

Materials Quality Assurance (QA) Stewardship Review of the Virginia Department of Transportation (DOT)

Review Conducted By

Federal Highway Administration (FHWA), Office of Pavement Technology

Federal Highway Administration (FHWA), Virginia Division Office

Virginia Department of Transportation (VDOT), Materials Division

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Scope

The objective of this assessment and information sharing was to review the Virginia DOT (VDOT) Materials Quality Assurance (QA) Program practices and procedures to assess compliance with current federal regulations, specifically 23 CFR 637, and to ascertain the status of the State's implementation of the QA regulation. The review looked at the entire QA program in the State with an emphasis on the use of contractor quality control (QC) test data in the agency acceptance decision.

Material practices involving the regulation were examined at the VDOT Central Office Materials Division, District Materials Sections, and project levels. Projects in the Salem and Hampton Roads Districts were reviewed along with available project QA testing records.

Itinerary

March 13 – Opening meeting in VDOT Central Office Materials Division

March 14 – Continue meeting in VDOT Central Office Materials Division, meeting in Salem District Materials Section

March 15 – Continue meeting in Salem District Materials Section

March 16 – Meeting in Hampton Roads District Materials Section and I-64 Coliseum Improvement Project

March 17 – Closeout with VDOT and FHWA Division Office.

Organizational Structure

The Materials Quality Assurance (QA) function is located in the Materials Division of VDOT. There are 9 districts in the VDOT. All but two districts, northern Virginia and Richmond have laboratories. Northern Virginia uses the Culpeper laboratory while Richmond uses the central laboratory. The district laboratories all report to the districts, but receive technical guidance from the Materials Division.

Materials Quality Assurance (QA) Program

The VDOT's QA program is described in the Materials Division Manual of Instructions. The Materials Division Manual of Instructions is available online and can be accessed at <http://virginiadot.org/business/materials-default.asp>. The manual contains the testing frequency guide, acceptance procedures for manufactured items, equipment calibration schedule, test procedures, and Independent Assurance (IA) procedures.

The State uses contractor testing data in the acceptance decision in Hot Mix Asphalt (HMA) and the Central Mix Aggregate (CMA).

Construction Inspection personnel from each project perform the plastic concrete testing and the soils/asphalt density testing. The district materials personnel handle plant monitoring and testing for HMA and CMA.

Independent Assurance (IA) program

The State uses both the system and the project approach for areas of IA. The State has comparison tolerances for IA. The frequency guide for testing is contained in the Manual of Instruction.

Personnel from the District Materials Laboratory perform the IA testing. The State uses the D2S limits published in the AASHTO Test Procedures for comparison tolerances. The State is gathering information to establish their comparison tolerances. The variability in the State is probably considerably lower than what the D2S limits would indicate due to modification of test procedures that allow fewer options and the technician certification programs.

For HMA mix properties and Central Mix Aggregate (CMA) plant results the State compares the individual split samples and performs a matched comparison analysis. For

the individual split samples the D2S limits are used for comparison. The matched comparison analysis is performed on multiple pairs using the paired t statistic. See fig. 1.

