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Specifications for Sampling Hot Mix Asphalt

New Standards Improve Quality and Consistency

New quality control and assurance standards are being implemented in many industries across the country. The new standards will enable government agencies to base specifications on measured values and statistical principles rather than average measured values alone. Specifications based on measured values and statistical principles more accurately account for variability than those based only on average measured values. As Figure 1 indicates, when asphalt testing is based on measured values alone the mean value can fall within the specification limits even when the curve describing the results includes values that are well outside of the limits. On the other hand, when testing is based on measured values and statistical principles, all values typically fall within the specification limits.

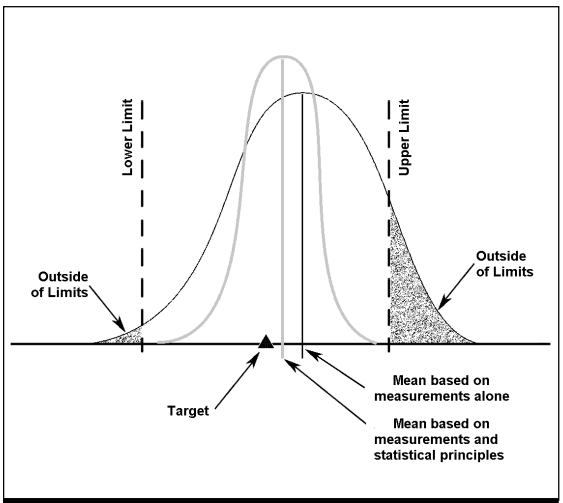


Figure 1. Measured vs. Statistical Values.

Source: Asphalt Paving Technology 2000, Volume 69.

Background

The Michigan Department of Transportation (MDOT) samples and tests hot mix asphalt (HMA) to determine pay adjustment factors for paving projects. Historically in Michigan, several different methods have been used to acquire samples of HMA. Sampling procedures can be simplified if they're based on one method, but very little data exists on which to base a comparison of the different methods.

This issue of Research Record describes a research project that compares results from three of the most common methods, used in Michigan, for sampling HMA behind the paver. The project also determined how the results affect pay adjustment factors on asphalt paving projects. The project, *An Analysis of Three Methods of Sampling Hot Mix Asphalt from Behind a Paver*, was undertaken by a team headed by Dr. R. Christopher Williams of Michigan Technological University (MTU). Cooperation between the Michigan Department of Transportation (MDOT), the Michigan Asphalt Paving Association (MAPA), and Mathy Construction Co., a private company based in Wisconsin, was an important element that contributed to the successful completion of this project. "MTU acted as a neutral entity between government and private industry," Dr. Williams explained, "I appreciate the cooperation and participation of everyone involved in this project."

Calculating Pay Adjustment Factors

In Michigan, pay adjustment factors are based on the following HMA characteristics:

- Asphalt binder content
- Air voids
- Maximum theoretical specific gravity
- Voids in mineral aggregate

When calculating pay adjustment factors, each HMA characteristic is compared to the job mix formula (JMF), which is the recipe of components that the asphalt producer uses to make the HMA. The JMF provides exact amounts of each component of the HMA. If the difference between the measured characteristic and the JMF is within the tolerance, no pay adjustment is applied. If the difference exceeds the tolerance, pay adjustments are applied.

Conflicting Opinions

Samples of HMA to calculate pay adjustment factors can be acquired before or after placement. Opinions on the best location for sampling differ depending on point of view. No hard data exists to definitively prove the advantage of one sampling practice over another.

The Federal Highway Administration (FHWA) encourages testing after placement in order to account for variability introduced by the paving equipment. The FHWA is at the forefront of the push for specifications based on statistical data.

MDOT also prefers that samples be acquired after placement. Gary Mayes, Supervising Engineer of the Bituminous Technical Services Group at MDOT, commented, "Sampling behind the paver is the most effective way to take into account the mechanical process of placing asphalt pavement. We're paying for asphalt on the road, so that's where we like to sample it." When asked about problems associated with patching the holes left by the samples, Mayes explained, "Sampling behind the paver is more labor-intensive, but the samples are more representative of the final product. And in the four to five years that we've been sampling behind the paver we have had no failures associated with sampling."

