NECEPT

Effectiveness of the DTT and MP1a

presented to

NEAUPG - Fall 2002

Newport, RI

by

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NECEPT

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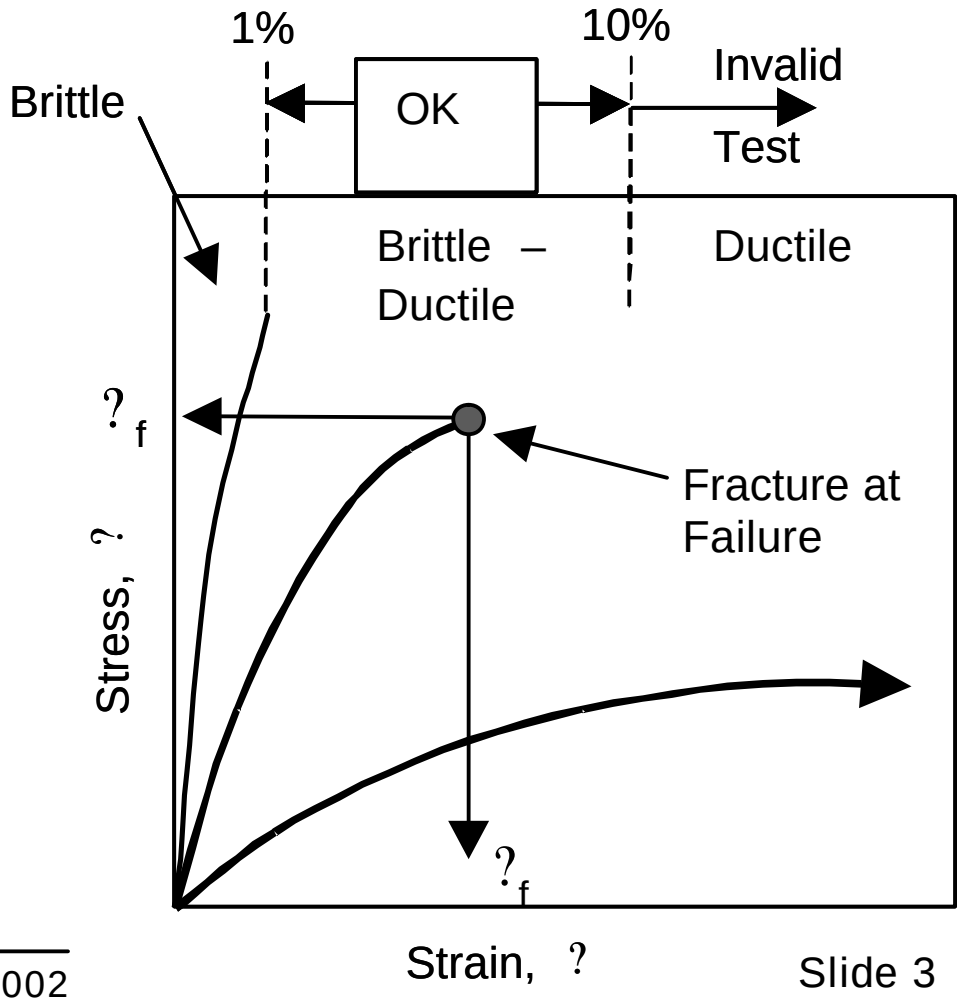
Background

- Early recognition of need
  - Pell, University of Nottingham, England
  - Van der Poel, DutchShell
- Anderson, Chemcrete work 1980's
- Anderson-Sharma-Dongre SHRP A-002A
- Post SHRP
  - Dongre continuing work at FHWA
  - Others