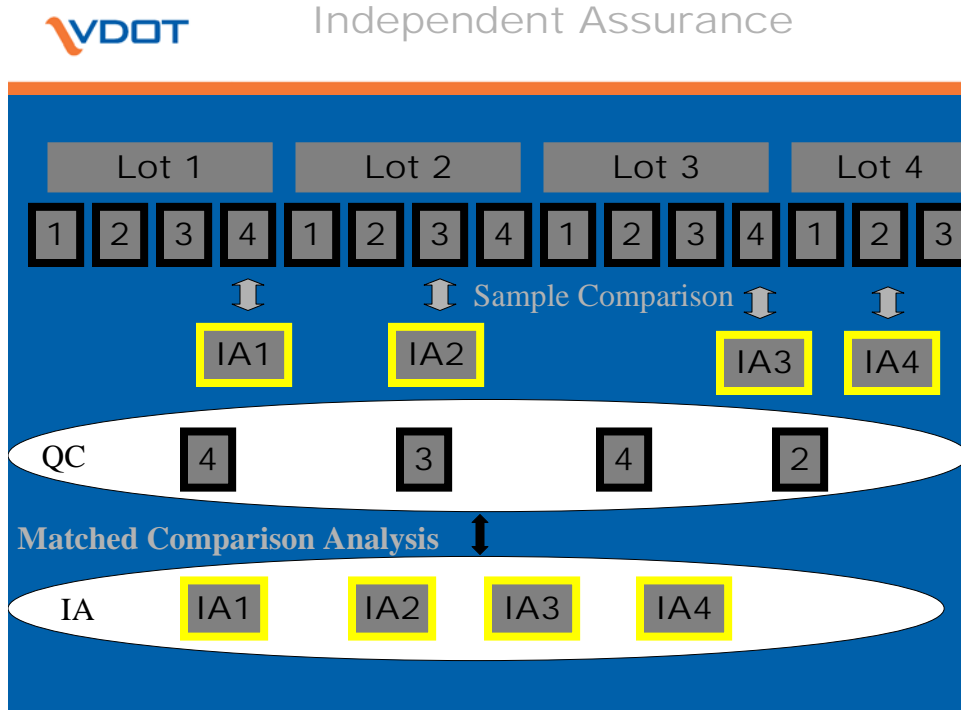


Figure 1.

The State’s forms for IA do not contain both the IA test result and the test result that it is being compared. However new forms for asphalt density IA and QA were issued in May 2006.

QA for density testing of HMA is performed by testing 20 percent of the lots and using a comparison tolerance for comparing the average result between the State and contractor test results.

Technician Qualification Program

The VDOT maintains technician certification programs, which include formal training and proficiency testing. The State requires recertification every 5 years. The State also cooperates with the Mid-Atlantic Region Certification Program (MARTCP). There are a

limited number of technicians that are granted certification through reciprocity with the MARTCP States. There are approximately 6500 technicians that are currently certified by VDOT.

The VDOT requires all testing to be performed by technicians that are certified. There are 10 areas that cover sampling and testing issues. Personnel that perform HMA or PCC mix designs are required to be certified.

Over the years, there have been a couple of technicians that have been decertified.

Laboratory Qualification

The Materials Division Laboratory and all the district laboratories are accredited by the AASHTO Accreditation Program.

The District materials laboratories review and approve the contractor's laboratories.

Calibration of Equipment

The State performs the calibration of state owned nuclear gages.

VDOT currently requires the technicians to routinely calibrate concrete air meters

Quality Control (QC) Program

The materials suppliers submit QC plans for VDOT review:

- HMA (for voluntary review)
- Aggregate suppliers (for voluntary review)
- PCC - (for review).

The QC plans are on file in the district and are not submitted on a project basis.

Hot Mix Asphalt (HMA)

The Superpave mix design method is being used. VDOT is using AASHTO T-283 as performed by the contractor to determine moisture sensitivity. The State has a limit of 80 percent retained strength. VDOT also uses the asphalt pavement analyzer for asphalt mix design. VDOT is also specifying asphalt binder using the PG grading system and uses AASHTO R-26 for acceptance of asphalt binder.

Contractors are required to submit a mix design to VDOT for approval. VDOT requires the mix design to be performed by personnel that have been certified.

Acceptance of the mix is based on asphalt content and gradation. The ignition oven is used for obtaining asphalt content and gradation. Mix volumetrics are monitored and can be used to shut down a contractor. Acceptance of the mix is based on verified contractor test results. The contractor samples and test samples at the rate of 4 samples per 2000 ton lot. VDOT takes independent monitor samples, at the beginning of production; a minimum of 4 samples are taken the first week of production and after the first weeks production a minimum of 2 samples per production week are taken. The monitor samples are taken at the plant by contractor personnel under the direction of the State personnel. The independent samples are split and a split is given to the contractor. Analysis is performed in two ways. First the split results are compared using D2S limits and then the independent sample run by the State is compared to the remainder of the contractor's results using the F&t tests. See figure 2. The contractor's results are faxed into the District materials labs the next day in some of the districts; however, this is not consistent throughout the state and is delayed in some of the districts. The faxing of data is the official submission of contractor data. The split comparison is made when the official data is received. This results in a delay in performing the F&t analysis.

