NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

GEOMATERIALS LABORATORY

AGGREGATE GROUP

AGGREGATE QC/QA PROGRAM

2026

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

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I. GENERAL DESCRIPTION

The North Carolina Department of Transportation (NCDOT), in partnership with the North Carolina Aggregates Association (NCAA), administers the **Aggregate Quality Control/Quality Assurance (QC/QA) Program** to ensure the consistent quality of aggregate materials used in NCDOT construction projects. This program establishes defined responsibilities for both aggregate producers and the Department with respect to material sampling, testing, and documentation.

Under this framework, aggregate producers are entrusted with the responsibility for quality control (QC) of the materials they supply. This includes performing QC sampling, conducting appropriate testing procedures, and maintaining comprehensive records for all aggregate shipments intended for use by the Department. In parallel, NCDOT performs quality assurance (QA) sampling, testing, and record keeping verifying the adequacy and effectiveness of each producer's control plan, as outlined herein.

The program applies to producers and suppliers of clean coarse aggregates, fine aggregates, and aggregate base materials destined for use in right of way applications. Subject to Departmental approval, the program may also be extended to encompass recycled and innovative sustainable materials appropriate for NCDOT projects.

It is the intent of the Aggregate QC/QA Program that material acceptance or rejection be determined based on an evaluation of the complete program. This includes a comparative analysis of producer-generated QC data, Departmental QA results, and any other relevant sample information.

Participation in the Aggregate QC/QA Program is a privilege and **does not relieve** the producer of the obligation to comply fully with all applicable provisions of the *NCDOT Standard Specifications for Roads and Structures.* The program serves as a collaborative mechanism to enhance communication, reinforce accountability, and support continuous improvement across the aggregate supply chain.

This manual contains standardized procedures for sampling and testing aggregate materials at production sites, including quarries, sand pits, and sales yards. Additional sampling and testing protocols applicable to other locations—such as NCDOT right of way, asphalt and concrete plants, and pipe or block production facilities—are available in supplemental documents including the *Aggregate Sampling Manual* and the *Hot Mix Asphalt Quality Management System Manual*.

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II. PROGRAM REQUIREMENTS

A. Basic Requirements

Participation in the **Aggregate Quality Control/Quality Assurance (QC/QA) Program** requires producers to meet a set of foundational criteria. These **five basic requirements** are designed to ensure that each participating facility demonstrates a consistent ability to produce and evaluate aggregates that meet the Department's rigorous standards.

5 Basic Requirements	
Ownership Update Form	Submit an Ownership Update showing proof of facility ownership.
Aggregate Materials	Provide aggregate materials that meet required gradation and quality standards.
Quality Control (QC) Plan	Have a written and approved in-house QC plan outlining procedures and responsibilities.
Certified Laboratory	Operate a certified on-site lab or receive written permission to use an approved off-site certified lab.
Certified QC Technician	Have at least one NCDOT-certified quality control technician assigned to the facility.

By meeting these five basic requirements, aggregate producers establish a firm foundation for participation in the QC/QA Program. Each component reflects NCDOT's commitment to oversight, transparency, and operational excellence—key values for delivering safe and enduring transportation infrastructure across North Carolina.

B. Plant Approval

The North Carolina Department of Transportation (NCDOT) offers **three paths** for aggregate producers and suppliers seeking approval under its Aggregate Quality Control/Quality Assurance (QC/QA) Program. Each pathway has different requirements based on location and the nature of aggregate use, ensuring a structured yet flexible approach to quality oversight.

Three Paths to Approval	
In-State Approval	Applies to producers **within North Carolina**, or **out-of-state producers** supplying raw aggregates or aggregates used in ready-mixed concrete that cross into NC. • These producers must comply with the **full scope** of NCDOT's Aggregate QC/QA Program.
Special Out-of-State Approval	Applies to out-of-state producers in one of the following categories: • Supply aggregate **only to out-of-state precast, prestressed, or concrete block facilities**, where the finished product is shipped into NC. • Supply aggregate to a **sales yard approved by NCDOT**. Note: These producers are not held to the full QC/QA program **if they participate in their own State's equivalent QC/QA program**.
Sales Yard Approval	Applies to facilities that **do not produce** aggregate but **distribute materials from approved producers**.

Note: This manual focuses on requirements for producers with In-State Approval. Details for Special Out-of-State and Sales Yard Approvals can be found in Sections IV (see page 26) and V (page 28).

