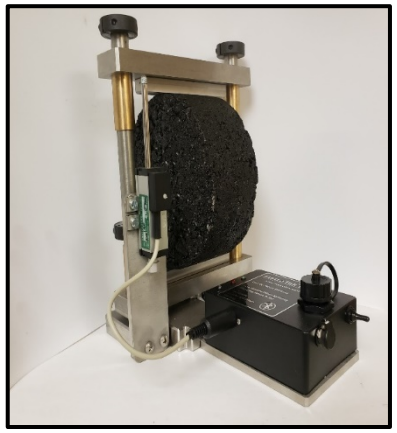
Rutting

Hamburg Wheel Tracking



HT-IDT/IDEAL-RT

Fatigue Cracking



IDEAL-CT

SCB Flexibility Index

Thermal Cracking

DC(T)

Moisture Damage

Hamburg Wheel Tracking

Task 3:

Collect existing performance test data, available from recent state/regional projects, and related historical field performance data on the representative pavements.

Task 4:

Analyze test and field performance data in order to develop preliminary recommendations for a BMD approach.

Task 5:

Identify gaps in the test and performance data, and develop an experimental plan for future research with the goal to further refine the development, validation, and implementation of a BMD approach for New England states.

Pavement Performance Collection

- Requested pavement performance and laboratory performance data (if exists) at last update meeting
  - Connecticut
    - PMS data provided
  - Vermont
    - PMS data download provided
    - Mixture test results
      - 2017 & 2018 Hamburg Wheel Tracking (rutting)
      - 2018 & 2019 SCB Flexibility Index (fatigue cracking)
  - Maine
    - Provided PMS data for test sections where performance testing was conducted
    - Provided Hamburg Wheel Tracking (rutting) and IDEAL-CT Index (fatigue cracking)


CONNECTICUT
DEPARTMENT OF TRANSPORTATION
125
1895 - 2020

Connecticut - Rutting

- With no laboratory to field comparison, best method to initiate performance criteria is through testing field cores
  - Good and poor performance

Good Rutting Performance (< 0.15 Inches)						
Traffic Level	RoadName	From	To	ADT x % Trk	RUT_AVG	SURFACE_ YEAR
Low	042 L	9.6	11.8	138	0.10	2016
	082 L	17.6	20	198	0.08	2016
	066 L	27.6	29.6	398	0.07	2018
	011 L	10	13.4	441	0.10	2015
	006 L	84	88	630	0.10	2016
	0.58 L	0.2	3.4	716	0.10	2015
Moderate	008 L&R	7.9	8.9	2944	0.11	2011/15
	072 L	3.2	3.9	2463	0.13	2017
	095 L	101.7	103.9	4335	0.07	2018
	291 L&R	3.2	5.1	4357	0.13	2010
	384 L&R	1.6	2.8	5345	0.09	2014/15
	084 L&R	16.7	18.7	6500	0.13	2008
High[1]	091 L&R	3.4	4.5	10479	0.13	2012
	084 L&R	61.1	62.4	12110	0.12	2014
	095 L	10	15	12848	0.10	2015/16
	084 L&R	65	66.3	14540	0.09	2012

[1] - Almost anywhere on 084, 091, and 095

Poor Rutting Performance (> 0.3 Inches)						
Traffic Level	RoadName	From	To	ADT x % Trk	RUT_AVG	SURFACE YEAR[1]
Low	201 L	15.5	17.7	68	0.43	2013
	695 L	2.1	2.7	214	0.4	2018
	167L	5.1	6.6	466	0.29	2018
	004L	36.5	38	550	0.29	2013
	044L	51.5	52.6	740	0.29	2014
Moderate	072L	2	2.8	2843	0.28	2017
High	084L	56.3	57.4	10688	0.33	2016

[1] - Older the resurface, more aged asphalt binder
(rutting may have occurred much earlier than present condition)

Connecticut – Fatigue Cracking

- With no laboratory to field comparison, best method to initiate performance criteria is through testing field cores
  - Good and poor performance – only Flexible Pavements Used (No Composite)

Good Cracking Performance (HPMS Crk Pct & WP+NWL Crk)						
Road Name	From	To	ADT x % Trk	HPMS Crk Pct	WP + NWL Crk	SURFACE YEAR
001 L	14.2	15.8	618	0	4.9	2017
001 L	28.2	20.4	633	0	5.2	2017
009 L	0.6	4	1284	0	5.4	2011
030 L	17.9	20.9	189	0	0.4	2017
058 L	1	3.5	797	0	3.2	2015
084 L	19.1	22.1	5956	0	22.6	2012
091 L	39	42	12415	0	0.9	2015
095 L	95	98	5700	0	11	2014
198 L	8.2	11.9	88.2	0	2	2009
244L	0	3	74.8	0	4.7	2014
395 L	0.6	3.6	2398	0	8.3	2009

Poor Cracking Performance (HPMS Crk Pct & WP+NWL Crk)						
Road Name	From	To	ADT x % Trk	HPMS Crk Pct	WP + NWL Crk	SURFACE YEAR
030 L	2.0	3.5	374	32.5	213	2000
045 L	2.2	3.7	78	32.8	180	1995
083 L	19.5	21.9	219	33.5	218	1998
179 L	5.0	8.0	118	25.6	145	1999
201 L	7.6	9.2	50.4	22.8	99	1993
305 L	1.0	3.0	566	19.0	132	1999
534 L	0.5	3.5	182	29.7	193	1996

VERMONT

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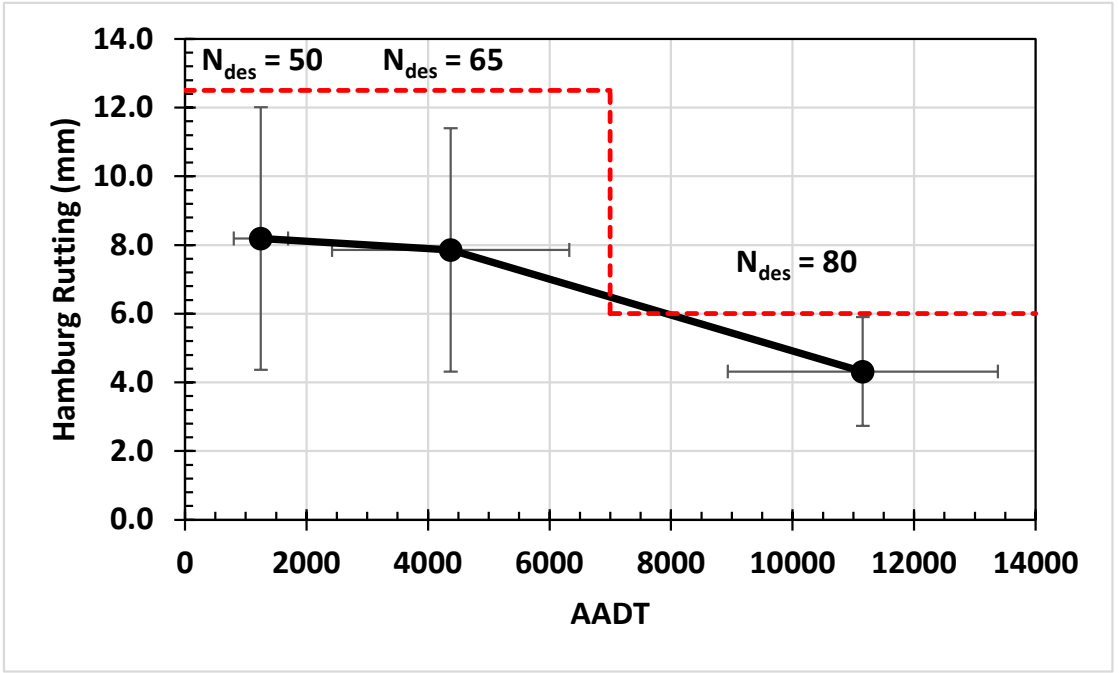
Vermont – Hamburg Wheel Tracking