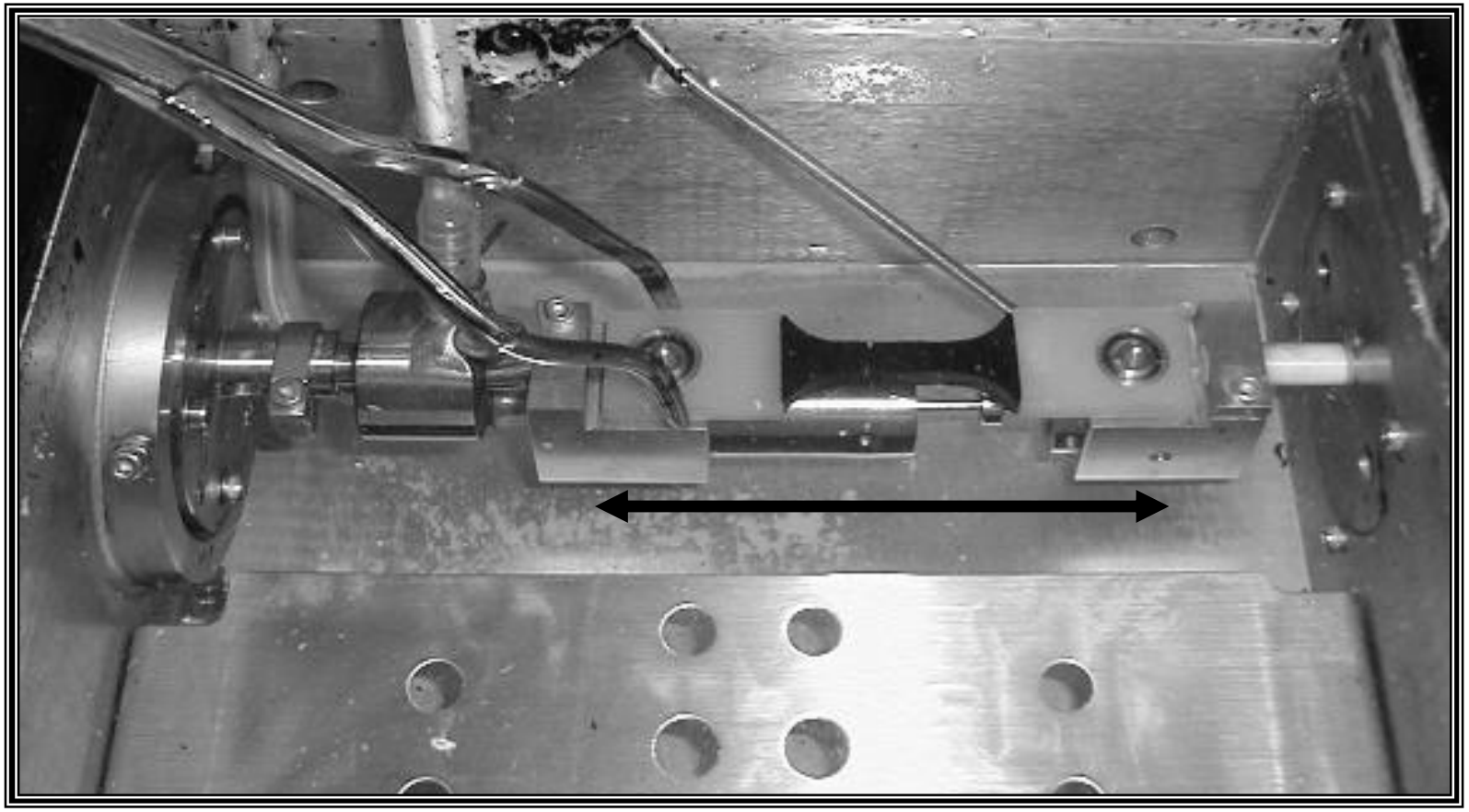
What is the direct tension test?

- Controlled strain rate test
- Tensile specimen is pulled until it ruptures
- Stress-strain test



- Stress to failure
- Strain to failure
- Energy to failure

Photograph of test



What is the question at hand?

- Two procedures for low temperature grading
  - AASHTO MP1 and AASHTO MP1a
- Question - Which procedure should we use in the Northeast?
- Basis for this decision?
  - Reliability of method in predicting critical cracking temperature
  - Relative cost of testing
- Critical cracking temperature predicts temperature where ***single event thermal cracking*** will occur

Status of test at close of SHRP - 1994

- Sample configuration complete
  - Dimensions
  - Gripping system
- Several details remained
  - Specimen molds
  - Machine compliance
  - Bath fluid
  - Specimen preparation
- Current status? Valid test method/equipment

