Aggregate
Quality Control/Quality Assurance
Program

February 2, 2017

A joint effort of the
North Carolina Department of Transportation
and the
North Carolina Aggregates Association

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I. GENERAL DESCRIPTION

The Aggregate Quality Control/Quality Assurance Program is designed to give aggregate producers more responsibility for controlling the quality of material they produce and to utilize the quality control information they provide in the acceptance process by the North Carolina Department of Transportation (NCDOT). It requires aggregate producers to perform quality control sampling, testing and record keeping on aggregates they ship for use by the Department. Also, it requires the Department to perform quality assurance and verification sampling, testing and record keeping to confirm the performance of the producers' control plan as set forth herein.

This program is designed for Aggregate Producers providing Clean Coarse or Fine Aggregates for use on or in products such as asphalt, concrete, block, etc., and when providing any type of aggregate base material, including cement treated base that is utilized on any type of NCDOT Maintenance or Contract Project whether purchased by a Contractor or sold directly to the Department for use on any current NCDOT right of way. Asphalt sand that is produced by and utilized by the same asphalt producer shall be tested according to the provisions of the *Hot Mix Asphalt Quality Management System Manual*.

It is the intent of this program that acceptance or rejection of material be based on the total program. Therefore, a comparison of the Quality Control, Quality Assurance, Verification, and other sample data may be used by the Department for acceptance or rejection of a lot of material.

Participation in this program does not relieve the producer of the responsibility of complying with all requirements of the *NCDOT Standard Specifications for Roads and Structures*.

This manual contains information regarding the sampling and testing of material at the Aggregate Producer's facility (quarry, sand pit, sales yard, etc.). Sampling and testing requirements at other locations (including but not limited to: present NCDOT right of way, asphalt, concrete, pipe, or block plants) may be found in other publications such as the *Aggregate Sampling Manual* or the *Hot Mix Asphalt Quality Management System Manual*.

II. PROGRAM REQUIREMENTS

A. Basic Requirements

There are four basic requirements for approval to participate in either Section.

- The source must be on the NCDOT Aggregate Physical Properties List.
- The facility must have an approved in-house quality control plan.
- The facility must have a certified laboratory or have written approval to use an off-site certified laboratory.
- The facility must have a NCDOT certified quality control technician.

B. Quality Control Plan

The Producer must prepare a written quality control plan. The plan may be generic, but must be site specific. The plan must indicate in detail how the Producer proposes to control the equipment, materials, and production methods to insure that the specified products are obtained. The plan must list the personnel responsible for production and quality control at the site and include information on how to contact each person. The following specific information must also be included in the plan:

- Identification of the physical location of the source, to include a description of the property site and reference to the nearest identifiable points such as highways and towns.
- A description of the signs used to identify each stockpile as intended for NCDOT usage. Stockpile signs must be legible from the cab of a truck fifty feet from the identified pile.
- A loading and shipping control plan which includes a description of the methods by which the products are to be loaded and shipped for use by the Department, including safeguards against loading improper aggregate, contamination, degradation, and segregation of the aggregate. The plan must also include methods of insuring that all products are accurately identified and that all shipping units are clean.
- A plan for dealing with quality control sample failures. This plan must include how the Producer plans to initiate an immediate investigation and how the Producer will implement corrective action to remedy the cause of the problem.

Two copies of the Producer's written quality control plan must be submitted with the original request for plant approval. Two copies of an updated Plant QC Plan must be submitted when changes are made to the plant's operations or ownership. A copy of the Plant's Ownership Update Form must be submitted by **December 31st** of each year or when there is a change to the plant's ownership. An example of the Plant Ownership Update Form may be found in Exhibit A.

C. Certified Laboratory

The Program requires all tests to be conducted at on-site or private laboratories certified by the Department. A list of certified private laboratories is provided on the Materials and Tests website. It is expected that each source, including distribution yards, will establish and maintain its own laboratory for the performance of quality control testing, but the Department will consider a producer's request to utilize a certified laboratory in the same general vicinity. The Producer must make this request in writing and have written approval, from the Department, before testing aggregates off site. The equipment required for a certified laboratory is listed in Exhibit B. Records on instrument calibration and maintenance and sample collection and analysis must be maintained at the laboratory. The Department may require a demonstration of the equipment. A list of equipment can be found in Exhibit B.

D. Quality Control Technician

All samples must be taken and tested by quality control technicians certified by the Department. The Producer must designate and identify the quality control technicians responsible at each plant. It is imperative that NCDOT sampling and testing procedures be followed and that NCDOT approved equipment be used in order to reduce the number of possible causes of differences between the producer's quality control results and the Department's quality assurance results.

Quality control technicians may be certified as NCDOT Aggregate QC/QA Sampling Technicians or as NCDOT Aggregate QC/QA Sampling and Testing Technicians. NCDOT QC/QA Sampling Technicians are authorized to take samples of materials, NCDOT Aggregate QC/QA Sampling and Testing Technicians are authorized to both sample and test materials.

At least one certified technician, either a NCDOT Aggregate QC/QA Sampling Technician or a NCDOT Aggregate QC/QA Sampling and Testing Technician must be on site at all times, unless prior approval has been granted by the Department for specific circumstances, when material that may be used on NCDOT Right of Way is being shipped. Technicians actively testing will be subject to assessments conducted by NCDOT personnel at least annually to insure proper procedures are followed.

Technicians are subject to loss of certification by revocation. The primary reason for the loss of a certification by this means would be the falsifying of test results, records, or reports. Other reasons that might lead to loss of certification include gross negligence or apparent incompetence on the part of the technician.

E. Plant Approval Process

The approval process requires the Producer to write the State Materials Engineer at NCDOT, Materials and Tests Unit, 1801 Blue Ridge Road, Raleigh, NC 27607, requesting that the plant be considered for acceptance into the program. This letter must identify the section(s) under which the plant would like to operate. It must identify the specific products that are to be produced. Two copies of the Producer's written quality control plan must be submitted with the request for approval.

Prior to plant approval, the Producer shall have produced at least 300 tons of material before it can be sampled, tested, and added to the NCDOT Aggregate Physical Properties List. A source must be on the NCDOT Aggregate Physical Properties List before it would be considered for approval for the QC/QA Program and must meet the general aggregate requirements, including but not limited to, L. A. Abrasion(AASHTO T96), Sodium Sulfate Soundness (AASHTO T104), and gradation requirements (AASHTO T11, T27). Fine aggregate must also meet the requirements of AASHTO T106.

The Department will review the Producer's written quality control plan and if it is approved, an on-site inspection will be scheduled. This on-site inspection will verify that the Producer's quality control plan has been implemented and is being followed and that at least one certified quality control technician is on site and will be present when material is being shipped under this program. The laboratory will be inspected and certified if it meets the requirements and has not already been certified. For a list of laboratory equipment required for testing, see Exhibit B. If either the Producer's quality control plan or laboratory does not meet NCDOT requirements, the Producer will be informed of the deficiencies in writing. Once the deficiencies have been addressed, the Producer may again request approval in writing to the State Materials Engineer.

F. Certification for Participation in the Aggregate QC/QA Program

If the Department has approved the Producer's written quality control plan and the on-site inspection confirms that the program requirements have been met, the Department will issue a certificate, valid for one year, certifying the plant for participation in the program. At the end of the year, and each subsequent year, the Department will conduct another on-site inspection and if all requirements are continuing to be met, the plant will be recertified for participation in the program for another year. This annual re-inspection of the plant will be scheduled after the Department has received two copies of the Plant’s updated QC Plan or a completed copy of the Plant’s ownership update form. Random inspections may be conducted at any time by the Department to verify compliance with the program requirements.

This certification will authorize the plant to operate under the applicable section(s) of this program.

III. AGGREGATE SAMPLING AND TESTING PROCEDURES

Sampling and testing is required when an Aggregate Producer is providing clean coarse aggregate or fine aggregate to be used in asphalt, concrete, pipe, brick and block, etc. It is also required when providing any type of aggregate base material, including cement treated base that is utilized on any type of NCDOT Maintenance or Contract Project whether purchased by a Contractor or sold directly to the Department. A description of sampling procedures can be found in Exhibit C.

A. Producer's Quality Control

The Producer's Quality Control (QC) samples are used by the Producer to monitor the quality of material being shipped. The Producer is to perform all aggregate sampling and testing in accordance with this manual.

1. Quality Control Sample - These samples are taken by the Producer to monitor the quality of material being shipped from an approved facility.

2. Lot Size - Lot sizes for aggregates shall be 2,000 tons for each size of material shipped to the Department, or a minimum of one sample per week for each size of material whichever comes first.

   If the producer elects to halt shipment for an extended period of time (i.e. 2 months or more), Materials and Tests must be notified.

3. Sampling - The certified plant technician is to obtain a sample from each lot shipped. QC samples will consist of one sample per lot. The sample is to be taken from the stockpile, conveyor belt or other location approved by the Department. Stockpile samples are to be taken from the same area of the stockpile from which material is being shipped. The minimum sample sizes for aggregate samples are as follows:

Aggregate Sample Weight Requirements (pounds)	
Material	**Quality Control**
Clean Coarse Aggregate	20
Fine Aggregate	10
Aggregate Base Material	35

4. Sample Identification and Record Keeping - It is critical that care be taken to properly label samples and record test data accurately.

   Producer's Quality Control samples are to be identified with consecutive numbers for each size material and stockpile; QC-1, QC-2, etc. The samples are to be numbered consecutively for the entire calendar year.

For ABC samples going to an NCDOT project, the QC Sample number is to be recorded by the Producer on the delivery ticket of the truck loaded immediately after the sample material is obtained in order that a RC Sample may be taken from the corresponding area of the roadway if needed.

All Quality Control test results are to be entered into the Department's internet based QAP System within five (5) business days of the sample being obtained.

Quality Control data for each size material is to be retained by the Producer for at least one year and made available to the Department upon request.

5. Test Procedures - Modifications to standard test procedures are permitted in some cases in this program. For clean coarse aggregate, no wash test is required on the Producer's split half of the Quality Control sample unless requested by the Department. For fine aggregate, the wash test, with rapid drying (see Exhibit E) being allowed, is to be performed on all samples. For ABC samples, soil mortar testing is required on all samples, see Exhibit M.

6. Check Samples - If the test results for a sample indicate the material does not meet the specification requirements, a check sample is to be immediately obtained by the Producer. The check sample is to be doubled in size and taken in the same manner as the original sample. The sample is to be clearly identified and split with one half tested by the Producer and the other half provided to the Department.

   If the check sample indicates the material meets the specification requirements, the Producer is to record on the test report form what is felt to be the reason for the original failure and then may resume normal testing procedures.

   If the check sample indicates the material does not meet the specification requirements, the Producer is to notify the Department. The Producer is to immediately initiate an investigation to determine the cause of the failure. The investigation is to include a review of the sampling procedures, the equipment used in the production and the testing of the material, and the testing procedures of the technician. If the cause can be attributed to one of the above categories, the Producer is to take corrective action to bring the material, equipment, or procedure into compliance. The Producer is to then record the corrective action on the test report form and take another check sample after the corrections have been made. The check sample is to be doubled in size and taken in the same manner as the original sample. The check sample is to be clearly identified and split with one half tested by the Producer and the other half provided to the Department for Quality Assurance (QA) check sample.

   If the second check sample indicates the material meets the specification requirements, the Producer may resume normal testing procedures.

   If the second check sample indicates the material does not meet the specification requirements, the Producer is to notify the Department and stop the shipment of material. The Producer is to

continue the investigation into these failures and work with the Department to determine the cause.

All check samples will be identified and follow the previous sample in consecutive order. (i.e., QC-7, QC-8, QC-9)

7. Noncompliance – If the Producer has failed to meet the minimum sampling frequencies described above, the Department will request in writing that the Producer explain the circumstances related to the incident. The Producer must respond in writing postmarked within one week of receipt of the request. If the Department finds the response inadequate, the Department will notify the Producer of the deficiencies and may remove the plant from the Program. If the Producer does not respond in writing, the Department may remove the plant from the Program. If removed from the Program, the Producer may request to have the plant reinstated once corrective actions have been taken.

8. Roadway Sampling - Producer's Roadway Quality Control (RC) samples are used to check the quality of the in-place material on a project. These samples may be taken by the Producer or Contractor from any lot of material. They will primarily be taken to provide additional information concerning the quality of a lot of material for which the Quality Control samples at the plant did not meet the specification requirements or from a sub lot of material that has been corrected on the roadway. The minimum sample size for RC samples is 70 pounds.

B. NCDOT Verification and QA Split Sampling

The Department's Verification and QA Split samples are used to verify the performance of the Producer's quality control plan.

Aggregate Sample Weight Requirements (pounds)		
Material	**QC/QA Split**	**Verification**
Clean Coarse Aggregate	40	20
Fine Aggregate	20	10
Aggregate Base Material	70	35

1. Verification Samples- Verification samples will be taken independent of the Producer's QC samples and will be sampled from each size of material shipped. Producers will be allowed to split the sample or take a sample adjacent to the Verification Sample for their internal informational purposes only. This Producer's sample will not be used as the next QC sample nor will it be entered into the Department's database.

2. QA Split Samples- QA Split samples will be taken and split for testing by both the Department and the Producer for each size of material shipped. The Department's representative will direct the sampling and splitting process in accordance with Exhibits C and D respectively. The Producer's half of the QA Split is recorded as the next QC sample for that product.

3. Lot Size – A Verification sample will be taken for every 10,000 tons for each size of material shipped or every two weeks, whichever occurs more often. QA Split samples for all aggregates will be 20,000 tons for each size of material shipped, or at least once per quarter. All Verification and QA Split sampling will be performed or observed by the Department's representative.

4. Sampling – The Department's representative is to obtain samples taken from the stockpile, conveyor belt or other location approved by the Department. Stockpile samples are to be taken from the same area of the stockpile from which material is being shipped (load face).

5. Sample Identification and Record Keeping – It is critical that care be taken to properly label samples and record test data accurately.

   The Verification samples are to be numbered in a sequential order at the beginning of each year or the first sample after a Producer's facility is accepted into the program. The number following "V" is the number for the independent sample, V-1, V-2, etc.

   The QA Split samples are to be numbered with a number corresponding to the appropriate Quality Control sample. The number following "QA" is the number of the corresponding Quality Control split sample, QA-1, QA-2, etc.

6. Test Procedures – All Verification and QA Split samples are to be tested at a Department laboratory. Modifications to standard test procedures are permitted in some cases in this program. When approved by the Department on a site-by-site basis, a Producer may rapid dry ABC Quality Control samples according to procedures outlined in Exhibit E. For ABC samples, soil mortar testing is required on all samples, see Exhibit M.

   Atterberg Limits (LL and PI) are not required to be performed on the Producer's half of the split sample, except for those plants identified by the Department as having potential problems. In those cases, the Producer is to determine the Atterberg Limits of one sample per 6,000 tons of material. Rapid drying will not be permitted for material from which the Atterberg Limits are determined.

7. QC/Verification Comparison – QC versus Verification samples will be compared using the f-test and t-test (F&T) data compiled by QAP. The data will be checked in accordance with "Optimal Procedures for Quality Assurance Specifications" FHWA-RD-02-095 (Appendix F). A report will be generated quarterly to compare the data for any discrepancies within the program.