To initiate the approval process, the **Producer must submit a written request** to the **NCDOT Aggregate QC/QA Engineer**:

J.J. Myers
Aggregate QC/QA Engineer
(336) 596-8768 (mobile)
jjmyers@ncdot.gov (email)

Plant Approval	
Submit a written request to the NCDOT Aggregate QC/QA Engineer (via letter or email).	Must Include: • Facility name and location • Types of aggregate materials • Intended usage (e.g., asphalt, precast/prestressed concrete, ready-mixed concrete)
Provide supporting documentation	• **Ownership Update** (use Exhibit A, *page 31*) • **Written Quality Control Plan** *(page 6)*
NCDOT Approved Materials	At least **300 tons of each material** must be produced before sampling and testing. • Upon passing tests, materials are listed on the **NCDOT Aggregate Physical Properties List**, meaning they're approved for use. • Testing must include L.A. Abrasion (AASHTO T96), Soundness (AASHTO T104), Gradation (AASHTO T11, T27), and Electrochemical tests when required.
On-Site Inspection	• NCDOT reviews implementation of the QC Plan • Verifies presence of certified QC technician during shipping • Inspects and certifies the lab (if not already certified) • See **Exhibit B** for the required lab equipment, *page 33*
Note: If deficiencies are found in the QC Plan or laboratory, the Department will provide a written notice. Once corrected, the Producer may reapply for approval.	

This approval process reflects NCDOT's commitment to **ensuring consistent quality**, **validating testing procedures**, and **maintaining accountability** throughout its infrastructure material supply chain. By offering multiple approval paths, the Department accommodates diverse producers while upholding rigorous standards for safety and performance.

C. Quality Control Plan

A crucial component is the requirement for producers to develop and maintain a **written Quality Control Plan (QC Plan)**. This plan establishes the procedures, personnel, and operational methods that ensure aggregate materials meet NCDOT's quality standards and are suitable for use in transportation projects.

To begin, the **QC Plan must be site-specific**, even if it utilizes a generic format. The Producer must clearly outline how the facility will **control equipment, raw materials, and production processes** relevant to the products intended for use by the Department. This includes a detailed listing of **personnel responsible for production and quality control**, accompanied by **up-to-date contact information**, which supports accountability and communication.

QC Plan	
Facility Location	A detailed description of the facility location, including reference points like highways or nearby towns
Stockpile Signage	Description of signs used to mark stockpiles for NCDOT use. **Signs must be readable from a truck cab at 50 feet**.
Loading & Shipping Control Plan	Explain how materials will be loaded and shipped, including: • Loading and shipping procedures ensuring proper handling and product integrity • Measures to prevent contamination, degradation, segregation, and incorrect loading • Methods to verify cleanliness of shipping units and maintain clear product identification
Response Plan for QC Failures	Outline procedures for: • Immediate investigation steps • Corrective actions to resolve the issue and prevent recurrence
Personnel Details	Names, roles, and contact information for staff responsible for production and quality control at the site
Note: The initial Quality Control Plan must be submitted to the **Aggregate QC/QA Engineer** alongside the plant approval request. An updated QC Plan is required anytime there are changes to facility operations or ownership.	

D. Certified Laboratory

Each aggregate source, including distribution yards, is required to operate a fully equipped quality control laboratory. This laboratory is essential for conducting material testing to ensure compliance with Department standards.

The criteria for an approved laboratory are detailed in **Exhibit B** *(page 33)* and specify requirements related to both equipment and infrastructure. The laboratory facility must be housed within a permanent structure, including:

- **Electricity**
- **Heating and air conditioning**
- **Proper ventilation and lighting**
- **Sink with running water**

If a facility is unable to meet the specified physical requirements, a **written request must be submitted** to the Aggregate QC/QA Engineer outlining the reasons for noncompliance. Approval may be granted upon thorough evaluation of the proposed accommodations.

Beyond physical setup, producers must maintain comprehensive **records** at the lab. These include:

Equipment & Records	
Required equipment is listed in **Exhibit B** *(page 33)*	
Labs must maintain	• Scale Calibration and Equipment Maintenance records • Sample collection logs • Gradation analysis records
NCDOT may request	• A demonstration of lab equipment • Review of all documentation

Although each facility is expected to establish and operate its own laboratory, the Department acknowledges that some producers may opt to use a certified off-site laboratory. In such instances, producers must submit a written request and obtain written approval from NCDOT prior to conducting off-site testing.

This process helps ensure that all testing remains transparent, consistent, and properly documented across facilities. A list of approved private laboratories is available on the Materials and Tests website, providing producers with alternative options that adhere to the QC/QA Program.

https://connect.ncdot.gov/resources/Materials/Pages/Materials-Manual-by-Material.aspx?Method=MM-01-02

E. Quality Control Technician

All quality control samples must be **taken and tested by technicians certified by the Department**. Producers are responsible for identifying and assigning these certified quality control technicians at each plant in both their Quality Control Plan and Ownership Update forms. **Technicians may hold either of two certifications: the NCDOT Aggregate QC/QA Sampling Technician, who is authorized to collect material samples, or the NCDOT Aggregate QC/QA Sampling and Testing Technician, who is authorized to both sample and test materials**.