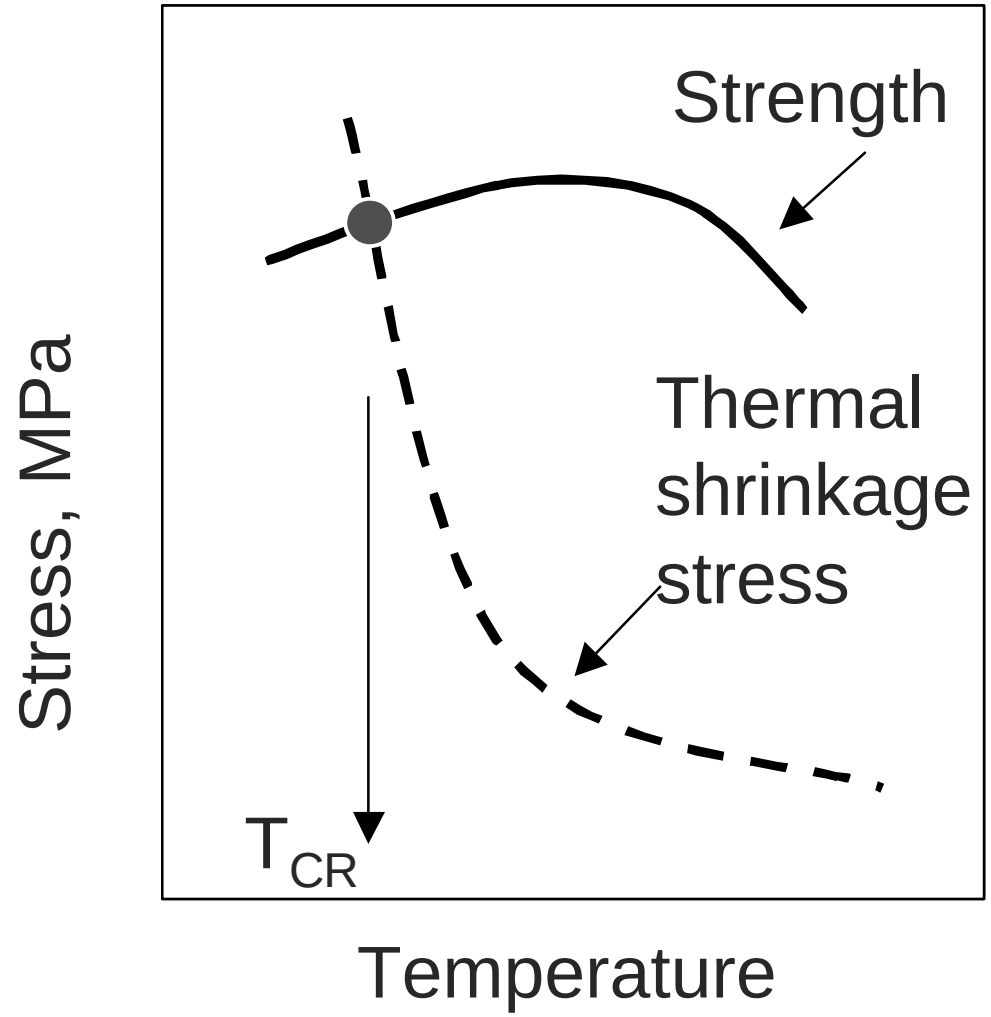
Issues resolved to date

- Specimen molds – metal versus silicone
- Bath fluid – potassium acetate
- Sample preparation
  - Need for heating
- Training
  - Lack of uniformity – method evolving
  - Chapter 9 of manual
- AASHTO MP1a defines use
  - Test procedure and specification

Why consider direct tension test?

- Provides an alternative method for low temperature grading
  - AASHTO MP1a versus AASHTO MP1
- Only binder test method that measures failure properties
  - Strain to failure
  - Stress to failure
  - Energy to failure
- Thermal fatigue?