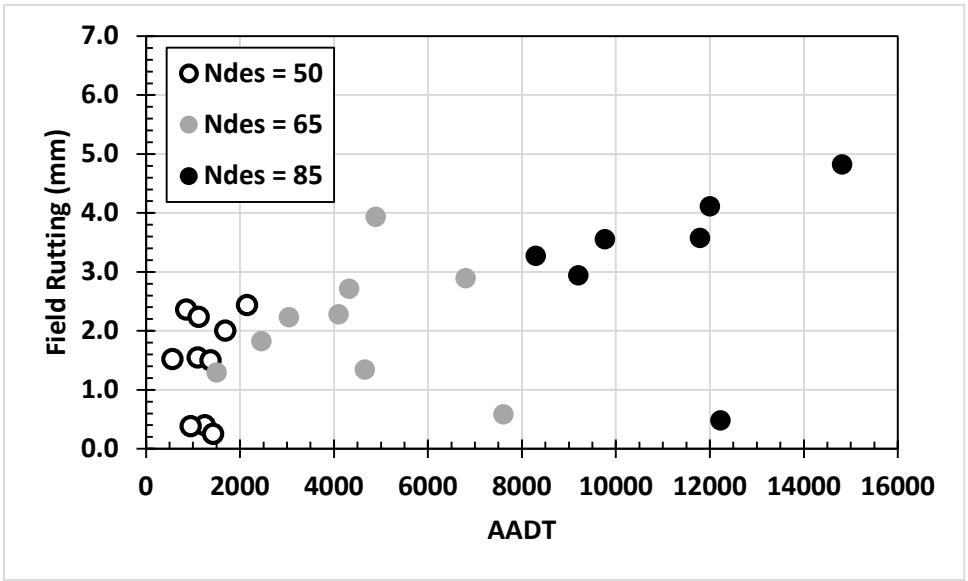
- General Mixture Performance – Yearly Comparison
  - Lack of consistency can create issues when trying to establish performance criteria
  - This is where PMS is very important
    - Obvious differences in mixture performance from lab
    - Are same differences found in field?
      - Actually, very minimal field rutting for both! **All projects had good rutting performance!**

Year Produced	Project	Mix Type	Producer	Rut Average (in.)	Ave. AADT	Ndes	PG Grade	Hamburg Rut Depth (mm)	Ave Pass Max.	SIP	SIP Depth	Strip Slope	Creep Slope
2017	Danville - St. Johnsbury STP FPAV(9)	Type IVS w/ 20%	Pike IND (702) - Waterford, VT	0.06	563	50	58-34	9.75	20000	13166	4.95	0.000499	0.000251
								12.5	17266	8885	5.26	0.000818	0.000367
2018	Reading - Windsor STP FPAV(11)	Type IVS w/ 20% RAP	Pike IND (720) - W Lebanon, NH	0.01	1427	50	70-28	3.49	20000	NA	NA	NA	0.000096
								2.6	20000	NA	NA	NA	0.000072
								3.92	20000	NA	NA	NA	0.000106
2018	Weathersfield - Reading STP FPAV(12)	Type IVS w/ 20% RAP	Pike IND (720) - W Lebanon, NH	0.02	1256	50	70-28	4.17	20000	NA	NA	NA	0.000111
								3.13	20000	NA	NA	NA	0.000086
								3.58	20000	NA	NA	NA	0.000093
								2.57	20000	NA	NA	NA	0.000072
								4.41	20000	16845	3.94	0.000141	0.000119
								3.5	20000	NA	NA	NA	0.000088
								3.61	20000	NA	NA	NA	0.000095

Vermont – Hamburg Wheel Tracking

- Final performance criteria for Hamburg must include traffic
- Figure shows recommended initial criteria for different mixes
  - N_{des} = 50 & N_{des} = 65 < 12.5 mm
  - N_{des} = 80 < 6.0 mm
- When evaluating average Hamburg rutting for N_{des} = 50 & N_{des} = 65, statistically equal
- AADT = 7,000 was selected at dividing area based on inflection point in Field Rutting vs AADT curve
- **Emphasize: All projects had GOOD field rutting performance**





Vermont – Hamburg Wheel Tracking

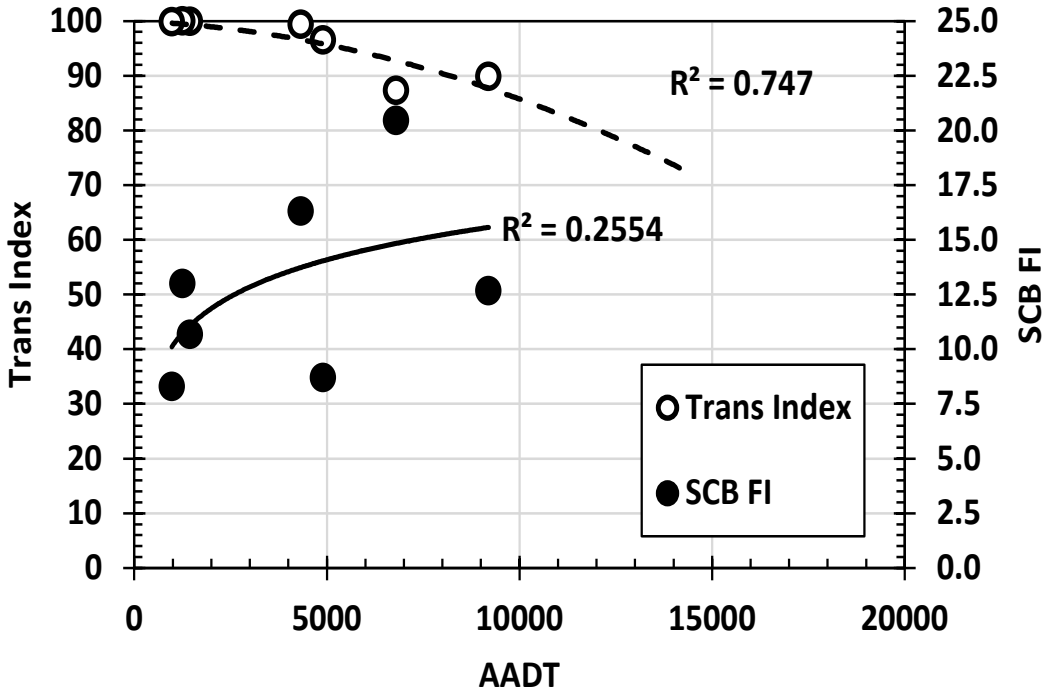
- Table of Poor Rutting Performance
  - Limiting factor to this work is the fact that all of the projects where Hamburg was conducted, low pavement rutting
    - Helps to have good and poor performing to develop criteria
  - Recommend field cores cut and tested to assess poor field performance

