ASPHALT PAVEMENT QUALITY CONTROL/QUALITY ASSURANCE PROGRAMS IN THE UNITED STATES

Nathan E. Butts
Graduate Research Assistant
Department of Civil and Architectural Engineering
University of Wyoming
P.O. Box 3295, University Station
Laramie, Wyoming 82071
Tel: (307) 766-5255
Fax: (307) 766-2221
E-mail: buttsn@uwyo.edu

Khaled Ksaibati, Ph.D., P.E.
Professor of Civil Engineering
Department of Civil and Architectural Engineering
University of Wyoming
P.O. Box 3295, University Station
Laramie, Wyoming 82071
Tel: (307) 766-6230
Fax: (307) 766-2221
E-mail: khaled@uwyo.edu

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ABSTRACT

Many of the State highway agencies (SHAs), in recent years, have adopted quality control/quality assurance (QC/QA) specification programs for the construction of asphalt pavements. This new specification is meant to improve the quality of the pavements through frequent testing and monitoring throughout the production and placement of the hot mix asphalt. With a QC/QA specification, the Contractor is responsible for the quality of the pavement, while the highway agency is responsible for the acceptance, rejection and/or price adjustment of that product. The University of Wyoming and the Wyoming Department of Transportation has combined their efforts to evaluate the effectiveness of QC/QA on the national level. In order to achieve this goal, a basic understanding of the status quo of the QC/QA programs is essential. A survey was prepared and distributed to the 50 SHAs to contrast and compare various QC/QA programs. Results of the survey indicated that 40 of 45 responding SHAs or nearly 90% have implemented an asphalt pavement construction QC/QA specification program. Although the first program emerged as early as in 1968, most of the programs were implemented after 1985, indicating that QC/QA are still in the stages of development. Different SHAs have different versions of QC/QA, which may vary significantly in the scope of QC/QA, QC responsibility, QA responsibility, QA testing, properties to be tested, certification of testers, variable control level, and incentive and disincentive policies. Previous evaluations of QC/QA by individual SHAs have resulted in positive reviews.

INTRODUCTION AND BACKGROUND

In recent years, many State highway agencies (SHAs) have adopted the use of quality control/quality assurance (QC/QA) specification programs for the construction of asphalt pavements. This introduction in specification is meant to promote the construction of better performing and longer lasting roadways by decreasing asphalt mixture variability throughout asphalt mixture production and placement. The use of such specifications is rapidly growing and gradually gaining wide acceptance within most SHAs (*1*).

According to the "Glossary of Highway Quality Assurance Terms" published by the Transportation Research Board, QC/QA specifications are also known as quality assurance specifications (*2*). QC/QA specifications are a combination of end result specifications, and materials and methods specifications. End result specifications are specifications that require the Contractor to take the entire responsibility for supplying a product or an item of construction. The highway agency's responsibility is to accept or reject the final product or to apply a price adjustment commensurate with the degree of compliance with the specifications. Materials and method specifications are specifications that direct the Contractor to use specified materials in definite proportions and specific types of equipment and methods to place the material (*2*).

Before the use of QC/QA specifications, the use of strict materials and method specifications was common practice among the SHAs. With the use of method specifications, the burden for quality control and inspection, both labor-intensive activities, was in the hands of the owner agency (*3*). With a QC/QA specification, the Contractor is responsible for quality control (process control), and the highway agency is responsible for acceptance of the product. QC/QA specifications typically are statistically based specifications that use methods such as random sampling and lot-by-lot testing, which let the Contractor know if the operations are producing an acceptable product (*2*). The quality of hot mix asphalt (HMA) being produced is measured by its volumetric and material properties. The promise of QC/QA is that better quality can be achieved by allowing the Contractor more direct control over his or her operation (*4*).

Specification development is by nature an evolutionary process (*5*). SHAs are in a constant process of specification development to meet constantly changing demands. QC/QA arose from three present day challenges in the highway construction industry. First, many of the SHAs are losing manpower at an unprecedented rate, particularly construction personnel such as plant inspectors, construction inspectors and materials technicians (*3*). Second, materials and method specifications required a representative of the highway agency direct each step in the construction process. Experience has shown that this tend obligates the agency to accept the completed work regardless of quality (*2*). And third, there is a growing public demand for better-quality roads.

