Synthesis and Review of Superpave Implementation

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16. Abstract

The purpose of this project is to facilitate the review and exchange of new technologies and practices being undertaken across the United States in the asphalt materials area for the Michigan Department of Transportation. The focus areas were on hot mix asphalt constituent materials: asphalt binder and aggregate, as well as hot mix asphalt. The information gained were from three primary areas:

- new technology,
- implementation of Superpave, and
- areas that needed research.

The information was transferred to the Michigan Department of Transportation through periodic meetings with presentations and quarterly reports. This final report acts as a final summary for the project.

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CHAPTER 1

INTRODUCTION

The purpose of this project was to facilitate the review and exchange of new technologies and practices being undertaken across the United States in the asphalt materials area for the Michigan Department of Transportation. The focus areas were on hot mix asphalt constituent materials: asphalt binder and aggregate, as well as hot mix asphalt. The information gained were from three primary areas:

- new technology,
- implementation of Superpave, and
- areas that needed research.

The information was transferred to the Michigan Department of Transportation through periodic meetings with presentations and quarterly reports. This final report acts as a final summary for the project.

The second chapter of this report outlines new technology being reviewed and/or implemented by other agencies in the United States. The third chapter acts as a summary chapter for the report. Appendix A to this report contains the five quarterly reports.

CHAPTER 2

NEW TECHNOLOGY AND SUPERPAVE IMPLEMENTATION

2.1 Introduction

Three focus areas for this project were aggregate, asphalt binder, and hot mix asphalt technology. Several meetings were attended across the United States with many occurring in Michigan. The sections below describe the meetings attended and the technology/information garnered.

2.2 Aggregate Technology

Chris Williams attended the National Stone Association – National Aggregate Association (NSA – NAA) Research Advisory Group Meeting in Birmingham, Alabama July 30- August 1 by invitation. The NSA – NAA Research Advisory Group outlined several potential research projects in a few different areas. This list and prioritization is attached in Appendix A of the *Second Quarterly Report.* The research projects identified by the NSA – NAA Research Advisory Group in 1998 is attached in Appendix B of the quarterly report as well. The two main aggregate issues discussed were the use of screenings and the influence of aggregate particle shape on pavement performance. An update on the Pavement Design, Construction, and Materials Enterprise (PDCM) as well as other ongoing research projects at Michigan Tech that are aggregate related was presented to the NSA – NAA. The PDCM Enterprise educational concept was well received by the aggregate industry.

The research project involved with measuring the specific gravity of fine aggregate is continuing to undergo refinement with Barnstead/Thermolyne. Michigan Tech was invited to participate in the

study by making specific gravity measurements using Micrometronics Accupyc and Geopyc to verify values and mercury porisimeter readings. The basic concept of the new device is to use a laser system that determines the point when reflected light measurements significantly change (the sample is going beyond the surface dried condition). This device has a lot of potential to significantly improve the repeatability of measuring fine aggregate specific gravities for a single operator and between laboratories. Michigan Tech received their Barnstead/Thermolyne fine aggregate specific gravity apparatus the week of December 30, 2001, and will be undergoing comparison testing over the next several months.

2.3 Asphalt Binder Technology

A meeting with MDOT and Michigan industry for a Bituminous Mixtures Specification (BMS) meeting was attended in Lansing on July 19, 2000. The primary discussion point was development of a polymer modified asphalt binder specification. Two main points for the new specification were for permanent deformation and durability performance. Some discussion pertaining to the percentages of polymer in the binder being reported were raised. The consensus was that an end result specification for polymer modified asphalt binders were preferred over specifying a minimum percentage of polymer.

A BMS meeting on November 30, 2000, raised questions on quality control testing of binder's. An example of the process that was followed in one case during the 2000 construction season was distributed. A discussion of responsibility for binder quality ensued (sampling trucks leaving a terminal verses trucks at plants). Placement of added information on truck slips was also discussed. A task group was formed to address the binder quality control testing.

Industry inquired about the newer binder specifications being balloted by AASHTO with the Direct Tension Test (DTT) and Bending Beam Rheometer (BBR). Chris Williams provided a presentation at the April 6, 2001, BMS meeting on the AASHTO proposed direct tension test procedures. The presentation is provided as part of this report in Appendix B.

At BMS meetings on June 5, 2001, and July 23, 2001, low temperature binder grade specifications for the Upper Peninsula of Michigan were discussed. The industry is interested in relaxing the low temperature binder grade from –34 to –28 Celsius. The Long Term Pavement Performance software indicates that this change would result in less than 75% level of reliability in some locations for surface mixtures. Chris Williams has been asked to report back at the January 8, 2002, BMS meeting on the corresponding levels of reliability for a -31 Celsius grade in the Upper Peninsula.

2.4 Hot Mix Asphalt Technology

A meeting with asphalt materials researchers at the National Center for Asphalt Technology (NCAT) at Auburn, Alabama occurred on August 2, 2000. A tour of the new NCAT facilities, test track, and discussion of ongoing research took place. The two research topics discussed in detail were the differences in compaction between Superpave Gyratory Compactors (SGC) and measurement of fine aggregate specific gravity. A device that will independently calibrate SGC's is being developed/refined and alpha tested. NCAT has found some differences between SGC's gyration angles when in compaction mode even though the manufacturer's calibration methods have been executed.

A meeting with the Army Corps of Engineers (COE) Waterways Experiment Station in

Vicksburg, Mississippi took place on September 25, 2000. A discussion of the COE's status of Superpave implementation revealed that the COE is fully implementing Superpave binder specifications. They are now examining the implementation of the Superpave mixture design procedures. However, they are continuing to have a lot of discussion with field personnel on the pros and cons between the Marshall and Superpave methods. The greatest concern the COE is facing with Superpave is the lack of a performance test. The COE method for preparing HMA laboratory specimens for beam fatigue and thermal stress restrained specimen testing is actual field compaction utilizing a sidewalk compactor. This compaction procedure follows the method that UC-Berkeley established during the Strategic Highway Research Program.

The Asphalt Pavement Analyzer (APA) User Group Meeting was attended in Jackson, Mississippi on September 26 and 27, 2000. A total of 21 State DOTs were represented at the meeting. Discussions on the use and specifications of the APA were held throughout the meeting. Table 2.1 on the following page summarizes how States are using the APA.

A newer device, the Corelok, has been presented as a device capable of more accurately measuring bulk specific gravity of compacted HMA samples and the maximum specific gravity of loose HMA. Michigan Tech will be acquiring a Corelok and will perform parallel testing on samples that are tested in accordance with AASHTO T 166 (*Bulk Specific Gravity of Compacted Bituminous Mixtures Using Saturated Surface-Dry Specimens*). Researchers at Michigan Tech are not as confident on the Corelok's ability to measure the *Maximum Specific Gravity of Bituminous Paving Mixtures* (AASHTO T 209) and may examine this test approach later.

Table 2.1 Current Asphalt Pavement Analyzer Test Criteria by State Department of Transportation Agencies

State (see footnotes)	Test Temp (C) and Reliability	Air Voids (target/range)	Compactor Type(s)	Seating Cycles	Number of Test Cycles	Test used in specs?	Criteria
AL, 1a	67 P98	4/1	SGC	25	8000	Y	<4.5mm TRZ
AR, 1a	64 P98	4/1	SGC	25	8000	Y	<3mm (>10E6), <5mm for others
DE, 2a	67	7/0.5	AVC	25	8000	N	<3mm (>10E6)
FL, 1ab	64 P98	7/0.5	AVC	25	8000	N	none
GA, 1ab	49	6/1	SGC	50	8000	Y	<5mm for all mixes
IL, 2ab	64 P98	7/1	SGC	25	8000	N	none yet
KS, 1ab	(<PG)	7/1	SGC	25	8000	N	developing, temps 52-58 C
KY, 2a	64 P98	7/1	SGC	25	8000	N	rule of thumb < 5mm
LA, 2ab	64 P98	7/1	SGC	25	8000	N	<6mm (research only)
MI	Under development, expect a tiered specification based on trafficking level and level of reliability						
MS, 1a	64 P98	7/1	SGC	50	8000	N	<10mm for all mixes
MO, 2a	64 P98	7/1	SGC	25	8000	N	evaluating
NJ, 1a	60	4 & 7/1	SGC	25	8000	N	evaluating
NC, 2ab	64 P98	7/1	SGC/AVC	25	8000	N	evaluating
OK, 2a	64 P98	7/1	SGC	25	8000	N	<5mm (>3E6), <6mm (0.3E6+), <7mm (<0.3E6)
SC, 2a	64 P98	7/1	AVC	25	8000	Y	<5mm for all Superpave
TN, 1ab	64 P98	7/1	SGC	0	8000	N	Rule of Thumb, <5mm to 6mm
TX, 2ab	64 P98	7/1	SGC	50	8000	N	Evaluating
UT, 2ab	64 P98	7/1	LKC	50	8000	Y	<5mm for all mixes
WV, 1ab	60	7/1	SGC	0	8000	N	evaluating, <6mm typical
WY, 2ab	52 P50	7/1	AVC	25	8000	N	evaluating

1 - Report manual measurements; use automatic measurements if available.
2 - Use automatic measurements to report; check with manual measurements.
a - Mix design.
b - Plant produced mixture.
SGC - Superpave Gyratory Compactor.
AVC - Pavement Technology, Inc. Vibratory Compactor.
LKC - Linear Kneading Compactor

A Wisconsin Asphalt Pavement Association meeting was attended in Middleton, WI on November 28-29, 2000. Discussions with the Wisconsin DOT revealed that different types of gyratory compactors may be producing different bulk specific gravity values and could be of concern. This was the same issue that NCAT researchers mentioned in August of 2000. Judy Ryan asked if Michigan Tech would participate in a round robin study looking at the gyratory compactor issue. Michigan Tech agreed to compact samples in three gyratory compactors they have in their facilities (big Pine, little Pine, and Brovold) and will provide statistical analysis support. The Wisconsin DOT central lab will mix samples and ship them to participating labs with heating/temperature instructions in January, 2001. Michigan Tech provided bulk specific gravity measurements for two different gyratory compactors, but have not been provided any feedback on the round robin testing.