When material is being shipped for use on NCDOT Right of Way, the Producer must ensure that at **least one certified technician**—holding either of the above certifications—is present onsite and available to work alongside Department personnel to obtain samples. This requirement also applies to shipments sent to vendors producing approved materials for the Department (e.g., Ready Mixed Concrete, Precast Concrete, Asphalt), unless prior approval has been granted by the Department. It is strongly recommended that each facility also designate at least one certified backup technician to ensure continuity in case the primary technician is unavailable.

Certifications for NCDOT Aggregate QC/QA Sampling and Testing are **valid for five years** from the date of successful program completion. To maintain certification, technicians seeking Aggregate QC/QA Sampling certification must attend the Sampling Certification Class. Those seeking Aggregate QC/QA Sampling and Testing certification must complete both sampling and testing classes and pass a skills performance evaluation conducted by an Aggregate QC/QA Specialist. Technicians who do not pass the written exams may retake them by registering for a reexamination session. If a technician fails a second attempt, they must reattend the relevant certification class.

Technicians are subject to loss of certification through revocation. The primary grounds for revocation include falsifying test results, records, or reports. Other causes for potential certification loss include gross negligence or clear incompetence in performing assigned duties.

Types of Certifications	
Technician Type	**Authorized Responsibilities**
NCDOT Aggregate QC/QA **Sampling**	**Obtain** samples ONLY
NCDOT Aggregate QC/QA **Sampling and Testing**	**Obtain and Test** samples
Certifications are **valid for five years** from the date of successful program completion	
Note: The Producer must list all certified technicians for each plant in both the **Quality Control Plan** and **Ownership Update Form**.	

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

If the Department approves the Producer's written Quality Control (QC) Plan and the on-site inspection verifies compliance with program requirements, a certification letter will be issued by the Aggregate QC/QA Engineer. This letter, **valid for one year**, confirms the plant's eligibility to participate in the program.

To maintain approved status beyond the initial year, the following actions must be completed annually:

3 Annual Requirements	
Annual Facility Assessment	The Department audits the producer's facility to confirm compliance with program standards and provides the final report to ensure transparency and accountability.
Quality Sample Testing	The Department conducts standardized tests—**Los Angeles Abrasion, Unit Weight, Soundness, and Electrochemical analysis**—on a required frequency to verify aggregate compliance.
Updated Documentation	• An updated **Aggregate QC/QA Plant Ownership Update Form by October 31 each year*** • A revised **Quality Control Plan**, if any **changes in operations or ownership** have occurred. o The Department may ask at any time for an updated QC Plan.
*Submitted via the **NCDOT QAP web-based portal**, supporting efficient and centralized recordkeeping.	

Once all three requirements are confirmed, the Aggregate QC/QA Engineer will renew the Producer's approval for an additional year.

Note: The Department reserves the right to conduct random inspections and comprehensive audits at any time to ensure ongoing compliance.

G. Modifications to the Producer's Approved Products List

Once a Producer is added to the North Carolina Department of Transportation's (NCDOT) Approved List, eligibility is granted to supply aggregate materials for Department projects.

To expand the range of approved materials, the Producer must follow a formal evaluation process to confirm that additional products meet applicable quality and specification standards. This process begins with written notification to the Aggregate QC/QA Engineer, which initiates official communication and the material assessment procedure.

The Producer is responsible for ensuring that at **least 300 tons** of the proposed aggregate material are available onsite for sampling purposes. This volume is necessary to facilitate representative testing and verify the consistency and suitability of the material for use in NCDOT projects. In the absence of a load face, samples must be collected from three distinct locations around the stockpile.

The Department is responsible for sampling and testing the material to determine compliance with specified gradation standards—a key indicator of particle size distribution and material performance in construction applications.

If the material meets all testing criteria, it will be approved for use by the Department. Thereafter, both the Producer and the Department must conduct routine sampling and testing as outlined in the *Aggregate QC/QA Program Manual* to maintain ongoing compliance and supply chain integrity.

Additionally, any changes to the Producer's Approved Products List—such as the addition or removal of materials—must be reported on the next required Ownership Update Form *(Exhibit A, page 31)*. This form serves as the official record of facility operations and must accurately reflect current product offerings.