Paving contractors prefer not to interrupt work flow or in any way compromise the placement of the HMA. Ervin Dukatz, Vice President of Materials and Research for Mathy Construction Co. would rather not disrupt the pavement surface. "I'm opposed to sampling after placement especially with the trend toward tighter smoothness specifications." Dukatz explained, "It's difficult to create a uniform pavement surface when you have to hand-place material in the holes left from sampling." Dukatz acknowledged the variability introduced by the mechanical process of placing the pavement, but he doesn't think the difference is significant enough to warrant disrupting the final pavement surface.

Until a study is performed that quantifies the differences between sampling before placement and sampling after placement, both sides will continue to disagree on the best location for sampling.

Acquiring Samples

The project used samples taken after placement but before compaction. The process involved acquiring samples by the *Ring and Plate* sampling method, the *Shovel and Plate* sampling method, and the *Shovel* sampling method. The purpose of the project was to establish baseline data for developing specifications.

The *Ring and Plate* sampling method uses a metal plate placed immediately in front of the paving machine. After the pavement is placed but before it is compacted, a circular template (a ring) is pressed into the pavement until it makes contact with the plate. The ring, plate, and pavement sample are then lifted free of the pavement mat. The material on top of the plate that is not confined by the ring is removed, and then the material from inside of the ring is divided and placed into sample containers for lab analysis.

Figure 2. Acquiring a Sample of HMA from Behind the Paver.

The *Shovel and Plate* sampling method is identical to the ring and plate method, except that a specially designed shovel is used instead of a ring to acquire the sample. The *Shovel* sampling method, as shown in Figure 2, uses only a shovel to acquire a sample.

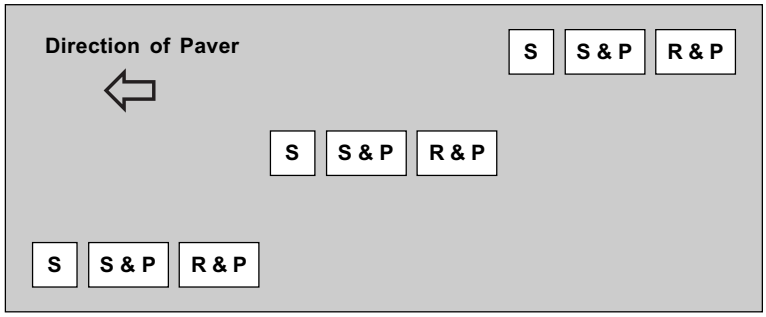
Figure 3 shows the distribution of samples on which the project findings were determined. Sampling from different locations on the pavement mat was necessary to obtain a representative sample across the entire width of the mat. Sampling from a variety of mixes was important to establish a relationship between mix characteristics and results of sampling that was independent of the sampling method.

Hypotheses

The primary hypothesis was that the sampling method that consistently yielded the lowest potential for incurring financial penalty, thereby producing the lowest payment adjustment, would be the most representative method for sampling HMA. In addition, the following hypotheses were made regarding asphalt mix characterization:

- Mixes for different traffic levels would affect pay factor adjustments differently.
- Mixes using fine graded aggregate would yield lower pay adjustments than mixes using coarse graded aggregate.
- Mixes using a larger Nominal Maximum Aggregate Size (NMAS) would yield lower pay adjustments than mixes using a smaller NMAS.

SAMPLING LOCATIONS



PAVEMENT TYPE

	Traffic Level			
	E3		E10 or E30	
Gradation	Fine	Coarse	Fine	Coarse
Mix Size				
2 or 3	X	XXX	X	XX
4 or 5	XXXX	X	X	XX

NOTES

S = Shovel Sample

S & P = Shovel and Plate

R & P = Ring and Plate

An "X" indicates three samples: one sample each of the *Ring and Plate*, *Shovel and Plate*, and *Shovel* sampling methods.

