Determination of Creep Compliance and Indirect Tensile Strength for the Mechanistic-Empirical Pavement Design Guide (MEPDG)

FINAL PROJECT REPORT

by

Amir Bahadori and Balasingam Muhunthan
Washington State University

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Pacific Northwest Transportation Consortium (PacTrans)
USDOT University Transportation Center for Federal Region 10
University of Washington
More Hall 112, Box 352700
Seattle, WA 98195-2700

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16. Abstract

This report provides details of the research, including data analyses and results, conducted into creep compliance and indirect tensile strength tests for use in the Mechanistic Empirical Pavement Design Guide (MEPDG). The study was conducted on field cores from the Idaho Transportation Department as part of an ongoing project at the University of Idaho. The data reported in this study were provided to University of Idaho researchers for use in the AASHTOWare Pavement ME thermal cracking database. By means of this database thermal cracking models in the AASHTOWare Pavement ME can be calibrated for the mixes used by the state of Idaho. Such local calibration will increase the reliability of these models for pavement design in Idaho.

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Chapter 1 Introduction

This report provides details of the research, including data analyses and results, conducted into creep compliance and indirect tensile strength tests for use in the Mechanistic Empirical Pavement Design Guide (MEPDG). The study was conducted on field cores from the Idaho Transportation Department (ITD) as part of an ongoing project at the University of Idaho. The test results reported in this report will be used by researchers at the University of Idaho to calibrate the AASHTOWare Pavement ME design software.

1.1 Summary of Work Completed

Dynamic modulus, indirect tensile (IDT) creep compliance, and strength are the three primary mechanistic properties of asphalt mix for asphalt pavement in the AASHTOWare Pavement ME. Thermal cracking is one of dominant distresses in the northern states in the U.S.

Based on NCHRP 01-40, the thermal cracking prediction by Pavement ME is *very sensitive* (highest category) to IDT creep compliance and IDT strength. As with dynamic modulus for asphalt mix, a material library and calibration of prediction models for IDT creep compliance and strength need to be completed for local materials before the Pavement ME can be meaningfully calibrated.

The scope of work for WSU included the following tasks:

- *(a) Design of experiment.* Fifteen different classes of ITD mixes were provided to us and used in this study. Each class included three mixes, and the three mixes of each class had different performance grades of binders.
- *(b) Material procurement*. Field cores from the 2015 paving season were delivered to WSU. These cores were taken from new paving projects.

(c) *IDT Creep compliance.* Creep compliance tests were conducted at different temperatures (-20, -10, 0ºC) and 100 seconds, in accordance with AASHTO T322. Three replicates were used for each mix.

(d) *IDT Strength.* IDT strength tests were conducted in accordance with AASHTO T322, and three replicates were used for each mix.

1.2 Organization of Report

This report consists of three chapters. Chapter 2 presents the inventory of the received field cores and results of the creep compliance and IDT strength tests conducted on them. Chapter 3 describes the activities planned for the future.

Chapter 2. Field Cores Inventory and Creep Compliance Test Results

2.1 Inventory of Procured Field Cores

The details of the field cores received by the WSU research team are shown in table 1.

Table 1 Summary of total received field cores

	Key Number	Specified Binder Grade	Nominal Max Aggregate Size	Class of Mixture
1	13435	PG 76-28	1/2"	SP5
2	13456	PG 76-28	1/2"	SP3
3	09822	PG 70-28	1/2"	SP3
4	13923	PG 70-28	1/2"	SP3
5	12431	PG 64-34	3/4"	SP5
6	12212	PG 64-28	3/4"	SP5
7	13518	PG 64-28	1/2"	SP2
8	10939	PG 76-28	3/4"	SP5
9	11239	PG 76-28	1/2"	SP6
10	12046	PG 70-28	1/2"	SP3
11	13474	PG 70-28	1/2"	SP3
12	10541	PG 70-28	1/2"	SP3
13	13823	PG 64-28	1/2"	SP3
14	7508	PG 70-28	3/4"	SP5
15	11686	PG 52-40	1/2"	SP3

The research team classified the received field cores on the basis of mix design parameters. The classification was based on their mix design type (SP) and the asphalt binder type, as shown in table 2. Each cell shows the available Nominal Maximum Aggregate Size (NMAS) for the combination of asphalt binder type and mix type. For some cases, more than one mix was available.