Thermal fatigue cracking – Reserve Strength

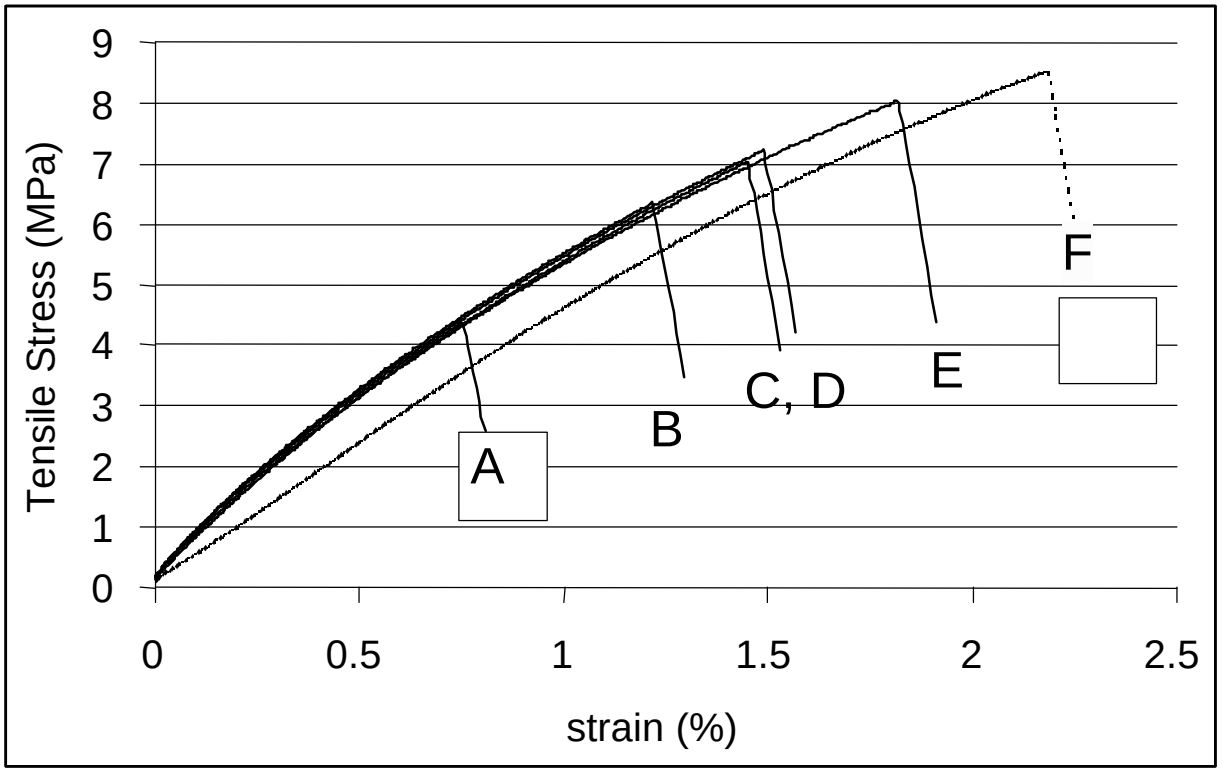


Test variability

- Questioned in past
  - DTT improved
- Combination of BBR and DTT seem to "iron out" testing error in both methods
  - Indications are that about same variability ***when consider grading temperature*** from AASHTO MP1 and AASHTO MP1a
  - Variability not issue