   An investigation can be initiated when a minimum of one sieve is out of specifications, but will be required when the F&T test indicates a single product has non-comparing means on two sieves for clean stone or three sieves for ABC or fine aggregate (not including soil mortar). The written investigation will be used to identify if there is any evidence that the populations are different or determine if poor quality material is being produced. The investigation may include lab assessment, technician assessments, and review of all test results.

If it is determined that the conditions are not being met, a warning letter to the Producer will be issued and a nine month probation period will be implemented for the specified product(s). If within the probation period, the F&T tests show non-comparing means and the written investigation indicates poor quality material, the Producer's specified product(s) may be removed from the program until corrective action has been taken and the specified product(s) have been reinstated by the Department.

8. QC/QA Split Comparison – QC versus QA Split samples will be compared using the Paired t-test based on the data provided in QAP. The data will be checked in accordance with "evaluation of Procedures for Quality Assurance Specifications" FHWA-HRT-04-046. A report will be generated quarterly to compare the data for any discrepancies within the program.

   If the results of the QA Split sample are not in agreement with the results of the corresponding Quality Control sample, i.e. outside the limits of Table I or Table II of Exhibit G, an investigation will be made to determine the source of the difference. The investigation will include a review of the testing procedures and the testing equipment. The results of the investigation will be recorded in the Materials Inspector's Comment Field in the Department's computerized tracking system (HiCAMS) and a copy given to the aggregate producer.

   If the cause is determined to be improper splitting or testing procedures, the appropriate certified technician will be notified. If the problem continues, the technician's certification may be revoked. If the cause is determined to be in the Producer's testing equipment or handling of the material the Producer is to take corrective action. If this problem continues, the Producer's approval to provide material to the Department may be revoked. If the cause is determined to be in the Department's testing equipment, the Department will take corrective action and notify the aggregate producer of the action.

9. Noncompliance–The Department will notify the producer of the deficiencies and corrective actions necessary to remain in the program. If the Producer does not respond in writing, the Department may remove the plant from the Program. If removed from the Program, the Producer may request to have the plant reinstated once corrective action has been taken.

C. Roadway Assurance/Acceptance and Independent Assurance

Roadway Assurance/Acceptance – Roadway Assurance (RA) samples are required to be taken in accordance with the current NCDOT Minimum Sampling Guide. Lot sizes, sampling procedures, acceptance limits, and other information related to RA Samples are described in the current *NCDOT Aggregate Sampling Manual*.

Independent Assurance - NCDOT Independent Assurance (IA) samples are required on all Federal-Aid projects. They are used to verify the performance of the Department's acceptance program to the FHWA.

GLOSSARY

Department Certified Laboratory- Any Department laboratory that has been certified for the purpose of testing aggregates. (Verification and QA Splits)
Department Representative- Any person(s) employed by the Department or individual(s) under contract with the Department for the purpose of sampling or inspecting aggregate production.
F-Test and t-Test- Statistical analysis used to compare the Verification samples with the Quality Control Samples. (α=.05)
Lot Size- Specified amount of material produced to be tested for approval. Tonnages are specified in the *NCDOT Minimum Sampling Guide*.
NCDOT- North Carolina Department of Transportation.
The Department- North Carolina Department of Transportation or any other state agency.
NCDOT Right of Way- Any boundary of land maintained by the state of North Carolina
Paired-t Test- Used to compare means on a specific size of aggregate or other material over time or in differing circumstances for QC/QA Split samples.
Plant Ownership Update Form- Document in Exhibit A that is updated yearly and required by December 31st of each year.
Producer- An approved person or organization that produces aggregates to be sold and used by the Department.
Producer's Certified Laboratory- Any laboratory that has been certified by the Department for the purpose of testing aggregates. The laboratory may be on site or off site with prior approval. (Quality Control)
QA Split Sample- A sample that is taken under the direction of the Department Representative by the QC Technician and split for testing by both the quarry and the Department. This sample will be entered into HICAMS.
QAP (Quality Assurance Program)- This system is intended to collect and analyze quality control and quality assurance data for the aggregate and asphalt industries that do business with NCDOT.
Quality Assurance- Procedural activity implemented in a quality system so that requirements and goals for a product are met. It is also used as a comparison with a standard for the specific material to monitor the process that is set in place.
Quality Control- Process in which the Producer monitors the quality of their material being shipped by taking random samples and conducting in house testing. This process will be tracked in the QAP System.
Quality Control Plan- A document developed by the Producer proposing how they will control equipment, materials, and production methods to insure that specified products are obtained.
Quality Control Technician- Any individual that has completed the NCDOT Aggregate QC/QA Sampling Technician or NCDOT Aggregate QC/QA Sampling and Testing Technician Certification course provided by the Department.
Verification Sample- A random and independent sample taken by a Representative of the Department for the purpose of verifying the Quality Control results.

IV. EXHIBITS

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EXHIBIT A- NCDOT AGGREGATE QC/QA PLANT OWNERSHIP UPDATE FORM

NCDOT Aggregate QC/QA Plant Ownership Update

Name of Company: _____

Name of Facility: _____
NCDOT Facility Number: CA ____ FA ____

Facility Mailing Address and Contact Information:

Street: _____
Street: _____
City: _____ State: _____ ZIP _____
Telephone: _____ FAX _____
Telephone: _____
Email: _____
Name and Title of Contact: _____

Facility Physical Address:

Street: _____
Street: _____
City: _____ State: _____ ZIP _____
Driving Directions from Major Landmark:
_____
_____
_____

Plant Personnel Responsible for Quality:

	Name	Title	Cert. Number[1]
1)			
2)			
3)			
4)			
5)			

Material:
List of Material Being Produced at Facility:
_____
_____
_____

The Information for this facility HAS changed since this form was last submitted? ☐YES / ☐NO

The Quality Control Plan for this facility HAS been revised since it was NCDOT Approved? ☐YES / ☐NO

If YES, attach copy of current Quality Control Plan to this document and submit for review.

I certify that the foregoing entries are correct.

Signature _____
Title: _____
Date: _____

[1] List NCDOT assigned Technician Certification Number if applicable.

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EXHIBIT B- TESTING EQUIPMENT LIST

List of Equipment Required for Certified Laboratory testing Coarse or Fine Aggregate

1) **Automatic shaker(s) for coarse and fine aggregate** (with clock timer, enclosed in insulated cabinet and mounted independent of building floor).

2) One set of **electronic scales**, readability and sensitivity of 0.1 gram, accurate to 0.1 gram or 0.1 percent of capacity with a minimum capacity of 2500 grams.

3) One set of **electronic scales**, readability and sensitivity of 20 grams, accurate to 20 grams or 0.1 percent of capacity with a minimum capacity of 50 kilograms (110 lbs).

4) A sufficient quantity of **pans** (24" x 12" x 3") for drying samples.

5) One **divider** (8" x 14" x -3/4" opening) with two catch pans and one pouring pan.

6) One **divider** (chute width 24" and adjustable 1/2" bars).

7) One **automatic shaker** with timer, cover and all sieve sizes required to test ABC and clean aggregates according to NCDOT Specifications.

8) Minimum of one set of 8" diameter **sieves** for testing ABC and one set of sieves for clean stone and fine aggregate. Must have all sieve sizes required to test ABC fines and clean aggregates according to NCDOT Specifications.

9) One **mortar bowl** (210 mm outside diameter).

10) One **pestle** (with 2" diameter rubber covered base or drill press with rubber disc).

11) One **wooden mallet** (1 3/4" x 3 1/2" x 6" with 1" diameter x 12 dowel centered).

12) A sufficient quantity of **sample cans** (approximately 400 gram capacity) and/or sample pans.

13) One **liquid limit machine** (with grooving tool), AASHTO T-89. (Required if identified as a source with potential plasticity issues)

14) One **oven,** gas or electric (thermostatically controlled @ 110 ^{0}C).
One oven **thermometer** (0 degrees to 150 degrees C)

15) A sufficient quantity of 2 oz. **moisture cans.**

16) One stiff blade **spatula** (3 1/2" x 13/16").

17) A sufficient quantity of **evaporation dishes**, 250 ml.

18) One pair of **tongs**.

19) Large stainless steel mixing bowl.

List of Equipment Required for Certified Laboratory ONLY testing Fine Aggregate

1) One **automatic shaker for fine aggregate** (with clock timer, enclosed in insulated cabinet and mounted independent of building floor).

2) One set of **scales**, readability and sensitivity of 0.1 gram, accurate to 0.1 gram or 0.1 percent of capacity with a minimum capacity of 2500 grams.

3) A sufficient quantity of **pans** for drying samples, and if used for AASHTO TP-33, must be of sufficient size to contain the funnel stand and to prevent loss of material.

4) One **divider** (8" x 14" x -3/4" opening) with two catch pans and one pouring pan.

5) Minimum of one set of 8" diameter **sieves** for testing fine aggregate. Must have all sieve sizes required to test according to NCDOT Specifications.

6) One **oven,** gas or electric (thermostatically controlled @ 110° C). One oven **thermometer** (0 degrees to 150 degrees C)

7) Sieve brushes.

EXHIBIT C- SAMPLING PROCEDURES

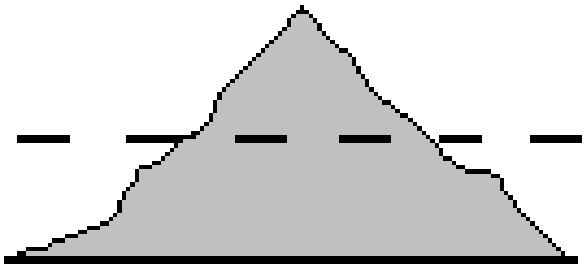
Sampling Procedures

I. Introduction

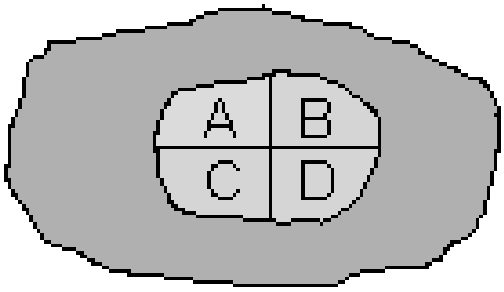
In order to reduce the number of variables that affect the correlation between, it is important that all samples be obtained following procedures in accordance with this manual.

II. Production Stockpile Sampling

For stockpile sampling, obtain the sample from an area that represents material being shipped. Before sampling, a visual inspection of the stockpile load face shall be conducted. If there is evidence of segregation or contamination, immediate corrective action must be taken. The material in question should be thoroughly mixed or removed before obtaining a sample. The sample shall be obtained from aggregate that has been picked up by a loading unit from the existing stockpile. The material from which the samples are to be obtained should be approximately one loader bucket load. The loading unit shall dump the material on the ground (as if loading a truck), then strike off and level to approximately half the original pile height. The flat surface shall be divided into four sections. Identify sampling areas as A, B, C, and D, as shown below. Opposite quadrants, such as A and D, shall be used to acquire the sample.



Material first dumped on ground



Material after being leveled off and sectioned

The sample shall be obtained using a square point shovel having the long edges turned up at right angles to the body of the shovel.
The shovel dimensions shall be: a standard squared end shovel with the outer edges rolled up approximately 2 inches, such that the overall dimensions of the shovel are approximately 11" long, 6" wide, with 2" sides. (See photo above)

III. Approved Stockpile Sampling

The lot size will be 2,000 tons of material, or a fraction thereof, placed in a stockpile. The certified plant technician is to obtain a Quality Control (QC) sample weighing a minimum of 35 pounds

The sample shall be obtained by removing the top six inches (1/4 layer) of the layer and sampling the underlying twelve inches (1/2 layer) of material using a steel sampling ring approved by the Department. This will leave an undisturbed six inches (1/4 layer) on the bottom of the layer.

Samples taken after a layer has been corrected should be taken in the same manner as the original sample with the exception that the sample shall be taken from the entire depth of the layer, including the corrective material.

IV. Roadway Sampling

Roadway Sampling is described in the current *NCDOT Aggregate Sampling Manua*l. Roadway Acceptance samples shall not exceed limits of Column C Table I-2.

V. Belt Sampling

A sampling lot shall be represented by obtaining three randomly located samples from approximately equal increments of the sampling lot. The three samples are to be combined and tested. The sample shall be taken from the conveyor belt before the material has passed through the pug mill, if a pug mill is being utilized.

The sample is obtained by isolating a cross section of the belt and removing all material inside of the isolated cross section. Samples obtained from a conveyor belt anywhere other than an approved QC/QA Aggregate facility shall not exceed limits of Column C in Table I-2.

VI. Tube Sampling

Fine aggregate samples may be obtained from the stockpile using a tube approved by the Department. The tube shall be a minimum of 1¼" (30mm) in diameter by 6 feet (2m) in length. The tube shall be constructed of aluminum or PVC.

The sample is obtained by inserting the tube into the stockpile at evenly spaced locations across the load face of the pile. A minimum of five insertions of the tube shall be made. The insertions are to be made at a minimum height of three feet from the bottom of the pile.

EXHIBIT D- PROCEDURES FOR SPLITTING AND LABELING SAMPLES

Procedures for Splitting Samples using a Splitter

Samples are to be split using one of the two following procedures:

I. Place half of the material (i.e. approximately 35 pounds of a 70 pound sample) in the top of the splitter. Open the splitter slowly, allowing the material to flow into the two catch pans. Switch the pans from one side of the splitter to the other and place the remainder of the material in the top of the splitter. Open the splitter slowly, allowing the remainder of the material to flow into the two catch pans.

or

II. Place all of the material in the top of the splitter. Open the splitter slowly, allowing the material to flow into the two catch pans. Compare the weights of the two pans to see if they are within 3% of each other (i.e. within 2.1 pounds for a 70 pound sample). If they are not within this tolerance, place all of the material back in the top of the splitter and repeat the procedure.

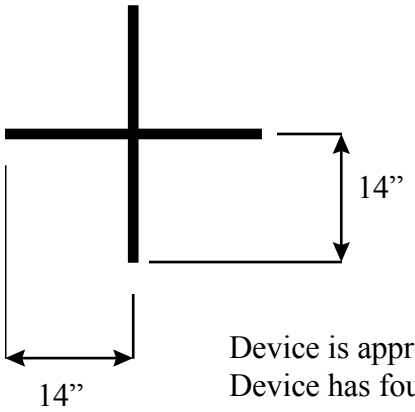
In both cases, the finger gate settings should be 1 1/2 times larger than the material being split, the area on which the splitter rests should be level, and the material should be split before the material is completely dry.

Procedures for Splitting Fine Aggregate Samples using a Divider

This procedure may be used in place of the splitter method described above for Fine Aggregate samples only. The procedure requires the use of an impervious surface such as a steel plate, and a four way divider. If a table is used, it shall be approximately 28 inches deep by 32 inches wide. The four way divider shall have legs approximately 28 inches long that intersect in the middle, forming a right angle. The device shall be approximately 5 inches tall. The material should be split before the material is completely dry.

Place all of the moist material in the center of the table. Remix the sample thoroughly and mound it in a cone shaped pile approximately 6 inches high. Push the four way divider down through the center of the pile until contact with the table surface is made. Slide the divider back and forth on the table surface to separate the fine aggregate sections from each other slightly. Remove two of the opposite quadrants (sections) of material. Remix the remaining two quadrants and repeat the procedure as necessary until the remaining material is the correct quantity for the test to be run.