The Minnesota Pavement Engineer's Conference in Minneapolis, Minnesota was attended on February 21-22, 2001. Warranties and Perpetual Pavements were presented at the conference as well as research findings at MN/Roads to date. The Minnesota DOT invited Chris Williams to serve on a MN/Road advisory board and assist in providing research topics for potential study. Michigan DOT input will be solicited for advancement to a tentative meeting on May 8-9, 2001.

A Bituminous Mixtures Specification Committee. In the afternoon, Chris Williams met with MDOT personnel from the bituminous unit and representatives from Thompson-McCulley to discuss the ongoing investigation of pavements on I-96 in Lansing. A field inspection of the pavements was done and locations identified for Falling Weight Deflectometer (FWD) testing. FWD testing has been completed by MDOT and is being processed. Cores have been taken from the field by MDOT and provided to Michigan Tech in late March of 2001 for evaluation and performance testing. Michigan Tech will be testing these samples in an APA and the proposed Superpave performance tests when the

test protocols become available.

The Midwest Pavement Preservation Consortium (MPPC) was attended in Grand Rapids, Michigan on April 10-11, 2001. The MPPC was a partner meeting that initiated several project statements for research, technology transfer, and training. The MPPC project statements were moved forward to the Sacramento Pavement Preservation meeting on June 21-22, 2001. Additional problem statements for pavement preservation were generated, resulting in about 30 one-page problem statements for AASHTO. The draft final document will be provided when complete, which is expected the next quarter.

The Minnesota DOT invited Dr. Williams to participate in helping identify research topics in the bituminous area for the next set of MN/ROAD experiments. Two ½-day meetings have taken place at the MN/ROAD test facility on May 9 and June 13, 2001. The Minnesota DOT has expressed a strong interest in partnering with other regional states on research. A three state meeting (Michigan, Minnesota, and Wisconsin) was planned for July 12 and 13, 2001 at Michigan Tech focused on HMA topics. The three states are looking at forming a National Pooled Fund Study for discussing and potentially pooling research and technology transfer monies to solve common pavement problems.

On May 31 and June 1, 2001, a meeting with Conoco in Houston, Texas, and Ponca City, Oklahoma, discussed the use of carbon fiber technology in HMA as well as a strategy to mitigate reflective cracking. A research project with Conoco has been initiated with $35,000 in cost share from Conoco being provided for purchase of a linear kneading compactor for use in Michigan Tech's laboratories. A linear kneading compactor is a versatile compactor capable of procuring samples up to 40cmX30cmX10cm. Samples procured from the linear kneading compactor will allow for 4-point bending beam fatigue testing and APA beam testing of mixtures to evaluate rutting, fatigue, and reflective cracking performance potential.

CHAPTER 3

SUMMARY

A successful study was done to provide the Michigan Department of Transportation knowledge of technology and issues related to asphalt materials. Technical papers were provided to MDOT on compact disc from the 2001 Transportation Research Board and 2001 Meeting of the Association of the Asphalt Paving Technologists. Five quarter reports were generated detailing new technology and research issues in asphalt materials.

The specific technology/issues identified that are likely of most interest to the Michigan DOT are listed below.

1. Measurement of fine aggregate specific gravity (Barnstead/Thermolyne SSDetect),
2. The use of screenings in hot mix asphalt,
3. The influence of aggregate particle shape on pavement performance,
4. The impact/benefit of implementing the Direct Tension Test in Superpave binder specifications,
5. Measurement of bulk specific gravity of compacted hot mix asphalt (Corelok),
6. Not all Superpave Gyratory Compactors are generating the same bulk specific gravity values for the same compaction effort for the same mixes,
7. The need for a performance test to accompany the Superpave Mixture Design system, and
8. A review of APA specifications in different states.

Discussion between the Michigan, Minnesota, and Wisconsin DOT's was initiated on areas that are of common interest for technology transfer and potentially research. These discussions are continuing into 2002 .

APPENDIX A

QUARTERLY REPORTS FOR PROJECT

FIRST QUARTERLY REPORT

Synthesis and Review of Superpave Implementation

I. Introduction

Michigan Technological University (MTU) is the principal contractor on this project, *Synthesis and Review of Superpave Implementation.* This First Quarterly Report is submitted to the Michigan Department of Transportation to outline the work accomplished during the reporting period, identify problems (current and anticipated), and to describe any deviations from the agreed Work Plan. This Quarterly Report is arranged by the tasks described in the project Work Plan.

II. Task 1: Participation in Ongoing Superpave Implementation Activities

This task has is an ongoing activity. Five significant meetings were attended during this quarter. The first meeting was meeting with MDOT and Michigan industry for a bituminous mixtures meeting in Lansing on July 19th. The primary discussion point was development of a polymer modified asphalt binder specification. Two main points for the new specification were for permanent deformation and durability performance. Some discussion pertaining to the percentages of polymer in the binder being reported were raised.

The second meeting attended was the National Stone Association – National Aggregate Association (NSA –

NAA) Research Advisory Group Meeting in Birmingham, Alabama July 30- August 1. The NSA – NAA Research Advisory Group outlined several potential research projects in a few different areas. This list and prioritization is attached in Appendix A. The research projects identified by the NSA – NAA Research Advisory Group in 1998 is attached in Appendix B too. Chris Williams provided an update on the Pavement Design, Construction, and Materials Enterprise as well as other ongoing research projects that are aggregate related to the NSA – NAA at Michigan Tech.

A third meeting occurred at the National Center for Asphalt Technology (NCAT) at Auburn, Alabama on August 2. A tour of the new NCAT facilities and test track took place. Discussions on the Pavement Design, Construction and Materials Enterprise as well as research topics took place. The two research topics discussed in detail were the differences in compaction between Superpave Gyratory Compactors (SGC) and measurement of fine aggregate specific gravity. A device that will independently calibrate SGC's is being developed/refined and alpha tested. NCAT has found some differences between SGC's gyration angles when in compaction mode even though the manufacturer's calibration methods have been just previously executed. The research project involved with measuring the specific gravity of fine aggregate is continuing to undergo refinement with Barnstead/Thermolyne. Michigan Tech was invited to participate in the study through making specific gravity measurements using Micrometronics Accupyc and Geopyc to verify values and mercury porisimeter readings.

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implementation of the Superpave mixture design procedures. However, they are continuing to have a lot of discussion with field personnel on the pros and cons between the Marshall and Superpave methods. The greatest concern the COE is facing with Superpave is the lack of a performance test. The method of preparing specimens the COE is using for beam fatigue and Thermal Stress Restrained Specimen Testing is actual field compaction utilizing a sidewalk compactor. This compaction procedure follows the method that UC-Berkeley has established. The compaction method

The last meeting attended was the Asphalt Pavement Analyzer (APA) User Group Meeting in Jackson, Mississippi on September 26 and 27. A total of 21 State DOTs were represented at the meeting. Discussions on the use and specifications of the APA were held throughout the meeting. The meeting minutes are expected soon, which will summarize how States are using the APA and will be provided to the MDOT TAG as soon as they are received.

II.1. *Task 1 Problems and/or Deviations from Work Plan*

There were no problems or deviations for Task 1 incurred during the reporting period.

III. Task 2: Synthesis of Implementation Activities Relevant to Michigan

The quarterly report submission covers this task of the project in that the information exchange is to occur through the quarterly reports.

IiI.1. Task 3 Problems and/or Deviations from Work Plan

There were no problems or deviations for Task 2 incurred during the reporting period.

IV. Project Meetings

No project meetings were held during this quarter. We are in the midst of scheduling a TAG meeting for the first quarter of 2001.

