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Guidelines for Project Selection and Materials Sampling, Conditioning, and Testing in WMA Research Studies

DETAILS

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AUTHORS

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NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

Responsible Senior Program Officer: E. T. Harrigan

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GUIDELINES FOR PROJECT SELECTION AND MATERIALS SAMPLING, CONDITIONING, AND TESTING IN WMA RESEARCH STUDIES

This digest summarizes the results of a "Workshop to Coordinate Key WMA Research Projects" sponsored by NCHRP Project Panels 9-43, 9-47, and 9-49 in conjunction with the AASHTO Highway Subcommittee on Materials, the Federal Highway Administration, and the National Asphalt Pavement Association. The workshop was held on May 13, 2011 at the National Academies' Arnold and Mabel Beckman Center, Irvine, CA. The notes on which this digest is based were prepared by Mr. Tom Baker, Washington State Department of Transportation; Messrs. Matthew Corrigan and John Bukowski, Federal Highway Administration; Dr. Jon Epps, Texas Transportation Institute; Dr. David Newcomb, formerly of the National Asphalt Pavement Association; and Dr. Edward Harrigan, National Cooperative Highway Research Program.

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INTRODUCTION

Warm mix asphalt (WMA) refers to asphalt mixtures produced at temperatures at least 50°F cooler than those typically used in the production of hot mix asphalt (HMA). The goal of WMA is to produce mixtures with similar strength, durability, and performance characteristics as HMA using substantially reduced production temperatures. Important environmental and health benefits are associated with reduced production temperatures, including lower greenhouse gas emissions, lower mix plant fuel consumption, and reduced exposure of workers to asphalt fumes. Lower production temperatures also can potentially improve pavement performance by reducing binder aging, providing added time for mixture compaction, and allowing improved compaction during cold weather paving.

The first WMA pavements were constructed in Europe in 1995 and in North America in 2004. Since that time, WMA production has substantially grown in the United States. For example, the FHWA estimates that 10% of the 358 million tons of asphalt mix placed nationwide in 2010 was WMA.

As the use of WMA has widened, so have the number of WMA technologies available to the industry. In 2011, 30 or more WMA technologies were available, classified into three broad categories: (1) those using organic additives, including waxes; (2) those using chemical additives; and (3) those using water-based foaming processes. Moreover, as these numbers suggest, WMA has rapidly moved from use in pilot and experimental projects to more routine, large-scale use. At present, at least 30 state departments of transportation (DOTs) have established specifications permitting the use of WMA.

This rapid growth in use of WMA use naturally raises questions about WMA pavement construction processes and the pavements' long-term durability and

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performance. Newcomb (*8*) has summarized these questions as follows:

- **Mix design:** What modifications to asphalt mix technology, if any, are required for designing WMA? How is the selection of binder performance grades impacted by the lower WMA production temperatures?
- **Long-term performance:** How do the short- and long-term performance and durability of pavements constructed with WMA compare with those constructed with HMA? How are these qualities affected by WMA technologies using foaming or chemical additives? Does WMA present an increased potential for distresses such as rutting and moisture damage?
- **Cost benefits:** What are the cost benefits of the reduced fuel consumption and emissions obtained with WMA?
- **Plant operations:** Is WMA compatible with the high production rates needed in the United States?
- **Control of mixing process:** Given that the various WMA mixing processes all differ to a greater or lesser degree from that of conventional HMA, are new guidelines needed for proper quality assurance of the mix?
- **Workability at the paving site:** Although the WMA may appear workable and easily compactable when produced, does it remain workable at the paving site?
- **Quick turnover to traffic:** Can WMA pavements be opened to traffic as soon as possible after construction, in a time frame similar to or earlier than conventional HMA pavements?

Answers to many of these questions are being pursued in WMA research studies informally coordinated through the FHWA's WMA Technical Working Group. For example, more than 15 state DOTs are currently sponsoring WMA research studies, and the 50 state DOTs are collectively sponsoring NCHRP projects investigating WMA mix design, the potential moisture susceptibility of WMA pavements, and whether WMA and HMA pavements provide significantly different short- and long-term performance. NCHRP projects planned for 2012 and later years will address the short-term laboratory aging of WMA for mix design and performance testing, characterization of foamed asphalt for WMA applications, and the use of recycled asphalt pavement (RAP) and recycled asphalt shingles (RAS) in WMA.

A potential shortcoming of such a large, diverse, and dynamic program is the difficulty of comparing results between laboratory and field studies using different experiment designs, conditioning protocols, and test methods to characterize the material properties and performance of WMA. To address this shortcoming, the "Workshop to Coordinate Key WMA Research Projects" was organized with the goal of fostering cooperation and coordination among research studies. Workshop participants sought to (1) identify the laboratory and field-test methods and sample preparation, curing, and conditioning procedures in use in FHWA-, NCHRP-, state DOT-, and industry-sponsored research projects and (2) agree on a core set of methods and procedures that would be commonly used, insofar as possible, in all present and future WMA studies. In addition, the workshop participants reviewed new and existing WMA field pavements included in short- and long-term WMA performance studies to facilitate sharing of their field materials and data, and developed selection criteria for future field pavements. The invited participants included researchers and practitioners from the public sector, academia, and industry, and representatives of the sponsoring organizations.