H. Assessment Program

The Assessment Program, **mandated** by the Federal Highway Administration (FHWA), replaces the Department's former Independent Assurance sampling requirements. Its primary objective is to validate the effectiveness of the Department's acceptance program as reported to the FHWA.

Aggregate technicians who actively perform testing are subject to assessment by North Carolina Department of Transportation (NCDOT) personnel at least once per calendar year. These assessments, conducted by certified Aggregate QC/QA Assessment Technicians, ensure testing procedures are executed accurately and consistently.

Technicians are exempt from assessment during any year in which they obtain initial certification or recertification.

Assessments will emphasize key techniques such as sampling, splitting, and testing of materials specific to those supplied by the Producer to the Department.

If a QC technician demonstrates deficiencies, the NCDOT Assessor must document the errors on the official assessment form. One opportunity for re-assessment will be provided. If the technician fails the re-assessment, additional training under the supervision of the Aggregate QC/QA Specialist will be required. Based on the nature of the deficiency, the technician may also be directed to retake the Aggregate QC/QA training course.

In cases of unsuccessful assessment, the Assessment Technician must submit a completed assessment form—detailing the reasons for failure—to both the Aggregate QC/QA Engineer and the IA Program Engineer.

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III. AGGREGATE SAMPLING AND TESTING PROCEDURES

A. Producer's Quality Control Procedures

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.

- **Quality Control Sampling**

  The Producer is responsible for collecting quality control (QC) samples from all approved materials and stockpiles. These samples are used to verify that materials being shipped to the Department remain consistent and compliant with specifications.

  Once a material has been approved, the minimum 300-ton stockpile requirement no longer applies. However, maintaining at least 300 tons is recommended to help ensure consistent material quality throughout production and shipment. In the absence of a load face, the Department may require samples to be collected from three distinct locations around the stockpile.

- **QC Lot Size**

  - **Sampling Requirements:** For each approved material stockpile, **obtain at least one sample for every 2,000 tons shipped, or one sample per week—whichever occurs first.**

Exceptions to Lot Sizes	
Exception A	Temporary Suspension of **All** Material Shipments
Exception B	Temporary Suspension of a **Single** Material Shipment
Note	
If the Producer has been **inactive for a duration that causes their annual requirements to expire**, the necessary evaluations must be **completed prior to reinstatement**.	

Exception A: Temporary Suspension of **All** Materials & Reinstatement

If a Producer voluntarily suspends the shipment of **all** materials for an extended period, but intends to resume shipments in the future, the following procedures apply:

1. **Voluntary Removal:** The Producer may request temporary removal from the Department's Approved List by notifying the Aggregate QC/QA Engineer.
2. **Proceeding with Shipping:** If a Producer's period of inactivity results in the expiration of annual sample validity or facility audit requirements. Before shipping can start:

    - Samples must be collected and tested in accordance with current program requirements.
    - Facility Audit: A full facility audit must be successfully completed.

If there is no remaining stockpile of any material, or if the existing stockpiles have less than 300 tons, the Producer must ensure a **minimum of 300 tons** is available before sampling may proceed.

During periods of inactivity under **Exception A**, the Producer may conduct bi-weekly sampling of approved material stockpiles, as outlined in established sampling/testing guidelines. Sample results are not required to be reported to the Quality Assurance Program (QAP), but complete records must be maintained and provided to the Department upon request. Department sampling and testing will cease until the Producer notifies the Aggregate QC/QA Engineer of intent to resume shipping.

Exception B: Temporary Suspension of a **Single** Material & Reinstatement

If a Producer elects to suspend the shipment of a **specific material** for an extended period and requests the removal of sampling/testing for that material, the following protocol shall apply:

1. **Voluntary Removal:** The Producer must notify the Department's Aggregate QC/QA Representative of the intent to stop shipments of the specified material.
2. **Stockpile Signage:** The Producer must remove identification signage or clearly mark the material as "non-DOT" to avoid misrepresentation of the material's acceptability for Department use.
3. **Ownership Update:** The removal of this material shall be documented in the facility's Ownership Update for the upcoming year.
4. **Proceeding with Shipping:** To restore the material to the approved list, a passing Verification sample conducted by the Department is required before shipments may resume. If no stockpile remains or if the existing stockpile is less than 300 tons, the Producer must ensure a **minimum quantity of 300 tons** is available before sampling is performed.

During periods of inactivity under **Exception B**, Department sampling and testing will cease.