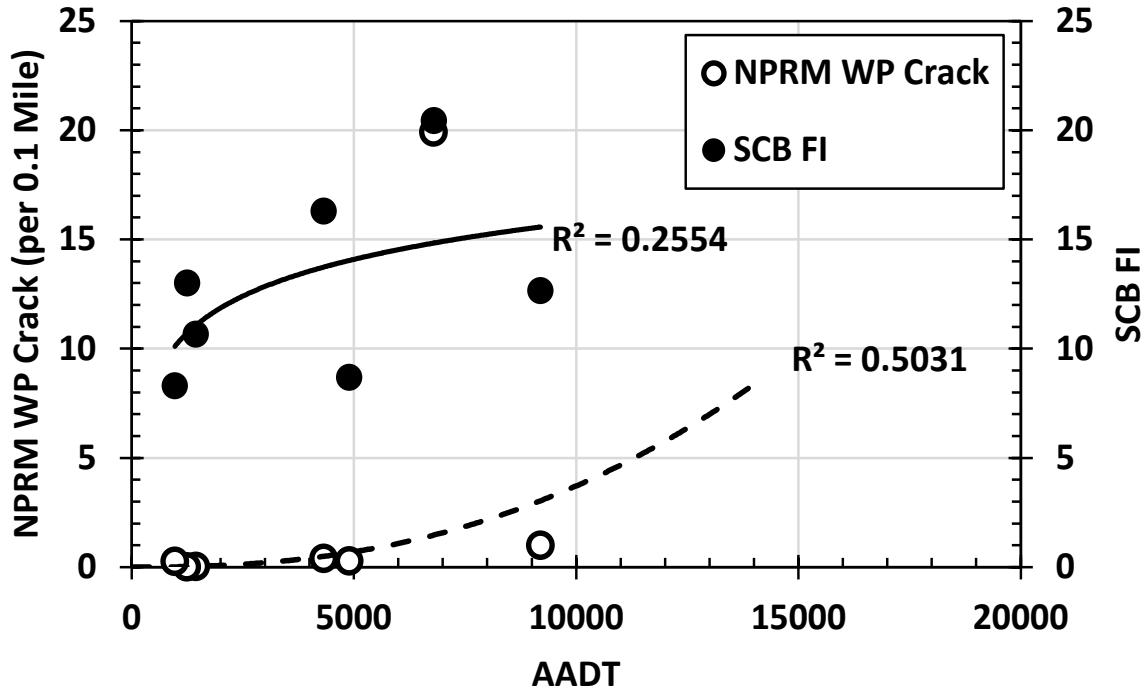
Poor Rutting Measurements

Route Name	ETE_From	ETE_To	ETE_Road	Begin Town	AADT	Rut Average	Rut Index	Last Work Project Name	Last Work Project Number	Last Work Year
VT 7A	21.4	25.2	V007A	MANCHESTER	6837	0.40	60.5	Manchester(CLS1*)	STP 2970(1)	2019
VT 9	3.1	5.5	V009	BENNINGTON	6379	0.35	65.4	Bennington	NH 2966(1)	2018
VT 11	3.6	6.6	V011	WINHALL	6789	0.72	28.4	Manchester-Peru	STP 2708(1)	2019
VT 12	58.4	58.8	V012	MONTPELIER CITY	3300	0.64	35.58	Montpelier	STP 2950(1)	2018
VT 67A	2.2	3.3	V067A	BENNINGTON	5950	0.28	72	Bennington	STP 2973(1)	2018
VT 100	1.0	4.0	V100	STAMFORD	1451	0.44	55.7	Stamford	FPAV(23)	2019
US 7	10.2	11.8	U007	BENNINGTON	8165	0.44	56	Bennington	NH 2966(1)	2018

Vermont – SCB Flexibility Index

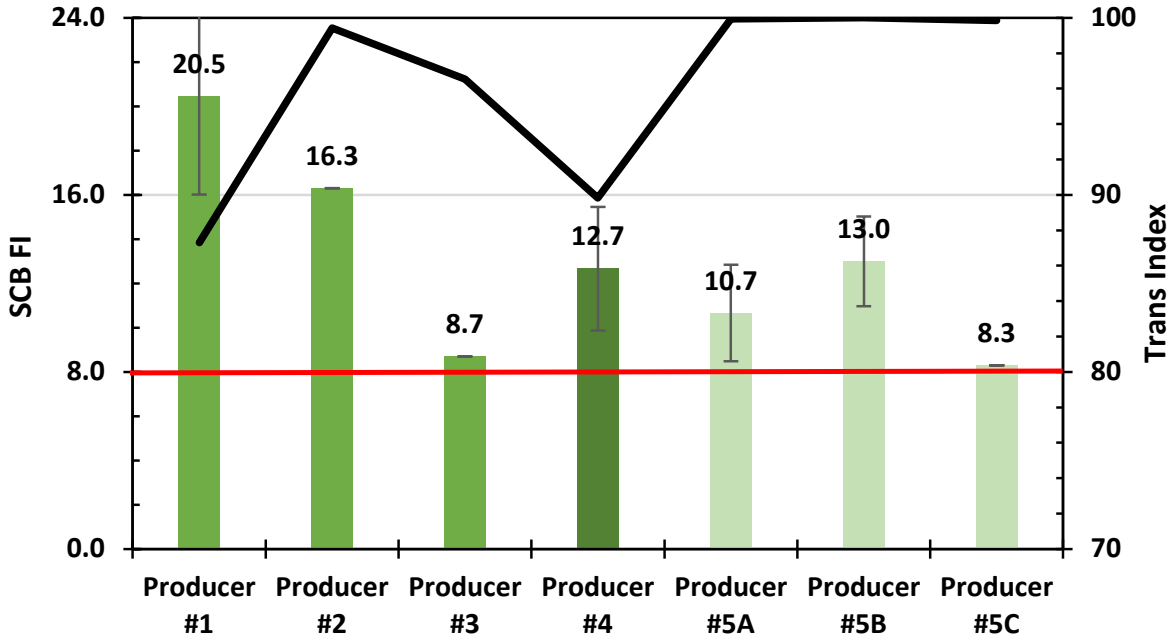
- Could not generate a simple relationship between SCB FI & Field Cracking
  - Cracking typically later life distress – only 2 years of field performance with SCB FI
    - Looked at only trying to compare the 2018 data
      - **PMS distress indices appear to be related to the traffic level (AADT) but still <u>shows low magnitudes of cracking in the field</u>**