Since QC/QA specifications are still relatively new to the asphalt pavement construction industry, it is important to determine the effects that the use of QC/QA specifications is having on the quality of pavements being constructed. It is important to determine whether or not the benefits of a decreased variable asphalt mixture and the related decreases in life-cycle-cost outweigh or balance the initial increases in construction cost. The University of Wyoming and the Wyoming Department of Transportation (WYDOT) has combined their efforts to evaluate the effectiveness of asphalt pavement QC/QA specifications on the national level. In order to achieve the goal, a basic understanding of the status quo of the QC/QA programs is essential. Although all QC/QA specifications are similar, there are many variations that can be found among the different SHAs. A questionnaire was prepared and distributed to the 50 SHAs. The survey is meant to contrast and compare the different QC/QA programs and specifications being used. This paper presents the results of this survey.

OBJECTIVES OF SURVEY

Copies of the asphalt pavement QC/QA specification questionnaire were mailed to all 50 SHAs in July 2001. The objectives of the survey were to:

1. Identify which SHAs are utilizing asphalt pavement QC/QA programs.
2. Gather information regarding the development of the asphalt pavement QC/QA programs that are in use.
3. Discover formal and informal evaluations of asphalt pavement QC/QA programs, which have been performed, and the results of those evaluations.
4. Determine the involvements of both the State and Contractor in asphalt pavement QC/QA programs.
5. Identify the asphalt pavement QC/QA testing requirements of different SHAs.
6. Determine the range of control demonstrated by the SHAs through pay factors, design parameters, and mixture properties.

RESULTS OF SURVEY

The asphalt pavement QC/QA survey consisted of about forty questions aimed at satisfying the objectives stated. There were 44 full responses to the questionnaire, and one partial response. All of the States except Arizona, Iowa, New Mexico, Tennessee, and Rhode Island responded to the questionnaire. The responses have been reduced and summarized in the sections that follow.

SHAs with QC/QA Program

Of the 45 SHAs responding to the survey, 40 or nearly 90% have implemented an asphalt pavement construction QC/QA specification program. Connecticut, Delaware, Hawaii, Massachusetts, and Montana were the only SHAs to indicate that they do not have an asphalt pavement QC/QA program. Delaware and Massachusetts, however, are planning to implement such a program in the near future.

For the 40 SHAs that responded to the survey and indicated to have an asphalt pavement QC/QA program, the years that these programs were implemented range from 1968 (New Jersey) to present. Most of the programs, however, were implemented just recently. Twenty-nine or more than 80% of the 35 SHAs that provided a date of implementation started their programs after 1985.

Scope of QC/QA

Within any State, there are many classifications of roadways, and the maintenance or construction projects needed vary in size. Since QC/QA introduces complexity and cost, it seems logical that it would not be used for all projects on all classifications of roadways. This was found to be true in the survey.

All of the 40 SHAs use QC/QA specification on interstate and primary roadways, and on projects larger than 5,000 tons of asphalt mixture. However, only 88% of them use a QC/QA specification for secondary roadways, and only 80% use it for projects smaller than 5,000 tons.

Quality Control Responsibilities

Of the 39 SHAs responding to the question and claiming to have an asphalt pavement QC/QA program, Colorado and Nevada were the only two to hold the State responsible for QC testing. The other 37 hold the Contractor responsible for QC testing. The responsibility for evaluating the QC test results is more evenly split. Of the 39 responding SHAs, 26 of them hold the Contractor responsible for the evaluation of QC testing, 9 accept the responsibility themselves, and 4 share the responsibility with the Contractor. When QC testing has been evaluated and corrective action needs to be initiated, 3 of the QC/QA programs are set up to have the SHA initiate corrective actions themselves, 3 of them share the responsibility for initiating corrective actions, and the remaining 33 hold the Contractor responsible for taking such actions.

Knowing which party is held responsible for all of the QC activities helps to characterize the asphalt pavement QC/QA programs that are being used by the SHAs, and the degree of the responsibility shift that has taken place toward the Contractor. When the SHAs were asked if they were moving to change the involvements with QC in any way, Colorado, Delaware, Ohio, Wisconsin, and Wyoming stated that they were. Colorado, Delaware, and Wyoming stated that the change being made involves the acceptance of the Contractor's QC test results for incentive and disincentive payment and quality acceptance. Ohio's new program puts even more responsibility on the Contractor, while Wisconsin is rewriting its program to conform to federal verification requirements.

Quality Assurance Responsibilities

All of the SHAs responding to the question and claiming to have an asphalt pavement QC/QA program perform QA testing. South Carolina added a note stating, "The Contractor does all QC and QA testing with the State doing QA verification testing at a ratio of 1:10 of the QA tests. Additionally, the State's Independence Assurance personnel obtain comparison samples on Federal Aid projects."