Sampling Procedures

Sampling must be conducted by a **Department-certified sampling technician**. The technician is responsible for collecting Quality Control (QC) samples from designated areas such as the **stockpile**, **conveyor belt**, **or another approved location**. When sampling from stockpiles, the technician must take samples from the **load face**—the same area being actively used for material shipment—to ensure accurate representation of the material being delivered. Sampling procedures must adhere to detailed guidelines outlined in **Exhibit C** *(page 35)*, ensuring technicians follow standardized methods across facilities.

To maintain consistency across all tests, the program specifies **minimum sample weight requirements** for each aggregate type:

Minimum Sample Weights (lbs.) *	
Material Type	Quality Control (QC)
Clean Coarse Aggregate**	**20**
Fine Aggregate	**10**
Aggregate Base Material	**35**

* Sample weights are based on dry material.

** When testing Clean Coarse Aggregates that pass 100% through the ¾" sieve (e.g., #78, #14M, #9), samples should be split into portions of **10 to 15 lbs** to prevent overloading testing sieves.

Sample Identification and Record Keeping

Producer's Quality Control (QC) samples must be labeled using **consecutive numbering** for each material size and stockpile (e.g., QC-1, QC-2, etc.). Numbering should remain sequential throughout the calendar year.

If a Producer maintains two or more stockpiles of the same material type—such as multiple ABC stockpiles—each pile must be distinctly identified (e.g., Stockpile 1 and Stockpile 2). The Department must be notified of these identifications to ensure proper tracking and documentation.

Sample Identification	
Sample Numbering	QC-1, QC-2, QC-3, etc.
Multiple Stockpiles	Stockpile 1, Stockpile 2, Stockpile 3, etc. Example: #57 • Stockpile 1 – QC-1, QC-2, QC-3, etc. • Stockpile 2 – QC-1, QC-2, QC-3, etc.
ABC Samples for NCDOT Roadway Projects	The QC **sample number must be recorded on the delivery ticket** of the truck that is loaded immediately following the sample collection.
Data Entry	All QC test results must be entered into the Department's internet-based QAP System **within five (5) business days** of sample collection.
Data Retention	The Producer is responsible for retaining QC data for each material size for a **minimum of one year** and must provide access to these records upon request by the Department. This may be in paper form or electronically.

Test Procedures

Modifications to standard testing procedures may be permitted to accommodate specific material types and improve operational efficiency, provided that quality control standards are upheld.

- **Coarse Aggregate** – See page 60
- **Fine Aggregate** – See page 70
- **ABC (Aggregate Base Course)** – See page 83
- **Atterberg Limits (Liquid Limit and Plastic Limit)** – See page 98

B. Check Sample Procedures

If a QC sample fails to meet the specifications, the aggregate producer shall **immediately** collect the first Check Sample from the same location using the original sampling method.

This check sample **must be doubled in size of the original sample and obtained in the same manner**.

The check sample shall:

- Be clearly labeled to distinguish it from routine QC samples.
- Be evenly divided into two portions:
    - One portion to be retained and tested by the producer.
    - One portion saved for the Department.

Once the check sample has been collected and properly divided, the producer shall promptly notify the Department's Aggregate QC/QA Representative of the sample's collection.

If the material meets specifications

- The producer shall document the suspected cause of the initial noncompliance.
- This documentation ensures traceability and supports corrective analysis.
- After documentation, the producer shall resume standard testing procedures in accordance with established QC protocols.

If the material does not meet specifications

- **The producer shall immediately notify the Department's Aggregate QC/QA Representative.**
- A thorough investigation shall be initiated to determine the root cause, including:
    - Review of sampling methods for compliance with standard procedures. Evaluation of production and testing equipment for malfunctions or inaccuracies.
    - Assessment of technician testing procedures to confirm proper execution and technique.

If the investigation identifies a contributing issue, the producer shall:

- Implement corrective actions to address the deficiency.
- Document all corrective actions taken to ensure traceability and compliance.

If the first Check Sample fails to meet specifications, the aggregate producer shall coordinate with an Aggregate QC/QA Representative to schedule the collection of a second Check Sample.

This sample must be taken from the same location using the original sampling method. The second Check Sample shall be doubled in size of the original sample and collected in the presence of both the aggregate producer and the Aggregate QC/QA Representative.

This second check sample **must be doubled in size of the original sample and obtained in the same manner**.

The check sample shall:

- Be clearly labeled to distinguish it from routine QC samples.
- Be evenly divided into two portions:
    - One portion to be retained and tested by the producer.
    - One portion to be submitted to the Department.

The producer shall submit QC test results for the second Check Sample within three (3) working days of reporting the first Check Sample results.

If the material meets specifications

- The producer shall document the suspected cause of the initial noncompliance.
- This documentation ensures traceability and supports corrective analysis.
- After documentation, the producer shall resume standard testing procedures in accordance with established QC protocols.