WORKSHOP RESULTS

The results of the workshop are presented in tables on the following pages. These tables present a proposed core set of criteria, methods, and protocols, including

- field project selection criteria (Table 1);
- specimen preparation methods (Table 2);
- conditioning methods for laboratory-mixed, laboratory-compacted (LMLC) specimens, plant-mixed, laboratory-compacted (PMLC) specimens, and plant-mixed, field-compacted (PMFC) specimens (Table 3);
- performance test methods for LMLC, PMLC, and PMFC specimens (Table 4, Table 5, Table 6, and Table 7); and
- binder and aggregate test methods (Table 8).

These criteria, methods, and protocols were arrived at through a consensus-building activity involving all the workshop participants. They represent the participants' collective judgment of the minimum complement necessary to enable correlation and comparison of results between or among WMA research studies. Use of this core set does not

(Text continues on p. 14.)

Table 1 Field project selection for short- and long-term performance studies.

Project length	**The minimum test section shall be ½ lane-mile in one travel lane located between intersections or interchanges. The plant temperature may be increased to produce the HMA control section. Shorter sections may be allowed if they are well planned and documented.** Notes: The ideal production per test section is 800–1000 tons or ½- to 1 day production or 1 tanker load of binder (400–600 tons of non-foamed WMA); these amounts will vary depending on the nominal maximum aggregate size (NMAS) of the mix. Although 1 day's production is often possible, test projects with control sections often are difficult to find. Selection of the minimum section length also must consider the type of WMA additive and where it is introduced.
Project and construction documentation	**NCAT and the University of Minnesota (for cold-climate projects) have developed detailed checklists for documenting field projects (see Appendix A).** Notes: Key considerations are (1) a condition survey of the existing pavement, (2) the pavement cross-section, (3) evaluation of pavement structural support, and (4) WMA production and compaction temperatures.
Control section definition	**The HMA control section must be identical to the WMA sections (including any RAP or RAS content) in all aspects but the presence of WMA, with the exception that the binder content of the control section may differ if necessary to attain identical air void contents in all sections.**
Minimum number of WMA technologies	**Minimum two technologies, plus a control.** However, this minimum number may be waived, depending on whether the project is a new pavement or an overlay on an existing pavement.
Other key features	(1) WMA and control sections must be surface mixes in the same travel lane and with the same pavement support throughout all sections. (2) The correct mix discharge temperatures for the WMA must be verified throughout the project. (3) New projects are favored, but existing projects may be used if the necessary requirements are met. It is sometimes feasible to work with the state DOT and contractor to add WMA sections to an HMA project through a change order. (4) Specific and systematic performance monitoring plans are required for new versus existing WMA projects. Both plan types should include the provision for forensic analysis when pavements exhibit significant distress. (5) In the event that a WMA project of interest was constructed without a control section, it may be possible to pair the WMA project with an otherwise unconnected HMA project constructed with similar materials, structure, condition, traffic, and climate (e.g., see Von Quintus, Mallela, and Buncher [*1*]). (6) Future field projects should consider (a) roadway functional classification (average daily traffic [ADT] and trucks per day [% trucks]); (b) a variety of mix types (e.g., stone mastic asphalt and open-graded friction courses); and performance in intersections. (7) RAP and RAS are permitted as long as identical control mixes are available. (8) For overlay projects, the WMA and control sections must have comparable levels of existing distress.

Table 2 Specimen preparation methods.

WMA binders for mix design	**Laboratory blending with low shear mechanical stirrer or foaming with laboratory-foamed asphalt plant, per the proposed appendix to AASHTO R 35 (*2*).** Notes: (1) Aggregate coating is the key measure of foaming. Use coating to help guide selection of temperature. (2) Mix design may not require production of foamed binder in laboratory. Rather, it may be feasible to add water and binder to a bucket mixer containing aggregate and obtain comparable results. (3) At present, there are three commercial units for producing foamed asphalt. It is not known how these units compare. Further, it is very difficult to test the properties of foamed binder in bucket during production, and the foaming is typically lost during transfer of the binder for mixing with the aggregate. In practice, however, no problems have been identified with foamed WMA. (4) Future research is needed to better define the requirements for laboratory production of foamed asphalt.
WMA binder extraction and recovery	A procedure such as that of Minnesota DOT is required. In the Minnesota DOT procedure, asphalt binder extractions are performed using AASHTO T 164 Method A (Centrifuge Method). Toluene is used as the extraction solvent for the first two washes with an 85:15 v/v mixture of toluene and 95% ethanol used for the third wash. ASTM D5404—Standard Practice for Recovery of Asphalt from Solution Using Rotary Evaporator—is followed for the binder recovery method with the following modifications: Bath temperature and vacuum settings for toluene distillation (60°C, 100mBar). Fines are removed from the extract by high-speed centrifuging at 2000 RPM for 35 minutes after volume of asphalt extract is reduced to ~500ml. Notes: (1) The FHWA memorandum *Extraction and Recovery Procedures at TFHRC Asphalt Laboratories* (Appendix B) provides detailed information on a preferred method of binder extraction and recovery. (2) The use of trichloroethylene (TCE) as the extraction solvent is discouraged. TCE is known to harden recovered binders beyond the *in situ* level. (3) Western Research Institute has developed an infrared spectroscopy method for detecting residual solvent in the recovered binder. (4) Research indicates that a higher temperature and vacuum than specified in ASTM D5404 may be required to effectively remove the toluene solvent from the recovered binder.