The number of QA tests performed for a typical project varies significantly among the SHAs. The amount of QA testing for most of the SHAs is based on lot size, occurs at a daily rate, or depends on the number of QC tests performed. Typically, Arkansas does one QA test for every 750 tons produced; Kentucky does one every 4000 tons; Minnesota does one per day; North Carolina does a minimum of 10% of the number required by the Contractor; North Dakota does two per day; Oregon does one for every 10 contractor QC tests performed; Utah does 4 QA tests per lot per day; and Washington does one per 400 tons for density, and one per 300 tons for gradations and asphalt content.

Quality Assurance Testing

The approximate ratio of the number of QA tests to the number of QC tests (QA:QC) ranges from 1:1 to as low as 1:10. For some of the SHAs, this ratio varies significantly and an approximate ratio is difficult to determine. The approximate ratios between the numbers of QA and QC tests performed among the SHAs are summarized in Table 1.

The QA tests that are performed by different SHAs are for a variety of purposes. Some of the SHAs use QA testing to verify QC test results. When the Contractor is responsible for QC testing, QA tests are performed to verify that contractor testing is being done properly and precisely. Others use QA testing to adjust the final pay. QA testing is considered in this case to measure the quality of the product being placed. Initial correlation is another area where QA test results are utilized. At the beginning of the production of (HMA), the SHA often performs QA tests mirrored by QC tests to make sure that all testing equipment is calibrated and that testing procedures are being followed. This will usually save the Contractor time and money throughout construction. Of the 39 SHAs to respond to this question, 26 use QA tests for QC test result verification, 16 use QA test results for final pay adjustments, and 6 use QA test results for initial correlations. Most of the SHAs use QA test results for more than one purpose. QA test results are also used for determining acceptance by a number of SHAs, and for contractor's QA test verification in Michigan.

Florida, Indiana, Maryland, Michigan, Ohio, Wisconsin, and Wyoming are all making a move to change the Contractor or State's involvement with QA testing in some way. The agency in Florida will start verifying contractor QC tests at a reduced rate. Indiana is going to start using contractor QC tests for acceptance and payment under contractor acceptance specifications and acceptance by certification. Maryland is looking to use statistical evaluation from AASHTO R 4-97 and NCHRP 9-7. State inspectors in Michigan will start performing total QA testing. Ohio's new 1056 program puts even more responsibility on the Contractor. Wisconsin is adjusting their specification to meet federal requirements for verification testing. And in Wyoming, the Contractor will start doing acceptance testing at the frequency and location designated by the state, and the state will be responsible for pay factor calculations and acceptance decision.

Properties to Be Tested for QC/QA

There are many tests to be run during the production and placement of (HMA). These tests are used to compare the characteristics of the (HMA) being produced and placed to characteristics that are known to represent a good product. A high quality pavement can be produced with the control of a select few of these characteristics. Density, asphalt content and aggregate gradation are three of the most commonly controlled characteristics. The specifications for QC testing, QA testing, or a combination of the two intended to control the production of asphalt mixture and the proper placement of the mixture vary with SHAs. Table 2 summarizes the mixture and mat characteristics controlled through the use of QC and QA testing of 39 different SHAs.

From Table 2, it can be seen that extracted and non-extracted aggregate gradations, clay content, extracted and non-extracted asphalt contents, air voids (AV), voids in mineral aggregate (VMA), voidless unit weight, dust-to-asphalt ratio, tensile strength ratio (TSR), mixture temperature, mat density, and smoothness make up the majority of the mixture and mat characteristics that are being controlled through QC and QA testing. Other mixture and mat characteristics that are sometimes required by the State for QC and QA testing include aggregate moisture content, liquid limit and plastic limit (LL&PI), coarse and fine aggregate angularities (FAA and CAA), Marshall stability, Marshall flow, bulk and maximum specific gravities, Superpave compaction gyratory numbers, mat thickness, and cross slope.

Certification of QC/QA Testers

Precise and accurate testing is an essential part of asphalt pavement QC/QA programs. Test results are many times used to determine the payment amount that a Contractor will receive for its work. It usually doesn’t matter whether the results are from QA or QC testing because in most cases the two are made to compliment one another. Many QC/QA specifications are set up in such a way that a few QA tests verify a group of QC tests. In these cases, both sets of tests need to be accurate and precise to avoid any conflict that may occur between the State and the

Contractor. In order to make the construction process as seamless as possible, certification is often required of material testers.