If the material does not meet specifications or results are not reported within 3 working days.

- **The producer shall immediately stop material shipment and notify the Aggregate QC/QA Engineer without delay.**
- The producer shall continue the investigation and collaborate with the Department to resolve the issue.

The investigation shall include:

- Review of sampling methods to confirm compliance with standard procedures.
- Evaluation of production and testing equipment for malfunctions or inaccuracies.
- Assessment of technician testing procedures to ensure proper execution and technique.

If the investigation identifies a contributing issue, the producer shall:

- Implement corrective actions to address the deficiency.
- Document all corrective actions taken to ensure traceability and compliance.

To Resume Shipping

Once the identified issues have been resolved to the Department's satisfaction, the Producer may resume aggregate shipments upon submission of **three consecutive Quality Control (QC) samples** that meet specification requirements.

Each sample must be collected in the presence of a Department Aggregate QC/QA Representative, doubled in size, and split. One half will be tested by the Department, while the Producer's portion will be used to confirm compliance. **For a sample to be accepted, the Producer's results must also be within the tolerance limits outlined in Table 2** ***(page 55),*** **relative to the Department's results.**

There is no time restriction for collecting the samples; however, if multiple samples are obtained on the same day, each must be taken from different depths of the load face within the stockpile.

Accurate labeling and documentation of check samples are critical for maintaining QC integrity. The following protocol must be observed:

- Each check sample shall be labeled using the original sample number followed by a sequential alphabetical suffix (e.g., QC-7A for the first check sample corresponding to QC-7, QC-7B for the second).
- This system ensures traceability and consistency throughout the sampling and reporting process.

- **Noncompliance Procedures**

If a Producer fails to meet the required sampling frequencies or submits material that does not comply with specifications—based on either Producer or Department test results—the Department will issue a formal written request for an explanation of the noncompliance.

The Producer must provide a **written response within one week** of receiving the request. If the response is deemed inadequate, the Department will identify the specific deficiencies and may remove the plant from the Program. Failure to respond in writing may also result in removal from the Program.

A Producer whose plant has been removed may request reinstatement upon completion of corrective actions deemed satisfactory by the Department.

C. 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.

Minimum Sample Weights (lbs.) *		
Material Type	**QCQA Split**	**Verification**
Clean Coarse Aggregate**	**40**	**20**
Fine Aggregate	**20**	**10**
Aggregate Base Material	**70**	**35**

* Sample weights are based on dry material.

** For Clean Coarse Aggregates where 100% passes the ¾" sieve (e.g., #78, #14M, #9), reduce the working sample size to **10–15 lbs.** to prevent overloading sieves during testing.

1. **Verification Samples –** Verification samples are collected **independently** of the Producer's Quality Control (QC) samples.

- **Each material size shipped** to the Department will be subject to sampling.
- Producers may collect samples for internal use; however:
  - These internal samples are for reference purposes only.
  - Shall not be used for future QC testing or reported to the Department.
- Producers may also request to split a Verification Sample, which will be permitted solely for internal reference purposes.

2. **Quality Assurance Split Samples –** QA split samples must be collected for each material size shipped to the Department.

- Samples are split for testing by both the Department and the Producer.
- A Department representative supervises the sampling and splitting process, following the procedures outlined in Exhibits C and D (pages 35 and 38).
- **The portion retained by the Producer serves as the next official Quality Control (QC) sample for that specific product.**

3. **Sampling Frequency**

Verification - Minimum Sample Frequency	
Material Type	Frequency
ABC and ABCRC	**Minimum 2 samples per month for each NCDOT approved aggregate stockpile.**
CORE Aggregates (#57, #57M, #67, #78M, 2S, and 2MS)	**Minimum 1 sample per month for each NCDOT approved aggregate stockpile.**
Non-CORE Aggregates	**Minimum 1 sample per month for each NCDOT approved aggregate stockpile that has only shipped** material since last visit.
Screenings (Washed, Dried, or Other)	Minimum 1 annual sample.

QA Quarterly Splits - Minimum Sample Frequency	
Material Type	Frequency
All NCDOT Approved Stockpiles	**Minimum 1 sample per quarter for each NCDOT approved aggregate stockpile .**
All Verification and QA Split Samples must be either collected or directly observed by a Department-authorized representative. This ensures consistency in sampling methods and preserves the reliability of test results.	

4. **Sampling Locations –** The Department's representative must collect samples from the **stockpile, conveyor belt, or another approved location**.

- When sampling from a stockpile, the material must be taken specifically from the *load face*—the area currently being shipped.