APPENDIX A: 2000 NSA Research Advisory Group Meeting

Prioritized List of Research Topics

From Research Advisory Group Meeting

Birmingham, AL

August 1, 2000

Fine Aggregate Asphalt Mixes

Fine-graded Superpave mixes typically outperform coarse-graded mixes. Research is needed to look at fine (< 9.5 mm) mixes, especially using "screenings," since these were not included in the SHRP research.

Influence of Aggregate Particle Shape on Performance

Aggregate particle shape influences performance of hot mix asphalt, portland cement concrete, and unbound base. Specifications typically are based on anecdotal evidence. Research is needed to quantify the influence of particle shape on performance and establish proper criteria. A precise, fast, cost effective and locally usable test (e.g. video imaging) is needed to describe particle shape and size distribution characteristics.

Accelerated Testing for Aggregate Performance Prediction

Aggregate specifications must be based on performance. Accelerated testing techniques are now available to accurately predict field performance. Research is needed to determine the best ways to incorporate these techniques into existing aggregate specifications.

Effect of Aggregate Properties on Concrete Workability

The commonly used slump test does not adequately predict workability of mixes containing high-fines, dense gradings or angular, rough-textured particles. Better predictive methods than the slump test are needed to gauge the effect of aggregate properties on workability.

Design Procedures Using Finite Element Modeling

Finite element models are superior to currently used layered-elastic models for accurately characterizing performance of unbound aggregate base materials. Additional research is needed to incorporate finite element analysis techniques into pavement design procedures.

Catalog of Base Material Properties

The evolving mechanistic pavement design procedures will eventually use finite element models to predict performance. These will require input of material characteristics obtained using sophisticated testing procedures. Most materials suppliers or designers will be unable to obtain these parameters easily or cost effectively, which will delay acceptance and use of proper design procedures. To insure that the best characterization of unbound aggregate base is utilized, a catalog of properties for different base materials is needed to make appropriate input values available for the finite element models.

Aggregate Property Influence on Performance

The identification and quantification of the influence of aggregate properties on end-use performance is needed, especially regarding the increasing use of construction warranties. Aggregate suppliers and customers need better understanding of these relationships in order to select products best suited for meeting warranty provisions. This includes changes in aggregate properties during production, handling, construction and

service.

Micro-Deval Test Evaluation

The Micro-Deval test procedure is being proposed as a better measure of aggregate durability. This test should be evaluated to determine its relationship to performance and to establish proper specification limits.

Brainstorming Topics

Research Advisory Group Meeting

Birmingham, AL

August 1, 2000

Hot Mix Asphalt -

- Fine Aggregate Mixes (<9.5 mm, screenings)
- Friction-Skid Resistance (Lab tests vs. field performance
- Shape vs. performance
- F&E Ratios – appropriate levels
- Correlation of aggregate surface energy to rutting and moisture sensitivity
- Accelerated testing - tie together performance and aggregate properties
- Performance of recycled materials as aggregates
- Aggregate properties that effect workability
- Aggregate properties that effect surface noise and rideability
- Aggregate degradation in the ignition oven

Portland Cement Concrete –

- Shape vs. performance
- Durability of high-fines concrete mixes
- Design of RCC as pavement
- ASR Mitigation and round robin for the new test

- More rapid test method for freeze-thaw (e.g. Cryogenic)
- Performance of recycled materials as aggregates
- Sulfate attack
- Develop a new test for workability (dynamic vs. static) - effect of aggregate properties
- Aggregates influence on design of pavement thickness and joint design
- Aggregate properties that effect surface noise and rideability
- Permeability/porous concrete – environmental issues and guidelines for use
- Aggregate properties for HPC
- Chlorides – test methods and significance to pcc (acid vs. water soluble)
- Fines for bleed resistance

Base –

- Rotational stresses – rutting potential (WES research – finite element modeling)
- Catalog of properties of different Base materials
- Design and construction of base
- Design procedures using finite element modeling
- Large-scale loading tests
- Revise AASHTO T294
- Aggregates industry to promote better lab tests and champion best modeling
- Performance of recycled materials as aggregates
- Stabilized materials/ fiber stabilized sands and fines
- Effect of recycled concrete leachate on fabric filters and the environmental impact

Miscellaneous –

- Performance vs. aggregate properties for shape and degradation (especially during production, handling, construction, and in-service)
- Education programs for designers and specifiers
- Best practice guidelines (degradation)
- Warranties – aggregate quality requirements
- Correlation of core tests and plant productivity
- Expert systems – knowledge base and transfer
- Carbonate aggregates in landfills
- Crushed aggregates for liners
- Video imaging – shape and grading (for plant use – cost effective)
- Micro-Deval evaluation
- Better traffic quantification
- Shape – best test methods and numerical quantification
- Resistively test methods
- Synthesis of research data on specific topics
- Applicability of Methylene Blue test

APPENDIX B: 1998 NSA Research Advisory Group Meeting

Prioritized List of Research Topics

From Research Advisory Group Meeting

Arlington, VA

August 11, 1998

4. Effect of aggregate shape, angularity, surface texture, and dust on HMA performance

   Several efforts are underway looking at individual characteristics as specified in Superpave mix designs. Effort is required to look at the combined effect on actual performance of pavements.

5. Optimizing gradation, shape, and texture of aggregates for portland cement concrete

   Concrete historically is made up of a coarse aggregate product and a natural sand. Work is underway looking at increasing the amount of manufactured sand fines (minus 200 sieve) permitted in concrete. Additional effort is need looking at the entire blended aggregate, as well as the influences of particle shape and surface texture, and to establish the level of each property needed to optimize the mixture and produce and economical mix with the desired properties.

6. Use of accelerated pavement tests (APT) to relate aggregate properties to HMA pavement performance

   APTs are equipment that study the effect of simulated real truck loads on full size asphalt pavement specimens. The have gained acceptance and are becoming a valid method to demonstrate performance outside the laboratory without waiting 8-20 years to get results from a real road. The proposed research

should permit quantification of the contribution of quality aggregates.

7. Develop protocol for selection of stabilizers for bases/subbases (including use of more fines)

Currently geotextiles and chemical additives are being used to develop drainable layers and are cutting into classical aggregate base sales. Research is need to develop a decision method (protocol) for designers and specifiers that will include information on the use of stabilizers to improve the properties of the aggregate base materials and allow aggregate base to compete on its true technical merits.

8. Characterization of aggregates for mechanistic design of bases

Future pavement design (currently being developed for the year 2002) will be a "mechanistic design" using stress-strain theory and strength of materials. Unbound aggregates (as in base courses) do not behave like other construction materials such as steel, concrete or HMA. Research is needed to develop information and test procedures to quantify aggregate behavior properties so that our materials are accurately considered in the new design procedures.

9. Characterization of aggregate shape, angularity, and surface texture

A method is needed to be able to truly account for aggregate difference due to: round vs. cubical vs. slivery and rough vs. smooth. Current methods do not differentiate accurately enough.

10. Grading variability at the HMA plant and its effect on volumetrics

We know that aggregates abrade each time they are handled during the mixing process and that changes the gradation. We also know that the gradation of an aggregate product varies slightly during quarry operations. We do not know what these variations do to the final HMA product as compared to the actual asphalt mix as designed in the laboratory. We need to know this for plant design and process control.

8-12-98

List of Research Topics

From Research Advisory Group Meeting

Arlington, VA

(As Typed by Rick Meininger from the Sheets, Some Editorial Clarification and Reorganization)

1 — Final Combined Priority List – In order by ranking as voted by the group

Effect of aggregate shape, angularity, surface texture, and dust on HMA performance

Optimizing gradation, shape, and texture of aggregates for PCC (PCC-12; PCC-6)

Use of accelerated pavement tests (APT) to relate aggregate properties to HMA pavement performance

Develop protocol for selection of stabilizers for bases/subbases (including use of more fines)

Characterization of aggregates for mechanistic design of bases

Characterization of aggregate shape, angularity, and surface texture

Grading variability at the HMA plant and its effect on volumetrics

2 — Hot Mix Asphalt Concrete (HMA) List

Dust in asphalt mixes

Degradation of aggregates through the plant and correction factors for design

Effect of aggregate shape, angularity, and surface texture on performance

Grading variability at the HMA plant and its effect on volumetrics

Development of a specification test for aggregate susceptibility to moisture damage in the mix (interface)

LA degradation requirement (include micro-deval test) related to performance of mix (AC-3)

Automatic grading system (AC-11)

Evaluation of volumetric grading systems

Asphalt concrete surface friction -- roll of aggregates

Development of lab test procedures to support volumetric mix design and production

Reduced cost for SMA mixtures (AC-8)

Encourage use of APT to relate aggregate properties to HMA performance

Moisture movement in asphalt mixtures

Develop lab techniques to quantify pore size distribution

Effect of moisture in aggregates on HMA production

3 — Portland Cement Concrete (PCC) List

Investigation of large stone mixes for pavements

Optimizing gradation of aggregates for PCC (PCC-12; PCC-6)

Optimization of aggregate shape to produce economical, workable concrete (PCC-12)