If one of the 4 samples appears to be questionable the contractor can request 5 additional samples to be taken from the roadway. The additional samples must be tested by the department or an AASHTO Accredited laboratory. The eight test results are then averaged and compared to the tolerances for 8 samples.

Acceptance for asphalt content and gradation is based on the mean of four tests results being within the tolerances from the job mix formula. Payment is adjusted based on adjustment points outside of the acceptance tolerance levels. A standard deviation for the season is also calculated and payment is also adjusted for falling outside the tolerance level for standard deviation.

The State currently is not verifying the correction factors for the ignition ovens, however all the contractors are using similar equipment and there is very little source change, thus this correction factor may not be as critical as would be in other regions of the country.

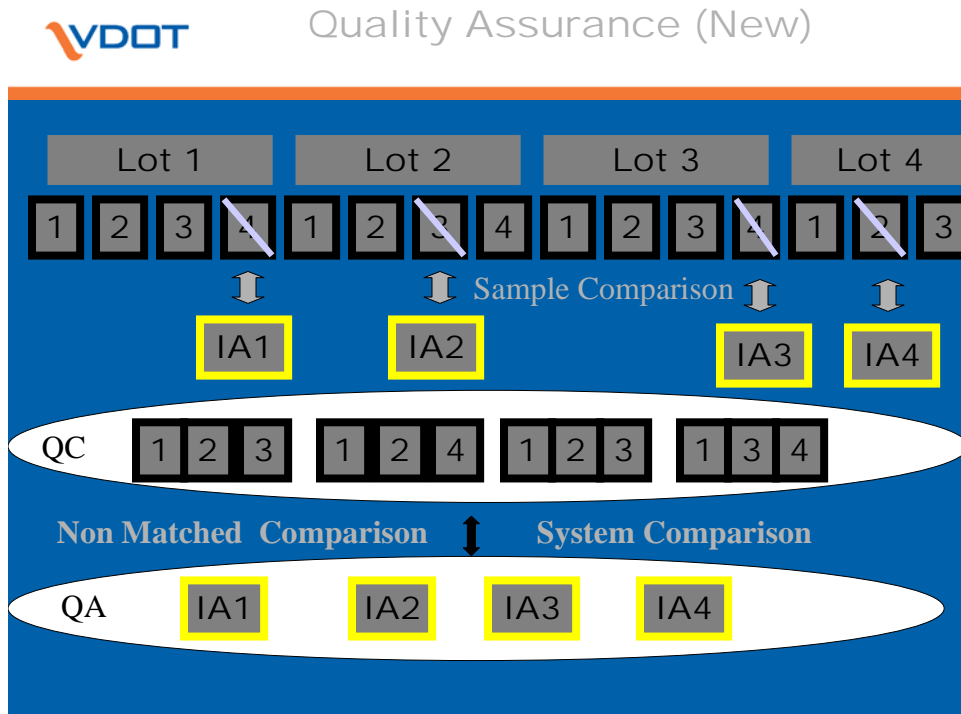


Figure 2.

Density of asphalt pavements is performed with a thin lift nuclear density gage with a printer. The target for density of the mat is based on a percent of control strip. The density of the control strip is determined with 3 sets of 2 cores (total of 6). The control strip is required to have a minimum of 92.2 for Superpave and 94.0 for SMA percent of maximum theoretical density. The specified minimum density of the mat is a minimum

of 98 percent of the control strip. Payment is based on verified contractor results. The state performs verification testing based on 20 percent of the lots. The average of ten readings taken in a 5000 foot section is considered to be a lot.

Payment for density is based on the average density value for each lot the contractor receives 100 percent pay for an average density of 98 to 102 percent of the control strip.

VDOT specifies smoothness with the International Roughness Index (IRI). The VDOT specification has provisions for a bonus up to 115%. VDOT measures IRI with a State owned van.