All of the responding SHAs having an asphalt pavement QC/QA program require some level of certification of the persons doing the testing. Of the 38 responding SHAs, all but Alaska require that all testing technicians doing QC testing be certified. Alaska is the only SHA that does not require any certification for technicians, supervisors, or engineers for QC testing. Only 10 of the 38 SHAs require the QC testing supervisors be certified. Of the 38 responding SHAs, all but Nebraska and Vermont require that all technicians doing QA testing be certified. Nebraska and Vermont are the only SHAs not to require any certification for QA testing. Only 8 of the 38 SHAs require the QA testing supervisors be certified.

Variable Control Levels

Not all projects are treated in the same respect. If a project is large or is deemed important by the SHA, the way the quality of that project is controlled may differ. Or, if a project is small enough, quality control of the materials may not be needed at all. These are the reasons why some SHAs may have different levels of control. These different levels of control are defined by their differing test requirements. If a project is considered very important, the SHA may require a larger variety of tests or a higher testing frequency to ensure a quality product.

Eighteen of the 39 responding SHAs use an asphalt pavement QC/QA specification that utilizes multiple levels of control. Among these SHAs, the number of levels of control ranges from 2 to 6. Seven of the SHAs utilize 2 different levels of control, four of them utilize 3, three utilize 4, one is utilizing 5, one is utilizing 6 different levels of control, and the rest did not provide the number of control levels used. The factors that influence the choice of level of control used on a project are summarized in Table 3. None of the 18 SHAs base their choice of level of control on the type of project funding or available personnel. Most of them, on the other hand, base their choice of level of control for a project on the quantity of material being produced. Some other factors that play a role in choosing the level of control are type and application of mixture, quality characteristics, mixture verification process at the start of production, and results of completed tests.

At different levels of control, the requirements of QC/QA vary. Table 4 shows some of the differences among the different levels of control for each of the 18 SHAs. These differences include QC testing frequency, QA testing frequency, and the number of properties. Some others are also included in the table.

Incentive and Disincentive Policies

QC/QA is built upon a statistically based specification, which is based on random sampling, where properties of the desired product or construction are described by appropriate statistical parameters (*2*). By knowing the properties that are representative of a quality product, SHAs are able to test and measure those properties in order to determine the quality of the product produced. With this ability, SHAs can pay the Contractor for the product that was produced regardless of the bid price. This use of pay adjustment is a disincentive to the Contractor, and is intended to encourage the production of a quality product. Incentives are also used in a similar fashion. All of the SHAs responding to the question use disincentives in their programs, and all but 4 of them use incentives. The SHAs not using incentives are Maryland, North Dakota, Virginia, and Wisconsin. Maryland, however, is in the process of including incentives.

The asphalt mixture and mat attributes that are considered by the SHAs for adjusting pay are summarized in Table 5. Mat density, asphalt content, air voids, aggregate gradation, and smoothness are commonly used asphalt pavement attributes used in the adjustment of Contractor pay. VMA, thickness, G_{mm}, cross-slope, and lab densities are some of the others that are considered by a few of the SHAs. The pay factor ranges corresponding to these attributes can also be found in Table 5. These pay factor ranges are representative of the range of product quality the SHA is willing to accept. Twenty of the 39 SHAs responding to the question use an equation that combines all of the individual pay factors. The composite pay factor (PF_c) equations provided can be seen in Table 6.

Program Evaluations

Twenty-four of the respondents having an asphalt pavement QC/QA program have evaluated their programs for effectiveness. Three of them are currently in the process of performing such an evaluation. The majority of the programs are under constant review, either in a formal or informal manner.

Of the SHAs that did a formal or informal evaluation of their QC/QA program, the majority of them were mostly concerned with a select few asphalt mixture properties. Ninety-one percent of the respondents used asphalt content (AC) as a variable for evaluation, 83% used density data, 78% used air void data, and 70% used aggregate gradation data. VMA was also used as a variable to evaluate programs by 48% of the SHAs that had responded. Dust-to-asphalt ratio, film thickness, rutting, and smoothness were among some of the other characteristics used in asphalt pavement QC/QA program evaluations.

The lengths of time between asphalt pavement QC/QA program implementation and evaluation ranged from 6 months to 6 years. These account for the majority of formal evaluations. Many informal evaluations are performed on a continuous or periodic basis.