Effect of aggregates on thermal and shrinkage response in pavements (including design)

Roll of aggregates during hydration of concrete

Aggregate-paste interface (PCC-19)

Roll of aggregates in DEF

Aggregate test methods for recycled PCC (PCC-13)

Roll of aggregates in D-cracking (PCC-14)

Effect of deicing salts on aggregate performance in PCC (PCC-17)

Roll of aggregates when popouts occur (PCC-18)

Roll of aggregates in permeability

Production of aggregates for High Performance Concrete (HPC)

4 — Unbound Aggregate Base List

Characterization of aggregates for mechanistic design

Evaluation of aggregate base course in pavement performance

Fines in pavement bases (UB-3)

Develop protocol for selection of stabilizers for bases/subbases (including use of more fines)

Mitigating the effect of recycled crushed concrete on fabric filters

Demonstration and promotion of sand filters as an alternative to fabrics

Measuring in-situ properties of bases (including anisotropic effects)

Development of constitutive models for predicting behavior of bases

Develop an aggregate materials characterization index for bases

Drainage characteristics of bases

5 — Other Research List

Characterization of aggregate shape, angularity, and surface texture

Minimizing fines in production

High wall assessment, and prediction of aggregate performance

Depletion of aggregate sources in urban areas

Serpentine rock issue (asbestos)

Definitive soundness or freeze-thaw test for performance prediction (alternative to C88; a rapid test)

Rapid test methods for QC/QA

SECOND QUARTERLY REPORT

Synthesis and Review of Superpave Implementation

I. Introduction

Michigan Technological University (MTU) is the principal contractor on this project, *Synthesis and Review of Superpave Implementation*. This Second Quarterly Report is submitted to the Michigan Department of Transportation to outline the work accomplished during the reporting period, identify problems (current and anticipated), and to describe any deviations from the agreed Work Plan. This Quarterly Report is arranged by the tasks described in the project Work Plan.

II. Task 1: Participation in Ongoing Superpave Implementation Activities

This task has is an ongoing activity. Three significant meetings were attended during this quarter. The first meeting was at the National Center for Asphalt Technology's open house in Auburn, Alabama on October 23 – 24, 2000. Several newer technologies were demonstrated at the open house, which may be beneficial to MDOT. The two most promising technologies are:

- Corelok
- Fine Aggregate Specific Gravity measurement device

The Corelok has been presented as a device capable of more accurately measuring bulk specific gravity of compacted HMA samples and the maximum specific gravity of loose HMA. Michigan Tech will be acquiring

a Corelok and will perform parallel testing on samples that are tested in accordance with AASHTO T 166 (*Bulk Specific Gravity of Compacted Bituminous Mixtures Using Saturated Surface-Dry Specimens*). Researchers at Michigan Tech are not as confident on the Corelok's ability to measure the *Maximum Specific Gravity of Bituminous Paving Mixtures* (AASHTO T 209) and may examine this test approach later.

Barnstead/Thermolyne has developed a new test device that measures fine aggregate specific gravity. The basic concept of the new device is using a laser system that determines the point when reflected light measurements significantly change (the sample is going beyond the surface dried condition). This device has a lot of potential to significantly improve the repeatability of measuring fine aggregate specific gravities for a single operator and between laboratories. Michigan Tech will be acquiring one these devices and has volunteered to participate in a round robin study. Tentatively, Michigan Tech will perform parallel testing according to AASHTO T 84 (*Specific Gravity and Absorption of Fine Aggregate*) and using Micromeritics Accupyc and Geopyc.

The second meeting attended was the Wisconsin Asphalt Pavement Association meeting in Middleton, WI on November 28-29, 2000. A Michigan Tech student, Jamie Olson, was the recipient of a $1000 scholarship recognizing her work in the asphalt pavement industry. Discussions with the Wisconsin DOT revealed that different types of gyratory compactors may be producing different bulk specific gravity values and could be of concern. Judy Ryan asked if Michigan Tech would participate in a round robin study looking at the gyratory compactor issue. Michigan Tech agreed to compact samples in three gyratory compactors they have in their facilities (big Pine, little Pine, and Brovold) and will provide statistical analysis support. The Wisconsin DOT

central lab will mix samples and ship them to participating labs with heating/temperature instructions in January, 2001.

The third meeting was meeting with MDOT and Michigan industry for a bituminous mixtures meeting in Lansing on November 30th at the Michigan Asphalt Pavement Association's new building. The primary discussion point was quality control testing of binder's. An example of the process that was followed in one case this past summer was distributed. A discussion of responsibility for binder quality ensued (sampling trucks leaving a terminal verses trucks at plants). Placement of added information on truck slips was also discussed.

Industry inquired about the newer binder specifications being balloted by AASHTO with the Direct Tension Test (DTT) and Bending Beam Rheometer (BBR). Chris Williams was asked to give a presentation on the DT and BBR specifications at the next mixture's specification meeting.

An afternoon meeting on November 30th discussing the study results for *The Development of Laboratory Performance Test Procedures and Trial Specifications for Hot Mix Asphalt took place at Construction and Technology.* At this same meeting, highlighting some of the technologies discussed above were presented.

II.1. Task 1 Problems and/or Deviations from Work Plan

There were no problems or deviations for Task 1 incurred during the reporting period.

III. Task 2: Synthesis of Implementation Activities Relevant to Michigan

The quarterly report submission covers this task of the project in that the information exchange is to occur through the quarterly reports.

IiI.1. Task 3 Problems and/or Deviations from Work Plan

There were no problems or deviations for Task 2 incurred during the reporting period.

IV. Project Meetings

A project meeting was held during this quarter on November 30th. We are in the midst of scheduling a TAG meeting for the first quarter of 2001.

THIRD QUARTERLY REPORT

Synthesis and Review of Superpave Implementation

I. Introduction

Michigan Technological University (MTU) is the principal contractor on this project, *Synthesis and Review of Superpave Implementation.* This Third Quarterly Report is submitted to the Michigan Department of Transportation to outline the work accomplished during the reporting period, identify problems (current and anticipated), and to describe any deviations from the agreed Work Plan. This Quarterly Report is arranged by the tasks described in the project Work Plan.

II. Task 1: Participation in Ongoing Superpave Implementation Activities

This task has is an ongoing activity. Five significant meetings were attended during this quarter. The first meeting was at the Transportation Research Board's Annual Meeting in Washington, D.C. on January 7-11, 2001. Copies of the TRB preprint CD will be provided to MDOT. Several issues and technologies were brought up during paper presentations, committee meetings and technology demonstrations. A fine aggregate specific gravity measurement device manufactured by Barnstead/ Thermolyne was reviewed in detail. Michigan Tech has recently ordered one of the first 12 production units and will be performing comparison testing with AASHTO T-84. A brief report on the technology will be provided to MDOT encompassing the test results and statistical analyses.

The second meeting attended was the National Asphalt Pavement Association's Annual Meeting in Orlando,

Florida on February 1-5, 2001. Michigan Tech provided an update on the Pavement Design, Construction, and Materials Enterprise to the NAPA Educational committee. Several universities and the Transportation Research Board have requested information on the Enterprise program. The Michigan DOT has hired three of the graduating students from the program and is employing three for summer internships.

The third meeting was with the Minnesota Department of Transportation and attending the Minnesota Pavement Engineer's Conference in Minneapolis, Minnesota on February 21-22. Warranties and Perpetual Pavements were presented at the conference as well as research findings at MN/Roads to date. The Minnesota DOT invited Chris Williams to serve on a MN/Road advisory board and assist in providing research topics for potential study. Michigan DOT input will be solicited for advancement to a tentative meeting on May 8-9.

The fourth meeting attended was on March 1 in Lansing, Michigan with the Bituminous Mixtures Specification Committee. In the afternoon, Chris Williams meet with MDOT personnel from the bituminous unit and representatives from Thompson-McCulley to discuss the ongoing investigation of pavements on I-96 in Lansing. A field inspection of the pavements was done and locations identified for Falling Weight Deflectometer (FWD) testing. FWD testing has been completed by MDOT and is being processed. Cores were also taken from the field by MDOT and provided to Michigan Tech in late March for evaluation and performance testing.

The fifth meeting of the quarter was at the Association of the Asphalt Paving Technologist in Clearwater, Florida on March 17-21. A compact disc of the proceedings of the meeting is being provided to MDOT.

Three copies of the 75th Anniversary Edition of AAPT are also being provided to MDOT. The edition summarizes a broad scope of technology and technical information covering the past 25 years. Copies of the preprint CD will be provided to MDOT.

II.1. Task 1 Problems and/or Deviations from Work Plan

There were no problems or deviations for Task 1 incurred during the reporting period.

III. Task 2: Synthesis of Implementation Activities Relevant to Michigan

The quarterly report submission covers this task of the project in that the information exchange is to occur through the quarterly reports.

IiI.1. Task 3 Problems and/or Deviations from Work Plan

There were no problems or deviations for Task 2 incurred during the reporting period.