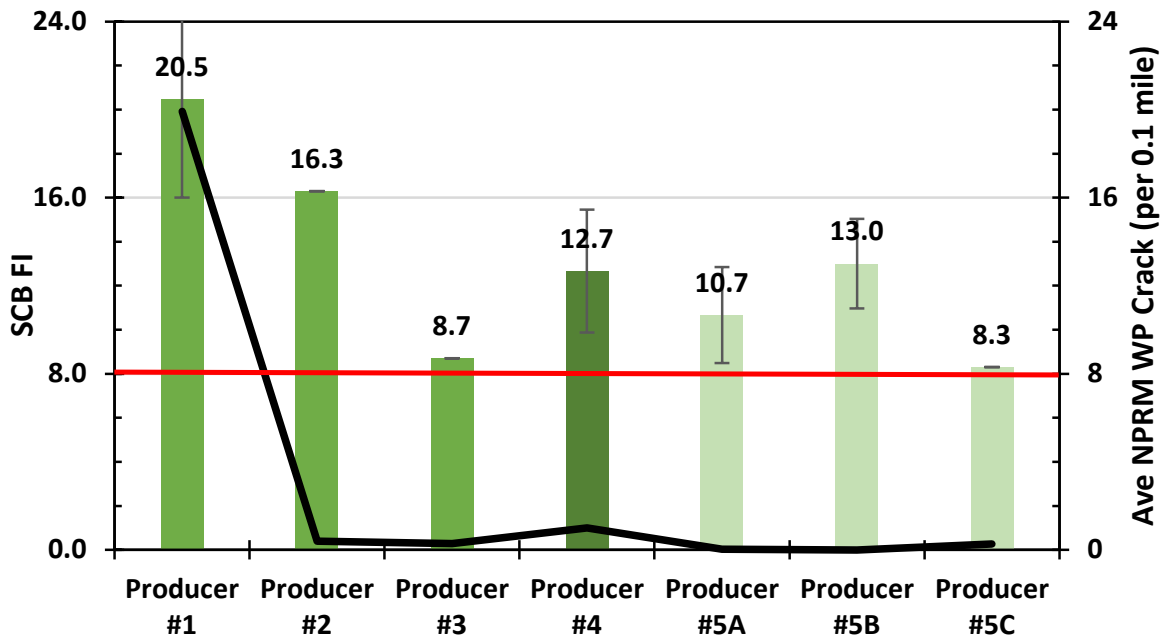




Vermont – SCB Flexibility Index

- Because significant field cracking was not observed in pavement sections, recommend initial SCB Flexibility Index > 8.0
  - **Need to continue to review these sections over time**





Vermont – SCB Flexibility Index – Poor Field Performance

- Table of Poor Fatigue Performance
  - Recommend field cores cut and tested to assess relationship between SCB FI and poor field performance
    - Will help to validate criteria

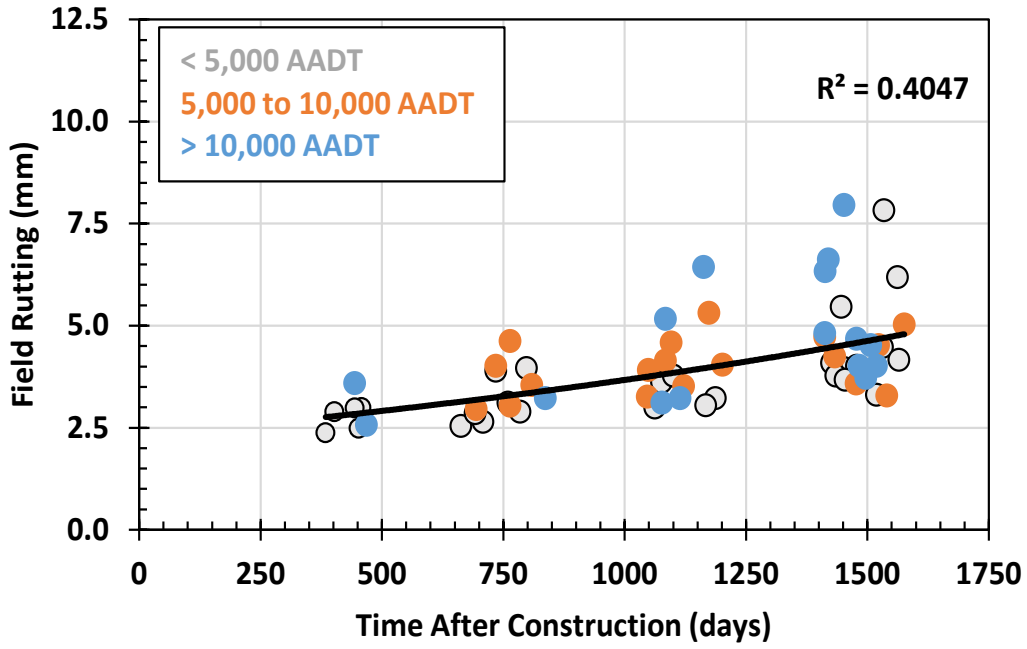
Poor Cracking Measurements (2018)

