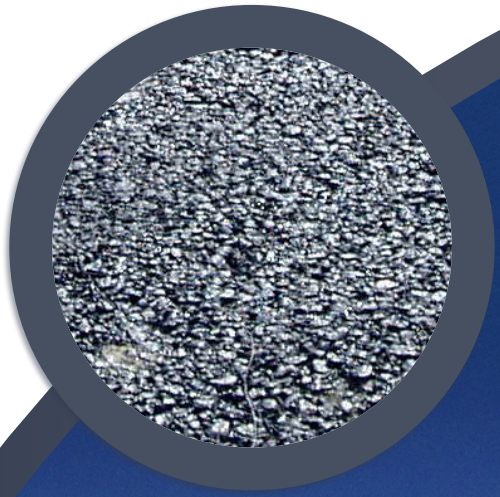
Quality Assurance Stewardship Review



Summary Report

2013–2018

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16. Abstract
The current program of Quality Assurance Stewardship Reviews was established by the Federal Highway Administration (FHWA) in fiscal year (FY) 2003 with the purpose of assessing agency quality assurance (QA) practices. By the end of 2018, all fifty-two State highway agencies (SHA), including Puerto Rico and the District of Columbia, had undergone at least one review. This *Summary Report* summarizes the findings of the twenty-seven SHA reviews completed in calendar years 2013 through 2018. Previous summaries of Quality Assurance Stewardship Reviews can be downloaded from https://www.fhwa.gov/pavement/stewardship.cfm.

The Quality Assurance Stewardship Reviews were a joint effort involving the SHA personnel along with FHWA personnel from Headquarters, Resource Center, and the Federal-aid Division Offices. Materials quality practices were examined at the SHA's headquarters, region/district, and construction project level locations.

The observations and findings from the Quality Assurance Stewardship Review program continue to play an important part in FHWA's oversight role. These reviews of SHA QA programs allow FHWA to identify and assess risks to the Federal-aid program. The reviews also provide an avenue to FHWA for the promotion and education of SHAs on new technologies.

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EXECUTIVE SUMMARY

A State highway agency's (SHA) quality assurance (QA) program is the process the SHA uses to determine whether it is obtaining the material or product that was specified. A considerable amount of Federal-aid construction dollars is used on pavement and material activities, creating a significant risk to the Federal-aid program if an SHA's QA program is inadequate. The Federal Highway Administration (FHWA) publishes its requirements for the QA program in 23 CFR 637 Subpart B. Proper implementation of this regulation helps ensure proper expenditure of Federal-aid funds. Additional information is provided in the Resources section of this *Summary Report.*

The current program of Quality Assurance Stewardship Reviews was established by the FHWA in fiscal year (FY) 2003 with the purpose of assessing SHA QA practices and verifying compliance with 23 CFR 637.205, 23 CFR 637.207, and 23 CFR 637.209. By the end of 2018, all fifty-two SHAs, including Puerto Rico and the District of Columbia, had undergone at least one review. This report summarizes the findings of the twenty-seven reviews completed in calendar years 2013 through 2018. At the time of the review, eighteen of these twenty-seven SHAs were identified as using contractor test results in the acceptance decision in some portion of their QA program. This practice, while permissible under 23 CFR 637.207(a)(1)(ii), does increase the overall risk to the program and is the focus of part of the FHWA Quality Assurance assessment tool.

These reviews allow FHWA to identify and assess risks as part of Federal-aid program oversight. Some key trends noted include:

- The majority of SHAs reviewed were in overall compliance with 23 CFR 637.205, 23 CFR 637.207, and 23 CFR 637.209.
- The use of contractor test results in the acceptance decision without adequate verification and statistical validation has continued to be documented in the reviews.
- Test sample integrity was also noted in multiple reviews as an issue. SHAs are responsible for ensuring that sample integrity is maintained per 23 CFR 637.205. This allows an SHA to be confident that the sample represents the material incorporated into the Federal-aid project.
- Random sampling is not only required to meet the regulatory requirements of 23 CFR 637.205(e) but also is important in providing a high level of confidence in the properties of the materials incorporated into the Federal-aid project. Several reviews of SHA projects noted the inconsistent use of random numbers for obtaining samples, inconsistent application of procedures, and application of biased procedures in this area.
- Several reviews indicated that SHAs were not keeping their documented QA processes and procedures current with improvements in their actual QA practices being conducted on projects as required by 23 CFR 637.205(a).
- Several reviews indicated that the documented QA processes and procedures in the approved QA program were not being followed on projects as required by 23 CFR 637.205(a).

These Quality Assurance Stewardship Reviews provide technical resources and assistance to SHAs and FHWA Division Offices to continuously improve their QA programs.

INTRODUCTION

Requirements for SHA sampling and testing programs have existed since the early 1960s. A considerable amount of Federal-aid construction funding is used on pavement and materials activities. Effective QA programs meeting 23 CFR 637.205, 23 CFR 637.207, and 23 CFR 637.209 will help ensure proper stewardship of the Federal-aid funding.