Divider for Splitting Fine Aggregate Samples



Device is approximately 5” tall.
Device has four legs attached at right angles, each leg is 14” long.
Construction is of 18 gauge or similar aluminum.

Sample Numbering and Identification

Each size or type of material will have its own series of consecutive sample numbers beginning with the number 1 for the first sample taken at the beginning of the calendar year. For example, beginning January 1 the number sequences for each of the following products taken from the same plant is as follows:

Quality Control Sample Identification

Product (size)	Sample Number Sequence beginning January 1
#57	QC-1, QC-2, QC-3, QC-4, etc.
#67	QC-1, QC-2, QC-3, etc.
#78M	QC-1, QC-2, QC-3, QC-4, etc.
Washed Screenings	QC-1, QC-2, etc.

*QA Split samples will follow the corresponding QC sample sequence.

Verification Sample Identification

Product (size)	Sample Number Sequence beginning January 1
#57	V-1, V-2, V-3, V-4, etc.
#67	V-1, V-2, V-3, etc.
#78M	V-1, V-2, V-3, V-4, etc.
Washed Screenings	V-1, V-2, etc.

Producer's QC Sample Card

M&T

PRODUCER'S QUALITY SAMPLE

QUARRY _____ DOT LAB # _____

PRODUCER _____ QUARRY # _____

SIZE MATERIAL _____ SAMPLE # _____

DATE SAMPLED _____ COUNTY _____ COUNTY # _____

QUANTITY REPRESENTED BY THIS SAMPLE _____

SAMPLED BY: _____

SUBMITTED BY: _____

TYPE SAMPLE:

☐ QUALITY CONTROL ☐ VERIFICATION

To be printed on 3 1/2" x 5 1/2" card stock

Each sample should be clearly identified by a properly filled out Sample Identification Card, similar to the one shown above.

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EXHIBIT E- RAPID DRYING PROCEDURE

Rapid Drying Procedure

A. Use metal frame (angle iron) to support standard drying pans a minimum of 4" above gas burner units or electric heating elements.

B. Sample size 30-40 pounds per pan (uniformly spread in pan)

C. For gas drying, adjust flame from burner units to avoid excessive heat directly to bottom of pan.

D. During drying of sample, technician should be present at all times to:
   1) Monitor and adjust heat when necessary,
   2) Mix, stir and turn the aggregate over in the pan to prevent scorching of the sample.

E. Allow sample to cool, stirring sample occasionally to assist in uniform cooling.

F. Process the cooled sample.

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EXHIBIT F- QAP SYSTEM FOR REPORTING SAMPLE TEST DATA AND RETRIEVING STATISTICS

The NCDOT Quality Assurance Program (QAP) is a web based Quality Control/Quality Assurance application (available at https://apps.dot.state.nc.us/vendor/qap) used by both the Department and material Producers/Suppliers who provide Aggregate or Asphalt materials to the Department for highway construction projects. The system provides web enabled data entry of individual QC & QA test results, secure file transfer of test results, access to individual and summary test reports, and statistical analysis tools.

QAP Getting Started Guide Website:
https://connect.ncdot.gov/resources/Materials/MaterialsResources/QAP%20Getting%20Started%20Guide.pdf

Each Producer/Supplier and applicable staff must be registered within the NCID system in order to access results.
What QAP allows users to do:

- Enter Aggregate QC and QA Test Results
- Upload Aggregate QC and QA Test Results
- Correct Aggregate QC and QA Test Results
- View Aggregate Test Reports

Producers/Suppliers have editing abilities for QC samples only. QA data will be available to the Producer once QC data has been entered and uploaded.
QAP Information Systems Liaison Contact Number: (919) 329-4200

QAP/HiCAMS User Registration Form

The following information is required to link each Quality Assurance Program (QAP) user's NCID with the HiCAMS application. Please fill out this form completely and return it to your company's QAP Account Administrator.

COMPANY INFORMATION

Business Name	
Business Address	
Contact Phone Number	

USER INFORMATION

Last 4 Digits of SSN	
Last Name	
First Name	
Middle Name/Initial	
Job Title	
User ID from NCID	
Email Address Linked to NCID Account	

Supervisor's Name	
Supervisor's Title	

For Use by Company Account Administrator Only

Account Administrator Name	
Administrator NCID User ID	

I hereby confirm that I am a designated Account Administrator for the above company and do authorize the above person to have access to my company's information available via the NCDOT QAP Application. I also verify the accuracy of the above user information.

Signed: _____

List of Material Names for HiCAMS QC/QA Batch Process in QAP

Aggregate, Coarse – English

Material Description	Code Name
Coarse Aggregate, #14M	**CA14M**
Coarse Aggregate, #4	**CA4**
Coarse Aggregate, #467M	**CA467M**
Coarse Aggregate, #5	**CA5**
Coarse Aggregate, #5 (VA Spec)	**CA5VA**
Coarse Aggregate, #57	**CA57**
Coarse Aggregate, #57M	**CA57M**
Coarse Aggregate, #6	**CA6**
Coarse Aggregate, #67	**CA67**
Coarse Aggregate, #68 (VA Spec)	**CA68VA**
Coarse Aggregate, #7	**CA7**
Coarse Aggregate, #78M	**CA78M**
Coarse Aggregate, # 8 (VA Spec)	**CA8VA**
Lightweight Concrete, (See Specs)	**CALWT**
Lightweight, Structural Concrete, (See Specs)	**CALWTSC**

Aggregate Base Course – English

Material Description	Code Name
Aggregate Base Course	**ABC**
Aggregate Base Course, Modified	**ABCM**
Aggregate Base Course, S-Gradation	**ABCSG**
Stabilizer Aggregate	**SA**

Aggregate, Fine – Asphalt – English

Material Description	Code Name
Asphalt Sand	**AS**
Baghouse Fines	**BF**
Screenings, Dry	**SD**
Screenings, Super-Washed	**SSW**
Screenings, Washed	**SW**

Aggregate, Fine – Concrete – English

Material Description	Code Name
Sand, 1S	**S1S**
Sand, 2MS	**S2MS**
Sand, 2S	**S2S**
Sand, 4S	**S4S**

Gradation Test Report Form

North Carolina
Department of Transportation - Materials and Tests Unit
Raleigh, North Carolina

Producer's Coarse Aggregate Quality Control Test Summary

Quarry: _____ Number: _____ Producer: _____ Page: _____

County: _____ Number: _____ Size Material: _____

Grading - Percent Passing

Date	Sample Number	Quantity (Tons)	2"	1.5"	1"	3/4"	1/2"	3/8"	#4	#8	#10	#40	200+	#40 @	200 @	L.L.	PI	Note: Sample Fails	Who Ran

+Place * in column if minus #200 is not run but is based on visual inspection. @ Soil mortar fraction for ABC.

Remarks:

cc: M&T Inspector
M&T Files

_____
Quality Control Technician

EXHIBIT G- TOLERANCES FOR COMPARISONS OF QC/QA GRADATIONS

Table 1- Tolerances for Comparisons of Coarse Aggregate QC/QA Gradations Sieve Sizes

	ABC*	#4	#467M	#5	#57 #57M	#6	#14M	#67	VA#5	VA#68	#7	VA#8	#78M
HiCAMS Size		CA4	CA467 M	CA5	CA57 CA57M	CA6	CA14 M	CA67	CA5VA	CA68VA	CA7	CA8VA	CA78M
2"													
1 1/2"	± 2	± 2	± 2		± 2								
1"	± 4	± 4		± 2	± 3			± 2	± 2	± 2			
3/4"		± 4	± 5	± 5		± 3		± 3	± 5	± 3	± 2	± 2	± 2
1/2"	± 5			± 2	± 5	± 4			± 2		± 3	± 3	± 3
3/8"		± 2	± 3	± 2		± 4	± 3	± 5	± 2	± 5	± 3	± 3	± 3
#4	± 6		± 2		± 3	± 2	± 5	± 3		± 3	± 5	± 5	± 5
#8					± 3		± 5	± 3		± 3	± 3	± 3	± 3
#10	± 5												
#16										± 2		± 2	
#40	± 5												
#80													
#200	± 3	± 0.5	± 0.5	± 0.5	± 0.5	± 0.5	± 0.5	± 0.5	± 0.5	± 0.5	± 0.5	± 0.5	± 0.5
Soil Mortar													
#40	± 6												
#200	± 5												
LL	± 4												

*Use ABC range for all base course materials such as: ABC, ABC Type A, ABC Type B, ABC-M, ABC-S, CTB, CTBC, SA, etc.

Table 2
Tolerances for Comparisons of Fine Aggregate QC/QA Gradations

Sieve Sizes	Asphalt Sand, SD, SW, SSW*	1S	2S	2MS	4S	Super Washed Screenings
HiCAMS Size	AS, SD, SW, SSW	S1S	S2S	S2MS	S4S	SSW
1/2"						
3/8"						
#4	± 2					± 2
#8	± 6	± 1	± 1	± 1	± 2	± 6
#10	± 6					± 6
#16	± 6	± 3	± 3	± 3	± 3	± 6
#30	± 6	± 3	± 3	± 3	± 3	± 6
#40	± 6					± 6
#50	±4	± 2	± 2	± 2	± 3	±4
#100	± 2	± 1	± 1	± 1	± 2	± 2
#200	± 2	± 1	± 1	± 1	± 1	± 2

*DS- Dry Screenings, WS-Washed Screenings, SWS- Super Washed Screenings

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EXHIBIT H- INDEPENDENT ASSURANCE SAMPLING AND TESTING

Independent Assurance Sampling and Testing

I. Introduction

As discussed in Section IV-C, Independent Assurance (IA) samples are required on all Federal-Aid projects. They are used to verify the performance of the Department's acceptance program to the FHWA.

II. Lot Sizes and Sampling Procedures

The lot size for ABC (Type A or B) and Cement Treated Base is 20,000 tons or a fraction thereof For Type A ABC, Type B ABC, or road-mixed CTB, the IA sample for a lot will consist of one sample, weighing a minimum of 70 pounds, taken from a location adjacent to the Roadway Assurance sample. For plant-mixed CTB, the sample will be taken from the belt of the pug mill immediately following the Roadway Assurance sample.

The gradation results of these samples will be correlated according to the procedures outlined in the statistical program for comparing Independent Assurance test results and acceptance test results. If the correlation results in a fair or poor rating, the Independent Assurance Section Supervisor will conduct an investigation as to the cause of the rating.

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EXHIBIT I - SPECIFICATIONS (GRADATIONS, LL, and PI)

Stabilizer Aggregate (SA)

TABLE I-1
AGGREGATE BASE COURSE FOR STABILIZATION
GRADATION ACCEPTANCE CRITERIA

Sieve Size	% Passing
l 1/2"	100
1"	72-100
1/2"	51-83
No. 4	35-60
No. 10	20-50
No. 40	10-34
No. 200	3-13
Material Passing No. 40 Sieve	
L. L.	0-30
P. I.	0-6

Producer's Quality Control Sampling
Plant Sampling:

The lot size for SA will be 2,000 tons of material, or a fraction thereof, shipped. The certified plant technician is to obtain a Quality Control (QC) sample, weighing a minimum of 35 pounds.

TABLE I-2
AGGREGATE BASE COURSE FOR
ABC, ABC-Type A, CTBC, and Select Material Class IV
GRADATION ACCEPTANCE RANGES

Column A	Column B % Passing	Column C % Passing
1 1/2"	100	98-100
1"	75-97	72-100
1/2"	55-80	51-83
# 4	35-55	35-60
# 10	25-45	20-50
# 40	14-30	10-34
# 200	4-12	3-13
Material Passing No. 10 Sieve (Soil Mortar)		
*# 40	40-84	36-86
*# 200	11-35	10-36
Material Passing No. 40 Sieve		
L. L.	0-30	0-30
* P. I.	0-4	0-4

* For information only, unless PI exceeds 4. If PI exceeds 4, soil mortar limits apply. If PI exceeds 6, material shall be rejected.

Producer's Quality Control Sampling

Plant Sampling:

The lot size for ABC will be 2,000 tons of material, or a fraction thereof, shipped. The certified plant technician is to obtain a Quality Control (QC) sample, weighing a minimum of 35 pounds.

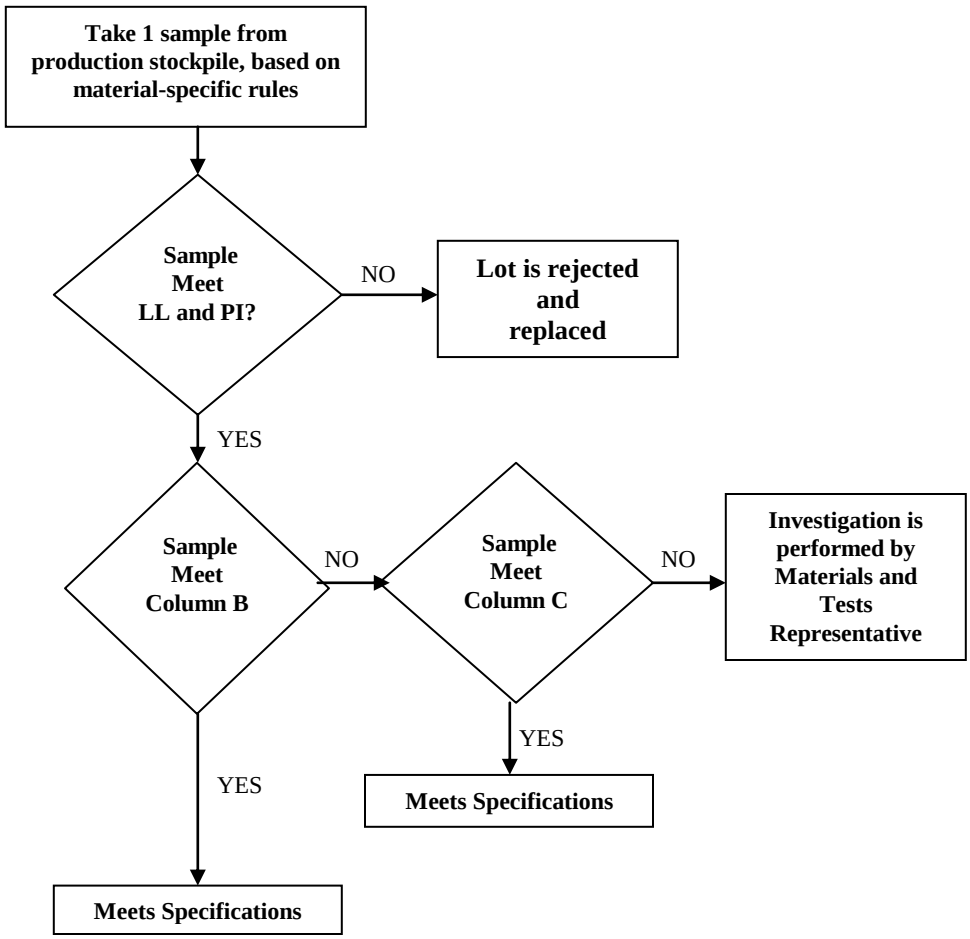
Roadway Correction:

When the Contractor chooses the option to correct the sublot, the Contractor will take 2 random Roadway Quality Control Samples from within the corrected sub lot. When the test results of the Contractor's two Roadway Samples fall within the limits as shown in Column B of Table I-2, the corrected sub lot will be acceptable for Quality Assurance Sampling by the Department.

The Contractor shall correct a QC lot on the roadway only once.