IV. Project Meetings

A project TAG meeting is being scheduled for the next quarter in June 2001.

FOURTH QUARTERLY REPORT

Synthesis and Review of Superpave Implementation

I. Introduction

Michigan Technological University (MTU) is the principal contractor on this project, *Synthesis and Review of Superpave Implementation.* This Third Quarterly Report is submitted to the Michigan Department of Transportation to outline the work accomplished during the reporting period, identify problems (current and anticipated), and to describe any deviations from the agreed Work Plan. This Quarterly Report is arranged by the tasks described in the project Work Plan.

II. Task 1: Participation in Ongoing Superpave Implementation Activities

This task has is an ongoing activity. Several significant meetings were attended during this quarter. The first meeting was the County Engineer's Meeting in Mt. Pleasant on April 3-4. A presentation on pavement preservation of asphalt pavements was presented. The presentation is being forwarded as part of this quarterly report.

On April 6, a bituminous mixtures specification (BMS) meeting was attended in Lansing, which a presentation on the AASHTO proposed direct tension test procedures was given by Dr. Williams. The presentation is provided as part of this quarterly report. A second BMS meeting in Lansing was attended on June 5. The main topics of discussion at the BMS meeting were a specification on thin HMA overlays and low temperature binder specifications for the Upper Peninsula.

The Midwest Pavement Preservation Consortium (MPPC) was attended in Grand Rapids, Michigan on April 10 and 11. The MPPC was a partner meeting that initiated several project statements for research, technology transfer, and training. The MPPC project statements were moved forward to the Sacramento Pavement Preservation meeting on June 21-22. Additional problem statements for pavement preservation were generated, resulting in about 30 one-page problem statements for AASHTO. The draft final document will be provided when complete, which is expected the next quarter. The two project statements Dr. Williams was asked to draft are attached as part of this quarterly report.

The Minnesota DOT invited Dr. Williams to participate in helping identify research topics in the bituminous area for the next set of MN/ROAD experiments. Two ½-day meetings have taken place at the MN/ROAD test facility on May 9 and June 13. The Minnesota DOT has expressed a strong interest in partnering with other regional states on research. A three state meeting (Michigan, Minnesota, and Wisconsin) is planned for July 12 and 13 at Michigan Tech focused on HMA topics.

A meeting with Conoco discussing use of carbon fiber technology in HMA as well as a strategy to mitigate reflective cracking took place in Houston, Texas and Ponca City, Oklahoma on May 31 and June 1. A research project with Conoco has been initiated with $35,000 in cost share from Conoco being provided for purchase of equipment in Michigan Tech's laboratories.

II.1. Task 1 Problems and/or Deviations from Work Plan

There were no problems or deviations for Task 1 incurred during the reporting period.

III. Task 2: Synthesis of Implementation Activities Relevant to Michigan

The quarterly report submission covers this task of the project in that the information exchange is to occur through the quarterly reports.

IiI.1. Task 3 Problems and/or Deviations from Work Plan

There were no problems or deviations for Task 2 incurred during the reporting period.

IV. Project Meetings

A project TAG meeting is being scheduled for the next quarter in July 2001.

FIFTH QUARTERLY REPORT

Synthesis and Review of Superpave Implementation

I. Introduction

Michigan Technological University (MTU) is the principal contractor on this project, *Synthesis and Review of Superpave Implementation.* This Fifth Quarterly Report is submitted to the Michigan Department of Transportation to outline the work accomplished during the reporting period, identify problems (current and anticipated), and to describe any deviations from the agreed Work Plan. This Quarterly Report is arranged by the tasks described in the project Work Plan.

II. Task 1: Participation in Ongoing Superpave Implementation Activities

This task has is an ongoing activity. Two significant meetings were attended during this quarter. The first meeting was at Michigan Tech with the Michigan, Minnesota, and Wisconsin DOT's. The purpose of the meeting was to see if there are potential areas of cooperation on research projects that the three States could identify and work on together. The main focus of the meeting was to set up a means for operating and then identify potential projects. A follow-up meeting was scheduled at Michigan Tech for October 4th. The meeting minutes for both the July 12 & 13 and October 4 meeting will be sent with this quarter report.

The second meeting was meeting with MDOT and Michigan industry for a Bituminous Mixtures meeting in Lansing on July 23rd and coincided with a TAG meeting for this project. The meeting focused on binder grades in the Upper Peninsula of Michigan. The industry is interested in relaxing the low temperature binder

grade from –34 to –28 Celsius. The Long Term Pavement Performance software indicates that this change would result in less than 75% level of reliability in some locations for surface mixtures.

A morning meeting on July 23rd discussed some of the study results for *The Development of Laboratory Performance Test Procedures and Trial Specifications for Hot Mix Asphalt took place at Construction and Technology.*

Barnstead/Thermolyne will be delivering their new test device that measures fine aggregate specific gravity as described in the January Quarterly Report. Michigan Tech will conduct companion testing in accordance with AASHTO T 84 (*Specific Gravity and Absorption of Fine Aggregate*) for comparison.

II.1. *Task 1 Problems and/or Deviations from Work Plan*

There were no problems or deviations for Task 1 incurred during the reporting period.

III. Task 2: Synthesis of Implementation Activities Relevant to Michigan

The quarterly report submission covers this task of the project in that the information exchange is to occur through the quarterly reports.

Iil.1. Task 3 Problems and/or Deviations from Work Plan

There were no problems or deviations for Task 2 incurred during the reporting period.

IV. Project Meetings

A project meeting was held during this quarter on July 23rd. A second TAG meeting was tentatively scheduled for September 19th to coincide with the Bituminous Mixtures Meeting with industry. Due to travel conditions resulting for events the previous week, September 11th, Michigan Tech postponed the meeting.

APPENDIX B

"Adding the Direct Tension Test to the Superpave Binder Specifications"

Why Change The PG Binder Specification?