Overall, the results of asphalt pavement QC/QA program evaluations have been very positive. Of the 24 responding SHAs that evaluated their QC/QA program, Maryland was the only one claiming to have mixed reviews and to discover that its program was still in need of adjustment. The other 23 programs proved to be effective. Alabama, California, Colorado, Georgia, Indiana, Maine, Pennsylvania, and Texas have all had the results of their evaluative analyses published.

The use of QC/QA specifications demand that many tests be performed before, during, and after the construction of asphalt pavement. This large amount of testing may increase the initial cost of construction. The use of incentives or bonuses may also cause a similar increase. Of 37 SHAs responding to the question, 10 claim that QC/QA is increasing the cost of construction, 1 states that it probably is, 18 claim that they are seeing no such increase, and 5 don't know whether QC/QA is causing increases in construction cost or not. The remaining 3 SHAs claim that there are increases in construction costs for some projects due to QC/QA, but that they are washed out overall. Of 30 SHAs, 15 estimate that 80% or more of the QC/QA projects bid receive an incentive.

CONCLUSIONS

In this paper, the responses of SHAs to a comprehensive survey of asphalt pavement construction QC/QA specification were summarized. The summary leads to the following conclusions:

- Of 45 SHAs that responded to the survey, 40 or nearly 90% have implemented an asphalt pavement construction QC/QA specification program.
- Although the first QC/QA program emerged as early as in 1968, most of the programs (more than 80%) were implemented after 1985. The QC/QA specifications for asphalt pavement construction are still in the stages of development.
- For most of the SHAs, the implementation of a QC/QA specification is a relatively new venture. Each SHA that uses a QC/QA specification for asphalt pavement construction has its own version of a similar concept.
- Different versions of QC/QA program may vary significantly in requirements. The differences include the scope of QC/QA, QC responsibilities, QA responsibilities, QA testing, properties to be tested, certification of testers, variable control level, and incentive and disincentive policies.
- Previous evaluations of asphalt pavement QC/QA specifications by individual SHAs have resulted in positive reviews. As a result of QC/QA specification, some SHAs are seeing an increase in initial construction costs, while most of them are not.

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LIST OF TABLES

TABLE 1 Approximate Ratio of QA to QC Tests

SHA	Ratio
Alabama	1:2
Alaska	Varying
Arkansas	Varying
California	1:10
Colorado	1:10
Florida	1:1
Georgia	Varying
Idaho	1:10
Illinois	1:5
Indiana	1:3
Kansas	1:4 mix properties, 1:2 density
Kentucky	1:4
Maine	1:2
Maryland	1:6, varying
Michigan	varying
Minnesota	1:4
Mississippi	1:10
Missouri	1:4
Nebraska	1:5
Nevada	Varying
New Hampshire	1:1
New Jersey	Varying
New York	Varying
North Carolina	1:10 min.
North Dakota	1:10
Ohio	1:4-6, depending on specifications and test types
Oklahoma	1:10
Oregon	1:10
Pennsylvania	Varying
South Carolina	1:10
South Dakota	1:5
Texas	1:4
Utah	1:1
Vermont	4:3
Virginia	1:4 mix, 1:1 density
Washington	Varying
West Virginia	1:10
Wisconsin	1:5
Wyoming	1:1