Route Name	ETE_From	ETE_To	ETE_Road	BeginTown	NPRM Condition CRK	NPRM WP Crack	Last Work Project Name	Last Work Project Number	Last Work Year
US 2	101.2	101.3	U002	CABOT	POOR	34.15	District Paving	NE19PAV702	2018
	101.3	101.4	U002	DANVILLE	POOR	26	District Paving	NE19PAV702	2018
	101.6	101.7	U002	DANVILLE	POOR	33.25	District Paving	NE19PAV702	2018
	101.7	101.8	U002	DANVILLE	POOR	35.75	District Paving	NE19PAV702	2018
	101.8	101.9	U002	DANVILLE	POOR	39.75	District Paving	NE19PAV702	2018
US 5	186.8	186.9	U005	DERBY	POOR	30.38	District Paving	NE19PAV902	2018
	187.5	187.6	U005	DERBY	POOR	30.67	District Paving	NE19PAV902	2018
US 7	10.3	10.4	U007	BENNINGTON	POOR	21	Bennington	NH 2966(1)	2018
	10.4	10.5	U007	BENNINGTON	POOR	27.5	Bennington	NH 2966(1)	2018
	10.5	10.6	U007	BENNINGTON	POOR	21	Bennington	NH 2966(1)	2018
	11.4	11.5	U007	BENNINGTON	POOR	56.75	Bennington	NH 2966(1)	2018
	11.5	11.6	U007	BENNINGTON	POOR	47	Bennington	NH 2966(1)	2018
	11.6	11.7	U007	BENNINGTON	POOR	41	Bennington	NH 2966(1)	2018
	145.9	146	U007	MILTON	POOR	32	District Paving	NE19PAV501	2018
VT 9	3.1	3.2	V009	BENNINGTON	POOR	24.75	Bennington	NH 2966(1)	2018
	3.5	3.6	V009	BENNINGTON	POOR	22.75	Bennington	NH 2966(1)	2018
	3.6	3.7	V009	BENNINGTON	POOR	31.75	Bennington	NH 2966(1)	2018
	3.7	3.8	V009	BENNINGTON	POOR	36	Bennington	NH 2966(1)	2018
	3.8	3.9	V009	BENNINGTON	POOR	23	Bennington	NH 2966(1)	2018
	4	4.1	V009	BENNINGTON	POOR	26.5	Bennington	NH 2966(1)	2018
	4.7	4.8	V009	BENNINGTON	POOR	20.75	Bennington	NH 2966(1)	2018
	5	5.1	V009	BENNINGTON	POOR	35.5	Bennington	NH 2966(1)	2018
	5.5	5.6	V009	BENNINGTON	POOR	42.75	Bennington	NH 2966(1)	2018
VT 14	93.3	93.4	V014	ALBANY	POOR	57.25	District Paving	NE19PAV901	2018
	93.4	93.5	V014	ALBANY	POOR	59	District Paving	NE19PAV901	2018
VT 67A	2.2	2.3	V067A	BENNINGTON	POOR	36	Bennington	STP 2973(1)	2018
	2.6	2.7	V067A	BENNINGTON	POOR	29.25	Bennington	STP 2973(1)	2018
	2.7	2.8	V067A	BENNINGTON	POOR	31.75	Bennington	STP 2973(1)	2018
	2.8	2.9	V067A	BENNINGTON	POOR	22.25	Bennington	STP 2973(1)	2018
	3	3.1	V067A	BENNINGTON	POOR	22.75	Bennington	STP 2973(1)	2018
	3.2	3.3	V067A	BENNINGTON	POOR	25	Bennington	STP 2973(1)	2018
VT 131	1.1	1.2	V131	CAVENDISH	POOR	41.5	District Paving	NE19PAV201	2018
	1.3	1.4	V131	CAVENDISH	POOR	51	District Paving	NE19PAV201	2018
	1.7	1.8	V131	CAVENDISH	POOR	42.25	District Paving	NE19PAV201	2018
	1.8	1.9	V131	CAVENDISH	POOR	34.25	District Paving	NE19PAV201	2018
	1.9	2	V131	CAVENDISH	POOR	53.25	District Paving	NE19PAV201	2018
	2.1	2.2	V131	CAVENDISH	POOR	42.75	District Paving	NE19PAV201	2018


DIRIGO
MAINE
MaineDOT

Maine - Rutting

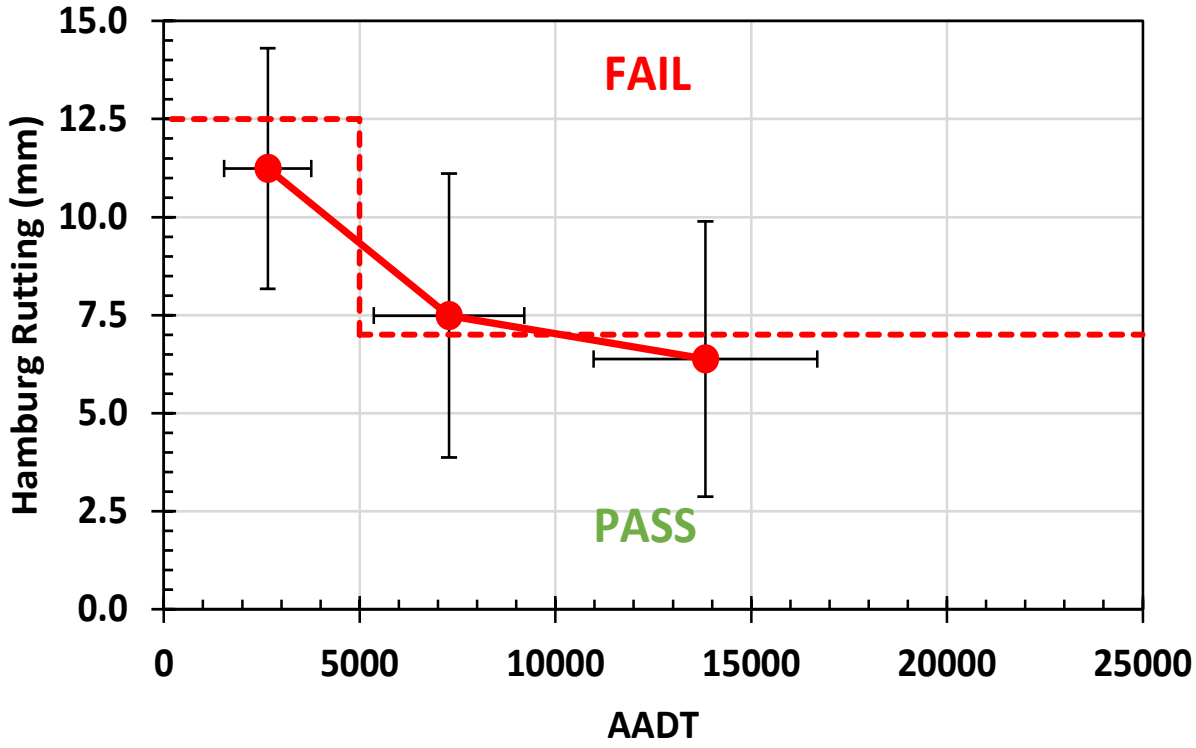
- Discussions with MaineDOT indicated that field rutting observed to continue well past first few years of field service
- Separating field rutting results out by time after placement clearly confirmed field rutting continues into 4th year of service life – regardless of AADT!
  - Therefore, criteria developed only using 4th year