Table 2 (Continued)

LMLC specimens for mix design	1. Mix design: 150-mm diameter × 115-mm high at N_{design}. 2. Moisture sensitivity: 150-mm diameter × 95-mm high at 7.0±0.5% air voids. Note: Some researchers may also use complementary lower and higher air voids, e.g., 4.0% and 9.0%. 3. Dynamic modulus and flow number with AMPT: 100-mm diameter × 150-mm high cored and sawn from 150-mm diameter × 175-mm high specimens at 7.0±0.5% air voids (per appendix to AASHTO R 35 and 2011 change to AASHTO TP 79). 4. IDT creep and strength: 150-mm diameter × 50-mm high prepared from gyratory specimen. Note: It is recommended to cut only one specimen from the center of each 115-mm high gyratory specimen. 5. Hamburg Test: 150-mm diameter × 62-mm high prepared from gyratory specimen. 6. Beam Fatigue Test: 380-mm long × 63-mm wide × 50-mm high beams cut from rolling-wheel compacted slabs. 7. Overlay Test: 150-mm diameter × 115-mm high.
PMLC specimens for quality assurance	1. Verify mix design: 150-mm diameter × 115-mm high at N_{design}. 2. Moisture sensitivity and resilient modulus: 150-mm diameter × 95-mm high at 7.0±0.5% air voids. 3. Dynamic modulus, flow number, and AMPT fatigue: 100-mm diameter × 150-mm high cored and sawn from 150-mm diameter × 175-mm high specimens; 7.0±0.5% or field air voids. 4. Indirect Tensile Test (IDT) creep and strength: 150-mm diameter × 50-mm high. 5. Hamburg Test: 150-mm diameter × 62-mm high.
PMFC specimens for quality assurance and long-term performance testing	1. 150-mm diameter cores: generally suitable for (a) bond strength, (b) in-place density and thickness, (c) air voids analysis, (d) IDT creep compliance and strength, (e) IDT dynamic modulus, (f) Hamburg Test, (g) Overlay Test, and (h) moisture sensitivity. Notes: (1) Some low-temperature IDT testing may be done with 4-in. diameter specimens due to load requirements for 150-mm diameter specimens. (2) A core barrel with a 150-mm inside diameter should be used. (3) Due to lift thickness limitations, 150-mm pavement cores are generally not suitable for (a) dynamic modulus and (b) flow number.

Table 3 Required conditioning methods.

LMLC SPECIMENS	
2 hours at WMA construction compaction temperature.	For WMA mix design and volumetric analysis, moisture sensitivity (AASHTO T 283 and T 324), and flow number (AASHTO TP 79). Notes: (1) This is the short-term conditioning recommended by NCHRP Project 9-43 as the best representation of aging at construction (see [*2*]). (2) This recommendation leads to decreased flow number requirements for WMA compared to HMA and possibly lower binder contents compared to an equivalent HMA mixture, and was based on data from mixtures with aggregate absorptions of 1.0% or less. (3) The flow number measured under these conditions may be indicative of a propensity of the mixture to early rutting. (4) For WMA mixtures containing RAP or RAS, the compaction temperature is that for the *virgin* binder.
2 hrs at WMA construction compaction temperature, then 16 hours at 140°F (per AASHTO T 283), then 2 to 2.5 hours at compaction temperature.	For WMA and HMA dynamic modulus (AASHTO TP 79), flow number (AASHTO TP 79), and moisture sensitivity (AASHTO T 283 and T 324) Notes: (1) This conditioning is intended to simulate aging after approximately 1 to 2 years in service. (2) Measurement of G_{mm} after conditioning provides an indication of extended binder absorption.
Long-term aging (per AASHTO R 30), 5 days at 85°C (after conditioning for rutting tests).	For WMA and HMA fatigue testing (AASHTO T 321 and TX-248-F) and low-temperature cracking testing (AASHTO T 322). Note: This conditioning is generally done on bulk specimens, but may be done on cored and sawn specimens if desired.
PMLC SPECIMENS	
16 hours at 140°F (per AASHTO T 283), then 2 to 2.5 hours at compaction temperature.	For WMA and HMA dynamic modulus (AASHTO TP 79), flow number (AASHTO TP 79), and moisture sensitivity (AASHTO T 283 and T 324). Notes: (1) This conditioning is intended to simulate aging after approximately 1-2 years in service. (2) The flow number measured before this conditioning may be indicative of the propensity of the mixture to early rutting.

Table 3 (Continued)

PMLC SPECIMENS (continued)	
From ambient temperature, reheat to compaction temperature for a target period of 2.5 hours.	For volumetric analysis.
For samples not at ambient temperature, note the temperature and reheat to compaction temperature, noting the time.	For volumetric analysis.
Long-term aging (AASHTO R 30), 5 days at 85°C (after conditioning for rutting tests).	For WMA and HMA fatigue testing (AASHTO T 321 and TX-248-F) and low-temperature cracking testing (AASHTO T 322). Note: This conditioning is generally done on bulk specimens, but may be done on cored and sawn specimens if desired.
Recommended minimum time between fabrication and testing.	5 days.
Recommended maximum time between fabrication and testing.	20 to 30 days unless specimens are properly vacuum sealed and stored. Record times and temperatures of storage.
PMFC SPECIMENS	
Drying as needed.	Take precautions when drying PMFC specimens at elevated temperatures to avoid damaging them.

Table 4 LMLC specimens: required performance testing for mix design.