Further refinements

- How to select replicates?
  - Currently discard lowest two measurements

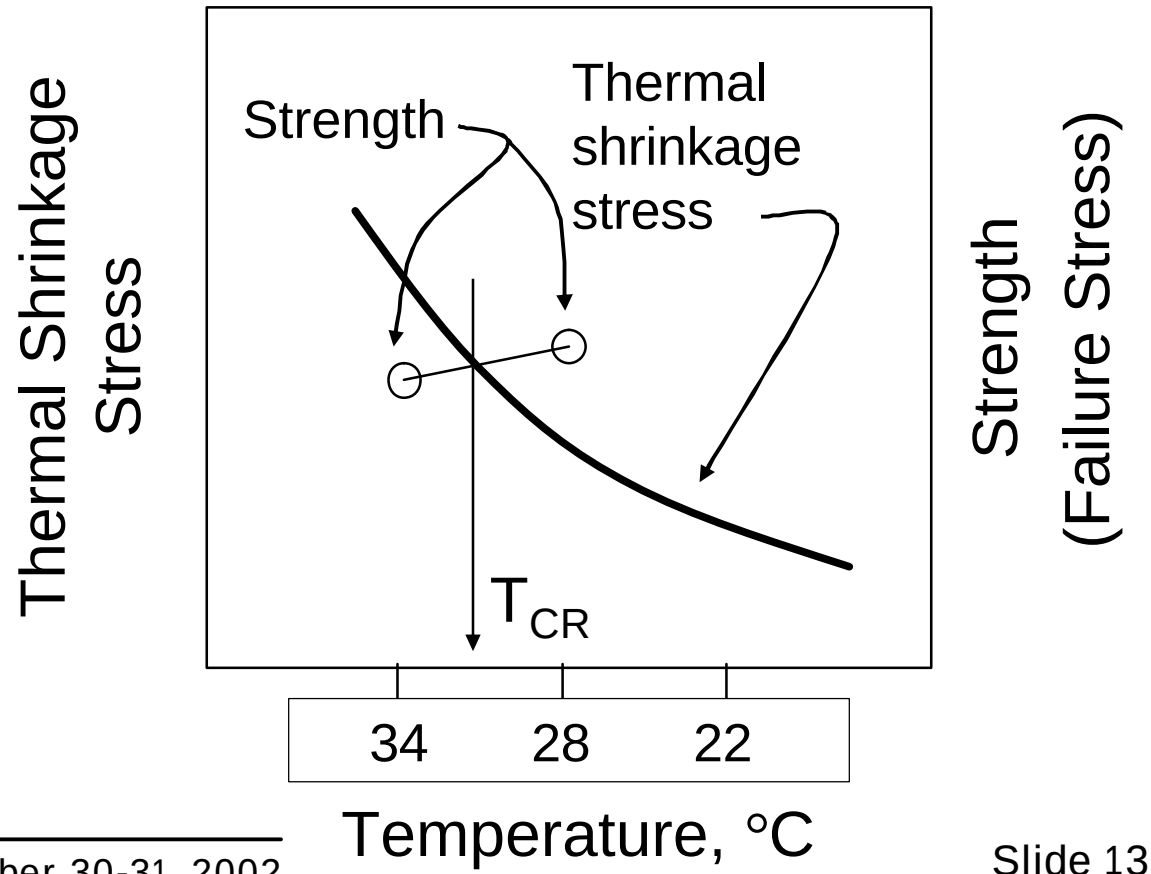


AASHTO MP1 – Testing requirements

- Conduct bending beam rheometer test
  - Determine lowest grading temperature where stiffness is ??300 MPa and m ??0.300
- ***Alternative*** – May waive stiffness requirement if ***strain*** at failure is ??1.00%
  - Not used very often
  - Requires one DT test
  - Intended to give "credit" to modified binders, especially polymer modified

AASHTO MP1a

- Different technique for ***low temperature***
- Compare ***strength*** to thermal shrinkage stress
- Define T_{CR}
- Single event