AADT	Age	Temp	Field Rutting (inches)	Field Rutting (mm)	HWT Rutting (mm)	HWT Passes	Stripping Slope	Creep Slope	Stripping	LC12 5S	LC12 5C
1106	1488	45	0.176	4.47	12.50	4626	4.27	1.45	2.94	4614	4592
1346	1491	45	0.308	7.82	11.83	16823	1.34	0.35	3.81	17508	20142
1875	1409	45	0.156	3.96	11.53	10022	2.34	0.64	3.65	17425	17390
2225	1435	45	0.158	4.01	12.50	9702	3.05	0.38	8.06	9699	9676
2365	1403	45	0.215	5.46	11.41	11633	1.61	0.85	1.88	14000	15856
2766	1519	45	0.244	6.18	12.50	12487	1.82	0.44	4.11	12487	12487
2834	1383	45	0.161	4.09	12.50	4452	5.44	1.08	5.03	4448	4434
3427	1392	45	0.149	3.77	2.60	19891	0.08	0.12	0.65	99751	99751
4022	1476	45	0.130	3.30	12.50	4680	6.01	1.12	5.35	4680	4680
4567	1411	45	0.145	3.67	12.50	6252	3.17	0.82	3.88	6249	6240
4825	1522	45	0.164	4.17	12.50	7346	3.87	0.72	5.39	7344.5	7332
5348	1533	45	0.198	5.03	12.50	7141	3.99	0.49	8.18	7140	7130
5924	1480	45	0.178	4.52	5.21	19994	0.34	0.17	1.96	41666	62501
7444	1390	45	0.167	4.24	7.73	20000	0.47	0.18	2.55	60023	62908
9094	1497	45	0.130	3.29	5.75	19996	0.41	0.16	2.61	36267	62528
9160	1434	45	0.141	3.58	3.72	19967	0.15	0.14	1.07	77220	83335
9186	1369	45	0.186	4.72	5.03	19932	0.15	0.26	0.58	48420	48420
10175	1440	45	0.158	4.01	4.12	19984	0.17	0.09	1.83	69131	110055
11999	1369	45	0.190	4.82	5.20	18620	0.72	0.19	3.87	52703.6	75457.3
12632	1377	45	0.261	6.62	7.91	16726	1.04	0.23	4.52	51310	51291
12793	1454	45	0.147	3.72	3.55	19943	0.13	0.15	0.87	79968.67	81595
13088	1464	45	0.178	4.52	3.85	19954	0.13	0.16	0.83	73570	73570
13298	1409	45	0.313	7.95	12.50	3074	8.00	1.20	6.65	3073	3066
13604	1476	45	0.158	4.01	2.84	19909	0.10	0.10	0.97	105189	115616
17347	1435	45	0.184	4.67	11.38	14791	1.63	0.42	3.86	18007	21051.2
19549	1370	45	0.250	6.34	6.12	19988	0.44	0.17	2.58	34352	57008

Maine - Rutting

- Using an average of AADT and Hamburg rutting for the 3 different AADT divisions, results indicate very similar performance for intermediate and high AADT
  - **Resulted in 2 thresholds above and below 5,000 AADT**
  - **Since field rutting was 0.15 to 0.3 inches, average Hamburg results were selected for criteria**