RUTTING	
Flow number	AASHTO TP 79. Note: Follow the procedure in Section 8.5 of the draft appendix to AASHTO R 35 (*2*).
Hamburg Test	AASHTO T 324 performed for moisture sensitivity. Note: Prepare specimens at air voids content of 7±1% and conduct test at standard conditions: 50°C under water.
MODULUS	
Dynamic modulus	AASHTO TP 79. Note: Provides necessary input data for pavement analysis with DARWin-ME.
FATIGUE CRACKING	
Beam Fatigue Test	ASTM D7460 in strain control.
Overlay Test	Strong alternative: Tex-248-F, *Test Procedure for Overlay Test,* January 2009.
THERMAL (LOW-TEMPERATURE) CRACKING	
IDT creep compliance and strength	AASHTO T 322. Note: Provides necessary input data for pavement analysis with DARWin-ME.
DURABILITY	
Moisture sensitivity	AASHTO T 283. Note: 1 freeze/thaw cycle.
Hamburg Test	AASHTO T 324. Note: Prepare specimens at air voids content of 7±1% and conduct test at standard conditions: 50°C under water.
OTHER	
Volumetric mix design	Per the procedure in the draft appendix to AASHTO R 35 (*2*).
Compactibility	Per the procedure in section 8.3 of the draft appendix to AASHTO R 35 (*2*).
Coating	AASHTO T 195, in accordance with the guidance in section 8.2 of the draft appendix to AASHTO R 35 (*2*). Note: Be aware of the inherent variability of the method and potential variability in results between different types of mixers.

Table 5 PMLC specimens: required performance testing for quality assurance.

RUTTING	
Flow number	AASHTO TP 79.
Hamburg Test	AASHTO T 324 performed for moisture sensitivity. Note: Prepare specimens at air voids content of 7±1% and conduct test at standard conditions: 50°C under water.
MODULUS	
Dynamic modulus	AASHTO TP 79. Note: Provides necessary input data for pavement analysis with DARWin-ME.
FATIGUE CRACKING	
Beam Fatigue Test	ASTM D7460 in strain control.
Overlay Test	Strong alternative: Tex-248-F, *Test Procedure for Overlay Test,* January 2009.
THERMAL (LOW-TEMPERATURE) CRACKING	
IDT creep compliance and strength	AASHTO T 322. Note: Provides necessary input data for pavement analysis with DARWin-ME.
Semi-Circular Bending Test	Strong alternative: Per Li and Marasteanu (*4*).
DURABILITY	
Moisture sensitivity	AASHTO T 283. Note: 1 freeze/thaw cycle.
Hamburg Test	AASHTO T 324. Note: Prepare specimens at air voids content of 7±1% and conduct test at standard conditions: 50°C under water.
OTHER	
G_{mm} (AASHTO T 209)	AASHTO T 209.
Volumetric properties	AASHTO R 35.
Gyratory compaction to N_{design}	AASHTO T 312.

Table 6 PMFC specimens: required performance testing for quality assurance and long-term performance.

RUTTING	
Hamburg Test	AASHTO T 324 performed for moisture sensitivity. Note: Prepare specimens at air voids content of 7±1% and conduct test at standard conditions: 50°C under water.
MODULUS	
Dynamic modulus by IDT method	Per the procedure in Kim, Seo, et al. (*5*).
Spectral analysis of seismic waves (SASW)	Strong alternative.
FATIGUE CRACKING	
Overlay Test	Strong alternative: Tex-248-F, *Test Procedure for Overlay Test,* January 2009.
THERMAL (LOW-TEMPERATURE) CRACKING	
IDT creep compliance and strength	AASHTO T 322. Note: Provides necessary input data for pavement analysis with DARWin-ME.
Semi-Circular Bending Test	Strong alternative: Per Li and Marasteanu (*4*).
DURABILITY	
Hamburg Test	AASHTO T 324 performed for moisture sensitivity. Note: Prepare specimens at air voids content of 7±1% and conduct test at standard conditions: 50°C under water.
Moisture sensitivity	AASHTO T 283. Note: 1 freeze/thaw cycle.
Bond strength between layers	For forensic analysis, as necessary. Per the procedure in West, Zhang, and Moore (*7*).
PAVEMENT CONDITION	
Visual distress survey	Per the FHWA LTPP Protocol.
Rut depth profile	
In-place thickness and density	Core or SASW measurements.
Smoothness (IRI)	With cooperation of state DOT.
FWD	As needed for forensic analysis. Per the FHWA LTPP Protocol.
Permeability	As needed for forensic analysis. Per the method in Cooley (*6*).
G_{mb}	AASHTO T 166 or T 331.
G_{mm}	AASHTO T 209.
Air voids analysis	AASHTO T 269.
Absorption (by calculation)	
DSR torsion bar	

Table 7 Summary of performance testing and specimen conditioning.