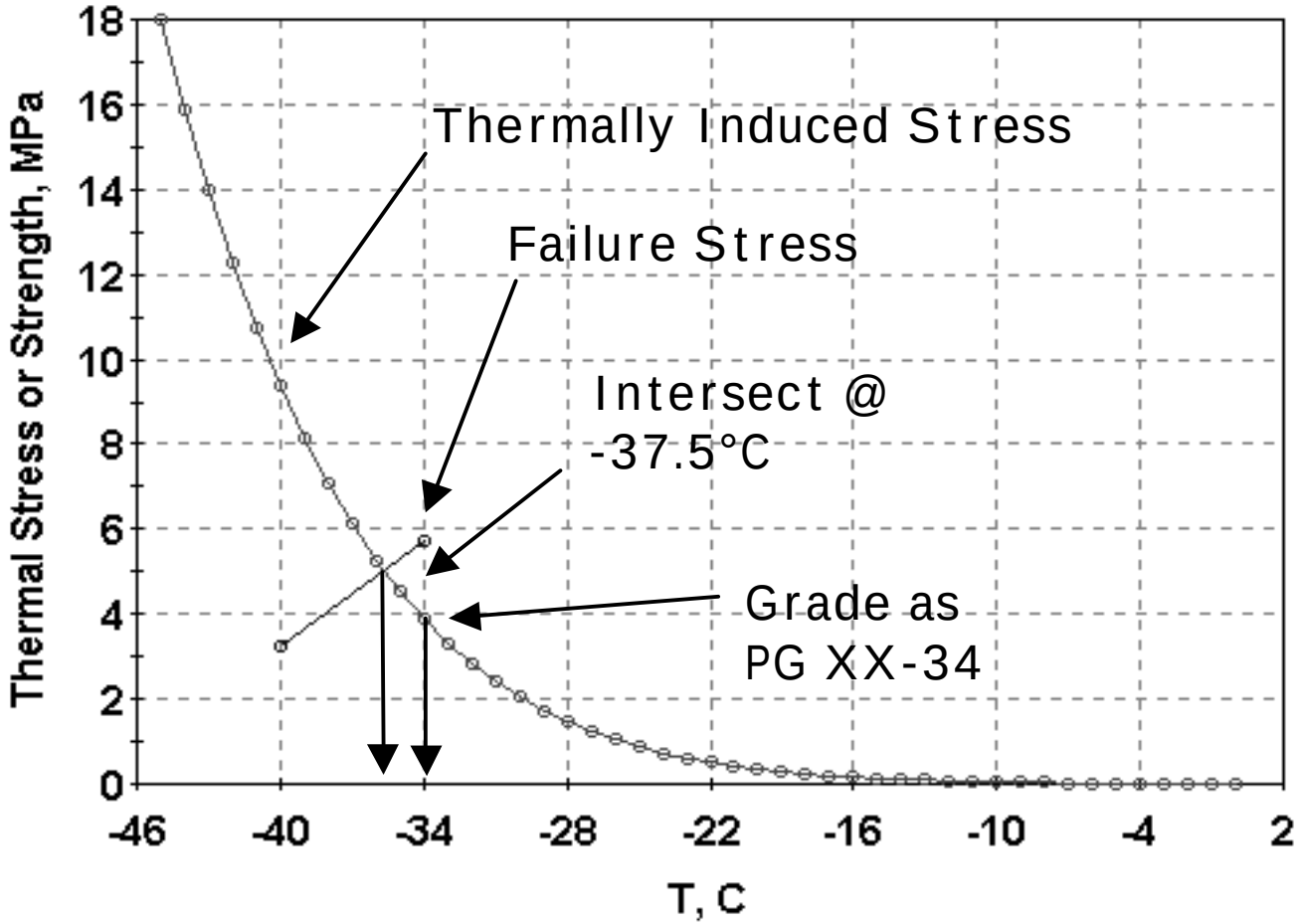
Same grades

Maximum Pavement Design Temperature, °C	Minimum Pavement Design Temperature, °C						
PG 46					-34	-40	-46
PG 52	-10	-16	-22	-28	-34	-40	-46
PG 58		-16	-22	-28	-34	-40	
PG 64	-10	-16	-22	-28	-34	-40	
PG 70	-10	-16	-22	-28	-34	-40	
PG 76	-10	-16	-22	-28	-34	-40	
PG 82	-10	-16	-22	-28	-34	-40	