The latest major revision to FHWA's sampling and testing regulations, titled "Quality Assurance Procedures for Construction," was published on June 29, 1995, as 23 CFR 637 Subpart B. This revision was made due to the need to improve the QA process as SHAs implemented the use of contractor testing in the acceptance decision as noted when the Final Rule was published in the Federal Register[1]. The concerns about the process were found through several national reviews performed by FHWA in the early 1990s. The current regulations apply to all Federal-aid highway projects on the National Highway System[2], though most SHAs, as evaluated during these reviews, have the same QA program regardless of whether the project was on or off the NHS or if Federal funding was used. The five most significant changes in the 1995 revision were as follows:

- Requirement for all testing personnel and laboratories to be qualified using SHA procedures per 23 CFR 637.209.
- Requirement for the SHA's central laboratory to be accredited by the AASHTO Accreditation Program (AAP) or a comparable laboratory accreditation program per 23 CFR 637.209(a)(2).
- Provision of flexibility in sampling and testing by allowing the use of contractor test results in the overall SHA acceptance decision, provided certain checks and balances are in place per 23 CFR 637.207(a)(1)(ii).
- Allowance for consultants to be used in performing dispute resolution or Independent Assurance (IA) if their laboratories are accredited by the AASHTO Accreditation Program or a comparable laboratory accreditation program per 23 CFR 637.209(a)(3) and 23 CFR 637.209(a)(4).
- Allowance for SHAs to use a system approach to IA instead of establishing frequencies based on individual project quantities, provided certain reporting requirements are followed per 23 CFR 637.207(a)(2).

In FY 2003, the current program of Quality Assurance Stewardship Reviews was established with the purpose of assessing agency QA practices and verifying compliance with 23 CFR 637.205, 23 CFR 637.207, and 23 CFR 637.209.

Between thirty and thirty-five SHAs use contractor test results in their acceptance decisions. The use of contractor testing may vary from collecting roadway surface profiles on new construction to performing extensive material testing on asphalt and/or portland cement concrete (PCC) pavements, making it difficult to assign a definite number.

[1] Federal Register, Volume 60, No. 125, pages 33712-33719.
[2] 23 CFR 637.201.

By the end of 2018, all fifty-two SHAs, including Puerto Rico and the District of Columbia, had at least one QA review. Table 1 provides a listing of the SHAs and the year(s) of their review from the start of the program in 2003 through 2018. Seventeen SHAs underwent two reviews.

This *Summary Report* provides an overview of the Quality Assurance Stewardship Review program and a compilation of the findings and observations from the twenty-seven individual SHA reviews completed in calendar years 2013 through 2018. Previous summaries of Quality Assurance Stewardship Reviews are available at https://www.fhwa.dot.gov/pavement/stewardship.cfm.

Table 1. SHAs with Quality Assurance Stewardship Reviews since 2003.

State Highway Agency	Calendar Year(s) of Review
Alabama	2009
Alaska	2016
Arizona	2009
Arkansas	2016
California	2004, 2011
Colorado	2003, 2018
Connecticut	2005, 2018
Delaware	2007
District of Columbia	2016
Florida	2010
Georgia	2004, 2009
Hawaii	2009
Idaho	2008, 2018
Illinois	2013
Indiana	2008, 2015*
Iowa	2012
Kansas	2008
Kentucky	2014
Louisiana	2013
Maine	2003, 2013
Maryland	2004, 2013
Massachusetts	2014
Michigan	2012
Minnesota	2005, 2018
Mississippi	2009
Missouri	2003,2012
Montana	2015
Nebraska	2006
Nevada	2006, 2018
New Hampshire	2010
New Jersey	2015
New Mexico	2007, 2018
New York	2004, 2010
North Carolina	2004
North Dakota	2017
Ohio	2011
Oklahoma	2003, 2008
Oregon	2005
Pennsylvania	2006
Puerto Rico	2017
Rhode Island	2008
South Carolina	2007, 2014
South Dakota	2013
Tennessee	2016
Texas	2011
Utah	2010
Vermont	2016
Virginia	2006, 2017
Washington	2011
West Virginia	2014
Wisconsin	2006, 2016
Wyoming	2007

* Asphalt mixture review only.

OBJECTIVE AND SCOPE OF QUALITY ASSURANCE STEWARDSHIP REVIEWS

The Quality Assurance Stewardship Reviews evaluated the SHAs' QA program practices and procedures and ascertained the status of the SHAs' implementation of and compliance with the QA regulation, 23 CFR 637.205, 23 CFR 637.207, and 23 CFR 637.209. Each review examined the entire QA program in that State, except as noted in table 1.

Typically, four Quality Assurance Stewardship Reviews have been conducted in each of the years, 2003 through 2018, as shown in figure 1. Eighteen of the twenty-seven SHAs completed in 2013 through 2018 were identified as using contractor test results in the acceptance decision in some portion of their QA program at the time of the review.