Traffic Level refers to the number of equivalent single axle loads (ESALs) over a 20-year period.

Gradation refers to the quantities of different sizes of aggregate in the asphalt mix.

Mix Size refers to the nominal maximum aggregate size (NMAS) in the asphalt mix. As the mix size increases, the NMAS decreases.

Figure 3. Distribution of HMA Samples.

Testing and Analyzing

The samples were tested using the same procedures that MDOT uses. Specific tests included:

- Bulk specific gravity of the gyratory compacted mix
- Maximum theoretical specific gravity
- Calculated asphalt binder content
- Calculated voids in mineral aggregate (VMA) based on calculated asphalt binder content
- Measured asphalt binder content
- Calculated VMA based on measured asphalt binder content

The results of the tests were analyzed to determine if statistical differences existed between sampling methods, and to determine risk, which is the potential for a contractor to incur a financial penalty.

Statistical Analysis

Pay factor adjustments were calculated using two different methods to determine if statistical differences existed between the sampling methods. First, pay factor adjustments were determined using *calculated* asphalt content values, as is currently done by MDOT. Pay factor adjustments were then determined using *measured* asphalt content values. The pay factor adjustment using calculated asphalt content was based on the effective specific gravity (G_{SE}), which was specified in the JMF for each mix. The pay factor adjustment using measured asphalt content was based on AASHTO T170, Recovery of Asphalt from Solution by Absorption Method using trichloroethylene.

Risk Analysis

Risk analysis evaluates potential consequences associated with different scenarios. @Risk™, a commercially available software package from Palisade Corporation, was used to determine risk. The software enabled the efficient creation of decision models for generating data based on different scenarios. Pay factor adjustments, which were calculated using statistical analysis, were recalculated using the risk data and the calculated and measured asphalt content values.

In conjunction with the risk analysis, the probability of achieving a certain pay factor adjustment was also calculated. Monte Carlo Simulation (MCS) was used to calculate the risk associated with each sampling method. Monte Carlo and Latin Hypercube probability sampling techniques were employed to generate random numbers for the MCS.

Results

The *Ring and Plate* and the *Shovel and Plate* sampling methods produced similar results. Overall, both methods produced lower pay factor adjustments than the *Shovel* sampling method. It was determined that the *Shovel* sampling method was not suitable for mixes

		Sampling Technique		
		Shovel	Shovel & Plate	Ring & Plate
Using Current MDOT Methodology	Calculated Asphalt Binder Content	-9.4%	-5.9%	-6.1%
	Measured Asphalt Binder Content	-9.3%	-9.4%	-9.7%
Using Risk Analysis	Calculated Asphalt Binder Content	-14.0%	-12.1%	-13.0%
	Measured Asphalt Binder Content	-15.0%	-11.7%	-12.2%

Table 1. Comparison of Pay Deduction Based on Sampling Technique and Analysis Method.

placed over a granular or milled pavement base, but when used over a smooth base the results were only slightly greater than those achieved with the *Shovel and Plate* method. Table 1 shows the actual results in terms of percent of pay adjustment.

Commenting on the research results, Mayes said, "This project helped us refine our test methods. We eliminated the *Ring and Plate* method because it was more difficult to perform and the results show that it offers no advantage over the shovel and plate method." Based on the results, the Bituminous Technical Services Group at MDOT removed the *Ring and Plate* sampling method from Michigan Test Method (MTM) 324*, Sampling Bituminous Paving Mixtures Behind Lay Down Machine*. MTM 324 now describes sampling using the *Shovel and Plate* method and the *Shovel* method.

The research project also resulted in the following observations regarding asphalt mix characterization:

- The traffic level designation of the mix had no affect on pay adjustment factors.
- Fine graded mixes are less prone to pay factor adjustments than coarse graded mixes.
- Mixes that use a larger NMAS are less prone to pay adjustment factors than mixes that use a smaller NMAS.

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