Base Material (ABC, ABC-Type A, CTBC, Class IV Select Material)

The following flowchart summarizes the roadway procedures when sampling and testing Type A ABC in the event of a QC failing sample and the Producer elects to obtain RC sample(s).



Cement Treated Base Course (CTBC)

Producer's Quality Control Sampling

Plant Sampling:

The lot size for aggregate base material for Cement Treated Base Course (CTBC) will be 2,000 tons of material, or a fraction thereof, shipped. The certified plant technician is to obtain a Quality Control (QC) sample weighing a minimum of 35 pounds from each lot of CTBC. Samples must be obtained using procedures outlined in Exhibit C and all samples must be taken prior to the addition of cement. Each sample is to be clearly identified. If a split sample is obtained, the other half of the sample will be retained and made available to the Department.

Rejections and Corrections:

If the Quality Control sample exceeds the limits shown in Column B of Table I-2, follow check sample procedures described in Section III of this manual. Once cement has been added to the material a check sample cannot be taken. The lot represented by the sample exceeding limits of Table I-2 will be rejected and shall be removed and replaced by the Contractor at no cost to the Department.

The material passing the No. 40 sieve shall not have a Liquid Limit in excess of 30 or a plasticity index in excess of 4. If any test result indicates values exceeding these, the lot will be rejected and shall be removed and replaced by the Contractor.

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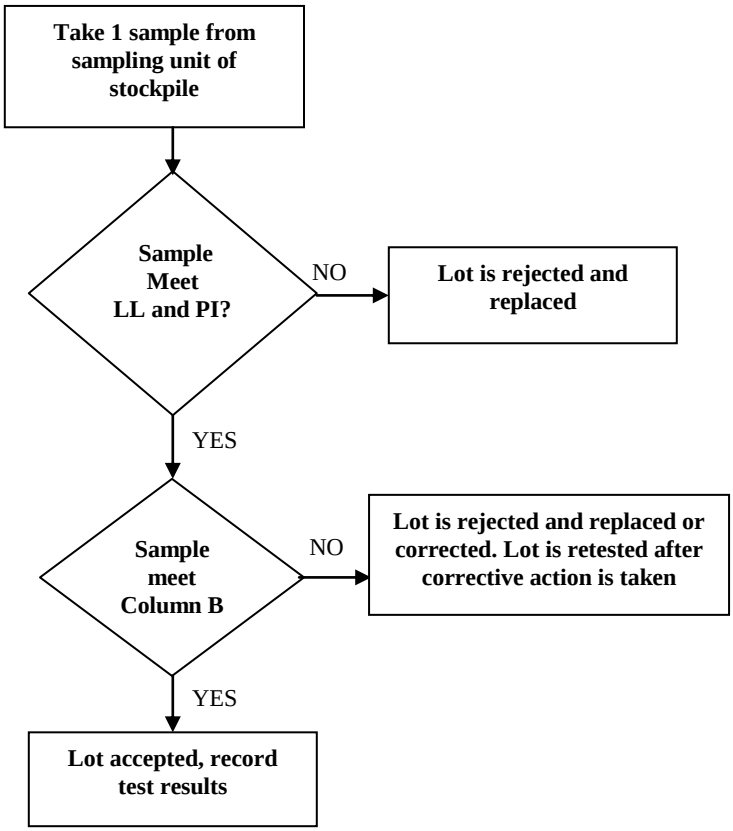
EXHIBIT J- PROJECT CONSTRUCTION OF APPROVED STOCKPILES (ABC- TYPE B)

Approved Stockpiles (ABC-Type B, Project Specific Stockpiles)

The following flowchart summarizes the QC procedures when sampling and testing Type B ABC.



(Approved Stockpiles are stockpiles that are constructed for a specific project.)

Notification of Intent to Construct an Approved Stockpile

The Producer will submit to the State Materials Engineer a notification of intent to construct an Approved Stockpile at least one month prior to the anticipated start date for construction of the pile. The notification shall include the location of the pile, dimensions, total anticipated tonnage, source of material, construction schedule, intended project (including location, Resident Engineer, NCDOT Project Numbers, etc.), anticipated project quantities (pile quantity is not to exceed 10% of the estimated quantity required for the project), contractor, and contact information for all responsible producer and contractor personnel. The Producer shall notify the State GeoMaterials Engineer at the completion of each layer and provide test results for approval

prior to the next layer being added. Continue this process until the pile has been built to completion.

Construction

1. The area on which the stockpile is to be constructed shall be reasonably level and free from stumps, wood, trash, loose earth, or other deleterious materials before stockpiling begins.
2. The material shall be stockpiled in layers not exceeding two feet in thickness. Each layer shall be constructed of sub-layers which shall not exceed 8 inches in thickness. Each sub-layer shall be spread and/or mixed so that segregated spots and variability are eliminated prior to placing the next sub-layer.
3. Material placed in the stockpile shall be uniform and "spot" additions of corrective material will not be permitted unless it is shown that such methods produce a uniform, non-segregated material.
4. Stockpiles shall be designated numerically (1, 2, 3, etc.) to ensure proper records of sampling, testing, etc.
5. In order to facilitate construction, a stockpile may be constructed in sections which shall be designated alphabetically (A, B, C, etc.). The limits of each section shall be identified by properly maintained corner stakes as the work proceeds in order to expedite construction of the remaining layers.
6. Each layer shall be spread and thoroughly mixed prior to sampling. No further mixing shall be done after sampling.
7. A stockpile shall contain a minimum of 5 layers or 10 feet in height before approval is given. The layers shall be set back at the edges at least 6 inches so that no roll-down of material occur.
8. The material shall contain approximately optimum moisture when placed in the stockpile. No sample shall be taken unless this condition is met.
9. Stockpiles shall exist separately and not connected to other stockpiles. Ramps used by equipment in constructing the stockpile shall be removed upon completion of the stockpile.
10. The top of a completed stockpile which is not to be used immediately shall be approximately level and shall contain a berm around the top edges at least 18 inches high to prevent wash down from rain.

Producer's Quality Control Sampling

The lot size will be 2,000 tons of material, or a fraction thereof, placed in a stockpile. The certified plant technician is to obtain a Quality Control (QC) sample weighing a minimum of 35 pounds. Sampling will be performed as described in Exhibit C, Section III.

Table J-1
Type B Aggregate Base Course
Acceptance Criteria for Completed Stockpiles

Column A	**Column B % Passing**
1 1/2"	100
1"	76-96
1/2"	58-76
#4	38-52
#10	28-42
#40	16-28
#200	5-11
Material Passing No. 10 Sieve (Soil Mortar)	
*#40	40-84
*#200	12-34
Material Passing No. 40 Sieve	
L.L.	0-30
*P.I.	0-4

* For information only, unless PI exceeds 4. If PI exceeds 4, soil mortar limits apply. If PI exceeds 6, material shall be rejected.

If the Quality Control sample does not meet the gradation requirements of Column B of Table I-2, or the LL and PI requirements of Column B of Table I-2, the procedures are as follows:

Correct the lot by either removing the material from the stockpile or by spreading the required amount of corrective material over the surface of the lot. Only one correction of a lot will be permitted and correction will not be allowed when the amount of material required exceeds 6 inches in depth, in which case the lot will be rejected and removed.

NCDOT Quality Assurance Sampling

All QA samples are to be tested at a Department laboratory.

All QA samples will be sampled by the Producer with the Department representative present one QA sample shall be obtained for each 8,000 tons of material stockpiled or per visit to the approved stockpile, whichever occurs more often.

Stockpile Approval

The Producer will submit to the State GeoMaterials Engineer a request for approval of the pile. The request shall include the location of the pile, dimensions, total tonnage, project (including location, Resident Engineer, NCDOT Project Numbers, etc.), and gradation summary (showing all individual QC Samples for the stockpile and the overall average gradation for the stockpile). In the event of three consecutive roadway assurance sample failures, the Department may withdraw the approval of the pile and will be sampled, tested, and accepted based on Exhibit I of this manual.

If the individual QC Samples meet the requirements of Column B of Table I-2 and the average of all QC Samples for the stockpile meet the requirements of Column B of Table J-1, the completed stockpile will be considered acceptable.

No additional material may be placed on a stockpile after it has been completed and approved. No material may be hauled from the stockpile until it has been approved.

EXHIBIT K- INVESTIGATION PROCEDURES FOR FAILING ROADWAY ASSURANCE SAMPLES

Procedures for Failing Roadway Assurance Samples

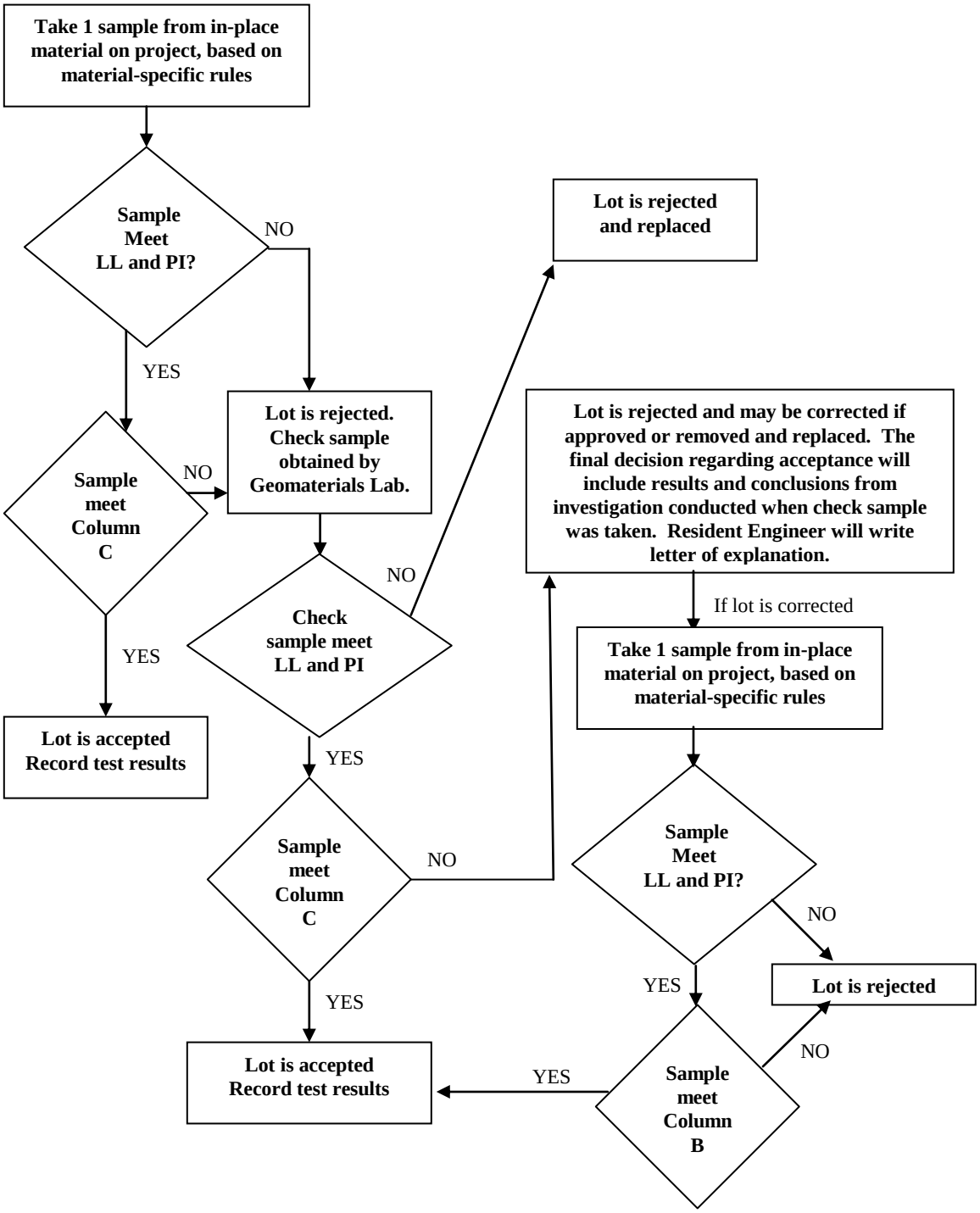


EXHIBIT L- FIELD PROCEDURE FOR INVESTIGATION OF ROADWAY ASSURANCE FAILURE FOR GEOMATERIALS LABORATORY

Procedure for Investigation of RA Failure

1) The State GeoMaterials Engineer notifies the GeoMaterials Training Engineer that a roadway sample has failed.

2) The technical trainer contacts the Resident Engineer for the project to arrange obtaining a check sample within 5 feet of the original sample location. The Department has the right to sample beyond the 5 feet original sample location if any conditions listed in 5 and/or 7 are present or any other extenuating circumstances that may influence the sample.

3) The technical trainer contacts the Area Construction Engineer for that Division, and a representative from the quarry supplying the ABC in question, to schedule a meeting on the project to investigate the failure. At this time, the quarry technicians may take a check sample adjacent to the Department's check sample for their information only.

4) Before any check sampling takes place, the ABC soil reports from the Department Laboratory are reviewed along with QC and QA to determine any trends or irregularities. Data will be obtained from the previous three months of sampling for comparison.

5) The technical trainer also interviews the ABC sampling technician to meet on the project if possible to discuss and confirm that he or she is certified to take ABC samples and that the proper sampling procedures were followed in the original sampling of the ABC. Items that will be reviewed include:

- using random numbers to determine sample location
- staying 2 feet away from edges of spread when sampling
- using the ABC steel sampling ring
- sampling completely through to the next layer of material
- making sure the quantity of the sample meets the 70 lbs. dry weight requirement
- was the mechanical spreader being utilized in the area in question
- could the sample have been taken on a seam where 2 lanes get blended together potentially leading to segregation
- noting any observations from the ABC sampling technician or other project inspectors that may be pertinent to the investigation

6) After consideration of the above information, a check sample will be taken in accordance with the current version of the Aggregate Sampling Manual and delivered to the Materials and Tests-GeoMaterials Laboratory following standard sample submittal practice.

7) Other considerations will be made if:

- it is impossible to sample within 5 feet of the original sample due to location (material covered, in a taper, unknown location of original sample)
- the dump and push method was used in a tapered area
- tailgated material was not sampled using the alternate method in accordance with Appendix E of the Aggregate Sampling Manual

EXHIBIT M AGGREGATE QC/QA SAMPLING AND TESTING TRAINING MANUAL

Test Procedures for Clean Coarse Aggregate and Fine Aggregate

Perform all aggregate sampling and testing in accordance with current specifications and procedures referenced in the *NCDOT Standard Specifications for Roads and Structures, Aggregate Sampling (Roadway)* and procedures outlined in this manual.

Aggregate for Concrete

Hydraulic cement concrete is a mixture of cement and water paste in which aggregate particles are embedded. Aggregate is granular material such as sand, gravel, crushed stone, and blast-furnace slag that usually occupies about 75 percent of the concrete's volume. Besides reducing volume changes due to drying shrinkage of the cement-water paste, aggregates are economical filler that reduces the cost of concrete. Aggregate properties significantly affect the workability of plastic concrete and also affect the durability, strength, thermal properties, and unit weight of hardened concrete.

Aggregate for Asphalt Mixes

Most of the material in an asphalt concrete mixture is aggregates. The aggregates contribute strength and stability to the completed pavement system. All of the particles needed in the aggregate that will meet specifications and do the job usually cannot be found in a single material; therefore, it becomes necessary to blend different sizes and materials in the proper quantities to produce the desired gradation.