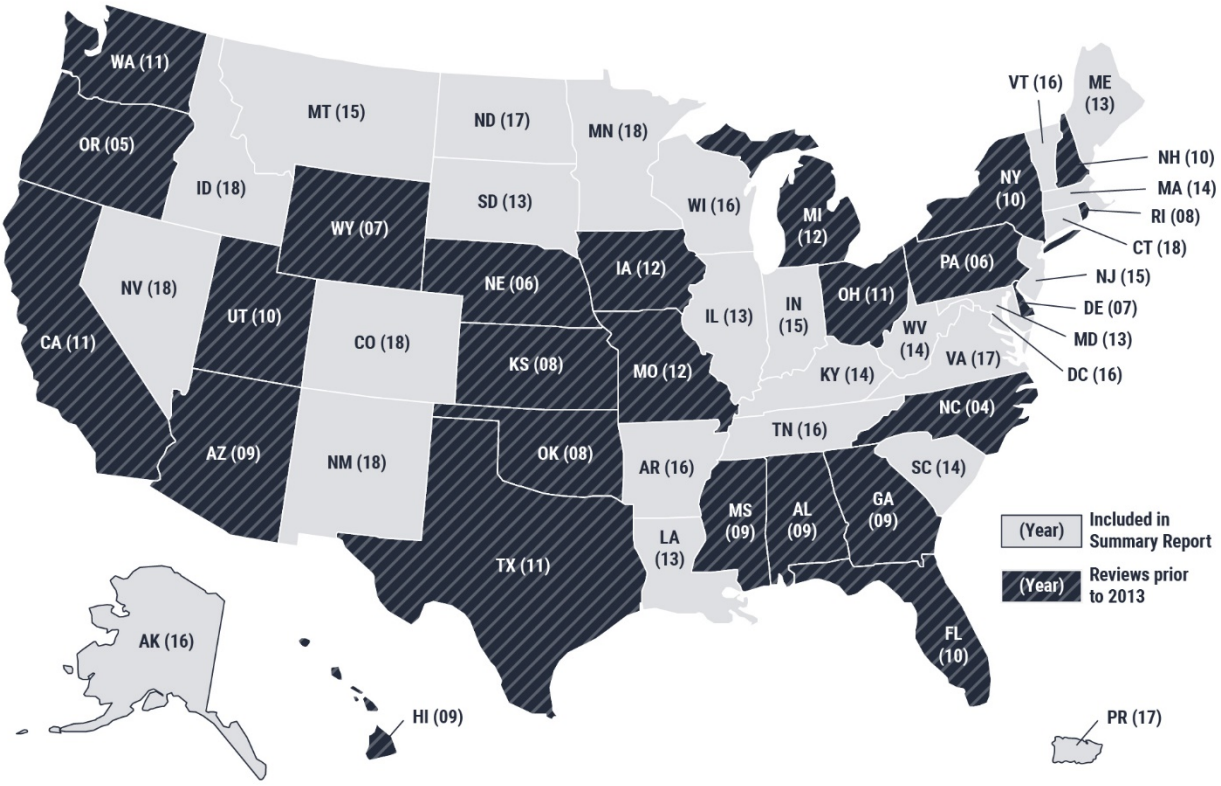

Figure 1. Most recent Quality Assurance Stewardship Reviews by calendar year.

REVIEW PROCEDURES

The Quality Assurance Stewardship Reviews were a joint effort involving the SHA personnel along with FHWA personnel from Headquarters, the Resource Center, and the Federal-aid Division Offices. Materials practices were examined at the SHA's headquarters, region/district, and construction project level locations.

Prior to the review, the FHWA Quality Assurance Review Guide (see Resources section of this *Summary Report*) was provided to the SHA. The Division Office and SHA provided QA program, specifications, and other related documents to the FHWA review team before the onsite visit. Entrance conferences were held, as appropriate, with key FHWA Division Office and SHA personnel to explain the evaluation and process. Closeout meetings were held with the Division and SHA personnel to share information obtained from the review.

The Quality Assurance Stewardship Reviews included:

- Planning, scheduling, and coordinating via emails and phone calls.
- Interviews with SHA headquarters, region/district, and field office personnel and FHWA personnel.
- Reviews of SHA policy and procedure documents including implementation strategies and office records where applicable.
- Visits to construction projects to assess field practices, including discussions with contractor quality control (QC) staff as appropriate.
- Identification of program strengths, opportunities for program improvements, and suggested practices for consideration.
  - Program strengths were areas where the SHA QA program employed effective processes and procedures to evaluate materials and minimize program risks.
  - Opportunities for improvement represented significant concerns about the SHA QA program and its implementation. These opportunities for improvement should be addressed in partnership between the FHWA Division Office and the SHA and are tracked by the FHWA Division Office and Headquarters.
  - Suggested processes and procedures that could help an SHA reduce its materials acceptance risks.
- A final report provided to FHWA Division Office.

OBSERVATIONS AND FINDINGS

Overall Compliance with 23 CFR 637 Subpart B

As noted earlier in this *Summary Report*, the Quality Assurance Stewardship Reviews evaluated the SHAs' QA program practices and procedures and ascertained the status of the SHAs' implementation of and compliance with the QA regulation, 23 CFR 637.205, 23 CFR 637.207, and 23 CFR 637.209. While the majority of SHAs reviewed were found to comply with the regulations, there were eight SHAs with one or more elements that were not in full compliance. Examples of noncompliance noted in the Quality Assurance Stewardship Reviews included:

- SHA not verifying contractor-collected ride quality data.[3]
- SHA technicians witnessing contractor testing rather than performing independent testing.[4]
- SHA's IA program not covering all Federal-aid projects on the NHS, but instead only those with a contract value more than $1,000,000.[5]
- On a design-build project, the SHA allowing the contractor to procure the independent quality firm.[6]

Noncompliance items were noted to both the respective SHA and FHWA Division Office and all SHAs brought their practices into compliance.

Program Strengths of the Twenty-Seven Quality Assurance Stewardship Reviews

As discussed previously in this *Summary Report*, program strengths were areas where the SHA QA program employed effective processes and procedures to evaluate materials and minimize program risks. Program strengths are summarized below.

While only about half of the twenty-seven reviews specifically noted consistent use of only one QA program (for projects on or off the NHS and with or without federal funding), none of the reviews noted multiple systems used by an SHA. Using the same QA program may lower the risk to the Federal-aid program as QA program personnel are less likely to be confused about the application of QA requirements on a project, regardless of funding or highway system.