TABLE 2 Mixture and Mat Characteristics Controlled in QC/QA

SHA	Agg. Grad. (extract)	Agg. Grad.	Clay Content	Asphalt Content (extract)	Asphalt Content	Air Voids	VMA	Voidless Unit Weight	Dust-to-Asphalt Ratio	TSR	Mix Temp.	Mat Density	Smooth-ness
Alabama	QC/QA	QC	QC/QA	QC/QA	QC/QA	QC/QA	QC/QA	QC/QA	QC/QA	QC/QA		QC/QA	QC/QA
Alaska		QA			QA							QA	
Arkansas					QC/QA	QC/QA	QC/QA	QC/QA				QC/QA	QC/QA
California	QC/QA	QC/QA	QC/QA	QC/QA	QC	QC/QA						QC/QA	
Colorado		QC/QA			QC/QA			QC/QA				QC/QA	
Florida	QC/QA	QC		QC/QA		QC/QA	QC	QC/QA	QC		QC/QA	QC/QA	QC/QA
Georgia	QC/QA	QC		QC/QA	QC/QA	QA		QC/QA			QC/QA	QA	QA
Idaho	QC	QC/QA		QC/QA	QC/QA	QA						QA	QC
Illinois	QC/QA	QC/QA			QC/QA	QC/QA		QC/QA				QC/QA	
Indiana	QC/QA	QC			QC/QA	QC/QA	QC/QA	QC/QA			QC/QA	QC/QA	QA
Kansas	QC/QA	QC/QA	QA	QC/QA		QC/QA	QC/QA	QC/QA	QC/QA	QC/QA	QC/QA	QC/QA	QC
Kentucky		QC			QC/QA	QC/QA	QC/QA				QC/QA	QC/QA	
Maine		QC/QA			QC/QA	QC/QA	QC/QA		QC/QA		QC/QA	QC/QA	QA
Maryland	QC/QA			QC	QA	QC/QA	QC/QA		QC/QA			QC/QA	
Michigan		QC			QC/QA	QC/QA	QC/QA	QC/QA				QA	QA
Minnesota	QC/QA	QC/QA		QC/QA	QC/QA	QC/QA	QC/QA	QC/QA	QC/QA	QA		QC/QA	QC
Mississippi	QC/QA	QC			QC/QA	QC/QA	QC/QA		QC/QA		QA	QA	QA
Missouri		QC/QA			QC/QA	QC/QA	QC/QA				QC/QA	QC/QA	QC/QA
Nebraska		QC/QA			QC/QA	QC/QA	QC/QA	QC/QA				QC/QA	QC/QA
Nevada		QA	QC		QA	QA	QA	QC		QC	QC	QA	QA
New Hampshire	QC/QA	QC		QC/QA		QA		QC/QA			QC	QC	QA
New Jersey	QC/QA		QC/QA	QC/QA		QC/QA	QC/QA		QC/QA		QC/QA		QC/QA
New York	QA	QC/QA		QA	QC/QA	QC/QA	QC/QA		QC/QA		QC/QA	QC/QA	
North Carolina	QC/QA		QC/QA	QC/QA		QC/QA	QC/QA	QC/QA	QC/QA	QC/QA	QC/QA	QC/QA	QA
North Dakota		QC/QA			QC/QA	QC/QA		QC/QA				QC/QA	

TABLE 2 (Continued)

SHA	Agg. Grad. (extract)	Agg. Grad.	Clay Content	Asphalt Content (extract)	Asphalt Content	Air Voids	VMA	Voidless Unit Weight	Dust-to-Asphalt Ratio	TSR	Mix Temp.	Mat Density	Smooth-ness
Ohio	QC/QA	QC/QA		QC/QA	QC/QA	QC/QA	QC		QC/QA		QC	QC	
Oklahoma		QC/QA			QC/QA	QC/QA						QC/QA	
Oregon		QC/QA	QC/QA		QC/QA	QC/QA	QC/QA	QC/QA		QC	QC/QA	QC/QA	QC
Pennsylvania	QC/QA	QC/QA		QC/QA	QC/QA	QC		QC	QC		QC/QA	QC	QC
South Carolina	QC	QC		QA		QA	QC	QC			QC	QC/QA	
South Dakota		QC/QA			QA	QC/QA		QC/QA			QC/QA	QC/QA	QA
Texas	QC	QC		QC	QC	QA	QC					QA	
Utah		QC/QA			QC/QA	QC/QA	QC/QA				QC	QC/QA	QC
Vermont	QC	QC			QC	QC/QA					QC	QA	
Virginia		QC/QA			QC/QA						QC/QA	QC/QA	QC/QA
Washington		QA			QA			QA				QA	
West Virginia		QC/QA			QC/QA	QC/QA	QC/QA					QC/QA	QA
Wisconsin	QC/QA	QC/QA			QC/QA	QC/QA	QC/QA	QC/QA					
Wyoming	QC	QC/QA			QA	QC					QC	QC/QA	QA

TABLE 3 Factors Used in Determining the Level of Control

SHA	Quantity of Material	Traffic Loads	Type of Facility	Type of Construction	Others
Alaska	X				
Arkansas	X				Type of mix
California					Quality characteristic
Colorado	X				Mix verification process at the start of production
Illinois			X	X	
Kansas	X				
Kentucky		X		X	Based on mix type/application
Maine	X	X	X	X	
Missouri	X			X	
New York		X	X		
Oregon	X				
Pennsylvania	X			X	
South Dakota					Results of completed tests
Vermont	X				
Washington	X				
West Virginia	X				
Wisconsin	X				
Wyoming	X	X	X		

