TECHBRIEF

Asphalt Pavement—Micro-Sampling and Micro-Extraction Methods

FHWA Publication No.: FHWA-HRT-15-051

FHWA Contact: Jack Youtcheff, HRDI-10, (202) 493-3090, jack.youtcheff@dot.gov

This TechBrief provides an overview of micro-sampling and micro-extraction of hot or warm mix asphalt pavement. Micro-sampling and micro-extraction have just recently become feasible because of the development of 4-mm dynamic shear rheometry (DSR).[1]

What Are Micro-Sampling and Micro-Extraction?

Micro-sampling is a method to collect small-scale samples (approximately equal to 200 g) using a rotary hammer drill, masonry bit, and vacuum collection system. Micro-extraction typically refers to the recovery of roughly 10 g of asphalt from about 200 g of pulverized pavement. The micro-extraction process involves many of the standard extraction procedures performed under American Association of State and Highway Transportation Officials (AASHTO) T319-15, *Standard Method of Test for Quantitative Extraction and Recovery of Asphalt Binder from Asphalt Mixtures*, only in a simpler, smaller-scale manner requiring substantially less equipment and solvent.[2] The micro-sampling and micro-extraction scheme is illustrated in figure 1.

Background

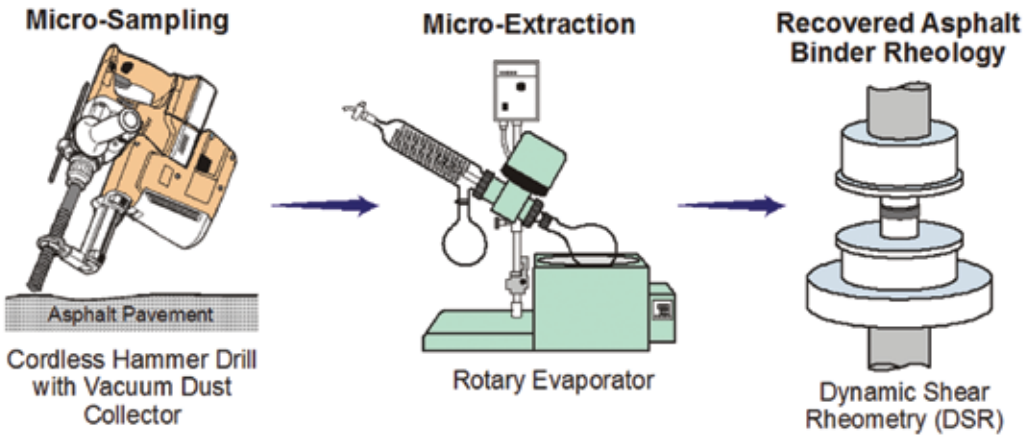
Asphalt pavement investigations often require collecting 101.6- or 152.4-mm-diameter cores from the roadway. Depending on the depth of the pavement, collecting a single core and then patching the hole can take as long as 10 min, and typically, several cores are collected, requiring 30 min or more with traffic control to close the lane. The core rig operator and traffic control personnel are exposed to traffic during the entire coring and patching process.

U.S. Department of Transportation
Federal Highway Administration

Research, Development, and Technology
Turner-Fairbank Highway Research Center
6300 Georgetown Pike
McLean, VA 22101-2296

www.fhwa.dot.gov/research

Figure 1. Micro-sampling and micro-extraction scheme.



Source: WRI.

Western Research Institute (WRI), with Federal Highway Administration support, has developed a new concept referred to as micro-sampling for pavement investigations in which the main interest is recovering and characterizing the asphalt binder. Micro-sampling simplifies and speeds up the sampling process and thus reduces the time workers are exposed to traffic. Micro-sampling involves drilling the pavement to the desired depth using a cordless hammer drill and a 25.4-mm masonry bit equipped with a vacuum collection system to collect the pulverized material. The method requires only a few minutes and only one drill operator. The asphalt is then recovered from the pulverized material using a micro-extraction method.

What makes both the micro-sampling and micro-extraction methods feasible is a new low-temperature rheology method recently developed at WRI, commonly referred to as 4-mm DSR.[3–5]

Four-mm DSR is an alternative to bending beam rheometry (BBR) and requires only a 25-mg sample. A BBR sample beam requires approximately 15 g, and usually several beams are required. Thus, performing BBR on recovered asphalt requires an entire core or a large core slice.