A few SHAs were noted as testing out specification changes on pilot projects which allowed contractors and SHAs to adapt to the revised specification prior to full implementation across the program.

Several SHAs conducted regular meetings, in many cases monthly, to discuss changes or issues in the QA program. This provided an opportunity for training and background information to be provided to field personnel and a venue for feedback from the field on the application of QA program elements.

[3] 23 CFR 637.207(a)(ii)(B).
[4] 23 CFR 637.205(d).
[5] 23 CFR 637.207(a)(2).
[6] 23 CFR 637.205(d).

Acceptance

Use of Contractor Test Results

Use of contractor test results in the acceptance decision has been an emphasis area from the beginning of the Quality Assurance Stewardship Reviews.

- While a majority of the twenty-seven SHAs reviewed used contractor test results, three had a very narrow application of contractor testing, such as only using contractor testing for pavement smoothness.
- An important item in the use of contractor testing, is the ability to validate those test results.[7] One strength is that many of the SHAs reviewed used the statistical *F* & *t* test[8] procedures in validating contractor test results to ensure that they come from the same population before using them in the acceptance decision.

Alternative Contracting Methods

Alternative Contracting Methods (ACM)—Design-Build (D-B), Construction Manager / General Contractor (CM/GC), Construction Manager at Risk (CMAR), and Alternate Technical Concepts (ATC)—have been used to accelerate project delivery, encourage the deployment of innovation, and minimize unforeseen delays and cost overruns. The use of these methods has become increasingly popular in highway construction during the years covered by this *Summary Report,* but these methods can create some risks in the QA program. In 2012, FHWA issued a Tech Brief related to this topic (see Resources section of *Summary Report*).

Alternative contracting methods were included in most of the SHA reviews; D-B was noted in the majority of those SHA reviews, with CM/GC and CMAR noted in just a few of the reviews. These reviews noted that most of the SHAs were effectively applying their QA program on these types of projects.

Percent within Limits

In recent years, FHWA has encouraged, but not mandated, the use of the percent within limits (PWL) specifications. PWL provides a powerful tool to characterize the quality of the material. A majority of the SHAs reviewed were using PWL for acceptance/payment.

Use of Random Numbers in Sampling

Federal regulation at 23 CFR 637.205(e) requires that "[a]ll samples used for quality control and verification sampling and testing shall be random samples." Random numbers were commonly used by the SHAs reviewed to generate sampling locations. Several of the SHAs consistently used random sampling procedure and application. Many States used an SHA-developed spreadsheet or computer program as a practice to generate and document their random number practice. Some of these reviews noted that these SHAs had implemented successful random number systems based on FHWA's suggestions from previous reviews.

[7] 23 CFR 637.207(a)(ii)(B).

[8] The *F*-test provides a method for comparing the variances (standard deviations squared, σ^2) of two sets of data by assessing the size of the ratio of the variances. The *t*-test provides a method for comparing the means of two independent data sets and is used to assess the degree of difference in the means.

Pavement Smoothness

For decades, the FHWA has used pavement smoothness as an indicator of pavement performance of the NHS and suggested smoother pavement practices. Most of the SHAs reviewed used the International Roughness Index (IRI) to quantify ride quality when measured by an inertial profiler. Inertial profilers allow efficient measurement, reduce traffic disruption, and are compatible with network-level pavement smoothness reporting. Profile Index (PI), as measured by a profilograph or calculated from the measured profile, was reported as being used by a few SHAs on PCC pavements only.

Properly qualified[9] profiling equipment and operators are used to minimize the risk for pavement smoothness incentive programs. Many SHAs used profiler equipment certification and operator certification as part of their QA program for pavement smoothness. About half the SHAs used contractor-collected pavement smoothness data with the remainder using SHA collected data.

PCC

PCC is a material used by SHAs both in structural and pavement applications. Several SHAs were recognized for requiring a project-level PCC QC plan to be submitted by the contractor prior to PCC production. Several SHAs required PCC ready-mix plants to be certified by the National Ready Mixed Concrete Association.

Several new technologies emerged in the PCC area during the review period. Most reviews contained voluntary practice suggestions for SHAs to investigate or implement technologies such as the Super Air Meter (see figure 2) or surface resistivity.

- Several SHAs had voluntarily evaluated concrete permeability by either a concrete surface resistivity or rapid chloride permeability (AASHTO T 277) test.
- Regarding PCC thickness and dowel bar alignment:
  - A few SHAs used MIT Scan technology (see figure 3) to determine PCC thickness or dowel bar location.
  - One SHA used ground penetrating radar to determine dowel and tie bar location in concrete paving.
- One SHA used optimized gradation (e.g., Tarantula Curve) in proportioning aggregate for PCC mixtures; a new technical approach being encouraged but not mandated by FHWA.

Figure 2. One make and model of Super Air Meter.

[9] 23 CFR 637.207(a)(1)(ii)(A).

Figure 3. MIT Scan T3 operated on a new PCC pavement to determine thickness.

Asphalt Mixture

Asphalt mixtures are widely used for both new and rehabilitated pavement applications. Asphalt mixtures have become more complicated over the years as production has moved from hot-mix asphalt produced with virgin aggregates mixed with neat asphalt binder to now include recycled materials, materials from the waste stream, asphalt binder modifiers, warm-mix production, and so on.