In order to accomplish this blending process correctly, it becomes extremely important that the materials to be blended be properly sampled and the gradation or sieve size be accurately determined.

1. **Test Procedures - Clean Coarse Aggregate**

The sample is obtained from a stockpile, conveyor belt, or any other location approved by the Department according to established procedures and taken to the laboratory. When sampling Clean Coarse Aggregate, follow the sampling procedures listed in Exhibit C.

Each sample should be clearly identified by a properly filled out Sample Identification Card, (Exhibit D).

If the sample is to be split with half to be made available to the Department use the procedures for splitting a sample (using a splitter) listed in Exhibit D.

The split half of the Quality Control (QC) Sample, when approved by the Department on a site-by-site basis, may be force dried as long as care and judgment are taken to avoid overheating. When rapid drying a sample, follow procedures listed in Exhibit E.
Coarse aggregate will be tested for gradation in accordance with AASHTO T 27 procedures and the wash test will be performed in accordance with AASHTO T 11.

Washed Gradation Procedures - Clean Coarse Aggregate (AASHTO T 11)

Test Procedures:

1. Once the sample is dried to a constant mass it is allowed to cool to the touch prior to proceeding with any testing procedures.
2. Split sample until a workable size of 1,000 to 2,000 grams is obtained. Follow procedures for splitting a sample described in Exhibit D.
3. Weigh and record weight of sample (Total dry Wt.).
4. Place sample in a container and cover with water to assure a thorough separation of material finer than the No. 200 sieve form the coarser particles.
5. Using a large spoon vigorously agitate contents within the container.
6. Immediately pour the wash water over a nest of sieves that are arranged with the coarser sieve on top.
7. Care should be used to avoid pouring the coarse particles out of the container.
8. Add water as previously described and repeat the procedures.
9. Repeat this process until the wash water is clear.
10. All material retained on the nested sieves shall be returned to the washed sample.
11. The washed aggregate shall be dried to a constant mass at a temperature of 110 ^{o} C (+/- 5 ^{o} C) [230 ^{o} F (+/- 9 ^{o} F)]. If using the Rapid Dry method follow the procedures in Exhibit E.
12. Weigh and record weight of the sample (Wt. after washing).
13. Calculate the percent passing the No. 200 sieve.

Calculation (formula):

$$\textit{Percent Passing No. 200 Sieve} = \frac{(\textit{Total dry Wt.} - \textit{Wt. after washing})}{\textit{Total dry Wt.}} \times 100$$

Example:
Assumption - a washed gradation test is performed on a sample of 57M material

Total dry Wt. = *1,520 grams*
Wt. after washing = *1,515 grams*

$$\textit{Percent Passing No. 200 Sieve} = \frac{(1{,}520 - 1{,}515)}{1{,}520} \times 100$$

Percent Passing No. 200 Sieve = ***0.3 % Passing***

Sieve Size	Percent Passing	Specification (Percent Passing)
# 200	0.3	0 – 1.0

Note: This sample meets Specifications for 57M passing the No. 200 Sieve for material that is tested from a stockpile at the quarry site.

Sieve Analysis Procedures - Clean Coarse Aggregate (AASHTO T 27)

Test Procedures:

1. Once the sample is dried to a constant mass it is allowed to cool to the touch prior to proceeding with any testing procedures.
2. When testing material which 100% passes the ¾ sieve, split the sample into a workable size of 10 to 15 pounds. Follow procedures for splitting a sample described in Exhibit D.
3. Based on the Specifications for the material being tested, the proper sieves are selected. Additional sieve(s) may be added as needed to determine Fineness Modulus or to prevent sieve overloading.
4. The sieves are placed into the mechanical shaker with the smallest opening on bottom and largest opening on top.
5. Weigh and record the weight of the sample.
6. Place the sample in the mechanical shaker and agitate for 10 minutes.
7. Carefully remove each sieve, weigh and record the retained material (cumulatively) using the following steps:
    a. Remove the top sieve weigh and record material retained
    b. Remove the next sieve from the shaker and add the retained material to the material from the first sieve.
    c. Record cumulative weight from both sieves
    d. Remove the next sieve from the shaker and add the retained material to the material from the two previous sieves.
    e. Record cumulative weight from all three sieves
    f. Repeat this process for each of the remaining sieves to the catch pan.
8. Calculate the cumulative percent retained for each sieve
9. Calculate the percent passing for each sieve.

Example of Calculating Percent Passing:

Assume a sieve analysis is performed on the 57M sample that was previously tested to determine the percent passing the No. 200 sieve (using the wash gradation test). Based on the test results**,** 0.3 percent passed the No. 200 sieve. The total weight of the (dry) sample used for the sieve analysis is **34.1 lbs**.

Step 1 - Determine Cumulative Percent Retained for each sieve:

$$\textit{Cumulative Percent Retained} = \frac{\textit{Cumulative Wt. retained}}{\textit{Total dry Wt. of sample}} \times 100$$

Example of 1" Sieve

$$\text{Cumulative percent retained} = \frac{1.4}{34.1} \times 100 = \textbf{4 \% retained}$$

Sieve Size	Cumulative lbs Retained	Cumulative Percent Retained
1 ½"	0	0
1"	1.4	4
½"	25.9	76
#4	32.1	94
#8	33.5	98
Pan	34.1	100

Step 2 - Determine Percent Passing for each sieve:

Percent Passing = 100 – Cumulative Percent Retained

Example of 1" Sieve

100 – 4 = **96 % passing**

Sieve Size	Cumulative lbs Retained	Cumulative Percent Retained	Percent Passing	Specs 57M
1 ½"	0	0	100	100
1"	1.4	4	96	95-100
½"	25.9	76	24	25-45
#4	32.1	94	6	0-10
#8	33.5	98	2	0-5
Pan	34.1	100	0	

Note: ½" sieve exceeds Specifications

Sieve Analysis – Clean Coarse Aggregate Work Problem 1

Check the following sieve analysis of a sample to determine if it meets the minimum specification requirements for a # 67 stone. This sample was taken at a Ready Mix Concrete Plant. Circle any sieves, if any, which exceed the minimum specifications.

Total weight of sample (oven-dried) = **35.6 lbs**

Sieve Size	Cumulative Lbs. Retained	Cumulative % Retained	Percent Passing	NCDOT Specs. (% Passing)
1 ”	0			100
¾ “	2.8			90 – 100
½ “	18.0			
3/8 “	27.4			20 – 55
#4	33.8			0 – 10
#8	35.0			0 – 5
Pan	35.6			
Passing #200 (wash method)				
#200			0.9	0 – 1.5

Does this sample meet the minimum Specifications for # 67 stone? _____

Note: The ½“ sieve is not a standard size for # 67 stone. The information is needed for use in design and control of plant mix asphalt.

Sieve Analysis - Clean Coarse Aggregate Work Problem 2

Check the following sieve analysis of a sample to determine if it meets the minimum specification requirements for a # 57 stone. This sample was taken at the quarry during production. Circle any sieves, if any, which exceed the minimum specifications.

Total weight of sample (oven-dried) = **36.1 lbs**

Sieve Size	Cumulative lbs. Retained	Cumulative % Retained	Percent Passing	NCDOT Specs. (% Passing)
1 ½ ”	0			100
1 “	1.1			90 – 100
½ “	19.8			25 – 60
#4	34.1			0 – 10
#8	35.2			0 – 5
Pan	36.1			
Passing #200 (wash method)				
#200			0.5	0 – 0.6

Does this sample meet the minimum Specifications for # 57 stone? _____

2. Test Procedures - Fine Aggregate

The sample is obtained from a stockpile, conveyor belt, or any other location approved by the Department according to established procedures and taken to the laboratory. When sampling Fine Aggregate, follow the sampling procedures listed in Exhibit D.

Each sample should be clearly identified by a properly filled out Sample Identification Card, (Exhibit C).

If the sample is to be split with half to be made available to the Department use the procedures for splitting a sample (using a splitter) listed in Exhibit D.

The split half of the Quality Control (QC) Sample, when approved by the Department on a site-by-site basis, may be force dried as long as care and judgment are taken to avoid overheating. When rapid drying a sample, follow procedures listed in Exhibit E.

Fine Aggregate will be tested for gradation in accordance with AASHTO T 27 procedures and the wash test will be performed in accordance with AASHTO T 11.

Washed Gradation Procedures - Fine Aggregate (AASHTO T 11)

Test Procedures:

1. Once the sample is dried to a constant mass it is allowed to cool to the touch prior to proceeding with any testing procedures.
2. Split sample until a workable size of 400 to 600 grams is obtained (Note: this sample size deviates from standard AASHTO procedures). Follow procedures for splitting a sample described in Exhibit D.
3. Weigh and record weight of sample (Total dry Wt.).
4. Place sample in a container and cover with water to assure a thorough separation of material finer than the No. 200 sieve form the coarser particles (ex. #8 - #16 plus #200 sieves.
5. Using a large spoon vigorously agitate contents within the container.
6. Immediately pour the wash water over a nest of sieves that are arranged with the coarser sieve on top.
7. Care should be used to avoid pouring the coarse particles out of the container.
8. Add water as previously described and repeat the procedures.
9. Repeat this process until the wash water is clear.
10. All material retained on the nested sieves shall be returned to the washed sample.
11. The washed aggregate shall be dried to a constant mass at a temperature of 110 ^{o} C (+/- 5 ^{o} C) [230 ^{o} F (+/- 9 ^{o} F)]. If using the Rapid Dry method follow the procedures in Exhibit D.
12. Weigh and record weight of the sample (Wt. after washing).
13. Calculate the percent passing the No. 200 sieve.

Calculation (formula):

$$\textit{Percent Passing No. 200 Sieve} = \frac{(\textit{Total dry Wt.} - \textit{Wt. after washing})}{\textit{Total dry Wt.}} \times 100$$

Example:

Assumption - a washed gradation test is performed on a sample of 2S sand

Total dry Wt. = *514.0 grams*
Wt. after washing = *504.9 grams*

$$\textit{Percent Passing No. 200 Sieve} = \frac{(514.0 - 504.9)}{514.0} \times 100$$

Percent Passing No. 200 Sieve = (1.770) or ***1.8 % Passing***

Sieve Size	Percent Passing	Specification (Percent Passing)
# 200	1.8	0 – 3.0

Sieve Analysis Procedures - Fine Aggregate (AASHTO T 27)

Test Procedures:

1. Once the sample is dried to a constant mass it is allowed to cool to the touch prior to proceeding with any testing procedures.
2. Based on the Specifications for the material being tested, the proper sieves are selected. Additional sieve(s) may be added as needed to determine Fineness Modulus or to prevent sieve overloading.
3. The sieves are placed into the mechanical vibrator with the smallest opening on bottom and largest opening on top.
4. Weigh and record the weight of the sample.
5. Place the sample in the mechanical shaker and agitate for 10 minutes.
6. Carefully weigh and record the retained material on each sieve (cumulatively) using the following steps:
    a. Carefully remove the nest of sieves from the shaker.
    b. Remove the top sieve weigh and record material retained
    c. Remove the next sieve and add the retained material to the material from the first sieve.
    d. Record cumulative weight from both sieves
    e. Remove the next sieve and add the retained material to the material from the two previous sieves.
    f. Record cumulative weight from all three sieves
    g. Repeat this process for each of the remaining sieves to the catch pan.
7. Verify mass of sample prior to sieving is within 0.3% of sample mass originally placed on nest of sieves
8. Calculate the cumulative percent retained for each sieve.
9. Calculate the percent passing for each sieve.

Example of Calculating Percent Passing:

Assume a sieve analysis is performed on the 2S sand sample that was previously tested to determine the percent passing the No. 200 sieve (using the wash gradation test). Based on the test results**,** 1.8 percent passed the No. 200 sieve. The total weight of the (dry) sample used for the sieve analysis is **514.0 grams**.

Step 1 - Determine the Cumulative Percent Retained for each sieve:

$$\textit{Cumulative Percent Retained} = \frac{\textit{Cumulative Wt. retained}}{\textit{Total dry Wt. of sample}} \times 100$$

Example of #4 Sieve

$$\text{Cumulative percent retained} = \frac{15.4}{514.0} \times 100 = \mathbf{3\ \%\ retained}$$

Sieve Size	Cumulative gms Retained	Cumulative Percent Retained
3/8 ”	0	0
#4	15.4	3
#8	51.4	10
#16	154.2	30
#30	257.6	50
#50	416.9	81
#100	488.3	95

Step 2 - Determine the Percent Passing for each sieve:

Percent Passing = 100 – Cumulative Percent Retained

Example of #4 Sieve

100 – 3 = **97 % passing**

Sieve Size	Cumulative gms Retained	Cumulative Percent Retained	Percent Passing	Specs 2S
3/8 ”	0	0	100	100
#4	15.4	3	97	95-100
#8	51.4	10	90	80-100
#16	154.2	30	70	45-95
#30	257.6	50	50	25-75
#50	416.9	81	19	5-30
#100	488.3	95	5	0-10

Sieve Analysis - Fine Aggregate Work Problem 1

Determine if the following sieve analysis of a sample meets the minimum specification requirements for a 2MS sand. This sample was taken at the job site prior to use. Circle sieves, if any, which exceed the minimum specifications.

Total weight of sample (oven-dried) = **547.9 grams**
Weight of sample after washing #200 = **506.5 grams**

Sieve Size	Cumulative gms Retained	Cumulative % Retained	Percent Passing	NCDOT Specs. (% Passing)
3/8 "	0			
#4	6.7			95 – 100
#8	68.8			80 – 100
#16	183.4			45 – 95
#30	355.3			25 – 75
#50	452.5			5 – 35
#100	503.9			0 - 20
Pan	506.5			
Passing #200 (wash method)				
#200				0 - 10

Does this sample meet the minimum Specifications for 2 MS sand? _____

3. **Fineness Modulus (F.M.)**

Fineness Modulus is defined by the American Concrete Institute (ACI) as "*an empirical factor obtained by adding the total percentages (by weight) of an aggregate sample retained on each of a specified series of sieves, and dividing the sum by 100".* Fineness Modulus (F.M.) is defined mathematically as the sum of the cumulative percentage retained on the standard sieves divided by 100. The Standard Size Sieves are 6", 3", 1 ½", ¾", 3/8", No. 4, No. 8, No. 16, No 30, No. 50, and No. 100. It is an index to the fineness or coarseness of the aggregate. The F.M. is an index of the fineness of the aggregate and should not be less than 2.3 or more than 3.1, nor vary by more than 0.20 from batch to batch.

F.M. Rating	Index Range
Coarse Sand	2.80 – 3.10
Medium Sand	2.50 – 2.80
Fine Sand	2.30 – 2.50

(**Note**: When testing the gradation, the No. 200 sieve is used as required in the Specification. However, it is **not** used in calculating the F.M. Do **not** include material retained in the Pan when calculating the F.M.)