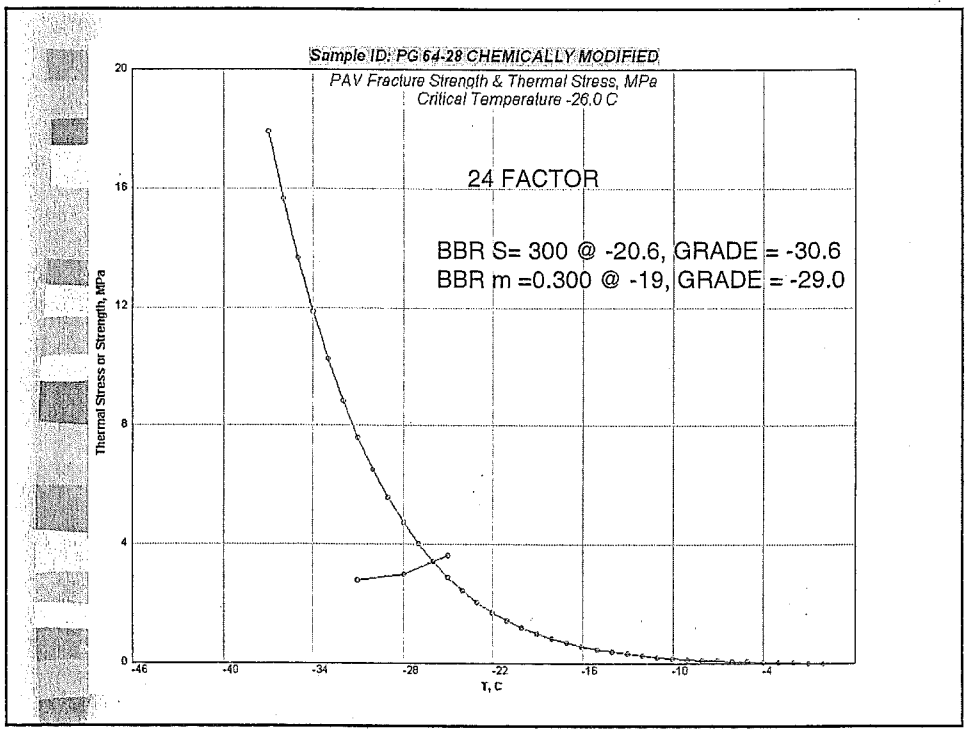
Adding The Direct Tension Test

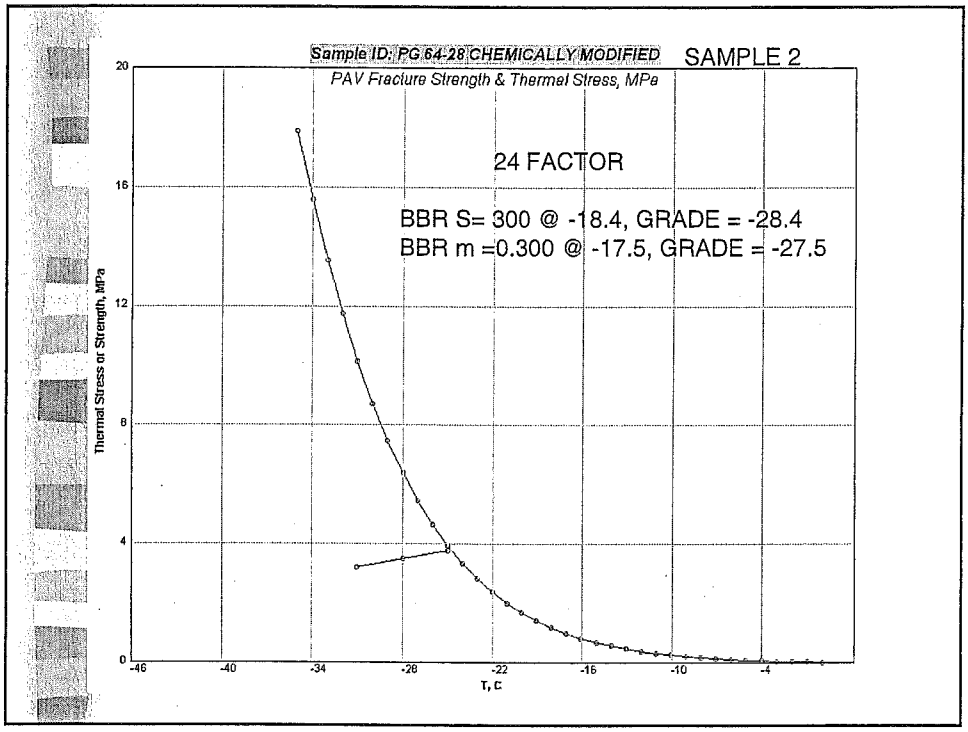
Change the PG Binder Low-Temperature Specification Because-

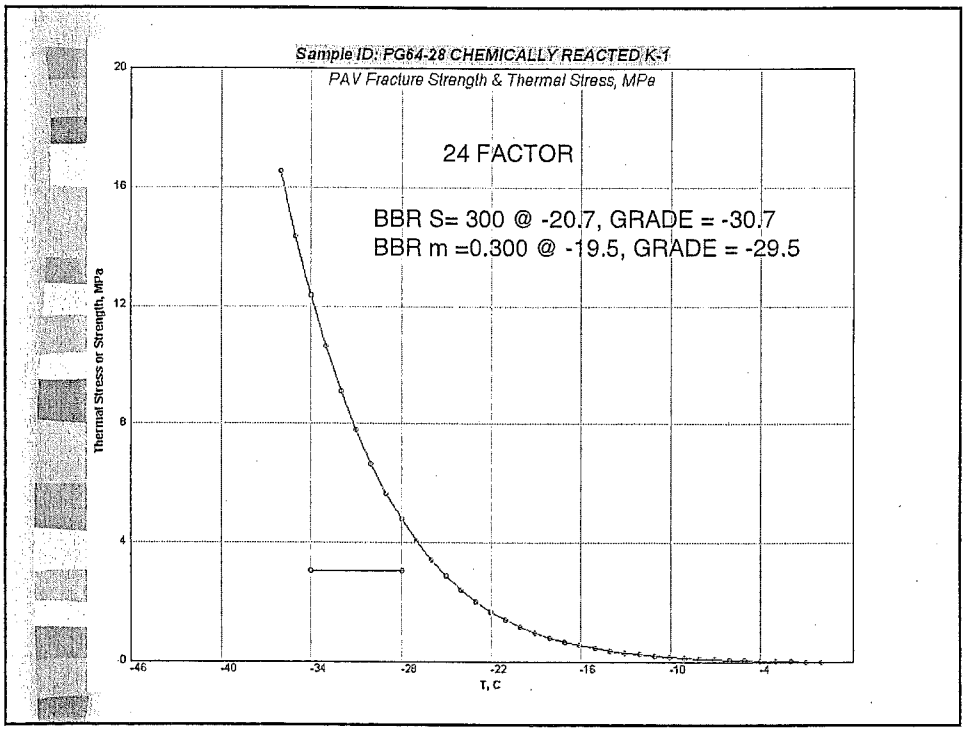
- Problems with m-value for PMAs
- S and m are easy to manipulate
- Strength of the Binder is not Considered
- Difficult to Distinguish Between
  - Straight Run
  - New Chemical Treatments (Modifications)
- S and m do not differentiate between Crude Sources

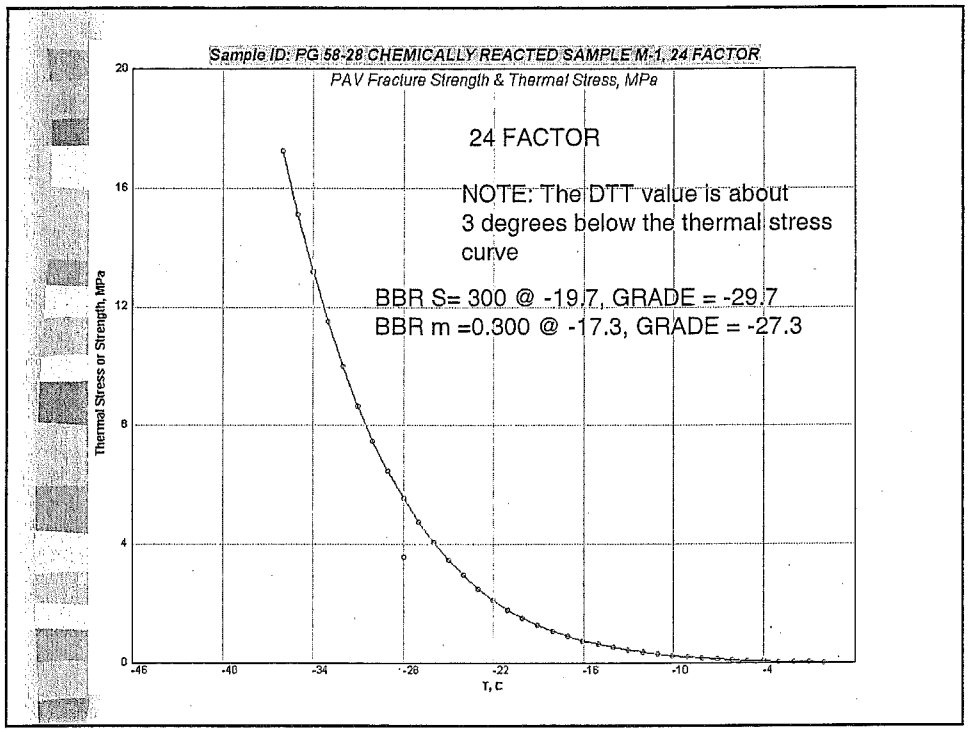
Effect of Polymer Network on m-value

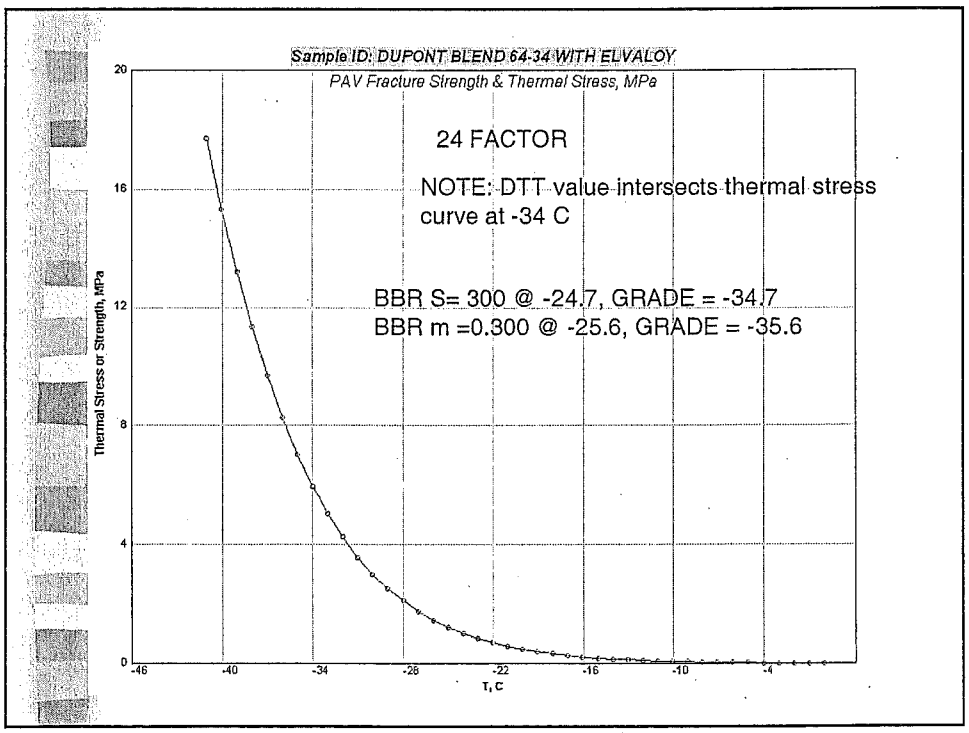
	T_{cr} m-value	T_{cr} S(60s)
Base AC	-39.7	-35.8
Base AC w/ 5% Polymer	-31.9	-36.3