Table 2 Summary of received field cores based on mix type and asphalt binder

SP\PG	PG 58-34	PG 58-28	PG 64-34	PG 64-28	PG 70-28	PG 76-28
SP2				12.5mm*		
SP3	12.5mm			12.5mm	12.5mm,12.5mm&12.5mm	
SP5			19 mm	19mm	19mm	12.5mm&12.5mm
SP6						12.5mm&19mm

*: The Numbers show available NMAS for the specified combination of asphalt binder PG and mix type

Detailed information on the selected field cores is provided in table 3.

Table 3 Detailed information on received field cores

Key Number	Project Name	District	Specified Binder Grade	NMAS	Class of Mixture	Mix Design
12212	US-95, Worley North, Kootenai Co. STG 2	1	PG 64-28	3/4"	SP5	A515-113
13435	US-95, Lewiston Hill NB & SB lanes	2	PG 76-28	1/2"	SP5	15011
13923	SH-44 W. State St. to JCT 55 North, Eagle	3	PG 70-28	1/2"	SP3	A515-034
13518	Swan Falls Rd. Dhoulder Widening	3	PG 64-28	1/2"	SP2	A515-182
10939	I-84 Meridian RD I.C	3	PG 76-28	3/4"	SP5	BO1400731
12046	Karcher/Middleton	3	PG 70-28	1/2"	SP3	BO1500218
10541	STP-8423, Amity Rd	3	PG 70-28	1/2"	SP3	BO1500237
11239	I-84, Snake RV Twin Bridges WB & EB	4	PG 76-28	1/2"	SP6	BO1500206
11239	I-84, Snake RV Twin Bridges WB & EB	4	PG 76-28	3/4"	SP6	BO1500207
13823	State, Dist. Wide Turn Bays./ Red Rock	5	PG 64-28	1/2"	SP3	BO1500507
7508	Cheynne S. Valley Connector	5	PG 70-28	3/4"	SP5	BO1500363
12431	I-15, Devils Cr to Marsh Valley Rd	5	PG 64-34	3/4"	SP 5	515-108
11686	Pancheri Dr. Bellin to SkylineTS 1 S1	6	PG 58-34	1/2"	SP3	215001

2.2 IDT Creep Compliance and IDT Strength Test Results

The low temperature property of the mixture was characterized by the test of creep compliance and indirect tensile (IDT) strength. The nondestructive creep compliance test for each sample was conducted first at temperatures of -20^{o}C, -10^{o}C and 0^{o}C, with a dead load duration of 100 seconds. All tests on field cores were performed on the basis of AASHTO T-322.

2.2.1 Creep Compliance Results

Tables 4 to 16 show the results of creep compliance for the selected mixes.

Table 4 Creep compliance test results (m^2/N) for mix 12212

Temperature\Time	1s	2s	5s	10s	20s	50s	100s
-20°C	3.41E-11	3.71E-11	3.65E-11	3.89E-11	4.05E-11	4.22E-11	4.73E-11
-10°C	5.38E-11	5.58E-11	6.29E-11	7.22E-11	8.24E-11	1.03E-10	1.18E-10
0°C	9.26E-11	1.01E-10	1.31E-10	1.59E-10	1.99E-10	3.13E-10	4.28E-10

Table 5 Creep compliance test results (m^2/N) for mix 13435

Temperature\Time	1s	2s	5s	10s	20s	50s	100s
-20°C	4.09E-11	4.34E-11	4.59E-11	4.91E-11	5.07E-11	5.65E-11	5.90E-11
-10°C	2.23E-11	2.39E-11	2.69E-11	3.03E-11	3.41E-11	4.11E-11	4.85E-11
0°C	4.18E-11	5.36E-11	7.13E-11	7.61E-11	9.18E-11	1.21E-10	1.65E-10
10°C	8.77E-11	9.81E-11	1.17E-10	1.42E-10	1.89E-10	2.99E-10	4.30E-10

Table 6 Creep compliance test results (m^2/N) for mix 13923

Temperature\Time	1s	2s	5s	10s	20s	50s	100s
-20°C	6.57E-11	7.02E-11	7.44E-11	8.39E-11	8.86E-11	9.80E-11	1.12E-10
-10°C	9.36E-11	1.06E-10	1.21E-10	1.40E-10	1.64E-10	2.05E-10	2.54E-10
0°C	2.01E-10	2.36E-10	3.04E-10	3.83E-10	4.88E-10	6.95E-10	9.06E-10