All reviewed SHAs used performance graded (PG) binders. A few SHAs added specifications such as Multiple Stress Creep Recovery requirements. While the Superpave PG binders were uniformly applied, there was more diversity in the mixture design methodology. Most SHAs used the Superpave volumetric mixture design with a Superpave gyratory compactor (see figure 4). A few SHAs were still using Marshall mixture design and one SHA was using the Hveem methodology.

Warm-mix asphalt (WMA) technologies can reduce energy consumption and emissions, provide better compaction on the road, produce paving mix that can be hauled for longer distances, and extend the paving season by allowing paving at lower temperatures[10]. Many SHAs reported having a permissive WMA specification where it is the contractor's option whether to use WMA. One SHA reported over 90 percent of the asphalt mixtures were WMA.

Other items noted as program strengths in the asphalt mixture area include:

- To improve resistance to moisture induced damage, most SHAs voluntarily used AASHTO T283, *Standard Method of Test for Resistance of Compacted Asphalt Mixtures to Moisture-Induced Damage*, to determine the moisture susceptibility of the mixture

[10] FHWA. 2020. EDC-1 Innovations. Accessed July 22, 2020.

Figure 4. One make and model of a Superpave gyratory compactor.

design. Some SHAs have made modifications to this procedure based on their experience and mixture performance in their State.

- To improve longitudinal joint performance, many SHAs have a longitudinal joint density specification.
- For rutting resistance, moisture damage, and mixture durability, several of the SHAs were noted as using a Hamburg wheel-track test (see figure 5) while an additional SHA was evaluating its use. A few additional SHAs were using an Asphalt Pavement Analyzer (APA).
- A few SHAs were noted for their processes to determine, verify, and/or use of aggregate specific gravity data in the evaluation of asphalt mixtures properties.

Figure 5. One make and model of a Hamburg wheel-track testing device.

- Most SHAs had the contractor perform the mixture design with a verification by the SHA. The verification varied with some SHAs doing laboratory testing of the asphalt mixture while others only performed a paper review of the contractor's submission.
- Many SHAs required a project-level QC plan by the contractor on asphalt mixture paving projects.
- Several SHAs required sampling loose mix behind the paver (see figure 6) or from the windrow in front of the paver, which is the preferred location that most closely represents final in-place material properties. Several additional SHAs allowed but did not stipulate sampling at these locations.
- One SHA used a method of determining and paying for the asphalt content as a percentage of asphalt mixes. A price adjustment was based on the difference between the asphalt content specified in the contract documents and the mix design is used to provide a level playing field for aggregates with different absorptions. This adjustment also reduces the incentive to the contractor to design mixtures with low asphalt cement contents.
- Some SHAs were noted for implementing tack coat bond strength testing to ensure that their tack coats were functioning as they intended.

Manufactured Materials

Manufactured materials play a key role in the construction of Federal-aid highway projects by SHAs. Many of the SHAs reviewed had published lists for SHA-qualified products, most of which are readily accessible on the internet.

Figure 6. Sampling behind paver to obtain loose sample of asphalt mixture.

The National Transportation Product Evaluation Program (NTPEP) is a voluntary AASHTO program that tests select manufactured materials. Several SHAs were moving toward expanded use of the NTPEP program. Some SHAs are specifying that materials need to be tested by the NTPEP before the material is considered for SHA approval. Most of the twenty-seven SHAs reviewed were active participants in the NTPEP.

Independent Assurance

Federal regulation at 23 CFR 637.203 defines an IA program as activities that are an unbiased and independent evaluation of all the sampling and testing procedures used in the acceptance program (see Resources section of this *Summary Report* for additional information). An IA program ensures that the sampling and testing are performed correctly and that the testing equipment used in the program is operating correctly and remains calibrated. It involves a separate and distinct schedule of sampling, testing, and observation.[11]

SHAs have options under the regulation as to the approach they take.[12] The IA program can be set up on a project basis, which is the traditional approach, or on a system basis. The difference in the two approaches is the basis of the frequency of testing (cover all projects versus cover all personnel). Some SHAs implemented a hybrid method, using both project and system approaches in their IA program. Figure 7 provides the breakdown of the IA approach used by the twenty-seven SHAs reviewed.

[11] 23 CFR 637.207(a)(2).
[12] 23 CFR 637.207(a)(2).