WRI proposes a new micro-extraction concept to recover the asphalt in the laboratory using substantially less organic solvent than traditional core extractions, thereby reducing the exposure of laboratory technicians to harmful, potentially carcinogenic fumes. Recovering the asphalt from micro-samples is simpler, faster, cheaper, and safer than traditional extraction of the entire core or a large core slice. The extra time and effort and the copious amounts of organic solvent needed to extract sufficient asphalt for BBR often limit its application in characterizing the low temperature rheology of recovered asphalt.

The micro-extraction method allows the use of two types of solvents: trichloroethylene and toluene/ethanol (85:15 (v/v) mixture of toluene and 95-percent ethanol). Recovering all of the asphalt from a core that is 50-mm thick and 150 mm in diameter would require roughly 12 L of solvent, whereas recovering the asphalt from a micro-sample weighing 200 g would require about 0.3 L.

The micro-sampling and micro-extraction concept as outlined here will have a major impact on field sampling and laboratory extraction. Core rigs are expensive and require at least a 189.3-L water tank plus patching material for the core hole. As mentioned previously, coring at just one spot on the road can take up to 30 min, and the patched core site is then prone to deterioration under traffic. Using a cordless hammer drill instead of a core rig to obtain pavement samples takes only about 5 min per sample. Sufficient pulverized material can be collected to allow chemical and rheological characterization of the recovered binder from the top surface (9.5-mm depth) and/or below the surface (25.4- to 76.2-mm depth). The extraction process in the laboratory is much faster and safer than extraction from a standard pavement core.

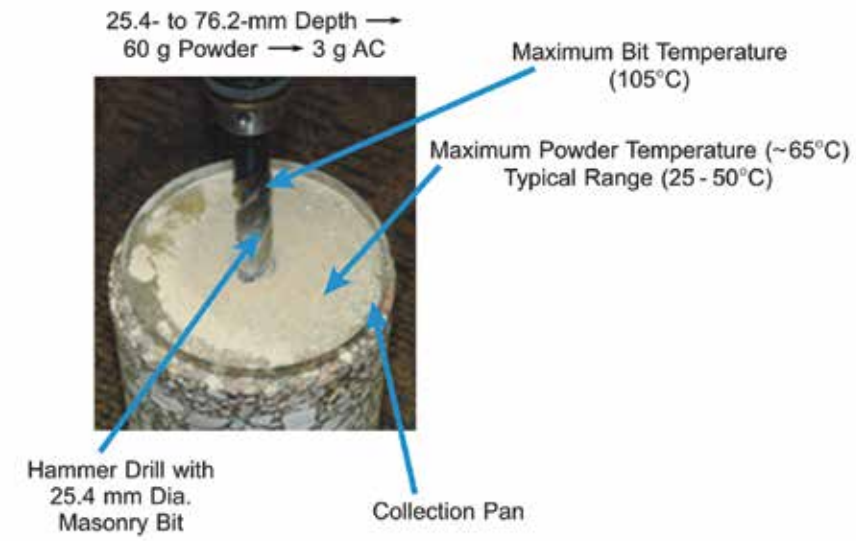
When performing a pavement investigation where the primary interest is in characterizing the recovered asphalt rheology, including the low temperature rheology, 4-mm DSR represents the breakthrough that makes micro-sampling and micro-extraction of asphalt pavement feasible.

For additional details on micro-sampling and micro-extraction, including the methods in AASHTO format, see the full report by Farrar et al.[6]

Micro-Sampling

During the development of micro-sampling with a hammer drill, there was a question about the temperature of the bit and whether it might get too hot and cause oxidation of the binder. Figure 2 summarizes the results of an experiment to measure the maximum bit and powder temperatures under sustained rotary hammer drilling of an asphalt pavement core. Maximum bit and powder temperatures of 105 and 65 °C, respectively, were observed. The powder temperatures are not particularly high in terms of causing unwanted oxidation to occur during the drilling process, especially considering the relatively short times involved. Because of the reduced contact time between the powder and the warm drill bit sample, the temperature should be significantly cooler when using a vacuum collection system.

Figure 2. Micro-field sampling, with temperatures during sustained drilling.



Source: WRI.

To evaluate differences between samples collected by drilling and slicing a core, the rheology of the recovered binders was examined. For these experiments, a vacuum collector system was used to collect the micro-sample rather than the metal pan shown in figure 2.