Table 7 Creep compliance test results (m^2/N) for mix 13518

Temperature\Time	1s	2s	5s	10s	20s	50s	100s
-20°C	6.47E-11	6.73E-11	7.22E-11	7.79E-11	8.61E-11	9.81E-11	1.09E-10
-10°C	1.10E-10	1.21E-10	1.39E-10	1.57E-10	1.83E-10	2.31E-10	2.83E-10
0°C	2.26E-10	2.70E-10	3.56E-10	4.46E-10	5.73E-10	8.01E-10	1.04E-09

Table 8 Creep compliance test results (m^2/N) for mix 10939

Temperature\Time	1s	2s	5s	10s	20s	50s	100s
-20°C	6.37E-11	6.96E-11	7.55E-11	7.85E-11	8.22E-11	9.15E-11	9.93E-11
-10°C	1.01E-10	1.09E-10	1.21E-10	1.35E-10	1.54E-10	1.86E-10	2.26E-10
0°C	1.79E-10	2.03E-10	2.47E-10	2.99E-10	3.72E-10	5.11E-10	6.65E-10

Table 9 Creep compliance test results (m^2/N) for mix 12046

Temperature\Time	1s	2s	5s	10s	20s	50s	100s
-20°C	5.13E-11	5.16E-11	5.57E-11	5.86E-11	6.19E-11	6.74E-11	7.04E-11
-10°C	7.13E-11	7.55E-11	8.43E-11	9.07E-11	1.01E-10	1.25E-10	1.46E-10
0°C	1.03E-10	1.17E-10	1.60E-10	2.02E-10	2.58E-10	3.64E-10	4.79E-10

Table 10 Creep compliance test results (m^2/N) for mix 10541

Temperature\Time	1s	2s	5s	10s	20s	50s	100s
-20°C	6.41E-11	6.63E-11	7.13E-11	7.45E-11	8.48E-11	9.20E-11	9.93E-11
-10°C	1.02E-10	1.05E-10	1.19E-10	1.30E-10	1.48E-10	1.75E-10	1.99E-10
0°C	1.78E-10	1.98E-10	2.46E-10	2.89E-10	3.56E-10	4.70E-10	6.08E-10

Table 11 Creep compliance test results (m^2/N) for mix 11239 (1/2")

Temperature\Time	1s	2s	5s	10s	20s	50s	100s
-20°C	5.64E-11	5.92E-11	6.31E-11	6.74E-11	7.39E-11	8.33E-11	9.24E-11
-10°C	7.87E-11	8.25E-11	9.02E-11	9.85E-11	1.08E-10	1.27E-10	1.49E-10
0°C	1.17E-10	1.31E-10	1.66E-10	2.01E-10	2.42E-10	3.29E-10	4.18E-10

Table 12 Creep compliance test results (m^2/N) for mix 11239 (3/4")

Temperature\Time	1s	2s	5s	10s	20s	50s	100s
-20°C	5.31E-11	5.59E-11	5.99E-11	6.19E-11	7.04E-11	7.51E-11	8.55E-11
-10°C	8.77E-11	9.54E-11	1.09E-10	1.23E-10	1.38E-10	1.69E-10	2.07E-10
0°C	1.37E-10	1.64E-10	2.00E-10	2.45E-10	3.05E-10	4.36E-10	5.87E-10

Table 13 Creep compliance test results (m^2/N) for mix 13823

Temperature\Time	1s	2s	5s	10s	20s	50s	100s
-20°C	3.54E-11	3.57E-11	3.89E-11	4.45E-11	4.47E-11	5.10E-11	5.55E-11
-10°C	5.66E-11	5.85E-11	6.62E-11	7.10E-11	7.76E-11	8.91E-11	1.04E-10
0°C	7.65E-11	8.65E-11	1.05E-10	1.25E-10	1.58E-10	2.27E-10	3.01E-10