Portland Cement Concrete (PCC)

The producers perform trial batches. The following information is supplied to VDOT, all batch weights, fresh concrete air content, concrete temperature and slump data are furnished from trial batching, including compressive strength and, for structural concrete, cylinders for the rapid chloride permeability test.

The VDOT district materials personnel reviews the information from the trial batches and approve the mix design. District materials maintains a file on each mix including the trial batch information along with the strength, air and for structural concrete rapid chloride permeability tests

Due to ASR concerns most mixes have some type of mineral admixture added. Approximately 50 percent of the mixes contain ground granulated blast furnace slag, 40 percent have fly ash, and 10 percent have other pozzolans.

All permeability test cylinders are sent to the central laboratory for testing.

Contractor's test results are used in the acceptance decision for PCC. Contractors are required, however, to have a certified concrete field technician present during placement. Fresh concrete testing is performed by VDOT certified construction personnel.

The testing equipment is owned and distributed by district materials.

Structural Concrete

Slump, air, compressive strength, and temperature are used for acceptance. Rapid chloride permeability testing is also performed on specified jobs

Slump and air is performed once per batch for first three, then once every three batches. Cylinders are fabricated every 100 yards.

Paving concrete

Slump, air, flexural strength, and temperature are used for acceptance.

Slump is performed twice per day. Air content is determined once per hour. One beam is molded per day.

Soils

VDOT limits lift thickness for embankments to 8 inches of loose material. The density target is based on the family of curves and one point proctors. VDOT specifications require 95% of AASHTO T 99 for density. The State uses one point proctors/family of curves along with nuclear gages to test for density. The top 6" (subgrade) is compacted to 100%. For backfill, the max lift thickness is 6 inches loose and compacted to 95%.

The State currently uses CBR and resilient modulus tests for pavement design.

Aggregates

The VDOT performs the following tests for quality: Los Angeles abrasion loss, magnesium sulfate soundness loss, organic impurities (fine aggregate) and deleterious material. These tests are performed every two years or as needed.

Acceptance of Central Mix Aggregate is based on verified contractor's tests. VDOT performs verification testing. Acceptance is based on gradation, Atterberg limits, cement content and moisture content. The contractor samples and test samples at the rate of 4 samples per 2000 ton lot. VDOT takes independent monitor samples. At the beginning of production; a minimum of 4 samples are taken the first week of production and after the first weeks production a minimum of 2 samples per production week are taken. The monitor samples are taken at the plant by contractor personnel under the direction of the State personnel. The independent samples are split and a split is given to the contractor. Analysis is performed in two ways. First the split results are compared using D2S limits and then the independent sample run by the State is compared to the remainder of the contractor's results using the F&t tests. See figure 2. The official submission of test data by the contractor is not made for some time.

For other aggregates (clean stone) used in untreated layers, the producer does his own testing under the Modified Acceptance program and periodically VDOT will pull a comparison sample

For testing of aggregates used in HMA other than quality, the contractor performs gradation QC testing and VDOT tests comparison samples.

For testing of aggregates used in PCC other than quality, the aggregate suppliers test for gradation, some concrete producers will check gradation and VDOT will periodically test the material.

Manufactured Materials

The basis of acceptance for the various materials including sampling and testing frequencies is contained the "Manual of Instructions Materials Division".

VDOT evaluates some manufactured materials and places them on the approved products list.

VDOT participates in the National Transportation Product Evaluation Program (NTPEP) and is a lead state on some materials. VDOT specifies on some materials that they must be tested by NTPEP before they will be placed on the approved products list.

The VDOT also uses the eastern consortium to evaluate HDPE pipe and they also use the AASHTO Product Evaluation List.

The VDOT Central laboratory oversees the management by the district of precast plants and concrete pipe plants.

Structural Steel Fabrication

State personnel usually cover steel fabrication within the state. The State uses consultants to inspect out of state steel fabrication. This is administered from the central office.

Computer Programs

VDOT is moving toward automating as much data collection as possible for HMA and CMA.

The State has a database of test results on the asphalt paving projects. The State also maintains district databases for test results on PCC.