The rheology (G* master curves) in figure 3 shows that samples collected with the rotary hammer drill and vacuum collection system compared with core slicing are essentially equivalent (within 5 percent).

Micro-Extraction

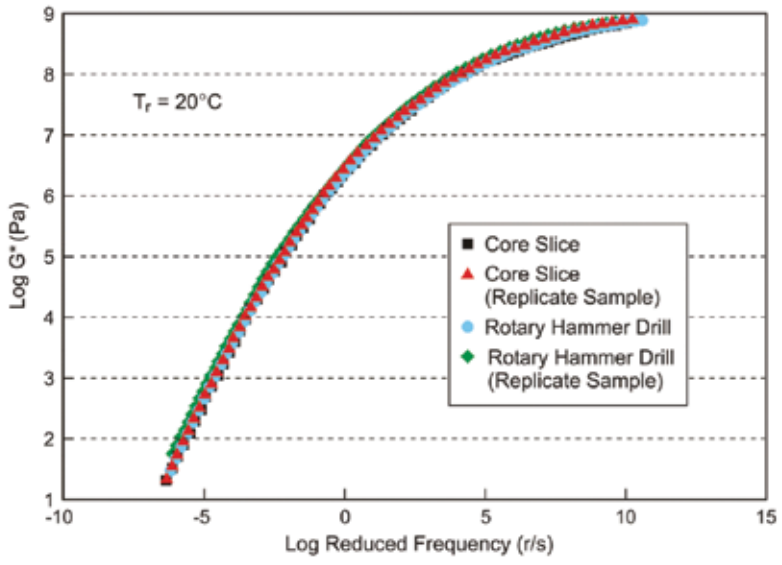
The micro-extraction method illustrated in figure 4 is a straightforward, simple modification of AASHTO T319-15.[2] T319-15 describes a procedure for the extraction and recovery of asphalt binder from asphalt mixtures that has a minimal effect on the physical and chemical properties of the recovered asphalt binder.[2] The method is intended for use when the physical or chemical properties of the recovered asphalt binder are to be determined.

T319-15 can also be used to determine the quantity of asphalt binder in the hot mix asphalt (HMA) or reclaimed asphalt pavement (RAP). However, because of the small quantity of sample involved, the micro-extraction process is not appropriate for determining the quantity of asphalt binder in either HMA or RAP.

The current AASHTO T319-15 is somewhat tedious and equipment-intensive.[2] The method uses an extraction vessel that was developed during the Strategic Highway Research Program. The equivalent method to T319-15 in ASTM is D6847-02, *Standard Test Method for Quantitative Extraction and Recovery of Asphalt Binder from Asphalt Mixtures*, which was withdrawn in 2010 because there were too few laboratories performing it to establish required inter-laboratory precision and bias.[7]

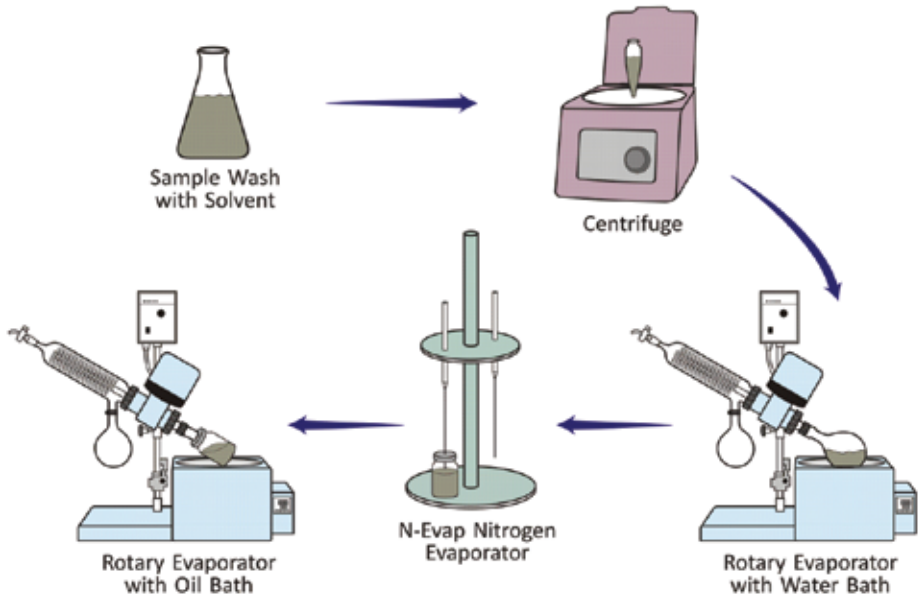
The micro-extraction concept allows the same solvents (trichloroethylene and toluene/ethanol—85:15 (v/v) mixture of toluene and 95-percent ethanol) to remove the asphalt from the aggregate as T319-15,

Figure 3. Comparison of the complex shear modulus (recovered binder from a core slice versus using a rotary hammer drill with a vacuum collector).