TABLE 4 Variations among Different Levels of Control

SHA	QC testing frequency	QA testing frequency	Number of properties	Others
Alaska				Number of acceptance tests
Arkansas				Additional testing
California	X	X		
Colorado	X		X	
Illinois	X	X		
Kansas	X	X		
Kentucky				Volumetric properties of mixes on mainline and shoulder applications (i.e., AC, AV, VMA, density, leveling)
Maine		X	X	
Missouri	X			
New York	X	X		
Oregon	X	X	X	Visual inspection along with previous test results indicating specification product has been supplied for job less than 2500 tons
Pennsylvania		X		
South Dakota	X	X	X	
Vermont		X		
Washington		X		Reduction in frequency for jobs less than 2500 tons
West Virginia	X			
Wisconsin	X	X		
Wyoming	X	X	X	

TABLE 5 Asphalt Pavement Attributes Used for Payment Adjustments and Their Corresponding Pay Factor Ranges

SHA	Pay Factor for Mat Density	Pay Factor for Air Voids	Pay Factor for Asphalt Content	Pay Factor for Aggregate Gradation	Pay Factor for Smoothness	Pay Factor for Other Attributes	
						Attributes	Pay Factor
Alabama	0.80 to 1.02	0.80 to 1.02	0.80 to 1.02		0.80 to 1.05		
Alaska	0.75 to 1.05		0.75 to 1.05	0.75 to1.05	$10,000 to $20,000		
Arkansas	N/A	N/A	N/A		3.0% to -4.0%		
California	0.75 to 1.05		0.75 to 1.05	0.75 to 1.05			
Colorado	0.75 to (1.025 to1.060)		0.75 to (1.025 to 1.060)	0.75 to (1.025 to 1.060)	0.0 to 0.10/sq. yd		
Florida	0.75 to 1.05		0.80 to 1.00	0.80 to 1.00			
Georgia	0.50 to 1.00	0.50 to 1.00	0.50 to 1.00	0.75 to 1.00	0.65 to 1.00		
Idaho	0.75 to 1.05	N/A	0.75 to 1.05	N/A	Grinding to 1.05		
Illinois	0.80 to 1.05	0.80 to 1.05	0.80 to 1.05				
Indiana	N/A	0.85 to 1.05	0.85 to 1.05	0.85 to 1.05			
Kansas	0.70 to 1.04	0.800 to 1.030			$203 to $152/0.1 mile section/lane		
Kentucky	0.85 to 1.05	0.85 to 1.05	0.85 to 1.00	0.75 to 1.00		VMA	0.85 to 1.00
Maine	0.55 to 1.05	0.55 to 1.05	0.55 to 1.05		0.75 to 1.05	VMA	0.55 to 1.05
Maryland	0.75 to 1.00		0.75 to 1.00	0.75 to 1.00			
Michigan	0.75 to 1.06	0.75 to 1.04	0.75 to 1.04			G_{mm}	0.75 to 1.04
Minnesota	0.50 to 1.04	0.50 to 1.00	0.50 to 1.00	0.50 to 1.00	0.50 to 1.00		
Mississippi	0.70 to 1.00	0.50 to 1.00	0.75 to 1.00	0.75 to 1.00	0.90 to 1.05	VMA	0.75 to 1.00
Missouri	0.00 to 1.05	0.00 to 1.05	0.00 to 1.05		0.93 to 1.07	VMA	0.00 to 1.05
Nebraska	0.70 to 1.00	0.50 to 1.02			0.90 to 1.05		
Nevada		0.70 to 1.05	0.70 to 1.05	0.70 to 1.05	0.90 to 1.05		
New Hampshire		0.75 to 1.05	0.75 to 1.05	0.75 to 1.05	0.75 to 1.05	Thickness, cross slope	0.75 to 1.05
New Jersey		N/A			N/A	Thickness	

N/A indicates that there is a pay factor range, but the numbers are unavailable.

TABLE 5 (Continued)