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

Verification Sample Numbering	
V Sample Numbering	**Label V samples sequentially (e.g., V-1, V-2, …)** Sequence begins each calendar year or upon facility acceptance into the program

Quality Assurance (QA) Sample Numbering	
QA Sample Numbering	**Label QA samples to match corresponding QC samples** (e.g., QA-1 with QC-1, QA-2 with QC-2) **Same pairing format applies to check samples** (e.g., QA-1A with QC-1A)

6. **V and QA Testing** – Verification and QA Split Samples must be tested at a Department Regional Laboratory or the Central Laboratory in Raleigh.

- **Annual Quality Samples**
  - Exclusively tested at the Department's Central Laboratory in Raleigh.

7. **QC/Verification Sample 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 can be generated to compare the data for any discrepancies within the program.

8. **QC/QA Split Sample Comparison - Statistical 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 can be generated 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 QC sample, i.e., outside the limits of Table 2 of Exhibit G *(page 55)*, 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 Department's computerized tracking system (HiCAMS) and a copy given to the aggregate producer and the Aggregate QC/QA Engineer.

If the cause is determined to be improper splitting or testing procedures, the appropriate certified technician will be notified. There will be a follow-up visit by an Aggregate QC/QA Specialist. 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. The follow-up visit will audit the documentation and observe the sampling process. 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.

Example: QC/QA Tolerance

ABC					
Sieve	QA-24	QC-24	Difference	Tolerance	Pass/Fail
1 ½”	100	100	**0**	**2**	**PASS**
1”	95	95	**0**	**4**	**PASS**
1/2”	60	59	**1**	**5**	**PASS**
#4	43	41	**2**	**6**	**PASS**
#10	32	30	**2**	**5**	**PASS**
#40	20	21	**1**	**5**	**PASS**
#200	6	4	**2**	**3**	**PASS**
Soil Mortar					
#40	63	69	**6**	**6**	**PASS**
#200	19	13	**6**	**5**	**FAIL**

QC/QA Comparison – Work Problem #1

#67					
Sieve	QA-13	QC-13	Difference	Tolerance	Pass/Fail
1”	100	100			
3/4”	94	95			
1/2”	---	---	---	---	---
3/8”	18	20			
#4	4	4			
#8	1	2			
#200	0	0			

QC/QA Comparison – Work Problem #2

2MS					
Sieve	QA-32	QC-32	Difference	Tolerance	Pass/Fail
3/8”	100	100			
#4	100	99			
#8	88	86			
#16	63	61			
#30	45	44			
#50	30	30			
#100	16	17			
#200	5.2	4.9			

9. **Noncompliance –** The **Aggregate QC/QA Engineer** will investigate any noncompliance by the Department’s QA staff with the QA Sampling and Testing manual (e.g., frequency, techniques). QA staff who violate requirements may face disciplinary actions, including **certification revocation** or **dismissal**.

IV. SPECIAL OUT-OF-STATE APPROVAL POLICY

The purpose of this policy is to establish the procedures for the use of out of state coarse and fine aggregate facilities that provide raw materials to out of state producers of manufactured products for use on NCDOT highways.

To become an approved Out of State Producer:

1) The Producer must be in compliance with the NCDOT's policy for out of state producers (see following page).
2) If a Producer is in compliance with the out of state policy, they must submit a letter to the Aggregate QC/QA Engineer requesting to be added to the Special Out-of-State Approved List. The Producer is to include what aggregate material sizes they would like to produce for the NCDOT and what the material will be utilized as (i.e., precast, prestressed, or concrete pipe plant).
3) A certified Material Technician with the Materials and Tests Unit will obtain Annual Quality Samples of the material to be provided to the Department (this will be done on an annual basis). Samples collected shall be tested for LA Wear, Soundness, etc. Also, Verification samples for gradation will be obtained for each size aggregate sold for production of precast/prestressed/concrete pipe units.
4) While Department samples are being processed, the Producer will need to submit an Ownership Update Form, and proof they are approved in the state they reside in. This could be a letter from the state or an approved QC Plan.
5) Once the samples are determined to be within specifications and the required documentation information from the Producer have been received, the quarry will receive a letter indicating they have been added to the Approved Producers List and can produce from that specific facility with that specific type product ONLY.
6) A Materials and Tests Technician will pull samples, as listed in step 3 for out-of- state aggregate facilities, once per year from the facility to remain active, and the facility will also need to submit an Ownership Update Form once per year.