Performance Testing					
Sample Type	**Modulus**	**Rutting**	**Fatigue Cracking**	**Low-Temperature Cracking**	**Durability**
LMLC PMLC	• Dynamic modulus (AMPT)	• Flow number (AMPT) • Hamburg Test	• Beam Fatigue Test • Overlay Test	• IDT • Semi-Circular Bending Test	• Lottman Test • Hamburg Test
PMFC	• IDT • SASW	• Hamburg Test	• Overlay Test	• IDT • Semi-Circular Bending Test	• Lottman Test • Hamburg Test

Specimen Conditioning				
		Conditioning		
Sample Type	**Test For**	**2 hrs @ WMA compaction temperature**	**2 hrs @ WMA compaction temperature 16 hrs @ 140°F + 2 hrs @ WMA compaction temperature**	**2 hrs @ WMA compaction temperature 16 hrs @ 140°F + 2 hrs @ WMA compaction temperature + 5 days @ 85°C**
LMLC	Mix design/volumetric analysis	X		
	Modulus		X	
	Rutting	X	X	
	Fatigue cracking			X
	Low-temperature cracking			X
	Durability	X	X	

(continued on next page)

Table 7 (Continued)

Sample Type	Test For	Conditioning		
		2 hrs @ WMA compaction temperature	16 hrs @ 140°F + 2 hrs @ WMA compaction temperature	2 hrs @ WMA compaction temperature 16 hrs @ 140°F + 2 hrs @ WMA compaction temperature + 5 days @ 85°C
PMLC[1]	Volumetric analysis	X		
	Modulus		X	
	Rutting		X	
	Fatigue cracking			X
	Low-temperature cracking			X
	Durability		X	

Sample Type	Test For	Conditioning
PMFC	Volumetric analysis	Dry and test
	Modulus	
	Rutting	
	Fatigue cracking	
	Low-temperature cracking	
	Durability	

[1]For samples of mix at ambient temperature, reheat at WMA compaction temperature for 2.5 hrs. For samples of mix not at ambient temperature, reheat at WMA compaction temperature and note time.

Table 8 Binder and aggregate testing.

BINDERS	
Continuous performance grade of extracted WMA binder	AASHTO R 29 without RTFO aging. Note: Done before and after PAV aging. Use a DSR capable of handling stiff binders.
Continuous performance grade of original WMA binder, to include modifiers added at the plant	AASHTO R 29. Note: Use a DSR capable of handling stiff binders.
Aging Index	
Multiple Stress Creep Recovery Test	AASHTO TP 70.
Linear Amplitude Sweep Test	Per Hintz, Velasquez, et al. (*3*).
Frequency sweep to develop master curve	
AGGREGATES	
Gradation	AASHTO T 27.
Bulk specific gravity and absorption	AASHTO T 84 and T 85.
Flat and elongated or AIMS method	ASTM D 4791 or use state or contractor data.
Sand equivalent	AASHTO T 176 or use state or contractor data.
Fine aggregate, uncompacted voids	AASHTO T 304 or use state or contractor data.
Coarse aggregate angularity	AASHTO T 335 or use state or contractor data.
Stockpile moisture content	AASHTO T 255 or use state or contractor data.
Geologic type	Yes or use state or contractor data.
LA Abrasion Test or Micro Deval Test	AASHTO T 96 or T 327 or use state or contractor data.
Soundness	AASHTO T 104 or use state or contractor data.

preclude the use of additional criteria, methods, and protocols that may be dictated by the specific objectives of a particular study. Also, the objectives of a particular research study will dictate which methods and protocols of this core set are used. For example, an experiment design for a study of WMA fatigue cracking potential would not likely require the inclusion of methods for rutting, moisture sensitivity, or low-temperature cracking from the core set.

Appendix A contains templates for documentation of field projects as referenced in Table 1. The templates are used with permission of the National Center for Asphalt Technology (NCAT) and the University of Minnesota. The NCAT template is applicable to any field project, whereas the University of Minnesota template is specialized to projects that are primarily focused on low-temperature cracking behavior.

Appendix B provides information on extraction and recovery procedures for asphalt binders referenced in Table 2. This information was prepared in the asphalt laboratories of the FHWA's Turner-Fairbank Highway Research Center (TFHRC).

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APPENDIX A: FIELD PROJECT DOCUMENTATION TEMPLATES FROM THE NATIONAL CENTER FOR ASPHALT TECHNOLOGY AND UNIVERSITY OF MINNESOTA

National Center for Asphalt Technology

General Asphalt Plant Information

Project Identification: **Date:**

Contractor:

Plant Location:

Plant Type:

- Drum -- Counter Flow ☐
- Drum -- Parallel Flow ☐
- Batch ☐

Plant Manufacturer:

Plant Modification(s) for WMA:

- YES ☐
- NO ☐

Describe Plant Modification:

Picture Checklist:

Facility	☐	Discharge of Material into Trucks (WMA)	☐
Plant Modification	☐	Discharge of Material into Trucks (HMA)	☐
Point of WMA Feed	☐	RAP Stockpile(s)	☐
Mix Conveyer to Silo	☐	RAP Processing System	☐
Cold Feed Bins	☐	Virgin Aggregate Stockpiles	☐

National Center for Asphalt Technology

General WMA Asphalt Information

Project Identification: **Date:**

Asphalt Information for WMA:

Base Binder PG:

Supplier:

Polymer Modified: Type of Polymer Modification:

Yes ☐

No ☐

Anti-Strip: Type of Anti-Strip:

Yes ☐

No ☐

Anti- Strip Dosage:

Hydrated Lime: Method of Introducing Hydrated Lime:

Yes ☐

No ☐

Hydrated Lime Dosage:

National Center for Asphalt Technology

General HMA Asphalt Information

Project Identification: **Date:**

Asphalt Information for HMA:

Base Binder PG:

Supplier:

Polymer Modified: Type of Polymer Modification:

Yes ☐

No ☐

Anti-Strip: Type of Anti-Strip:

Yes ☐

No ☐

Anti-Strip Dosage:

Hydrated Lime: Method of Introducing Hydrated Lime:

Yes ☐

No ☐

Hydrated Lime Dosage:

National Center for Asphalt Technology

General Asphalt Mix Information

Project Identification: **Date:**

Warm Mix Asphalt (WMA) Technology Information:

WMA Technology Used:

Terminal Blend:		Additive:		Water Injection:		Mechanical:	
Yes	☐	Yes	☐	Yes	☐	Yes	☐
No	☐	No	☐	No	☐	No	☐

Dosage Rate:

Target Mixing Temperature: Target Compaction Temperature:

Hot Mix Asphalt (HMA) Information:

Target Compaction Temperature:

Target Mixing Temperature:

Comments:

National Center for Asphalt Technology

General Aggregate Information

Project Identification: **Date:**

Aggregate Information:

NMAS:

Aggregate Stockpile Sheltered:

Yes ☐

No ☐

Virgin Aggregate Type:

Reclaimed Asphalt Pavement (RAP):

Yes	☐	Millings	☐	Fractionated	☐
No	☐	Single Source	☐	Screened	☐
		Multiple Source	☐	Paved Under Stockpile	☐
		Sheltered	☐	Stockpile on Incline	☐

Comments on RAP Stockpile Condition:

Comments on RAP Processing:

National Center for Asphalt Technology

Production Information

Project Identification:	**Date:**

Estimated Tons of WMA:

Estimated Tons of HMA:

Tons of WMA Produced per Hour:

Tons of HMA Produced per Hour:

WMA Time in the Silo:

HMA Time in the Silo:

Number of Trucks Hauling WMA:

Number of Trucks Hauling HMA:

Comments on WMA Production:

Comments on HMA Production:

National Center for Asphalt Technology

General Construction

Project Identification:	**Date:**

Aggregate Identification:	**Oven Temperature:**

Sample ID	Weight of Tin	Weight of Tin with Mix Reading 1	Weight of Tin with Mix Reading 2	Weight of Tin with Mix Reading 3	Weight of Tin with Mix Reading 4	Weight of Tin with Mix Reading 5	Weight of Tin with Mix Reading 6	Weight of Tin with Mix Reading 7	Weight of Tin with Mix Reading 8

National Center for Asphalt Technology

Energy Information

Project Identification:	**Date:**

Mix Identification:

Time		°F	°F	°F	°F	BH	BH	°F	%	%	%	%	Fuel Meter	%	Cumul. Tons
	TPH	Mix Temp	Stack Temp	BH Temp (Inlet)	BH Temp (Outlet)	Pressure (Inlet)	Pressure Outlet	Agg Temp	Drag Amps	Drum Amps	Damper	Burner		Shell Temp	

Fuel Meter Units: _______________ e.g., gallons, liters, CFM

Electrical Usage:_____________________

Start:________________

End:_________________

National Center for Asphalt Technology

Site Equipment Information

Project Identification:	**Date:**

Mix Identification:

Type of Paver:

Number of Rollers:

Breakdown Roller Type:	**Mode:**		**Frequency:**
	Vibratory:	☐	
	Static:	☐	

Intermediate Roller Type:	**Mode:**		**Frequency:**
	Vibratory:	☐	
	Static:	☐	Tire Pressure:

Breakdown Roller Type:	**Mode:**		**Frequency:**
	Vibratory:	☐	
	Static:	☐	

National Center for Asphalt Technology

Weather at Plant

Project Identification: **Date:**

Mix Identification:

	Ambient Temperature (°F)	Wind Speed (MPH)	Humidity (%)
0 hour			
1 hour			
2 hours			
3 hours			
4 hours			
5 hours			
6 hours			
7 hours			
8 hours			

Rain:

Yes ☐

No ☐

Amount of Rainfall:

Comments on Weather:

National Center for Asphalt Technology

Weather at Site

Project Identification: **Date:**

Mix Identification:

	Ambient Temperature (°F)	Wind Speed (MPH)	Humidity (%)
0 hour			
1 hour			
2 hours			
3 hours			
4 hours			
5 hours			
6 hours			
7 hours			
8 hours			

Rain: Amount of Rainfall:

Yes ☐

No ☐

Comments on Weather:

National Center for Asphalt Technology

General Construction

Project Identification: **Date:**

Mix Identification:

Pavement Lift Thickness:

Laydown Speed:

Rolling Pattern:

Breakdown Roller:

Intermediate Roller:

Finishing Roller:

Temperature:

	Reading 1	Reading 2	Reading 3
Temperature in Auger:			
Temperature Behind Screed:			

National Center for Asphalt Technology

Pavement Cooling

Project Identification: **Date:**

Mix Identification:

Sect. ID:	Time	Minutes Passed	Ambient Temp.	Reading 1	Reading 2	Reading 3	Roller Pass		

National Center for Asphalt Technology

Compaction Curve

Project Identification: **Date:**

Mix Identification:

Sect. ID:	Time	Minutes Passed	Ambient Temp.	Mat Temp.	Density	Roller	Roller Pass		

Nomination of State Field Test Sites

University of Minnesota: MnDOT Report MN/RC 2007-43[1]

Nomination of State Field Test Sites

The selection of field samples was of critical importance to the project and therefore the site identification and sample acquisition merited a lot of consideration and was performed with a lot of care. Asphalt overlays and asphalt pavements that include RAP were not considered in this study to eliminate additional factors that influence performance.

The selection of field sites was based upon the recommendations made by the participating states. The site nomination form used by the states to provide the preliminary information required by the research team for the selection of the field sites is attached at the end of this document (Table A-3).