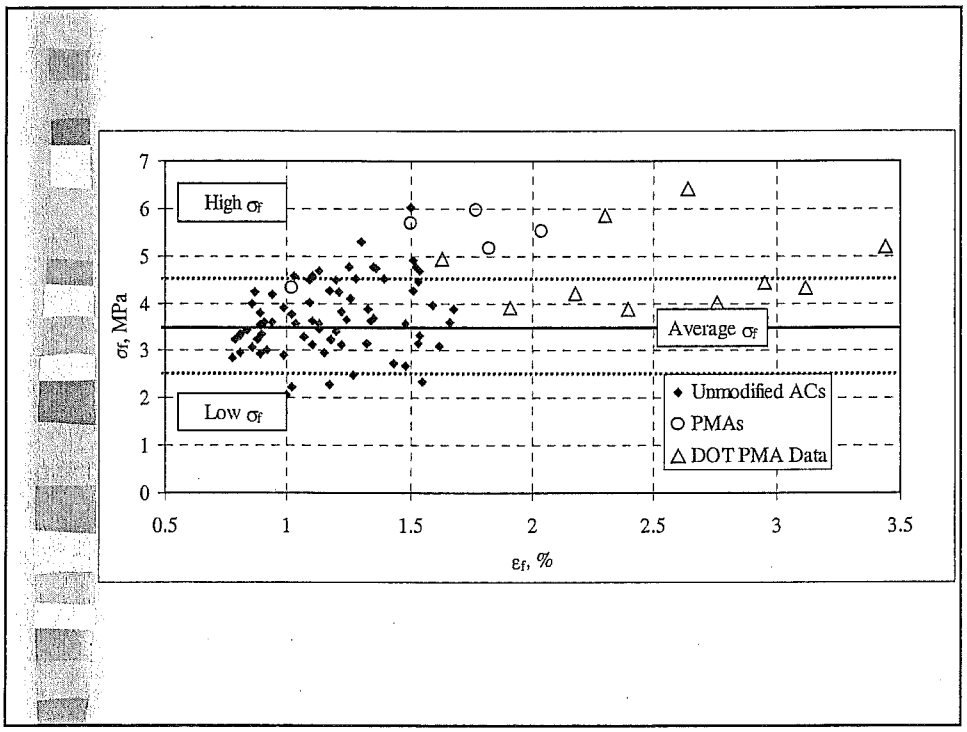


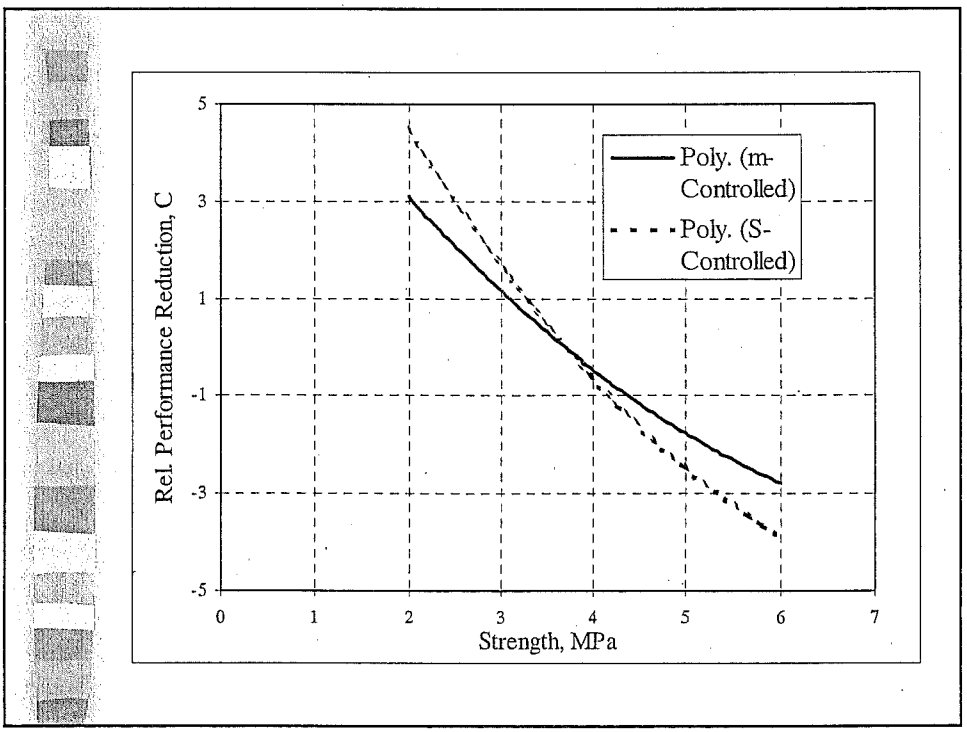

Sample ID: PG 64-28 CHEMICALLY MODIFIED
SAMPLE 2
PAV Fracture Strength & Thermal Stress, MPa
24 FACTOR
BBR S= 300 @ -18.4, GRADE = -28.4
BBR m =0.300 @ -17.5, GRADE = -27.5
Thermal Stress or Strength, MPa
T, C


Sample ID: PG64-28 CHEMICALLY REACTED K-1
PAV Fracture Strength & Thermal Stress, MPa
24 FACTOR
BBR S= 300 @ -20.7, GRADE = -30.7
BBR m =0.300 @ -19.5, GRADE = -29.5
Thermal Stress or Strength, MPa
T, C


Sample ID: PG 58-28 CHEMICALLY REACTED SAMPLE M-1, 24 FACTOR
PAV Fracture Strength & Thermal Stress, MPa
24 FACTOR
NOTE: The DTT value is about 3 degrees below the thermal stress curve
BBR S= 300 @ -19.7, GRADE = -29.7
BBR m =0.300 @ -17.3, GRADE = -27.3
Thermal Stress or Strength, MPa
T, C


Sample ID: DUPONT BLEND 64-34 WITH ELVALOY
PAV Fracture Strength & Thermal Stress, MPa
24 FACTOR
NOTE: DTT value intersects thermal stress curve at -34 C
BBR S= 300 @ -24.7, GRADE = -34.7
BBR m =0.300 @ -25.6, GRADE = -35.6
Thermal Stress or Strength, MPa
T, C

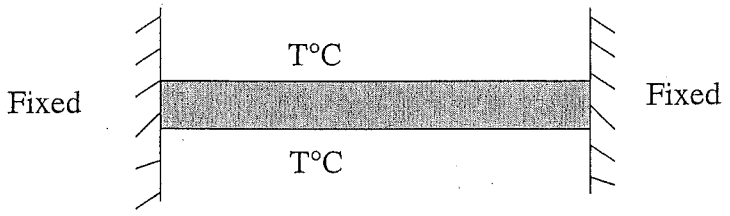

High σf
Low σf
Average σf
Unmodified ACs
PMAs
DOT PMA Data
σf, MPa
εf, %
0
1
2
3
4
5
6
7
0.5
1
1.5
2
2.5
3
3.5


Poly. (m-Controlled)
Poly. (S-Controlled)
Rel. Performance Reduction, C
Strength, MPa
5
3
1
-1
-3
-5
0
1
2
3
4
5
6
7

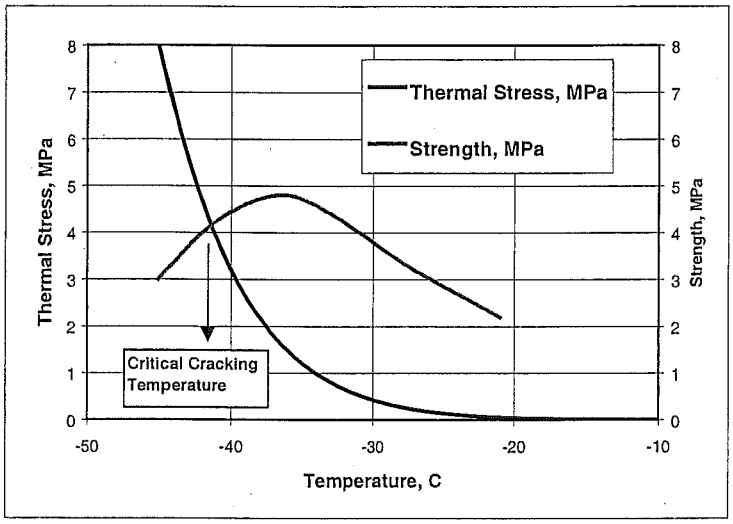
Change the PG Binder Low-Temperature Specification Because-

- New Procedure is Robust and Rational
- Considers Binder Strength
  - Strength is Quality Sensitive
  - Strength Can Differentiate Between Crude Sources
- Benefits of PMAs are Accounted
- No False Positives!