Table 14 Creep compliance test results (m^2/N) for mix 7508

Temperature\Time	1s	2s	5s	10s	20s	50s	100s
-20°C	3.99E-11	3.68E-11	3.85E-11	4.03E-11	4.16E-11	4.34E-11	4.85E-11
-10°C	6.21E-11	6.90E-11	7.78E-11	8.19E-11	8.93E-11	9.86E-11	1.10E-10
0°C	1.21E-10	1.35E-10	1.61E-10	1.90E-10	2.29E-10	3.05E-10	3.89E-10

Table 15 Creep compliance test results (m^2/N) for mix 12431

Temperature\Time	1s	2s	5s	10s	20s	50s	100s
-20°C	5.82E-11	6.29E-11	6.87E-11	7.40E-11	8.15E-11	9.60E-11	1.12E-10
-10°C	9.84E-11	1.06E-10	1.29E-10	1.53E-10	1.93E-10	2.49E-10	3.05E-10
0°C	2.41E-10	2.88E-10	3.95E-10	5.21E-10	6.92E-10	1.01E-09	1.33E-09
10°C	6.66E-10	8.02E-10	1.12E-09	1.51E-09	2.04E-09	3.06E-09	4.03E-09

Table 16 Creep compliance test results (m^2/N) for mix 11686

Temperature\Time	1s	2s	5s	10s	20s	50s	100s
-20°C	5.39E-11	5.73E-11	6.03E-11	6.73E-11	7.47E-11	9.12E-11	9.82E-11
-10°C	1.00E-10	1.14E-10	1.37E-10	1.61E-10	1.91E-10	2.34E-10	2.69E-10
0°C	2.06E-10	2.49E-10	3.07E-10	3.67E-10	4.52E-10	6.02E-10	7.45E-10
10°C	7.65E-10	9.35E-10	1.35E-09	1.83E-09	2.56E-09	3.57E-09	4.57E-09

2.2.2 IDT Strength Results

The IDT strength test for each sample was conducted at a temperature of -10°C for PG 6428 mixes, and for PG 64-34 samples, it was performed at -20 °C. Tables 16 through 28 show the results of the IDT strength tests for selected mixes.

Table 17 IDT test results (kPa) for mix 12212

Sample	1	2	3	Average
IDT	4967	4602	4746	4771

Table 18 IDT test results (kPa) for mix 13435

Sample	1	2	3	Average
IDT	5351	5000	4890	5080

Table 19 IDT test results (kPa)for mix 13923

Sample	1	2	3	Average
IDT	5450	5205	4959	5204

Table 20 IDT test results (kPa) for mix 13518

Sample	1	2	3	Average
IDT	4883	5236	4962	5027

Table 21 IDT test results (kPa) for mix 10939

Sample	1	2	3	Average
IDT	3601	3739	3680	3673

Table 22 IDT test results (kPa) for mix 12046

Sample	1	2	3	Average
IDT	3956	3527	4286	3923

Table 23 IDT test results (kPa) for mix 10541

Sample	1	2	3	Average
IDT	3563	3658	3376	3532

Table 24 IDT test results (kPa) for mix 11239-1/2”

Sample	1	2	3	Average
IDT	3787	4214	3879	3960

Table 25 IDT test results (kPa) for mix 11239-3/4”

Sample	1	2	3	Average
IDT	4335	4093	4795	4408

Table 26 IDT test results (kPa) for mix 13823

Sample	1	2	3	Average
IDT	4229	4216	4807	4417

Table 27 IDT test results (kPa) for mix 7508

Sample	1	2	3	Average
IDT	4309	4425	4967	4567

Table 28 IDT test results (kPa) for mix 12431

Sample	1	2	3	Average
IDT	4100	4425	4451	4325

Table 29 IDT test results (kPa) for mix 11686

Sample	1	2	3	Average
IDT	6617	5996	5937	6183

Chapter 3. Conclusions and Work Planned for the Future

The data reported in this study were provided to the University of Idaho researchers for use in the AASHTOWare Pavement ME thermal cracking database. By means of this database thermal cracking models in the AASHTOWare Pavement ME can be calibrated for the mixes used by the state of Idaho. Such local calibration will increase the reliability of these models for pavement design in Idaho. The researchers at the University of Idaho, headed by Dr. Fouad Bayomy, are in the process of running the Pavement ME Design software to calibrate the thermal cracking coefficients. The database consisting of the original results and analysis are available to other users upon request.

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