State Field Sampling

Based on the different types of tests and sample geometry requirements the following number of samples and original material quantities are required as a reasonable minimum:

Table A-1 Overall samples required per site.

Field Sample Types	Number of Samples
(18" x 6" x core depth) beams, see Figure A-1	**9**
6" cores (outside diameter)	**36**
Loose HMA mix, kg	**300kg**
Asphalt binder (1-gallon bucket)	**1**

For the field samples both 6" outside diameter cores and 6" x 18" beams were obtained, as indicated in Table A-1. The depths of the samples were as large as practically possible and should include the asphalt layers and the interface with the aggregate base.

The samples were marked on the top surface to show the direction of traffic and should be labeled in the manner shown in Table A-2.

[1] Marasteneau, M., A. Zofka, et. al. *Investigation of Low-Temperature Cracking in Asphalt Pavements—A Transportation Pooled Fund Study.* Minnesota Department of Transportation Report MN/RC 2007-43, St. Paul, MN, 2007.

Table A-2 Sample identification.

Investigation of Low-Temperature Cracking in Asphalt Pavements	
State	
Roadway	
Direction	**EB – WB – NB – SB**
Date sampled	/ /
Sample type	**Beam/Core** **Loose HMA/AC Binder**
Sample number	**________ of __________**
Other observations	

Sampling was performed between the wheel paths at 50-foot intervals as shown in Figure A-1. A suggested detail of the sampling area is shown in Figure A-2.

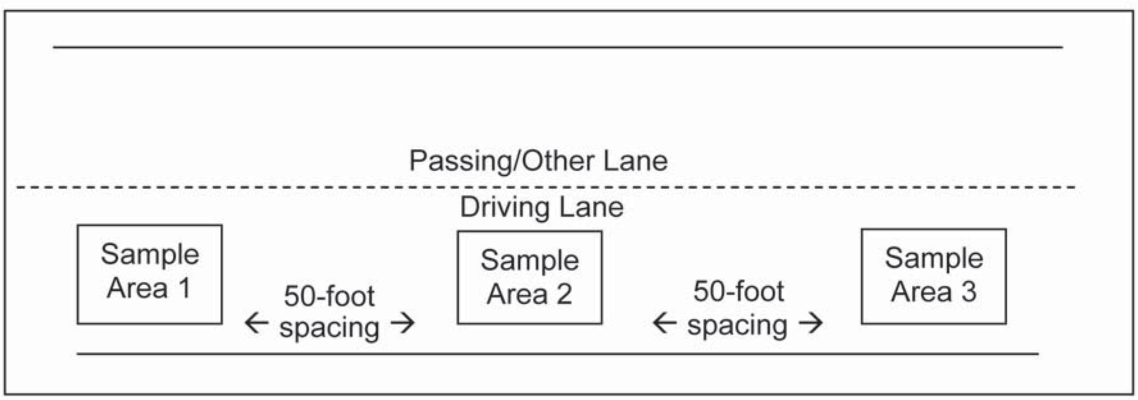

Figure A-1 Sampling areas in the 500′ test section centered between the wheel paths.

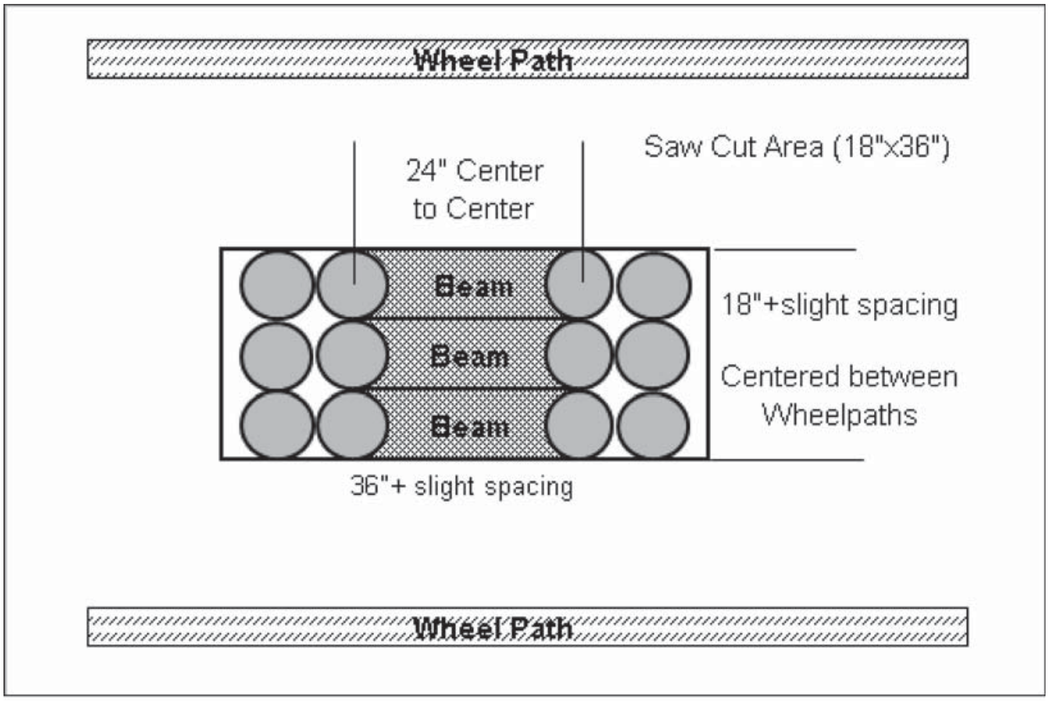

Figure A-2 Example of sampling area detail (12 cores and 3 beams).