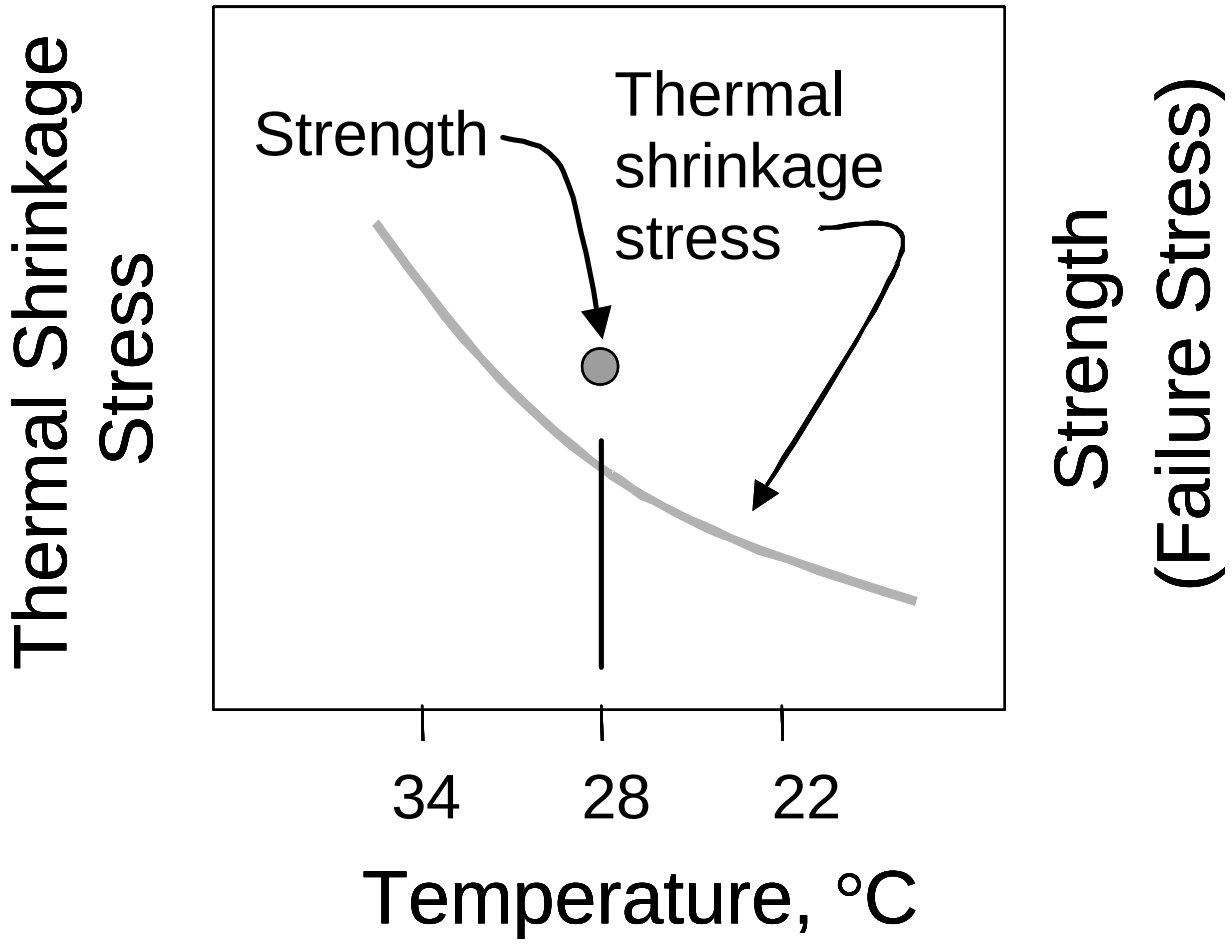
AASHTO MP1a – Testing requirements

- Testing to determine grade – grade is unknown
  - BBR test at two temperatures
    - – - thermal shrinkage stresses
  - DT test at two temperatures
    - – - interpolate to find temperature where thermal shrinkage stress equals
- Testing to verify grade – acceptance testing
  - BBR test at two temperatures as above
    - – - thermal shrinkage stresses
  - DT test at a single temperature
    - – - strength > thermal stress

Determining grade of unknown



Verification - Acceptance



Cost of AASHTO MP1a vs. AASHTO MP1

- AASHTO MP1 - acceptance
  - One BBR test
- AASHTO MP1a - acceptance
  - Two BBR tests
  - One DTT test
- Is improved reliability justified by increased cost?

What data are available?

- Round robins
  - Limited but forthcoming
- Binder ETG
- FHWA Studies
- Northeast supplier information
  - Limited in quantity
  - Not all information was collected
    - DTT at two temperatures
    - BBR at two temperatures

FHWA Round Robin (Dongre)

Lab.	Binder AA-1		Binder RRA	
	MP1A	MP1	MP1A	MP1
1	-32.4	-33.7	-29.5	-29.2
2	-30.6	-32.8	-29.4	-28.6
3	-31.1	-31.5	-30.1	-29.0
4	-32.3	-32.8	-30.0	-29.5
5	-32.4	-33.7	-29.8	-30.0
6	-31.1	-33.0	-30.2	-29.2
7	-32.9	-31.7	-30.4	-29.4
8	-32.6	-33.0	-29.6	-29.7
9	-31.5	-32.3	-29.7	-28.1
Average	-31.9	-32.7	-29.9	-29.2
Std. Dev.	0.80	0.80	0.30	0.60
CV,%	2.5	2.4	1.0	2.1

SEAUPG Round Robin

T_{cr} °C		
Lab No.	PG64-22	PG76-22
1	-23.7	-26.6
2	-26.3	-28.6
3	-26.1	-26.1
4	-24.6	-24.3
5	-25.8	-31.6
6	-26.2	-29.1
Average	-25.5	-27.7
STDEV	1.1	2.6
COV, %	4	9