Fineness Modulus Example

Total weight of the sample (oven-dried before washing) = **514.8 grams**
Oven dry weight (after washing #200) = **504.0 grams**

Step 1 – Determine Cumulative Percent Retained for each sieve

$$\textit{Cumulative Percent Retained} = \frac{\textit{Cumulative Wt. retained}}{\textit{Total dry Wt. of sample}} \times 100$$

Sieve Size	Cumulative gms Retained	Cumulative % Retained
3/8 "	0	0
#4	15.1	3
#8	50.4	10
#16	119.9	23
#30	289.1	56
#50	434.2	84
#100	490.9	95
Pan	504.0	

Step 2 – Determine the Fineness Modulus Index

The Fineness Modulus (F.M.) is defined mathematically as the sum of the cumulative percentages retained on standard sieves divided by 100.

$$\textbf{F.M. Index} = \frac{(0 + 3 + 10 + 23 + 56 + 84 + 95)}{100} = \frac{271}{100} = \mathbf{2.71}$$

Fineness Modulus Work Problem 1

Complete the following sieve analysis to determine if this sample of 2S material for use in concrete meets minimum Specifications. This sample was taken at the job site prior to use. Calculate the Fineness Modulus (F.M.) of this material.

Total weight of sample (oven-dried) = **573.0 grams**
Weight of sample (after washing #200) = **557.4 grams**

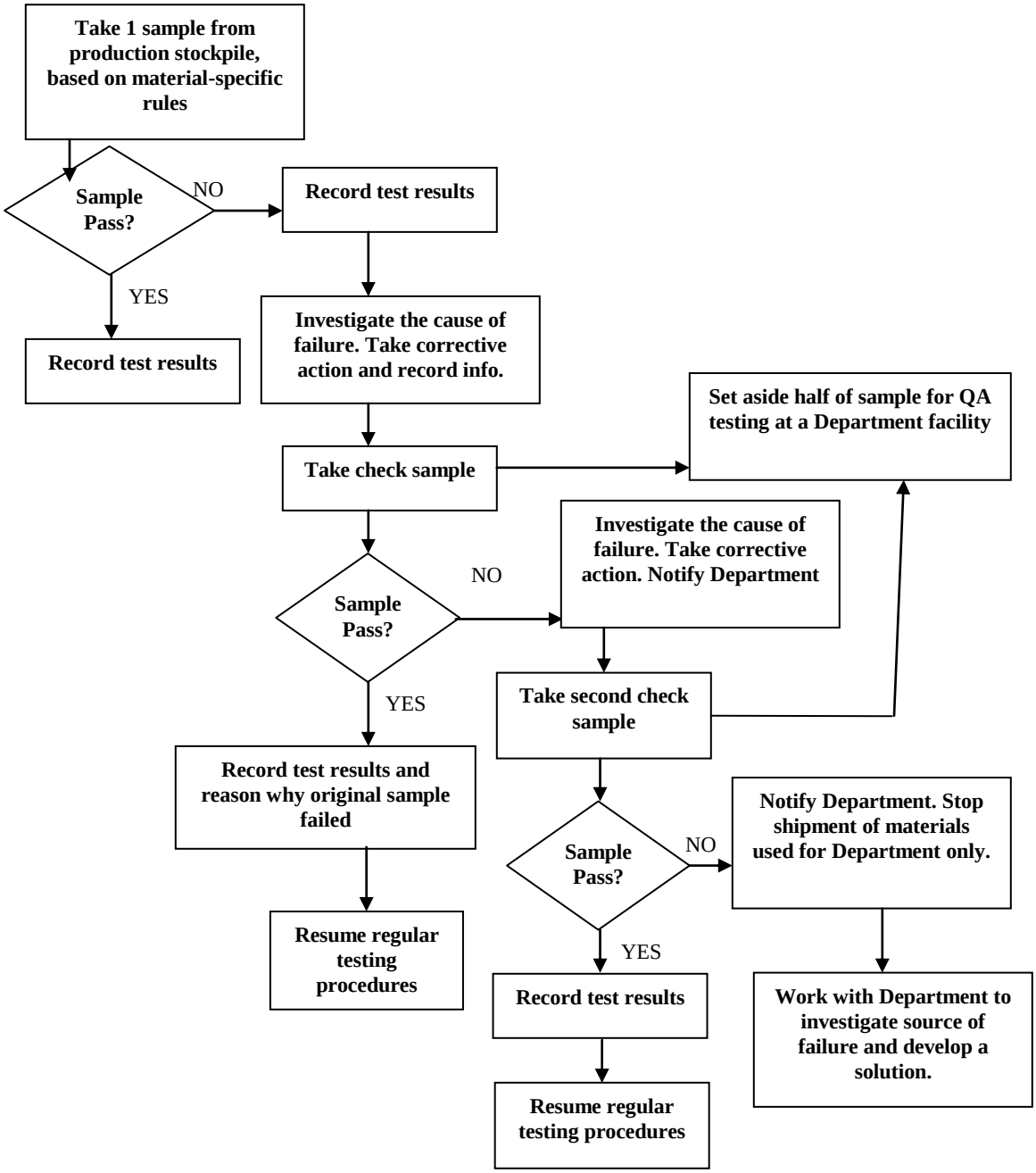
Sieve Size	Cumulative gms Retained	Cumulative % Retained	Percent Passing	NCDOT Specs. (% Passing)
3/8 "	0			100
#4	0			95 – 100
#8	22.9			80 - 100
#16	171.9			45 – 95
#30	286.5			25 – 75
#50	429.8			5 – 30
#100	521.4			0 – 10
Pan	557.4			
Passing #200 (wash method)				
#200				0 – 3

Determine the F.M. Index = _____

Based on the F.M. Index, this material is rated as a _____ Sand.

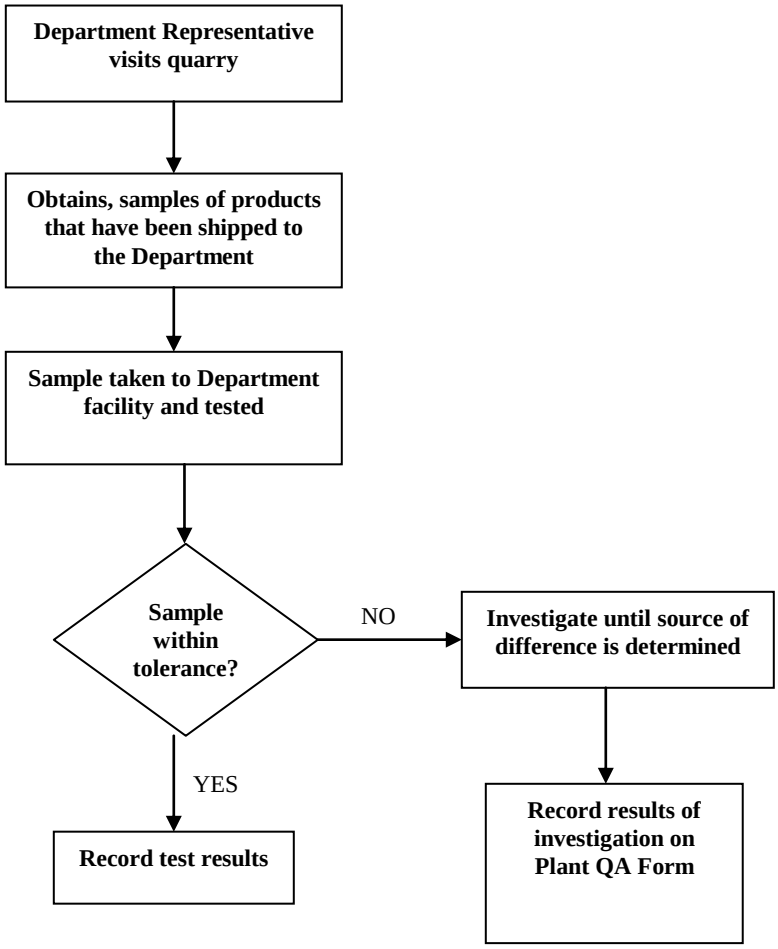
A. Coarse
B. Medium
C. Fine

AGGREGATE QC PROCESS- FLOW CHART



CLEAN COARSE AGGREGATE AND FINE AGGREGATE QA PROCESS – FLOWCHART

The following flowchart summarizes the QA procedures for sampling and testing clean coarse and fine aggregate.



Example of QC Sampling

Scenario: Beginning the second week of January Hard Rock Quarry begins shipping 57M for the first time this calendar year. This material is being shipped to a local concrete producer, asphalt producer, and Department maintenance facility. Based on production and amount of material ordered this material will be shipped for approximately the next 3 weeks. The following tables summarize the tonnage shipped each day along with number of samples and sample numbering.

Week 1 of shipping 57M (for the calendar year)				
Day	Quantity Shipped	Destination	Samples	Remarks
Monday	650 tons	Concrete and Asphalt	QC-1	First sample of material for year
Tuesday	855 tons	Concrete, Asphalt and DOT	No sample	
Wednesday	2,020 tons	Concrete, Asphalt and DOT	QC-2	
Thursday	1,220 tons	Concrete, Asphalt and DOT	No sample	
Friday	600 tons	Concrete and Asphalt	QC-3	Close out the week

During Week 1 of this scenario 5,345 tons of 57M was shipped. Based on the minimum sampling frequency of one sample per 2,000 tons, 2.67 samples are required. In order to prevent a possible shortage of samples we **strongly** recommend "closing out" each week. Therefore, for this example, 3 samples are obtained and tested.

Week 2 of shipping 57M				
Day	Quantity Shipped	Destination	Samples	Remarks
Monday	4,220 tons	Concrete and Asphalt	QC-3, QC-4	
Tuesday	3,320 tons	Concrete, Asphalt and DOT	QC-5, QC-6	
Wednesday	4,140 tons	Concrete, Asphalt and DOT	QC-7, QC-8	
Thursday	2,125 tons	Concrete, Asphalt and DOT	QC-9	Total tonnage for week 13,805 tons
Friday	1,020 tons	Concrete and Asphalt	QC-10	Close out the week

During Week 2 of this scenario 14,825 tons of material was shipped. Based on the minimum sampling frequency of one sample per 2,000 tons, 7.41 samples are required. In order to prevent a possible shortage of samples we **strongly** recommend "closing out" each week. Therefore, for this example, 8 samples are obtained and tested.

Week 3 of shipping 57M				
Day	Quantity Shipped	Destination	Samples	Remarks
Monday	0 tons		No sample	
Tuesday	100 tons	DOT	No sample	
Wednesday	100 tons	Concrete	No sample	
Thursday	40 tons	DOT	QC-11	1 sample per week
Friday	0 tons		QC-12	Split Sample (QA-12) obtained when Department representative visits plant

During Week 3 of this scenario 240 tons of material was shipped for the week. Though less than 2,000 tons of material was shipped this week a minimum of one sample is required if any material is shipped. QC-12 obtained on Friday was required due to visit by a Department representative.

TEST PROCEDURES – AGGREGATE BASE PRODUCTS

1. **Types of Aggregate Base Products**

Aggregate Base Course (ABC) consists of a well-graded blend of fine and coarse aggregate particles. When ABC is placed meeting the required specifications and compacted to the minimum density requirements, it functions as an excellent foundation for the pavement structure. The major structural function of an aggregate layer serving as a pavement base course or sub-base is to distribute the stresses applied to the pavement surface from traffic loading. Aggregate Base Course can provide sufficient strength and rutting resistance to maximize bearing capacity and reduce rutting failure within the pavement layers. A quality ABC layer can also provide additional benefits such as, controlling pumping, reducing frost action, improving drainage of surface or subsurface water, controlling volume change in the subgrade when expansive soils are present, and minimizing the lateral movement of the flexible pavement system.

Cement Treated Base Course (CTBC) is an aggregate base material with the addition of cement and is generally used on highways with high traffic volumes. CTBC offers the same benefits as ABC; however, the addition of cement provides a higher strength or bearing capacity.

Aggregate Base Course (Modified) (ABC-M) is an aggregate base type product with a different gradation specification when compared to ABC. ABC-M is generally used for maintenance stabilization.

Stabilizer Aggregate (SA) is an aggregate base type product with a different specification requirement when compared to ABC. SA is generally used on construction projects for subgrade stabilization.

2. **Types of ABC**

Type A ABC – Production Pile. Type A ABC is ABC from a production pile. A production pile can have new material added while existing material is being shipped to a customer. Procedures for accepting material, taking roadway assurance check samples, correcting material, applying penalties, and rejecting material are provided in Exhibit I.

Type B ABC – Approved Stockpile. Type B ABC is ABC that is used to build an Approved Stockpile. An Approved Stockpile differs from a production pile in that specific procedures must be followed as it is constructed. Additional information regarding Approved Stockpiles is provided in Exhibits I and J.

When sampling aggregate base material, the sample is obtained from a stockpile, conveyor belt, or any other location approved by the Department according to established procedures and taken to the laboratory. When sampling aggregate base material, follow the sampling procedures listed in Exhibit C.

Each sample should be clearly identified by a properly filled out Sample Identification Card, see Exhibit D.

Use the procedures for splitting a sample (using a splitter) listed in Exhibit D.

The Quality Control (QC) Sample, when approved by the Department on a site-by-site basis, may be force dried as long as care and judgment are taken to avoid overheating. When rapid drying a sample, follow procedures listed in Exhibit E. If the quarry is required by the Department to test for Plasticity Index (P.I.) then the sample must be dried at a temperature not exceeding 60 ^{o} C or 140 ^{o} F.

3. **Test Procedures – Aggregate Base Products**

Sieve Analysis Procedures – Aggregate Base Products (AASHTO T 27)

Test Procedures:

1. Once the sample is dried to a constant mass it is allowed to cool to the touch prior to proceeding with any testing procedures.
2. The 1 ½", 1", ¾", ½", $^{3}/_{8}$", #4 and #10 sieves are placed in the mechanical shaker with the smallest openings on bottom and largest openings on top. A pan is placed in the shaker to catch the -#10 material. The ¾" and $^{3}/_{8}$" sieves are not necessary to determine gradation but are inserted to prevent overloading other screens.
3. Weigh and record the weight of the sample.
4. Place the sample in the mechanical shaker and agitate for 10 minutes.
5. Carefully remove each sieve, weigh and record the retained material using the following steps:
   a. Weigh and record material retained on the 1 ½" sieve
   b. Add retained material from the 1" sieve to the 1 ½" material.
   c. Weigh and record the cumulative weight of material retained on 1" sieve
   d. Add retained material from the ¾" sieve to the 1 ½" and 1" material.
   e. Add retained material from the ½" sieve to the 1 ½", 1", and ¾" material
   f. Weigh and record as the cumulative weight of material retained on the ½" sieve
   g. Add retained material from the $^{3}/_{8}$" sieve to the 1 ½", 1", ¾", and ½" material.
   h. Add retained material from the #4 sieve to the 1 ½", 1", ¾", ½", and 3/8" material
   i. Weigh and record the cumulative weight of material retained on the #4 sieve.
   j. Add retained material from the #10 sieve to the 1 ½", 1", ¾", ½", $^{3}/_{8}$", and #4 material
   k. Weigh and record the cumulative weigh of material retained on the #10 sieve.
   l. The - #10 material in the shaker pan is reduced by splitting to a sample size of approximately 800 – 1200 grams and placed in a sample can. This sample of - #10 material is used to determine the percent passing the #40 and #200 sieves and, if required, the Liquid Limit (L.L.) and Plasticity Index (P.I.).