Table A-3 Low-temperature project nomination form.

State			
Type–Number (I-35, US-12, ST-11)	-		
Nearest City (# miles west of ___)			
Latitude/Longitude (estimated)	Lat = Long =		
Traffic (ADT/% trucks/ESALS)	/ /		
Pavement Layer Description (HMA—PG Grade per lift) (Base) (Subbase) (Subgrade—Existing Soil)	**Layer Description**	**Thickness**	**Year**
HMA Aggregate Description			
Performance Ranking (circle)	(1 = Best) **1 – 2 – 3 – 4 – 5** (5 = Worst)		
Record/Sample Availability	**Answer**	**Comment**	
Construction Records	**Yes/No**		
Original Construction Lab Testing	**Yes/No**		
Historical Research Data (Part of another research study?)	**Yes/No**		
Pavement Management Data (# years of ride, distress, video)	**Yes/No**		
Pavement Instrumentation	**Yes/No**		
Original HMA Loose Mix*	**Yes/No**		
Original Asphalt Binder*	**Yes/No**		
Original HMA Aggregates*	**Yes/No**		
***If not available are other "typical" materials obtainable?**	**Yes/No**		
***Other items worth reporting*:**			

APPENDIX B: EXTRACTION AND RECOVERY PROCEDURES AT TFHRC ASPHALT LABORATORIES

There are three standard methods related to extraction and recovery of asphalt binders from asphalt mixtures:

1. AASHTO T 164-06/ASTM D2172-01, *Standard Method of Test for Quantitative Extraction of Asphalt Binder from Hot-Mix Asphalt (HMA)*
2. ASTM D 5404-97, *Standard Practice for Recovery of Asphalt from Solution using the Rotary Evaporator*
3. AASHTO T 319-03, *Standard Method of Test for Quantitative Extraction and Recovery of Asphalt Binder from Asphalt Mixtures*

For extraction and recovery of asphalt binders, a combination of AASHTO T 164 and ASTM D 5404 or AASHTO T 319 may be used. In AASHTO T 164, centrifuge extraction (Method A) is preferred to the reflux (Method B) because it minimizes heat hardening of the asphalt binder. **For *routine* extraction and recovery of asphalt binders, it is recommended to use AASHTO T 319 since this method was designed to minimize solvent hardening of the binder, provide complete removal of the solvent, and more completely extract the asphalt binder from the aggregate.** Several different solvents may be used such as n-Propyl bromide; trichloroethylene (TCE), reagent grade; or toluene, reagent grade. There is large variability associated with determining recovered binder properties; however, the type of solvent used between TCE, toluene, and n-Propyl bromide does not produce statistically significant differences in the results for Superpave Binder Tests.

For *routine* extraction and recovery of asphalt binders, Turner Fairbank laboratories will use toluene, reagent grade, as the solvent and, according to AASHTO T 319, after the third wash toluene, reagent grade, combined with ethanol, absolute, in proportions of 85% toluene and 15% ethanol will be used. Ethanol is typically added to remove more asphalt from the aggregate. It is not recommended to use n-Propyl bromide due to its short shelf life and there may be product-specific problems with polymer modified asphalts and polyphosphoric acid (PPA) modified asphalts. TCE with 15% ethanol has been shown to be a superior solvent for removing most of the asphalt binder from aggregate[1]; however, this is not so much a concern as is the concern for maintaining the bulk binder properties. Unfortunately, the effects of TCE on the chemistry of the recovered binder are not understood. Further, it has been shown that TCE solvent produces higher (i.e., stiffer)[3] and hardened[2] recovered binders. Finally, TCE and related solvents were phased out for environmental reasons.[3]

Due to the nature of research, other solvents may be used on a case-by-case basis for specialized extractions. For example, tetrahydrofuran (THF) may be necessary for use with some polymer-modified binders or rubber-modified binders. THF should not be used on a regular basis (i.e., substituted for toluene) and must be used with care due to its high flammability. PPA-modified asphalt binders should be extracted by other solvents (other than lab-grade TCE and n-Propyl bromide, toluene, toluene/ethanol, and THF) that do not contain stabilizers that react with the acid in the binder.[4]

[1] Cipione, C.A., R.R. Davison, B.L. Burr, C.J. Glover, and J.A. Bullin. Evaluation of Solvents for Extraction of Residual Asphalt from Aggregates. *Transportation Research Record: Journal of the Transportation Research Board, No. 1323,* Transportation Research Board of the National Academies, Washington, D.C., 1991, pp. 47–52.

[2] Abu-Elgheit, M.A., M.J. Ijam. Change in Consistency and Composition of Trichloroethylene- and Trichloroethane-Treated Asphalts (Annotation). *Talanta,* Vol. 29, pp. 1131–4, 1982.

[3] Stroup-Gardiner, M., J.W. Nelson. Use of Normal Propyl Bromide Solvents for Extraction and Recovery of Asphalt Cements. NCAT Report 00-06, November 2000.

[4] Important Note When Recovering Binders Containing PPA. The Asphalt Institute. http://www.asphaltinstitute.org/ai_pages/Technical_Focus_Areas/Important_Note_Recovering_Binders_Containing_PPA.pdf. Accessed on October 20, 2009.

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