NEAU/PG Round Robin – Before Training

Lab No.	SS 11					SS 12				
	-12°C		-18°C			-12°C		-18°C		
	Strain*	Stress*	Strain*	Stress*	Tcr °C	Strain*	Stress*	Strain*	Stress*	Tcr °C
1	5.22	4.43	1.29	4.08	.	3.52	4.01	0.95	3.88	.
2	2.04	3.02	0.63	2.90	-24.6	1.46	2.63	0.90	3.02	-25.1
3	4.75	3.96	.	.	.	4.51	3.82	.	.	.
4	5.21	4.50	.	.	.	5.99	4.63	.	.	.
5	1.71	3.12	0.71	3.61	-23.5	5.73	4.23	1.69	5.89	.
6	1.21	2.45	.	.	.	.	.	.	.	.
7	5.98	4.44	1.09	4.34	-27.9	6.33	4.26	1.43	4.69	-29.1
8	4.24	3.96	.	.	.	3.13	3.66	.	.	.
9	1.07	2.66	0.39	2.33	-25.2	3.15	3.97	0.59	3.02	-24.6
10	7.78	4.28	.	.	.	9.21	4.00	.	.	.
11	4.03	4.25	1.84	6.26	.	8.49	4.08	1.43	5.07	.
12	7.49	4.44	.	.	.	6.92	4.19	.	.	.
13	5.94	4.69	1.39	5.72	.	5.13	4.44	1.88	6.46	.
14	2.34	3.78	1.51	5.98	-27.8	.	.	1.58	5.96	-29.2
Avera	4.22	3.86	1.11	4.40	-25.8	5.30	3.99	1.31	4.75	-27.0
SD	2.24	0.74	0.49	1.46	1.97	2.29	0.50	0.45	1.34	2.49

Kluttz at Asphalt Binder ETG

AC	SBS	TP42 Critical Cracking Temperature		MP1a PG Grade	
		3%	5%	3%	5%
A	Control	-25.4		-22	
	1	-25.3	-25.9	-22	-22
	2	-24.5	-25.2	-22	-22
	3	-23.1	-23.5	-22	-22
	4	-25.6	-26.1	-22	-22
	5	-28.3	-28.6	-28	-28
	6	-27.6	-29.9	-22	-28
B	Control	-25.2		-22	
	1	-26.0	-24.5	-22	-22
	2	-26.6	-23.9	-22	-22
	3	-25.1	-23.9	-22	-22
	4	-23.7	-20.7	-22	-16
	5	-25.2	-17.5	-22	-16
	6	-28.0	-28.1	-28	-28

D'Angelo Asphalt Binder ETG

Binder	T_{cr} Current Spec	T_{cr} Proposed Spec
70-22 Air Blown	-24.5	-22.5
70-22 Conventional	-25.1	-22.5
70-22 SBS Modified	-26.0	-30.5
Chemically Modified 64-28 A	-29.0	-28.0
Chemically Modified 64-28 B	-27.5	-27.0
Chemically Modified 64-28 K1	-29.5	-27.5
Chemically Modified 58-28 M1	-27.3	-27.0
Elvaloy Modified 64-34 DP	-34.7	-36.0

Northeast Data

- Requested of suppliers by states
  - Generally not available in complete form
- Decided to make direct contact with suppliers
  - Need BBR at two temperatures
  - Need DTT at two temperatures
  - Not always available
    - Now referring to original data sheets
    - Procedure to determine T_{CR} is NOT user friendly
  - Complete analysis and report by 12/31/02

Summary of data to date

Property	Temperature, C
S = 300MPa	-30.3
m = 0.300	-28.8
Tcr	-29.3
Tcr - S=300MPa	0.8
Tcr - m = 0.300	-0.5

When is DTT/AASHTO MP1a Effective?

- Modified materials
  - Added benefit at low temperatures
  - Approximately 2?C lowering of grading temperature
- Identification of “oddball” material
- Future enhancements to PG spec
  - Use DTT alone
  - Fracture properties for fatigue
- Message – ***Keep DTT alive***

Recommendations

- Continue with AASHTO MP1 for non-stretch grades
  - Additional cost does not justify use of MP1 at this time
- Allow supplier to opt for AASHTO MP1a in stretch grades
- Complete evaluation of currently available data
- In-depth analysis of selected sampling in 2003
- Decision pending actions by Binder ETG

Thanks for your indulgence