SHA	Pay Factor for Mat Density	Pay Factor for Air Voids	Pay Factor for Asphalt Content	Pay Factor for Aggregate Gradation	Pay Factor for Smoothness	Pay Factor for Other Attributes	
						Attributes	Pay Factor
New York	0.60 to 1.05	0.85 to 1.05			N/A		
North Carolina	0.50 to 1.00	0.50 to 1.00	0.50 to 1.00	0.70 to 1.00			
North Dakota	N/A		N/A				
Ohio	0.70 to 1.04		0.70 to 1.00	0.70 to 1.00	Replace to 1.05		
Oklahoma	0.50 to 1.00	0.79 to 1.00	0.80 to 1.00	0.76 to 1.00	0.80 to 1.03		
Oregon	0.75 to 1.05		0.75 to 1.05	0.75 to 1.05	0.75 to 1.05		
Pennsylvania	0.50 to 1.00		0.50 to 1.00	0.50 to 1.00	bonus: $0 to $300/0.1 lane-mile		
South Carolina	0.85 to 1.05	0.85 to 1.05	0.85 to 1.05			VMA	0.85 to 1.05
South Dakota	0.85 to 1.05	0.85 to 1.05			0.90 to 1.04		
Texas	0.700 to 1.050					Lab Density	0.70 to 1.05
Utah	$0.91 to -2.27/ton		$0.91 to -2.27/ton	$0.91 to -2.27/ton	N/A		
Vermont	0.80 to 1.03	0.93 to 1.03					
Virginia	N/A		N/A	N/A	N/A		
Washington	0.75 to 1.02		0.75 to 1.03	0.75 to 1.03			
West Virginia	0.88 to 1.00	0.92 to 1.00 (Superpave)	0.92 to 1.00 (Superpave)				
Wisconsin		0.50 to 1.00	0.75 to 1.00	0.75 to 1.00		VMA	0.75 to 1.00
Wyoming	0.50 to 1.10		0.75 to 1.05	0.75 to 1.05	N/A		

N/A indicates that there is a pay factor range, but the numbers are unavailable.

TABLE 6 Composite Pay Factor Equations Used by SHAs for Adjusting Payment

SHA	Composite Pay Factor Equation
California	PF_C = Sum of ($W_i \times PF_{QCi}$) where, W = weighting factor, PF_{QC} = individual quality characteristic pay factor, i = quality characteristic index number.
Colorado	$PF_C = 0.20 \times$ Gradation $+ 0.30 \times$ AC $+ 0.50 \times$ Density Smoothness is a separate element.
Idaho	$PF_C = 0.40 \times PF_{DENSITY} + 0.30 \times PF_{ASPHALT} + 0.30 \times PF_{AGGREGATE}$
Illinois	$PF_C = 0.50 \times (PWL) + 0.55$, with a final pay cap of 1.03 where PWL = percent within limits.
Indiana	$PF_C = 0.20 \times$ AC $+ 0.35 \times$ Mat Density $+ 0.35 \times$ AV $+ 0.10 \times$ VMA
Kentucky	$PF_C = 0.10 \times$ AC $+ 0.25 \times$ AV $+ 0.25 \times$ VMA $+ 0.40 \times$ Density (by cores) for mix accepted by volumetrics, i.e., Superpave mix used on mainline applications.
Maine	$PF_C = 0.60 \times$ Density $+ 0.20 \times$ Voids $+ 0.10 \times$ VMA $+ 0.10 \times$ AC On pilots, smoothness is a separate pay adjustment.
Missouri	$PF_C = 0.25 \times (PF_{DENSITY} + PF_{AC} + PF_{VMA} + PF_{AIRVOIDS})$ Smoothness applied separately. Removal required if total pay factor less than 50%.
Nebraska	(Single Air Void) $\times$ (Ave. of 4 Air Void) $\times$ (Density) All pay adjustments apply to mainline tonnage. Only density adjustments apply to shoulder tonnage.
New Hampshire	Weight factors: gradation, 0.15; AC, 0.15; AV, 0.20; thickness, 0.10; smoothness, 0.30; and cross slope, 0.20.
New Jersey	Currently it is the average of the individual pay factors for air voids, thickness, and smoothness, but a new specification is being developed, which is believed to be a significant improvement.
Oklahoma	$PF_C = [3 \times$ (AC + AV + Density) + Gradation]/10 Smoothness is independent.
Oregon	Factors depend on type of HMA. Smoothness is evaluated separately.
Pennsylvania	$Lp = Cp \times [(2P_D + P_M)/400]$ where Lp = lot payment, Cp = contract unit price per lot, P_D = density, P_M = sum of %AC & % passing #200 sieve payment factors.
South Carolina	$LPF = 0.20 \times PF_{AC} + 0.35 \times PF_{AV} + 0.10 \times PF_{VMA} + 0.35 \times PF_{DENSITY}$
South Dakota	50:50 between mat density and AV.
Texas	TPA = (A + B)/2 where A = bid price $\times$ production lot quantity $\times$ pay adjustment factor for production, B = bid price $\times$ placement lot quantity tested for air voids $\times$ pay adjustment factor for placement + bid price $\times$ placement lot quantity not tested for air voids $\times$ 1.00.