Model

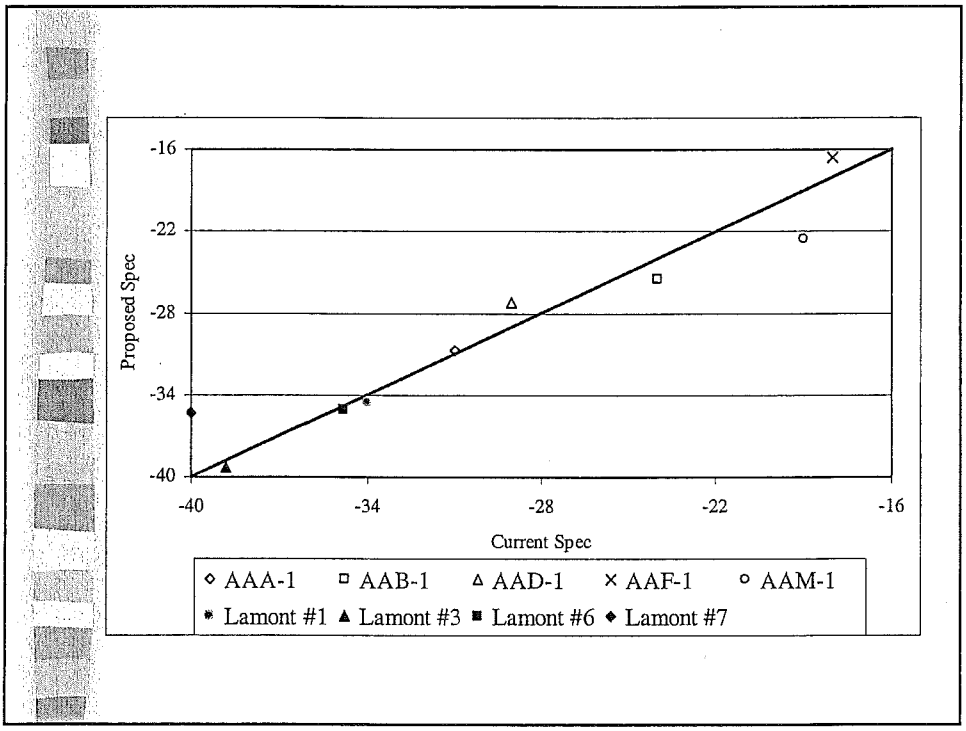


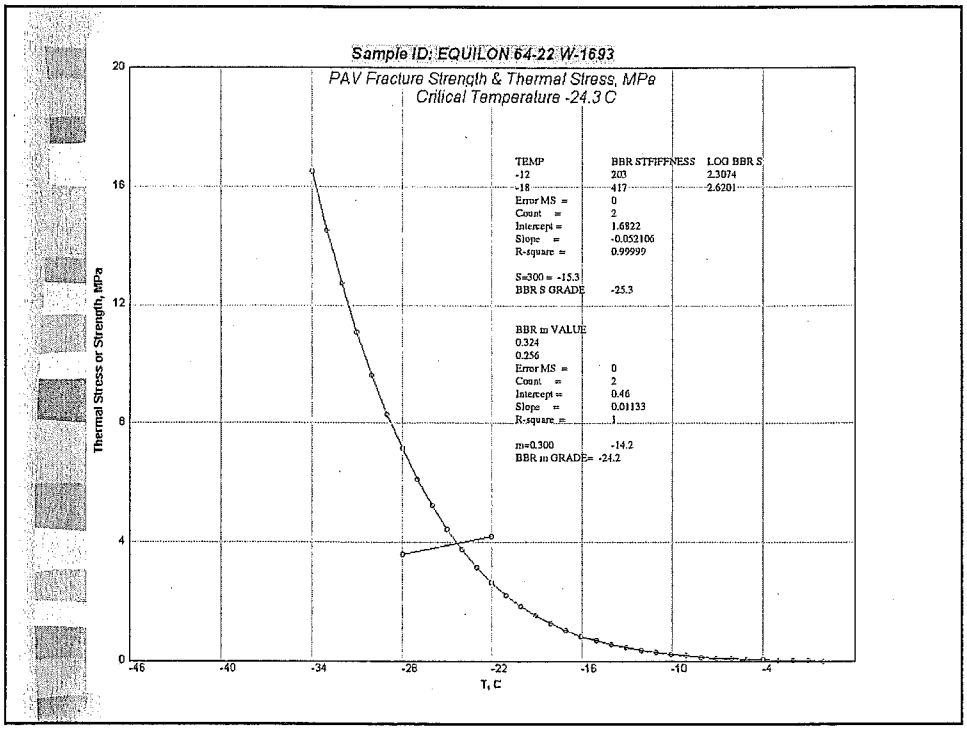
New Low-Temperature Cracking Specification Proposal



Specification Parameters?

- $\sigma_{thermal} < \sigma_{failure}$
- $\sigma_{thermal} = S \bullet \varepsilon_{thermal} = S \bullet \alpha \Delta T < \sigma_{failure}$
- therefore, $\alpha \Delta T < \sigma_f / S$
  - but α is constant, so
- Minimize S and Maximize σ_f
- What about the m-value ?


-16
-22
-28
-34
-40
Proposed Spec
-40
-34
-28
-22
-16
Current Spec
◇ AAA-1
□ AAB-1
△ AAD-1
× AAF-1
○ AAM-1
* Lamont #1
▲ Lamont #3
■ Lamont #6
◆ Lamont #7


Sample ID: EQUILON 64-22 W-1693
PAV Fracture Strength & Thermal Stress, MPa
Critical Temperature -24.3 C
TEMP BBR STIFFNESS LOG BBR S
-12 203 2.3074
-18 417 2.6201
Error MS = 0
Count = 2
Intercept = 1.6822
Slope = -0.052106
R-square = 0.99999
S=300 = -15.3
BBR S GRADE -25.3
BBR m VALUE
0.324
0.256
Error MS = 0
Count = 2
Intercept = 0.46
Slope = 0.01133
R-square = 1
m=0.300 -14.2
BBR m GRADE= -24.2
Thermal Stress or Strength, MPa
20
16
12
8
4
0
-46
-40
-34
-28
-22
-16
-10
-4
T, C

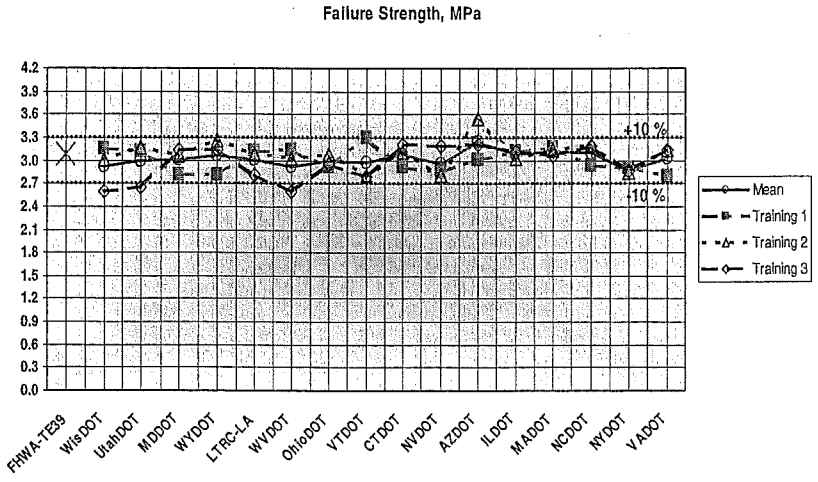
Sample	T_{cr} (S(60s))	T_{cr} (m-value)	T_{cr} (model)	T_{min} (field)	T_{min} (field)	Model Cooling Rate	Field Cooling Rate
	C					C/hr	
Depth	12.5mm				air	12.5mm	
Black Max	-39.6	-40.6	-38.0	approx. -38	approx. -45	1	NA
Mapco	-32.5	-31.1	-32.5	approx. -33	approx. -35	1	NA
PA-TestSec #1	-18.8	-23.4	-16.0	-19.5	-28.9	1	2-3
PA-Test Sec #3	-26.5	-26.7	-26.0	< -22.3	<-32.8	1	2-3
PA-Test Sec #5	-22.6	NA	-21.0	> -19.5	> -28.9	1	2-3
PA-Test Sec #5	-22.6	NA	-18.5	> -19.5	> -28.9	3	2-3

Effect of Polymer Modification Current vs. Proposed

Binder	T_{cr} Current Spec	T_{cr} Proposed Spec
70-22 Air Blown	-24.5	-20.5
70-22 Conventional	-25.1	-20.5
70-22 SBS Modified	-26.0	-28.5

Training of DOT Personnel

- Six DOT Techs Per Group
- 2 DTTs – Plan to Have 3 DTTs
- 20 h Total at Instron in Boston
- Data
  - Citgo 67-22 Asphalt
  - 3 sets of Tests (6, 6, and 3)
- Trained 16 DOT Techs to Date



Acknowledgements

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