Source: WRI.

Figure 4. Micro-extraction scheme.



Source: WRI.

but there are a number of proposed departures from T319-15 that dramatically simplify and reduce exposure to harmful, potentially carcinogenic fumes during the extraction process. The most important departure from T319-15 is the substantial reduction in the amount of solvent required.

Conclusions

The micro-sampling and micro-extraction methods described here are viable alternatives to standard coring and extraction. Micro-sampling involves drilling the pavement to the desired depth using a cordless hammer drill and a 25.4-mm masonry bit and then collecting the pulverized material with a vacuum collection system. The method requires only one drill operator and takes about 5 min to drill sufficient pulverized material to allow chemical and/or rheological characterization of the recovered binder from top surface (9.5-mm depth) and below the surface (25.4- to 76.2-mm depth).

The asphalt is then recovered from the pulverized material using a micro-extraction method that only requires about 0.3 L of solvent.

Benefits include the following:

- Improved safety during pavement sampling by reducing the time the sampling crew and traffic personnel are exposed to traffic.
- Improved safety in the laboratory by substantially reducing the amount of organic solvent required and exposure of laboratory technicians to harmful, carcinogenic fumes from the solvent.
- A simpler, faster method to collect pavement samples for forensic studies on the recovered asphalt to determine what is causing a particular distress (e.g., fatigue cracking or raveling) and what is the best rehabilitation strategy.
- Improved extraction results because the micro-sample is pulverized and

removing the asphalt is faster than with conventional core extractions. Furthermore, less asphalt is left behind on the aggregate.

- Reduced cost by reducing the time to perform sample collection in the field and the time to recover the binder in the laboratory.

References

1. Federal Highway Administration. (2016). *TechBrief: 4-mm DSR (Dynamic Shear Rheometry)*, FHWA HRT-15-053, Washington, DC.
2. AASHTO. (2015). *Standard Method of Test for Quantitative Extraction and Recovery of Asphalt Binder From Asphalt Mixtures*, American Association of State and Highway Transportation Officials, Washington, DC.
3. Sui, C., Farrar, M.J., Tuminello, W.H., and Turner, T.F. (2010). "New Technique for Measuring Low-Temperature Properties of Asphalt Binders With Small Amounts of Material," *Transportation Research Record 2179*, 23–28.
4. Sui, C., Farrar, M.J., Harnsberger, P.M., Tuminello, W.H., and Turner, T.F. (2011). "New Low-Temperature Performance-Grading Method Using 4-mm Parallel Plates on a Dynamic Shear Rheometer," *Transportation Research Record 2207*, 43–48.
5. Farrar, M., Sui, C., Salmans, S., and Qin, Q. (2014). *Determining the Low Temperature Rheological Properties of Asphalt Binder Using a Dynamic Shear Rheometer (DSR)*, Western Research Institute, Laramie, WY.
6. Farrar, M.J., Grimes, R.W., Wiseman, S., and Planche, J-P. (2014). *Asphalt Pavement—Micro-Sampling and Micro-Extraction Methods*, Western Research Institute, Laramie, WY.
7. ASTM D6847-02. (2002). *Standard Test Method for Quantitative Extraction and Recovery of Asphalt Binder From Asphalt Mixtures*, ASTM International, West Conshohocken, PA.

Researchers—This TechBrief on micro-sampling and micro-extraction was prepared by WRI and is the result of several years of research at WRI with the support of FHWA.

Distribution—This TechBrief is being distributed according to a standard distribution. Direct distribution is being made to the Divisions and Resource Center.

Availability—This TechBrief may be obtained from the FHWA Product Distribution Center by e-mail to report.center@dot.gov, fax to (814) 239-2156, phone to (814) 239-1160, or online at http://www.fhwa.dot.gov/research.

Key Words—Pavement sampling, asphalt sampling, asphalt extraction.

FEBRUARY 2018

FHWA-HRT-15-051
HRDI-10/02-18(200)E