6. Split sample until a minimum of 300 grams is obtained. The remaining - #10 material is set aside for determining Liquid Limit and Plasticity Index if required.
7. Weigh and record weight of sample (Total Dry Wt., pre-washing).
8. Place sample in container and cover with water.
9. Using a large spoon vigorously agitate contents within the container to assure a thorough separation of material finer than the #200 sieve from the coarser particles..
10. Immediately pour the wash water over a nest of sieves that are arranged with the coarser sieve on top (ex. #8 - # 16 plus the #200 sieves).
11. Care should be used to avoid pouring the coarse particles out of the container.
12. Add water as previously described and repeat steps from 9 – 11.
13. Repeat this process until the wash water is clear.
14. All material retained on the nested sieves shall be returned to the container.
15. The washed aggregate shall be dried to a constant mass at a temperature of 110 ^{0}C (+/- 5 ^{0}C [230 ^{0}F (+/- 9 ^{0}F)]. If using the Rapid Dry method follow procedures in Exhibit D.
16. Once the sample is dried it must be allowed to cool to the touch prior to performing any additional tests.
17. Weigh and record weight of the sample (Total Dry Wt.., after washing). Calculate the percent passing the #200 sieve.
18. Place sample in a mechanical shaker with a nest of sieves, including a catch pan, and cover plate. The sieve sizes are as follows: #30, #40, #100, and #200 (place sieves with the largest openings on top and the smallest on bottom). The #30 and #100 are included to prevent overloading of the sieves.
19. The sample is screened for 10 minutes in the mechanical shaker.
20. Add the material retained on the #30 sieve to the material retained on the #40 sieve.
21. Weigh and record the material retained on the #40 sieve
22. Add the material retained on the #100 sieve to the material retained on the #40 sieve.
23. Add the material retained on #200 sieve to the #40 and #100 material.
24. Weigh and record the cumulative material from the #40, #100, and #200 sieve to determine the cumulative weight retained on the #200 sieve.
25. Verify mass of sample after sieving is within 0.3% of mass placed on nest of sieves.
26. Calculate the cumulative percent retained on each sieve to the #10 sieve.
27. Calculate the percent passing each sieve down to the #10 sieve.
28. Calculate the cumulative percent retained on the #40 and #200 sieve (- #10 material or Soil Mortar).
29. Calculate the percent passing on the #40 and #200 sieves.
30. Complete the gradation results with the percent passing for each sieve (top to bottom).
31. When reporting the #200, use the percent passing the #200 sieve by wash.

Example of Calculating Percent Passing:

Assume this sieve analysis is performed on ABC. The total weight of the (dry) sample used for the sieve analysis is **41.4 lbs**.

Step 1 - Determine Cumulative Percent Retained for each sieve:

$$\textit{Cumulative Percent Retained} = \frac{\textit{Cumulative Wt. retained}}{\textit{Total dry Wt. of sample}} \times 100$$

Example of 1" Sieve Cumulative Percent Retained = $\frac{2.3}{41.4}$ x 100 = **6 % retained**

Sieve Size	Cumulative lbs Retained	Cumulative Percent Retained
1 ½"	0	0
1"	2.3	6
½"	13.3	32
#4	23.7	57
#10	29.1	70
Pan		

Assume this sieve analysis for the - #10 (Soil Mortar) material began with a dry weight of **320.0 grams**

Step 2 - Determine Cumulative Percent Retained for the #40 and #200 sieves (- #10 material or Soil Mortar):

$$\textit{Cumulative Percent Retained} = \frac{\textit{Cumulative Wt. retained}}{\textit{Total dry Wt. of sample}} \times 100$$

Example of #40 Sieve

Cumulative percent retained = $\frac{153.6}{320.0}$ x 100 = **48 % retained**

Sieve Size	Cumulative gms Retained	Cumulative Percent Retained
#40	153.6	48
#200	227.2	71

Step 3 - Determine Percent Passing for each sieve:

Percent Passing = 100 – Cumulative Percent Retained

Example of 1” Sieve

100 – 6 = **94 % passing**

Sieve Size	Cumulative lbs Retained	Cumulative Percent Retained	Percent Passing
1 ½”	0	0	100
1”	2.3	6	94
½”	13.3	32	68
#4	23.7	57	43
#10	29.1	70	30

Example of #40 Sieve (Soil Mortar):

100 – 48 = **52 % passing**

Sieve Size	Cumulative gms Retained	Cumulative Percent Retained	Percent Passing
#40	153.6	48	52
#200	227.2	71	29

Step 4 – Determine Percent Passing for each sieve (total sample):

Percent Passing Total Sample (#40) = Percent Passing #10 x Percent Passing #40 x 100

Example: % Passing #40 (total) = 0.30 x 0.52 x 100 = 15.6 or **16 % Passing**

Percent Passing Total Sample (#200) = Percent Passing #10 x Percent Passing #200 x 100

Example: % Passing #200 (total) = 0.30 x 0.29 x 100 = 8.7 or **9 % Passing**

Sieve Size	Percent Passing
1 ½”	100
1”	94
½”	68
#4	43
#10	30
#40	16
#200	9
Soil Mortar	
#40	52
#200	29

Sieve Analysis – ABC Work Problem 1

Assume the following results represent sample QC-20. Determine the percent passing for each sieve (including Soil Mortar). The total weight of the sample is **82.3 lbs** and a **347.2gram** sample was used to test the soil mortar (#40 and #200 sieves).

Sieve Size	Cumulative lbs Retained	Cumulative Percent Retained	Percent Passing
1 ½”	0		
1”	4.9		
½”	28.0		
#4	46.9		
#10	55.1		
#40	------	------	
#200	------	------	
Soil Mortar			
#40	180.4 gms		
#200	252.2 gms		

Sieve Analysis – ABC Work Problem 2

Assume the following results represent sample QC-21. Determine the percent passing for each sieve (including Soil Mortar). The total weight of the sample is **81.1 lbs** and a **351.2 gram** sample was used to test the soil mortar (#40 and #200 sieves).

Sieve Size	Cumulative lbs Retained	Cumulative Percent Retained	Percent Passing
1 ½”	0		
1”	4.5		
½”	27.8		
#4	46.4		
#10	54.8		
#40	------	------	
#200	------	------	
Soil Mortar			
#40	182.6gms		
#200	262.1gms		

Gradation Specifications – ABC Work Problem 1

Using the results from Work Problems 1 and 2 (QC-20 & QC-21), determine if any of the two sampling lot exceeds Specifications for Gradation. Place a single asterisk if a Gradation Specification. The Specifications are provided and are also listed in Table I-2 Exhibit I.

Sieve Size	Percent Passing QC-20	Percent Passing QC-21	Gradation Specs Column B	Gradation Specs Column C
1 ½”			100	98 – 100
1”			75 – 97	72 – 100
½”			55 – 80	51 – 83
#4			35 – 55	35 – 60
#10			25 – 45	20 – 50
#40			14 – 30	10 – 34
#200			4 – 12	3 – 13
Soil Mortar				
#40			40 – 84	36 – 86
#200			11 - 35	10 - 36

(*) - Gradation Specification exceeded

Atterberg Limit (Liquid Limit and Plasticity Index) Procedures

If the quarry has been identified by the Department as having potential problems with Liquid Limit (LL) or Plasticity Index (PI), the Atterberg Limits must be determined for each 6,000 tons of material shipped. The Liquid Limit is defined as the moisture content at which a soil passes from a plastic state to a liquid state and is determined by AASHTO T 89. The Plastic Limit is defined as the moisture content at which a soil passes from a semisolid state to a plastic state and is determined by AASHTO T 90. The Plasticity Index (PI) is the numerical difference between the Liquid Limit and Plastic Limit (**P.I. = L.L. – P.L**.).

Obtaining - #40 Material

To determine the Atterberg Limits, use the remaining - #10 material that was set aside while performing the sieve analysis (Step 5 k). Since the Liquid Limit and Plasticity Index are determined on the - #40 material, the sample must be separated into two parts. This can be accomplished by sieving the material over a #40 sieve and a catch pan. The fraction retained on the #40 sieve shall be ground in a mortar with a rubber-covered pestle or suitable mechanical device in such a manner as to break up the aggregation of material particles without fracturing the individual grains. If the sample contains brittle fragments such as flakes of mica, fragment of sea shell, etc., the grinding operation shall be done carefully and with just enough pressure to free the fragments from adhering to particles of finer material. After grinding the sample, it is to be re-sieved over the #40. The grinding and sieving process are repeated until the following conditions are met:

- Repeated grinding only produces a small amount of - #40 material
- Rubbing the + #40 material between the thumb and forefinger indicates the material is clean

Once clean, the remaining + #40 material is discarded. The - #40 material (in catch pan) is thoroughly mixed and placed into a sample can. This sample will be used to determine the Liquid Limit and Plasticity Index and should be clearly identified.

Inspection and adjustment of Atterberg (or Liquid Limit) Device

The Atterberg Device shall be inspected to determine that it is in good working order, that the pin connecting the cup is not worn sufficiently to permit side play; that the screws connecting the cup to the hanger arm are tight; and that a groove has not been worn in the cup through long usage. The grooving tool shall be inspected to determine that the critical dimensions are as shown in Figure1.

By means of the gauge on the handle of the grooving tool, and the adjustment plat H
Figure 1, the height to which the cup C is lifted shall be adjusted so that the point on the cup which comes in contact with the base is exactly 1 cm (0.3937 in.) above base. To adjust for the one centimeter lift, the strike point on the cup must be determined. To determine the strike point,

place carbon paper between the cup and rubber base and turn the handle several times to get a carbon mark on the bottom of the cup. Place a piece of scotch tape across the middle of the carbon mark and slide the handle of the grooving tool until it touches the tape. The adjustment plate H shall then be secured by tightening the screws, I. With the gauge still in place, the adjustment shall be checked by revolving the crank rapidly several times. If the adjustment is correct, a slight ringing sound will be heard when the cam strikes the cam follower. If the cup is raised off the gauge or no sound is heard, further adjustment shall be made.

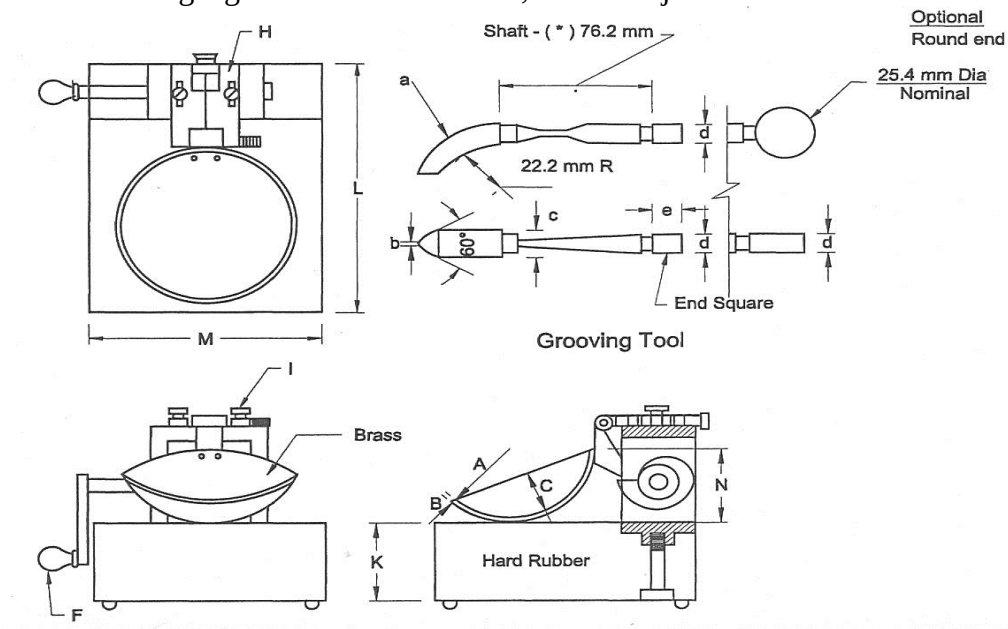


Figure 1 – Atterberg Device

Atterberg Device							
	Cup Assembly				Base		
Dimension	A	B	C	N	K	L	M
Description	Radius of Cup	Thickness of Cup	Depth Of Cup	Cup at Cam Follower to Base	Thickness	Length	Width
Metric, mm	54	2.0	27	47	50	150	125
Tolerance, mm	2	0.1	0	1.5	5	5	5
Grooving Tool							
	Curved End				Gage		
Dimension	a	b	c		d	*e	
Description	Thickness	Cutting Edge	Width		Depth	Length	
Metric, mm	10.0	2.0	13.5		10.0	15.9	
Tolerance, mm	0.1	0.1	0.1		0.2	------	

Note: Plate "H" may be designed for using (1) one securing screw (I).
An additional wear tolerance of 0.1 mm shall be allowed for dimension "b" for used grooving tools.
Feet for base shall be of resilient material.
(*) Nominal dimensions.

All tolerances specified are plus or minus (+/-) except as noted above.

Liquid Limit Test Procedures (AASHTO T 89)

No Liquid Limit results required if test cannot be performed (i.e. the material is non-plastic).

1. Verify the Atterberg Device is calibrated for a 1 centimeter drop of the brass cup.
2. Thoroughly mix and obtain 50 to 100 grams of the - #40 material and place it in an evaporating dish.
3. Add water to the sample in the dish.
4. Mix the sample and water together with a spatula by stirring and kneading the sample.
5. If needed, continue adding water and mixing until the sample is near the Liquid Limit (based on judgment and experience of person conducting test).
6. Using the spatula, place material in lower half of the brass cup using as few strokes as possible (excess strokes will bring the water to the top of the sample).
7. Using the spatula strike off the sample to a depth of 1 centimeter in the cup.
8. Using the grooving tool, make a groove in the sample from the top to the bottom (verify the sample and grooving tool blade are the same depth).
9. Attach the brass cup to the Atterberg Device.
10. Turn the crank 25 times at a rate of approximately 2 turns per second.
11. If the sample comes or flows together on the 25th blow between ¼" to ½" in the cup then the material is considered to be at its liquid limit. If this does not occur on the 25th blow then the sample will have to be dried or more water added to reach the liquid limit.
12. If repeating these steps to achieve the liquid limit, thoroughly clean and dry the grooving tool and brass cup between each series.
13. If the requirements are met, use the spatula to obtain a slice of material which flowed together by cutting at right angles to the groove from edge to edge (approximately 30 grams).
14. Place the sample into a moisture can or watch glass of known weight.
15. Weigh and record the weight of the sample.
16. Place the sample in an oven set at 110 ^{o} C (+/- 5 ^{o}) or 230 ^{o} F (+/- 9 ^{o}) for three hours or until dry.
17. Carefully (Caution: Hot) remove sample from oven.
18. Place glass on top of container to determine if moisture is forming on the glass. If moisture forms, place sample back in oven. Repeat this process until sample is dry.
19. If dry, allow sample to cool to room temperature.
20. Weigh and record weight
21. Calculate percent of moisture and record
22. Discard material

Plastic Limit Test Procedures (AASHTO T 90)

Since the moisture content for the Liquid Limit is higher than the Plastic Limit this procedure will dry the sample back to the moisture content at which the material remains plastic. If the Liquid Limit test cannot be performed, report the Plasticity Index (P.I.) as non-plastic (N.P.).