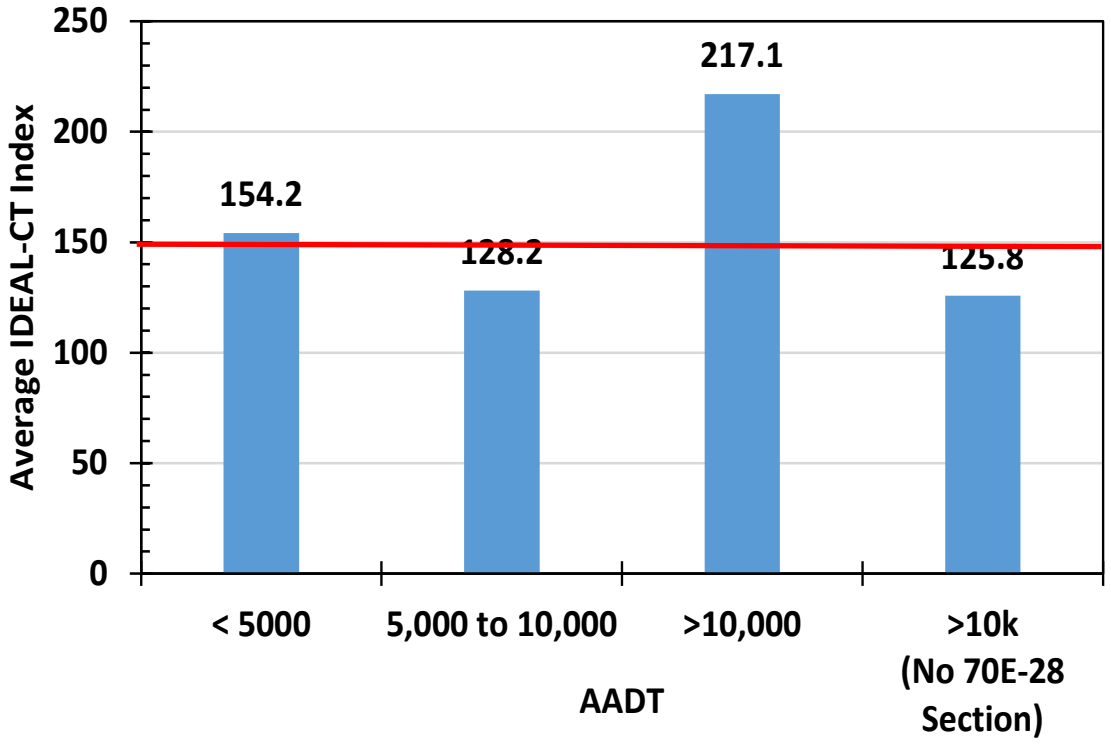


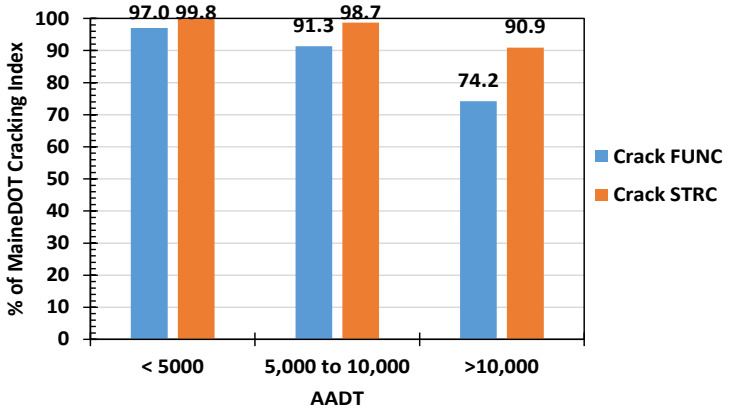
Maine – Fatigue Cracking

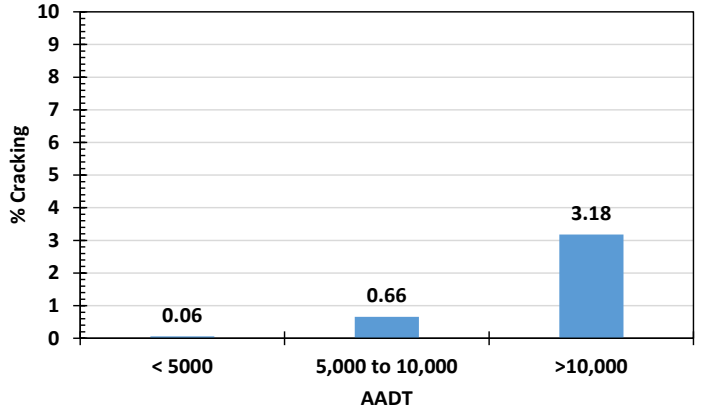
- Divided MaineDOT performance based on 3 AADT Levels;
  - < 5,000 AADT; 5,000 to 10,000 AADT; and > 10,000 AADT
- Field performance does show that as the AADT divisions increase in magnitude, greater field distress is observed
  - Therefore, need to make sure higher AADT levels achieve better IDEAL-CT Index

Maine – Fatigue Cracking

- Final Recommendation
  - IDEAL-CT Index > 150 for all mixes at test temperature of 25°C
    - Intermediate and higher AADT had more field cracking but lower IDEAL-CT when compared to the lower AADT
    - Criteria would have resulted in 10 of 18 mixes failing (8 failing when considering two mixes resulted in IDEAL-CT Index of 145.0







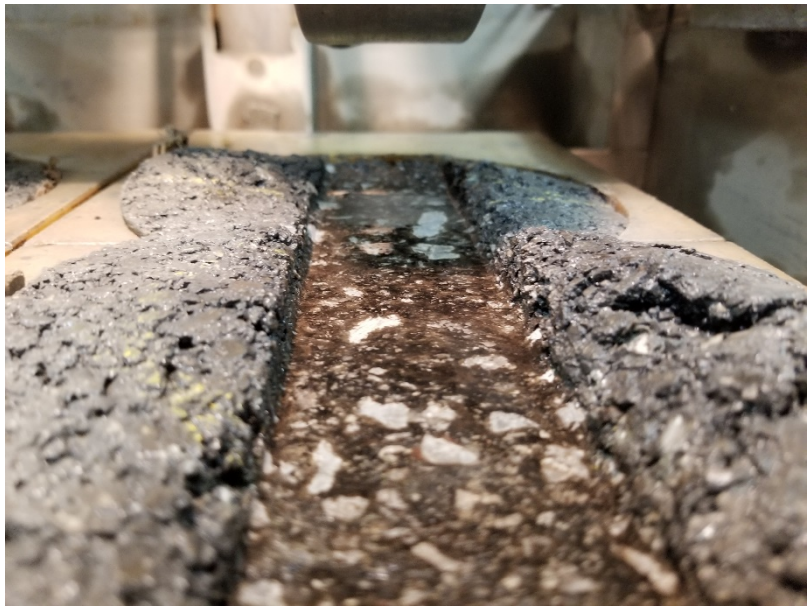
Gaps Needed to be Identified

- Necessity for include aging in mixture evaluation
- Test method/procedure selection to include testing during Quality Control
  - Pay adjustment
  - Sampling frequency
  - Aging?
- Internal communication and data sharing/availability of state agency
  - Materials Bureau, Pavement Design, and Pavement Management
- Need or want for a regional test method(s)
  - Pro's = one set of test procedures; leveraging of equipment; round robins
  - Con's = may force state agency into a test method (develop database, equipment purchase, etc.)
- Only 3 states participated in study at varying levels

NETC
Future Recommendations

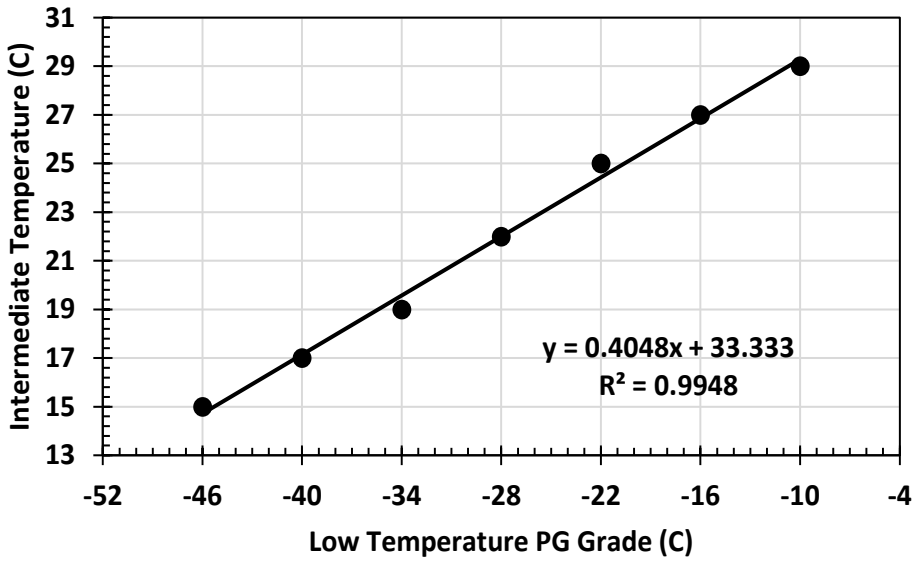
1. Criteria Validation - Performance Testing of Field Cores