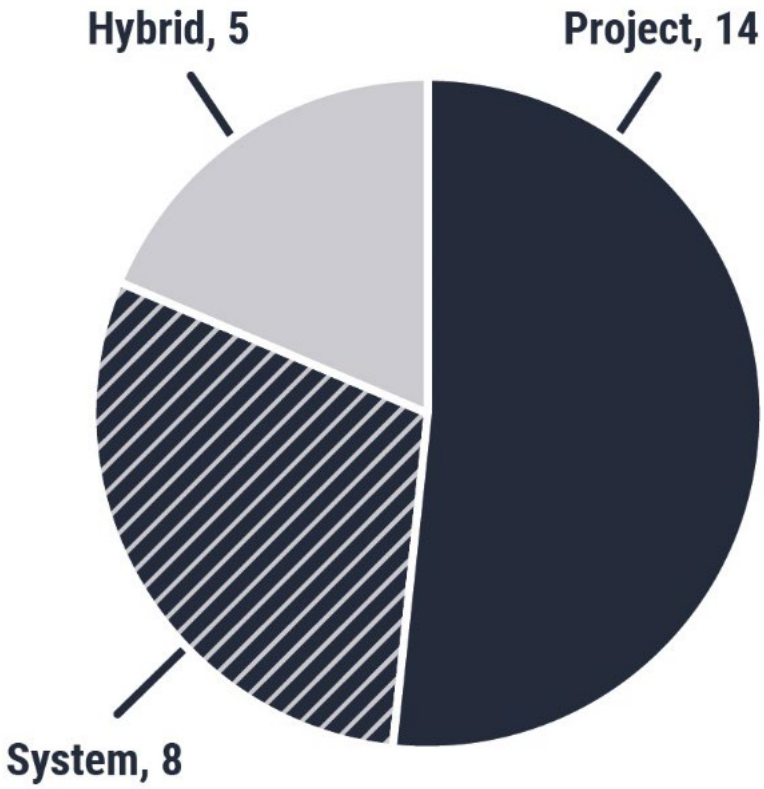

Figure 7. Distribution of SHAs' approach to IA at the time of the reviews.

The IA program is a key requirement[13] to reduce the risk to construction quality. Several of the SHAs were noted for regularly updating IA comparison tolerances.[14] Additionally, a few SHAs used their annual IA reports[15] to identify deficiencies and trends in technician performance, which were then used to guide future IA program improvements.

Technician and Laboratory Qualification

Technician Qualifications

Federal regulation at 23 CFR 637.209(b) requires that all sampling and testing data used in the acceptance decision or the IA program shall be executed by qualified sampling and testing personnel. While the details of the qualification are left to the SHAs, FHWA provides guidance in its "Non-regulatory Supplement for 23 CFR Part 637 Subpart B—Quality Assurance Procedures for Construction" (see Resources section of this *Summary Report* for additional information).

The program strength noted in the reviews was that five years was the most common length of time for a technician certification to be valid, which is in accord with FHWA's recommendation.[16]

[13] 23 CFR 637.207(a)(2).
[14] 23 CFR 637.207(a)(2)(iii).
[15] 23 CFR 637.207(a)(2)(iv).
[16] See Resources section of *Summary Report* for Non-regulatory Supplement NS 23 CFR § 637B, "Quality Assurance Procedures for Construction," Item 3.d.5.

Laboratory Qualifications

Like technician qualifications, 23 CFR 637.209(a)(1) requires that all contractor, vendor, and SHA testing used in the acceptance decision be performed by qualified laboratories. Among the program strengths noted in the laboratory qualification area were:

- All the reports noted that the central laboratory was accredited by the AAP.
- Several SHAs had district or regional laboratories that were also accredited in whole or in part by AAP.
- A few of the SHAs reviewed required that contractor or consultant labs that performed certain functions (such as asphalt mix design) be accredited by AAP.
- Most of the reviewed SHAs required district or regional labs to be reviewed annually.
- As part of the tiered process, many SHAs used district or regional labs to review project field labs that are performing acceptance testing.

Records and Data Management

A comprehensive and readily accessible database of material test results can support a comprehensive QA program. Many of the SHAs reviewed used AASHTO SiteManager to collect and store material test results. Some of these SHAs used it more completely than others, allowing the analysis of test results to update specification limits or comparison testing tolerances. Several of the remaining SHAs reviewed had systems developed internally or by the local university that accomplished a similar function for collecting and storing test results so that they can be analyzed.

Opportunities for Improvement from the Twenty-Seven Quality Assurance Stewardship Reviews

Opportunities for improvement from the reviews are summarized below.

Acceptance

Use of Contractor Test Results

Validation of contractor test results is a key requirement before those test results are used in the acceptance decision.[17] A few of the SHAs reviewed used individual test tolerances to validate contractor test results rather than using a more powerful, statistically valid method such as *F* & *t* testing of SHA versus contractor test results.

Additionally, a few of the SHAs reviewed used contractor-collected smoothness testing with no SHA verification testing. One review also noted that an SHA was allowing contractors to determine the density of soils and aggregate layers with nuclear density gages without adequate verification; the only verification was that the test was witnessed by an SHA employee.

[17] 23 CFR 637.207(a)(1)(ii)(B).

Use of Consultants

SHAs may use consultants to fill numerous roles in their QA program. Some SHA reviews noted that consultants had a potential conflict of interest on projects where they obtained or tested materials for acceptance.[18]

Alternative Contracting Methods

As discussed earlier, alternative contracting methods have become more prevalent in Federal-aid highway construction. Although most of the SHAs reviewed utilized one or more alternative contracting methods, many of the SHA reviews that utilized these techniques noted QA risks or potential program improvements.

Use of Random Numbers in Sampling

During the reviews, it was suggested that several SHAs develop or improve their documented procedures for random sampling. Additionally, it was noted that while some SHAs had adequate procedures, several SHAs received suggestions to improve their field practice of random sampling. Several reviews noted the inconsistent use of random numbers for obtaining samples, the provision of advance notice to the contractor of sampling locations, the inconsistent application of procedures, and the application of biased procedures.

Security for Samples Transported by Contractor Personnel

Many SHAs use contractor resources to transport or store samples. About half of the SHAs had security issues with samples that were obtained or transported by contractor personnel. Adequate sample security must be provided to ensure the integrity of the samples.[19] Figures 8 and 9 illustrate examples of sample security practices from two of the reviews.

Figure 8. Example of tamper-proof zip tie on a canvas sample bag.

Outliers

Some of the SHAs evaluated received suggestions to assess their documented and specified method of determining whether a test result is an outlier. Outliers should not be removed from the analysis without proper investigation of the sampling and testing process for a documented error.