1. Take the remaining material in the brass cup (from Liquid Limit test) and form it into a ball (approximately 15 grams).
2. Break the ball into 4 approximately equal ellipsoidal masses and place each on unglazed paper.
3. Using your fingers, roll each ellipsoidal mass individually (on the paper) out into a 1/8" diameter thread. Use only minimal pressure with your fingers and roll at an angle.
4. Repeat the rolling process on the paper until the material crumbles before reaching a 1/8" diameter thread.
5. Once the first piece is rolled down collect and set it to the side. Repeat this procedure with each of the remaining (3) pieces (Steps 3 and 4). Note: Use clean paper for each mass "roll-down".
6. Re-roll the total sample into one ball with your fingertips.
7. Place the sample into a moisture can or watch glass of known weight.
8. Weigh and record the weight of the sample.
9. Place the sample in an oven set at 110 ^{o} C (+/- 5 ^{o}) or 230 ^{o} F (+/- 9 ^{o}) for three hours or until dry.
10. Carefully (Caution: Hot) remove sample from oven.
11. Place glass on top of container to determine if moisture is forming on the glass. If moisture forms, place sample back in oven. Repeat this process until sample is dry.
12. If dry, allow sample to cool to room temperature.
13. Weigh and record weight.
14. Calculate percent of moisture and record.
15. Discard material.

Formulas/Calculations - Liquid Limit, Plastic Limit, and Plasticity Index:

$$\textit{Liquid Limit (LL)} = \frac{(\textit{Wt. cup and Wet Soil} - \textit{Wt. cup and Oven Dry Soil})}{\textit{Wt. of Oven Dry Soil}} \times 100$$

$$\textit{Plastic Limit (PL)} = \frac{(\textit{Wt. Cup and Wet Soil} - \textit{Wt. Cup and Oven Dry Soil})}{\textit{Wt. of Oven Dry Soil}} \times 100$$

Plasticity Index (PI) = Liquid Limit – Plastic Limit

Example of Liquid Limit, Plastic Limit, and Plasticity Index

Liquid Limit Results (Wt. in grams)				
Wt. of Cup	Wt. of Cup & Wet Soil	Wt. of Cup & Dry Soil	Wt. of Dry Soil	Wt. of Water
66.3	86.0	82.2	15.9	3.8

Liquid Limit (LL) = $\frac{(86.0 - 82.2)}{15.9} \times 100 =$ **23.8**

Plastic Limit Results (Wt. in grams)				
Wt. of Cup	Wt. of Cup & Wet Soil	Wt. of Cup & Dry Soil	Wt. of Dry Soil	Wt. of Water
63.1	75.0	72.9	9.8	2.1

Plastic Limit (PL) = $\frac{(75.0 - 72.9)}{9.8} \times 100 =$ **21.4**

Plasticity Index (PI) = 23.8 – 21.4 = **2.4**

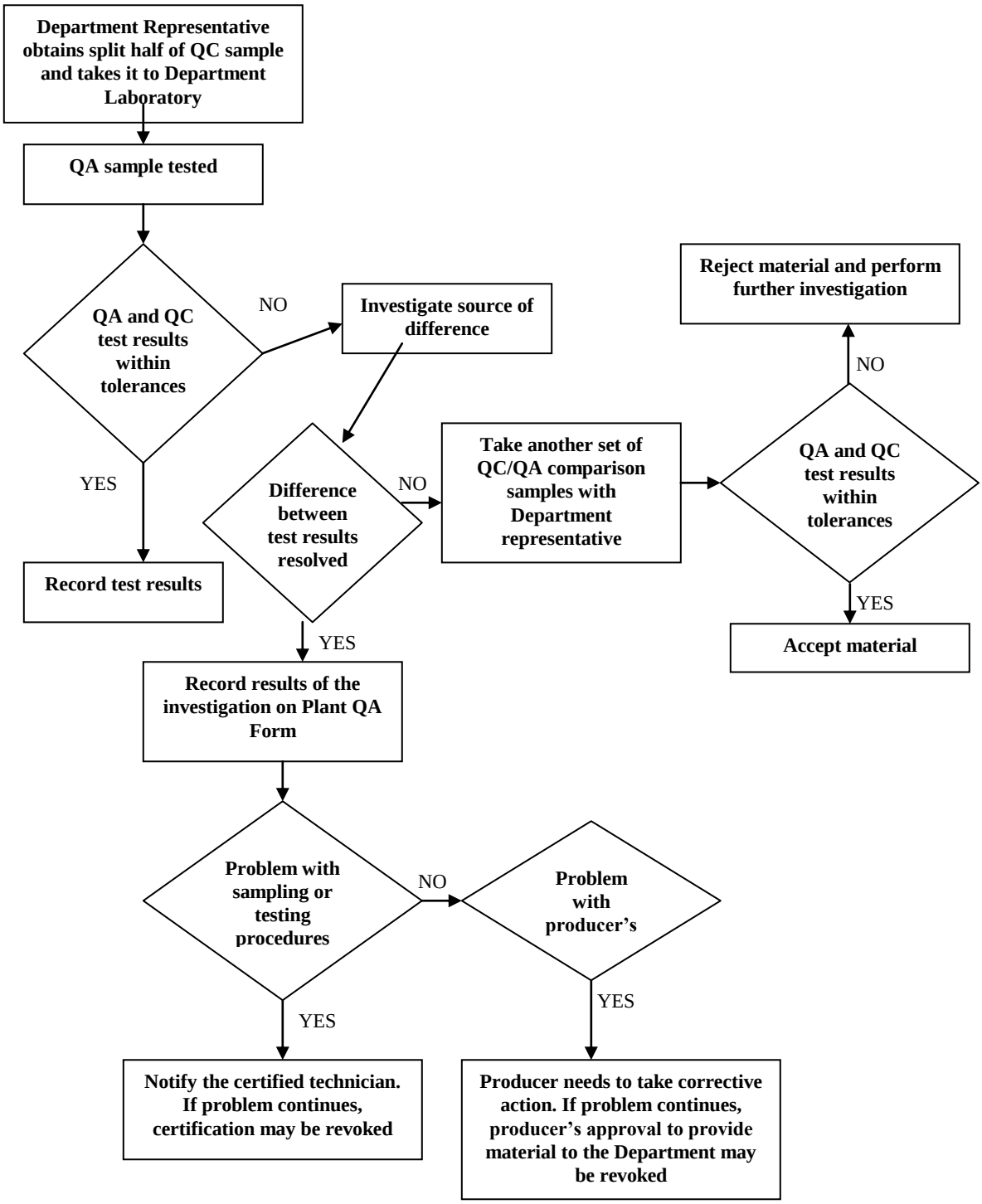
Based on the results of this example a Liquid Limit (**LL**) of **24** and a Plasticity Index (**PI**) of **2** would be reported.

Once the calculations are completed determine if the results exceed any of the Specifications for Liquid Limit (LL) or Plasticity Index (PI) and record the results on the appropriate form.

Procedures for accepting material, taking roadway check samples, correcting material, applying penalties and rejecting aggregate base material are provided in Exhibit I.

AGGREGATE BASE COURSE PRODUCTS QA SPLIT SAMPLE PROCESS – FLOWCHART

The following flowchart summarizes the QA Split sample procedures when sampling and testing an aggregate base type product. Refer to Exhibit F for tolerances between QC and QA test results.



SAMPLE SELECTION, NUMBERING AND IDENTIFICATION

A verifiable random selection process must be used when sampling base course material. Randomly selecting a sample location prevents biased sampling and a simple procedure using random numbers can accomplish this task. An example of computer generated numbers may be as follows:

For random numbers, use ASTM random number charts, random numbers provided below or any other method approved by Materials and Tests.

(I) Random Sample Numbers

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
2	9	5	2	6	6	4	1	3	9	9	2	9	7	9	2	7	9	7	9	5	9	1	1	3	1	7	0	5	6	2	4
4	1	6	7	9	5	2	4	1	5	4	5	1	3	9	6	7	2	0	3	5	3	5	6	1	3	0	0	2	6	9	3
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2	7	5	4	9	1	4	3	1	4	0	5	9	0	2	5	7	0	0	2	6	1	1	1	8	8	1	6	6	4	4	6
5	8	7	0	2	8	5	9	4	9	8	8	1	6	5	8	2	9	2	2	6	1	6	6	6	0	6	9	2	7	6	3
9	2	6	3	2	4	6	6	3	3	9	8	5	4	4	0	8	7	3	8	6	0	2	8	5	0	4	8	2	6	8	3
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9	5	6	8	2	8	3	5	9	4	2	7	3	6	6	8	2	5	9	6	8	8	2	0	1	9	5	5	6	5	1	5
8	2	4	3	1	5	7	9	1	9	3	0	5	0	2	6	3	4	2	6	7	0	8	8	3	9	9	1	7	1	5	1
5	6	6	7	3	5	1	3	9	2	7	0	6	2	9	8	6	3	9	6	7	3	0	6	7	8	9	8	7	8	4	2
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6	9	1	7	4	1	1	3	7	3	4	0	6	8	5	3	1	1	7	2	7	2	2	9	1	2	7	9	5	0	8	5
8	2	4	1	4	1	2	4	4	1	3	1	9	5	0	0	5	6	5	7	3	9	3	2	5	9	4	2	3	3	1	7
7	9	1	3	3	7	0	9	5	9	4	4	9	7	6	3	2	7	5	5	4	2	1	1	4	9	9	5	8	6	5	7
9	3	8	5	7	1	2	5	3	2	3	0	0	7	3	7	2	9	5	7	1	0	1	3	6	3	6	9	4	4	9	4
3	4	3	6	6	2	9	3	6	0	2	5	9	3	8	4	3	3	4	3	1	0	7	1	1	4	6	8	4	8	0	1
9	0	9	4	1	6	3	4	5	0	7	0	0	6	6	4	6	5	1	0	0	9	1	8	4	6	0	1	4	2	9	4
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7	7	8	1	3	7	6	0	2	8	9	5	7	6	5	3	0	0	9	1	7	0	1	2	1	3	0	8	1	9	4	6
9	7	4	2	9	6	9	4	7	3	4	7	0	0	1	7	9	5	7	2	1	8	5	0	0	1	1	6	1	8	9	9
9	4	2	0	9	2	1	0	8	7	8	7	9	3	7	5	4	6	6	3	0	3	9	6	6	7	1	7	5	5	6	2
1	1	7	9	3	5	7	1	5	9	9	2	3	0	5	9	9	0	1	5	5	6	0	8	2	3	4	8	8	1	4	4
0	7	0	8	4	0	1	1	4	0	5	7	1	5	5	0	1	6	7	4	1	3	7	6	5	2	4	3	4	4	2	7
6	3	5	0	3	9	9	6	3	7	9	5	2	1	7	6	8	1	8	2	4	5	1	4	6	3	4	9	3	4	8	3
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6	2	0	8	9	5	9	8	9	6	2	3	2	1	1	4	7	7	4	7	2	0	9	6	5	0	2	7	0	5	6	1
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2	3	4	9	1	5	9	4	7	1	5	2	0	2	5	7	4	0	4	1	4	1	0	5	3	1	8	0	9	8	0	6

CALCULATING RANDOM LOCATION TYPE A AND TYPE B ABC

Type A ABC Random Numbers Calculation

Each sampling lot is to be 2,000 tons.

The following example demonstrates how random numbers are used to determine the tonnage where each sample is to be taken for Type A ABC:

Step 1 - Random numbers:

1234 (column numbers)
2952
4167
2730 (random numbers)
0560
2754

Step 2 - Calculate tonnage for the sample within the first 2,000 ton lot using a random number from columns 1 and 2 above. In this example the number is 29. Place a decimal in front to get the random number of **0.29.** Multiply the random number by the tonnage as shown below:

2,000 tons x 0.29 = **580 tons** (Pull the sample)

Step 3 – Strike a line through the random number 29 (do not use again). Go to the next random number (52) when calculating the tonnage for the next sampling lot.

This process would be repeated for each sample.

Type B ABC Random Numbers Calculation

The following example demonstrates how random numbers are used to determine the location in the stockpile where each sample is to be taken for Type B ABC:

Step 1 - Random numbers:

1234 (column numbers)
~~29~~52
4167
2730 (random numbers)
0560
2754

Since the sample will be taken from a Type B ABC stockpile, the width and length of the pile will be used to determine sampling locations. For this example the pile is 200 feet in length and 100 feet in width.

Step 2 - Calculate the random length for the sample using a random number from columns 3 and 4 above. In this example the number is 52. Place a decimal in front to get the random number of **0.52**. Multiply the random number by the length of the pile (refer to the calculations below). Determine a random width by using a random number from columns 1 and 2 above. In this example the number is 41. Place a decimal in front to get the random number of **0.41**. Multiply the random number by the width of the pile (refer to the calculations below).

200 feet x 0.52 = **104 feet length**
100 feet x 0.41 = **41 feet width**

Step 3 – Measuring the calculated distances from a fixed reference point on the pile location the point for the sample. Once a reference point is established it must remain the same until the pile is approved by the Geomaterials Engineer.

Step 4 – Strike a line through the random numbers 52 and 41 (do not use again). Use the next numbers in the sequence (67 and 27) when calculating the next sample location.

This process would be repeated for each layer of the stockpile until the pile is completed and approved by the Geomaterials Engineer.

Random selection and numbering ABC samples – Example

Assume: A quarry has been awarded a contract to supply ABC for a construction project this year and begins shipping March 15. This is the first ABC shipped for the calendar year. Based on the number of trucks and location of the project the Contractor is projected to place approximately 2,000 to 3,000 tons per day. In addition to this project maintenance trucks of the Department are obtaining ABC. Based on calculations the tonnage a sample is to be taken and the sample number would be as follows:

Random Numbers: **1 2 3 4** (column number)
5 8 7 0
9 2 6 3
2 0 0 2
9 5 6 8
8 2 4 3

Day	Tonnage shipped	Tonnage Shipped cumulative	Based on random # the following samples would be obtained (daily cumulative tonnage sample is taken)	Remarks
Monday	2,800	2,800	QC-1 (1160)	QC-2 pulled on Tuesday

Calculations: **QC-1** = 2,000 tons x 0.58 = **1160 tons**
QC-2 = 2,000 tons x 0.70 = 1400 tons + 2,000 tons = **3,400 tons** (pull sample the following day)

Day	Tonnage shipped	Tonnage Shipped cumulative	Based on random # the following samples would be obtained (daily cumulative tonnage sample is taken)	Remarks
Tuesday	2,900	5,700	QC-2 (3400)	QC-3 pulled on Wednesday

Calculations: **QC-3** = 2,000 tons x 0.92 = 1840 tons + 4,000 = **5840 tons** (pull sample the following day)

VI. References

Standard Specifications for Transportation Materials and Methods of Sampling and Testing, American Association of State Highway and Transportation Officials

EXHIBIT N QC/QA PROGRAM CONTACT INFORMATION

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(919) 733-8742 (fax)
Website: https://connect.ncdot.gov/resources/Materials/Pages/default.aspx

Contact - information regarding sampling or testing procedures, QC/QA Class scheduling or the Program (i.e. getting on the Program, Physical Properties List, Equipment Wavier, etc.)

State GeoMaterials Engineer
Mehdi Haeri
(919) 329-4150 (phone)
(919) 733-8742 (fax)
mheari@ncdot.gov (email)

Contact – information regarding HiCAMS/QAP

Information Systems Liaison
Francine Ward
(919) 329-HELP (4357) (phone)
(919) 733-8742 (fax)
fdward@ncdot.gov (email)

Information regarding the QC/QA Aggregate Sampling and Testing Class Schedule can also be found on the NCDOT Materials and Tests Unit website.

https://connect.ncdot.gov/resources/Materials/Pages/SoilsLaboratoryTrainingSchools.aspx