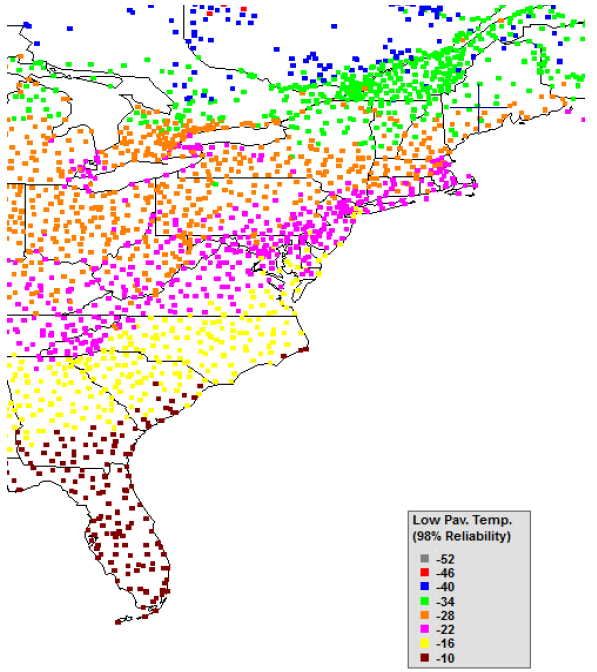
- Proposed test sections will help validate criteria
  - Good and poor field performance
- Things to be careful of when testing field cores
  - Influence of air voids on test results
    - Fully dry prior to measurement (wet coring)
      - CoreDry
  - To be taken away from distress areas
    - Between wheelpaths and outside of wheelpath
  - Minimum thickness/specimen size to confidently run test method
    - Full depth cores can be used after cutting for Hamburg
    - Thickness correction for SCB and IDEAL-CT



2. Adjustment of Fatigue Cracking Test Temperature

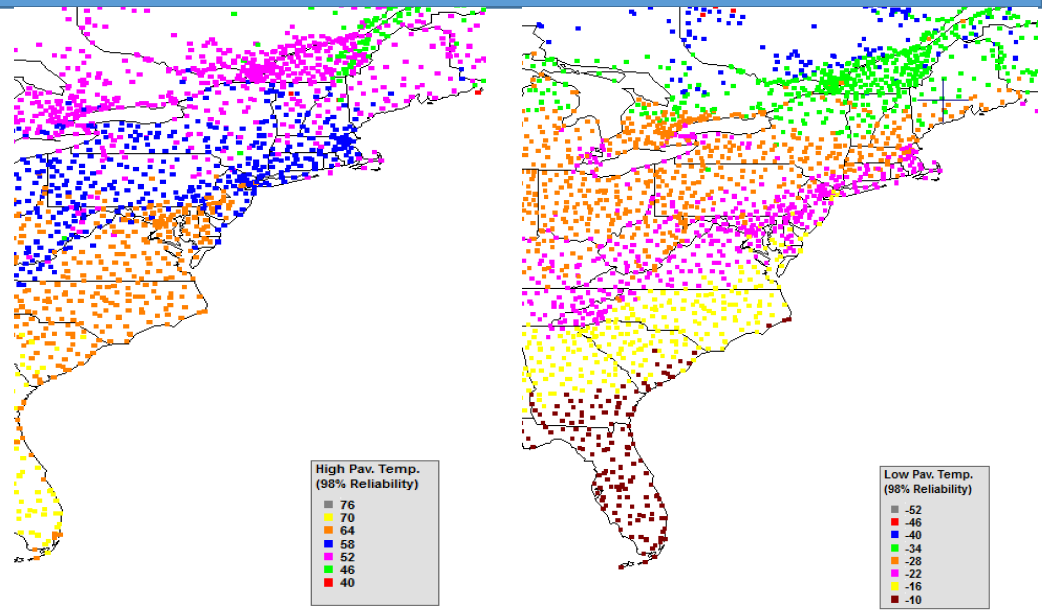
- Maine and Vermont currently using test temperature of 25°C for IDEAL-CT and SCB FI, respectively
- Selected test temperatures may not represent regional intermediate temperature
  - Results in superior laboratory performance due to asphalt binder grade
- Recommend the states consider evaluating the recommended intermediate temperatures from NCHRP 9-59 project
  - Based on required low temperature PG grade at 98% reliability

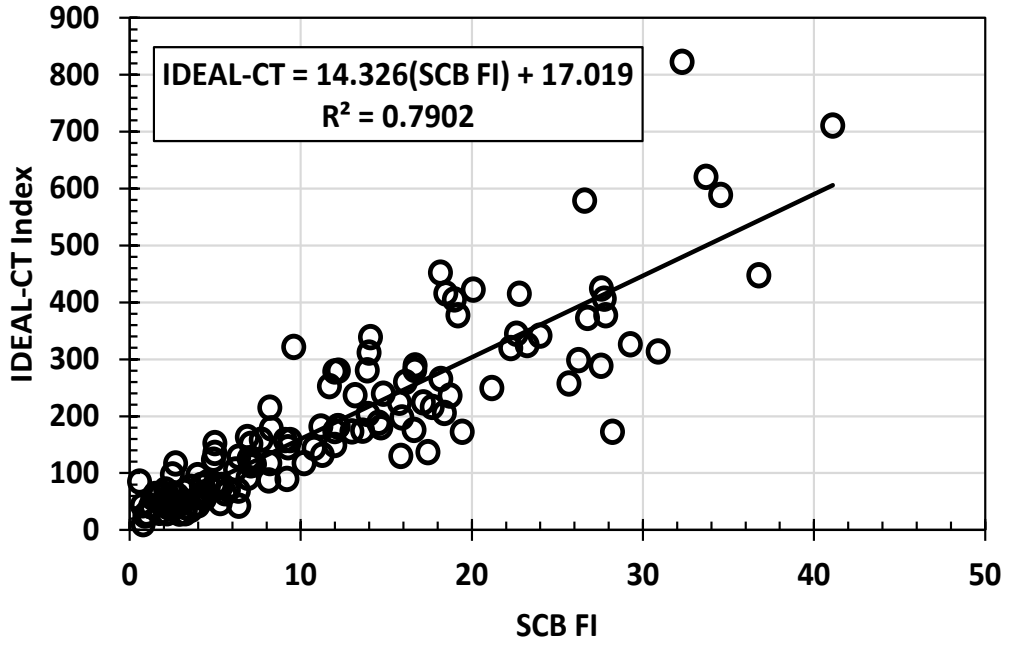




3. Regional Test Parameter/Criteria Agreement

- Maine and Vermont using same rutting test (Hamburg) but different fatigue cracking tests
- May be beneficial for region by consolidating criteria and establishing "Regional" criteria due to similarities in climate/traffic
  - Hamburg
    - AADT < 6000: Rutting < 12.5 mm
    - AADT > 6000: Rutting < 6.5 mm
  - Fatigue Cracking
    - SCB FI 8.0 ≈ IDEAL-CT Index 132
    - IDEAL-CT Index 150 ≈ SCB FI 9.3





4. Evaluation of Other State Agencies in NETC

- Completed study included 3 states of different levels of data supplied
  - Connecticut – PMS data only
  - Maine – Performance data and respective field data
  - Vermont – Performance data and complete PMS
- How are other states in NETC approaching BMD?
  - MassDOT
  - NHDOT
  - RIDOT
- Areas of support needed?
  - Communication between Materials and PMS groups within state agencies

Thank you