Asphalt Mixture

Multiple items were noted across the twenty-seven reviewed SHAs as opportunities for improvement. Items noted in the reports included:

[18] 23 CFR 637.205(d).
[19] 23 CFR 637.205(d).

Figure 9. Example of sample security with tamper-proof tape on cardboard sample boxes.

- Several SHA reviews noted issues with the determination, verification, or use of aggregate specific gravity in asphalt mixtures. This creates issues with accurately calculating mixture volumetric properties such as voids in mineral aggregate (VMA) and asphalt content.
- A few SHAs were reported as having issues with asphalt mixture specific gravity determination, verification, or its use in the mixture design and its impact on acceptance and pay for in-place density. Some SHAs are using equipment for the rapid drying of material samples (see figure 10) to obtain results more quickly.
- Most of the SHAs allowed or required loose asphalt mixture to be sampled at the plant or from haul trucks, rather than the preferred location near the paver. This raises a potential risk of how representative the sample is of the material incorporated into the Federal-aid project. Several of these SHAs did allow sampling from the mat behind the paver or the windrow placed in front of the paver but did not require it.
- Ignition furnaces (see figure 11) were suggested to a few SHAs as a method of determining asphalt cement content. When using this method, proper determination of correction factors directly impacts the test result. Several SHAs were noted for issues with the correction factor being used for ignition furnaces, using the same correction factor for multiple ignition furnaces, or using contractor-reported correction factors.
- Several SHAs were noted for issues with the determination of asphalt binder content (e.g., using producer's recordation on plant tickets, calculation from inventory records).
- Many SHAs received suggestions to include volumetric properties as part of the acceptance decision for asphalt mixes or to expand their use of volumetric properties in acceptance or pay factors. The addition of volumetric properties also requires that it be included in the SHA's IA program and frequency of testing.

Figure 10. Example setup of rapid material sample drying equipment used by an SHA.

Figure 11. Example ignition furnace setup at an SHA laboratory.

Manufactured Materials

It was suggested some SHAs develop a qualified products list (QPL) to standardize manufactured product acceptance and reduce the need for project documentation. Keeping the QPL current was noted as an issue in at least one SHA.

Independent Assurance

Several opportunities for improvements were noted in the reviews in the IA area, including:

- IA tolerances should be updated in a majority of the reviewed SHAs.
- Multiple SHAs received suggestions that the annual IA analysis and reports be improved to be more comprehensive as well as to identify problems (and potential solutions) with testing. Also noted was that results from alternative contracting projects should be included in the annual IA reports when the system approach is used.

Several reports suggested that the IA programs be expanded to include testing of significant items (such as asphalt mixture volumetric properties and plastic PCC testing) and to ensure that all testers are included, whether they are SHA, contractor, or consultant personnel. For example, one SHA did not operate nuclear density gauges and did not have an established IA procedure to monitor the consultants that utilized nuclear density gauges for acceptance. SHAs using the system approach typically have a goal of annually covering 90 percent of active testers. A few of the SHAs had trouble meeting that goal.

Technician and Laboratory Qualification

Technician Qualifications

One SHA was observed as using different qualification processes whether the technicians were SHA, contractor, or consultant employees. In other SHAs, it was observed that even though technicians were qualified, they were not consistently following the QA procedures on projects. In some reviews, SHA technicians were observing contractor testing rather than performing the required verification testing themselves.

Laboratory Qualifications

Many of the reviews noted that SHAs should improve their qualification methods for regional/district, contractor, and producer laboratories.

Records and Data Management

Some of the SHAs reviewed had no centralized computer database to allow the mining of material test data for analysis. Reviewers suggested that those SHAs develop a data management system that allowed for the comprehensive analysis of QA program test results.

Effective Practice Suggestions

Effective practice suggestions were based on processes and procedures that were observed in prior reviews of other SHAs and could help an SHA reduce their materials acceptance risks. SHAs were encouraged to consider the practices as resources allowed. Some of these processes and procedures were developed or refined during the time of the subject reviews. Trends from the twenty-seven reviews are summarized below.

In the PCC area, it was noted during some of these reviews that implementing a concrete surface resistivity test for PCC mixtures could improve PCC durability. Several SHAs were encouraged to consider optimized gradation (e.g., Tarantula Curve) in the proportioning of aggregates for PCC mixtures for improved quality.

During several of these reviews SHAs were encouraged to consider a joint density specification to improve the performance of asphalt pavements. Although problems with longitudinal joint performance have been recognized for years, there was an increased emphasis on joint density specifications during the timeframe of these reviews.

CONCLUSION

Observations and findings from the Quality Assurance Stewardship Review program continue to play an important part in FHWA's oversight role. These reviews of SHA QA programs allow FHWA to identify and assess risks to the Federal-aid program:

- The majority of SHAs reviewed were in overall compliance with 23 CFR 637.205, 23 CFR 637.207, and 23 CFR 637.209.
- The use of contractor test results in the acceptance decision without adequate validation has continued to be documented in the reviews.
- Test sample security was noted as an issue in multiple reviews. SHAs are responsible for ensuring that sample integrity is maintained. to be confident that the sample represents the material incorporated into the project.[20]
- Random sampling is not only required to meet the regulatory requirements of 23 CFR 637.205(e), it is important to providing a high level of confidence in the properties of the materials incorporated into the Federal-aid project. Several reviews of SHA projects noted the inconsistent use of random numbers for obtaining samples, inconsistent application of procedures, and application of biased procedures in this area.
- Several reviews indicated that SHAs were not keeping their documented QA processes and procedures current with improvements in their actual QA practices being conducted on projects as required by 23 CFR 637.205(a).
- Several reviews indicated that the documented QA processes and procedures in the approved QA program were not being followed on projects as required by 23 CFR 637.205(a).