Findings:

1. Overall the state is in compliance with federal regulations involving Construction materials.
2. The State is commended for their use of an innovative statistical verification system that is used for the asphalt plant testing and CMA testing.
3. The State is commended for having their District laboratories AASHTO Accredited.

4. The State is commended for their Technician Qualification Program.
5. The State is commended for their participation and use of the National Transportation Product Evaluation Program (NTPEP).
6. The State is commended for their use of IRI as their quality characteristic for smoothness and for measuring it with a State van.
7. The State is commended for their acceptance program for manufactured materials that takes into consideration the criticality of the specific materials.
8. The State is commended for their Central office reviews of precast and pipe plants to ensure consistency.
9. The State is commended for their use of High performance concrete.
10. The State is commended for their specifications that deal with ASR.
11. The State is commended for their specification requiring low permeability mixes.
12. The State is commended for the use of the asphalt pavement analyzer for asphalt mix design.
13. The Salem district is commended for the excel database for asphalt information and the recognition for the need for additional testing.
14. The State is commended for beginning the collection of volumetric data.
15. The State is commended for the documentation of the materials procedures.

Standard practices in other States:

16. HMA program

- a. The official contractor testing data from the contractor is obtained the next day. This has the potential for reducing the amount of time to validate the contractor's data and reduce the State's risks of having unacceptable material being produced.
- b. The current state of the practice is to accept asphalt mixes with volumetric properties.
- c. The current state of the practice is to use Percent Within Limit (PWL) type specifications to accept materials. This method has been shown to be the best method to take variability into consideration.
- d. States are examining their test procedures to eliminate options in order to reduce testing variability.
- e. Most States are using the maximum theoretical density as the target density. Percent of control strip density specifications can allow poor density pavements to be accepted
- f. States are examining their validation procedures to reduce the telegraphing of the sampling times so contractors can not change processes before a verification sample is obtained. In particular the VDOT should examine the density process for HMA and CMA.
- g. The state of the practice is to verify the initial Gmm determined by the contractor which is used at the start of production
- h. The state of the practice is to verify the field ignition correction factors during production.
- i. The state of the practice is to obtain the IA/QA sample as soon as they arrive at the plant and not provide the contractor time to adjust the mix prior to the sample being obtained. Another preferable option would be to take the samples on the roadway. The contractor would then not know when the sample was being obtained.
- j. Most states have developed tolerances to compare an individual QC and QA/IA to the Job Mix Formula (JMF).

- k. Most States have developed guidelines for the allowable JMF revisions to ensure the proper binder content is maintained
 - l. Most States verify the aggregate bulk specific gravity and ensure the appropriate values are used during the mix design process.
17. The following observations were made about VDOT's Independent Assurance (IA) program. The following suggestions are offered for consideration for improvements to the Independent Assurance (IA) program.
- a. The IA reports do not include both the IA test result and the result that is being compared.
 - b. The tolerances that are used for comparing IA test results have not been analyzed using the available data
 - c. VDOT uses a system and project approach whereas other states use a system approach. We have observed the benefits of using a system approach to be: 1) some technicians are covered multiple times, some of which may not need the coverage. And 2) All technicians routinely performing testing are covered.
18. Most States are moving toward the development of a comprehensive system for automated collection and data analysis. The State is commended for their work in the area and is encouraged to continue. VDOT has a statewide database for asphalt mixes and central mix asphalt. The state has a hard copy data base in each district for concrete mixes.
19. Most States are requiring contractors to perform QC testing and VDOT requires QC testing in the area of HMA. VDOT does not have specification requirements for the contractor to perform process control tests for soil density and concrete field tests.
20. The verification reports for HMA and CMA are not included in the final project files.

21. For asphalt mixes the current specification allows retesting when failing test results are obtained. The retest results are averaged to the failing test results and compared to the requirements for one result. A specification requirement for 2 results does not exist. The current retest system is biased toward the contractor. Statistically all values have the same probability of being chosen. When retesting is only performed when failing results are obtained and the failing results are averaged with the additional test result, the process becomes biased toward the contractor.

22. VDOT currently requires the technicians to routinely calibrate fresh concrete air meters. Most states have developed a procedure to ensure that technicians periodically calibrate the air meters.