The reviews also provide an avenue for FHWA to identify benefits and implementation practices of new technologies. Featured new technologies included:

- Optimized gradation (e.g., Tarantula Curve) for proportioning aggregates in PCC mixtures.
- MIT Scans for determining PCC pavement thickness and dowel and tie bar location and orientation.
- Super Air Meters, which can be used to assess properties of the PCC air-void system beyond the air content. The result is a measurement that has been shown to correlate well with the spacing factor measurement from ASTM C457 and freeze-thaw performance data such as ASTM C666.
- PCC permeability and surface resistivity to provide a rapid indication of concrete's resistance to chloride ion penetration.
- Contractor testing validation that is statistically based and robust. One challenge in this area can be the limited access to new technology that is only owned by the contractor. This can make independent verification difficult for SHAs (e.g., smoothness profiling as

[20] 23 CFR 637.205(d).

well as intelligent construction technologies such as pavement mounted thermal profiling).

The observations and findings identified opportunities for improvement relating to the SHAs' QA programs, and technical resources have been provided to assist States where requested.

Since 2016, SHAs—in partnership with FHWA Division Offices—have been providing documented responses on completed and planned actions in response to review findings and suggestions. Four reviews noted the status of suggestions from previous Quality Assurance Stewardship Reviews. Almost all the regulatory deficiencies and most suggestions for the SHAs' QA programs were implemented. Where appropriate, these Quality Assurance Stewardship Reviews have followed up to reinforce prior FHWA reviews.

In addition to the program-level Quality Assurance Stewardship Reviews discussed in this *Summary Report*, FHWA Division Offices conduct more focused process reviews and oversight activities, often supported by the FHWA Resource Center and Headquarters. These additional oversight activities often cover some of the same topics as these Quality Assurance Stewardship Reviews and provide additional follow-up on findings and suggestions.

Continuing the Quality Assurance Stewardship Reviews will improve the quality of materials on Federal-Aid highway projects by the:

- Identification of program risks and initiation of program improvements.
- Identification of effective practices and new technologies.
- Successful implementation of new practices and technologies identified in follow-up reviews.
- Training opportunities for FHWA Division personnel.

These Quality Assurance Stewardship Reviews provide technical resources and assistance to SHAs and FHWA Division Offices to continuously improve their QA program.

RESOURCES

The following resources are available for use by SHAs when implementing policies and practices to address the opportunities for improvement identified in the Quality Assurance Stewardship Reviews.

American Association of State Highway and Transportation Officials (AASHTO). 2018. AASHTO Standard Recommended Practice R 9-05. "Standard Practice for Acceptance Sampling Plans for Highway Construction." AASHTO, Washington, DC.

Construction Inspection and Approval. 2006. "Quality Assurance." *Code of Federal Relations.* Non-regulatory Supplement NS 23 CFR § 637B. Office of Federal Register.

Construction Inspection and Approval. 2013. "Quality Assurance Procedures for Construction." *Code of Federal Regulations*. 23 CFR § 637B.

Federal Highway Administration (FHWA). 2003. *Optimal Procedures for Quality Assurance Specifications*. FHWA-RD-02-095. Federal Highway Administration, Washington, DC.

Federal Highway Administration (FHWA). 2004. *Evaluation of Procedures for Quality Assurance Specifications*. FHWA-HRT-04-046. Federal Highway Administration, Washington, DC.

Federal Highway Administration (FHWA). 2004. Technical Advisory 6120.3. *Use of Contractor Test Results in the Acceptance Decision, Recommended Quality Measures, and the Identification of Contractor/Department Risks.* Technical Advisory 6120.3. Federal Highway Administration, Washington, DC.

Federal Highway Administration (FHWA). 2006. *Chapter 1 I—Questions and Answers on the Quality Assurance Regulation (23 CFR 637).* Federal Highway Administration, Washington, DC.

Federal Highway Administration (FHWA). 2011. *Independent Assurance Programs*. FHWA-HIF-12-001. Federal Highway Administration, Washington, DC.

Federal Highway Administration (FHWA). 2012. *Construction Quality Assurance for Design Build Projects*. FHWA-HRT-12-039. Federal Highway Administration, Washington, DC.

Federal Highway Administration (FHWA). 2013. *Acceptance of Non-Structural Precast Elements.* Tech Brief. FHWA-HIF-13-045. Federal Highway Administration, Washington, DC.

Federal Highway Administration (FHWA). 2017. "Chapter 1 IV—Quality Assurance Stewardship Review." *Materials Notebook.* Federal Highway Administration, Washington, DC. Accessed January 13, 2020.

Federal Highway Administration (FHWA). 2017. *Materials Quality Assurance.* Federal Highway Administration, Washington, DC. Accessed February 15, 2020.

Federal Highway Administration (FHWA). 2017. *Quality Assurance Stewardship Activities.* Federal Highway Administration, Washington, DC. Accessed February 15, 2020.

National Highway Institute (NHI). 2009. *NHI Course 134064, Transportation Construction Quality Assurance.* To be replaced in 2020 by NHI Course 131141, "Quality Assurance for Highway Construction Projects."