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

APPROVAL POLICY FOR OUT OF STATE AGGREGATE FACILITIES THAT PROVIDE RAW MATERIALS USED IN MANUFACTURED PRODUCTS FOR NCDOT

The purpose of this policy is to establish the procedures for the use of out of state coarse and fine aggregate facilities that provide raw materials to producers who make manufactured products for use on NCDOT highways:

- The producer/supplier of the manufactured product incorporating the aggregate must be on the NCDOT Approved list.
- The aggregate facility supplying aggregate to the approved producer/supplier must also be on the NCDOT approved list of Coarse and Fine Aggregates.
- The aggregate facility must be an approved producer/supplier in the state in which the facility is located.
- If the host state does not have an approved list for aggregates or other formal approval process, then the producer will have to have, as a minimum, test data from a private accredited testing laboratory confirming basic material qualities for the aggregate.
- The aggregate facility must have a published Quality Control Plan that addresses the frequency of quality control checks and who is responsible for taking and testing the samples.
- The above listed information will be submitted to the Quality Assurance Engineer for review before approval is granted (compliance with NCDOT's QC/QA Aggregate Program may be waived provided the all the above criteria is met).
- The Department will visit the out of state facility at a minimum of once per year to take verification samples.
- NCDOT personnel have the authority to perform unannounced quality assurance inspections of the facilities furnishing aggregates used for NCDOT work at any time without notice.
- A facility that does not comply with this policy or that is not actively furnishing material to approved manufacturers for NCDOT work will be taken off the approved list.

To illustrate, the following example is provided:
A fine aggregate facility in Georgia furnishes sand to be used in the production of concrete for an NCDOT Approved Precast Concrete manufacturer. For this example, the precast concrete manufacturer must be on the NCDOT approved list of precast concrete suppliers. The supplier of the aggregate must also be listed on the NCDOT approved list of Coarse and Fine Aggregates but does not have to comply with all the QC/QA program requirements provided that facility is currently on Georgia DOT's approved list of Coarse and Fine Aggregates or they provide a Quality Control plan and test data confirming basic material qualities for the aggregate.

Requests for approval shall be submitted by Email or Mail to:

J.J. Myers
Aggregate QC/QA Engineer
Phone: (336) 596-8768
Email: jjmyers@ncdot.gov

V. SALES YARD APPROVAL POLICY

A **Sales Yard** will be considered any facility that sells aggregate material not manufactured onsite. Like an approved producer, the Sales Yard must also be on the NCDOT Approved List. The material sold can come from one or multiple facilities. However, these facilities must all be on the NCDOT Approved List as well. If source facilities are not on the approved list, they must follow the Aggregate Approval Guidelines to become approved.

To become an approved Sales Yard:

1) The facility shall send a letter to the Aggregate QC/QA Engineer requesting to sell (XYZ) material and document the source facility from which the material is coming from.
2) Create a 300-ton stockpile of the material to be sold. This stockpile shall be clearly labeled.
3) Assign a QC Technician to the facility for sampling and testing purposes. This QC Technician must possess a valid Aggregate QC/QA Sampling and Testing certification through the Department. This Technician does not have to remain onsite at all times but must be readily available to obtain samples as needed with Department personnel. If multiple attempts must be made by the Department to arrange sampling with this Technician, the Department reserves the right to require that a QC Sampling Technician be onsite at all times as material is being shipped to the Department.
4) Submit a QC Plan and Ownership Update Form indicating the material that will be sold and where it originates from.
5) The certified QC technician for the Sales Yard must submit a request to be added to the QAP System to log testing data.
6) A Materials & Tests Technician will then sample the material for gradation and annual quality verification and perform a laboratory inspection. If no onsite laboratory, then an offsite laboratory can be utilized if a request is made in writing, and it is an approved NCDOT Laboratory. If using an offsite laboratory, the facility is still required to have a splitter <u>onsite</u> large enough to split samples with NCDOT.
7) Once the material has passed, a letter will be sent to the Sales Yard approving them and the material. The Sales Yard will be given a Facility ID number. The facility will then have to start sampling and entering the material into QAP. A Materials and Tests Technician from the Department will continue to sample and test the material for gradation purposes as per the QC/QA Manual. After approval, further Annual Quality samples will not be required from the Sales Yard. Annual Samples will be obtained from the original source of the material on an annual basis.

VI. 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 ID Number: **CA:** _____ **FA:** _____

Is Facility Approved as "Out of State Producer" only providing materials to Precast, Prestressed, Concrete Pipe, and/or Asphalt facilities that are also Out of State? (To qualify, facility cannot ship raw aggregate across NC state line or to Ready Mixed Concrete Facilities) **YES:** _____ **NO:** _____

Mailing Address (Can be Facility's Main/Coorprate Office) & Contact Information to this Location:

Street: _____

City: _____ State: _____ ZIP: _____

Telephone: _____ FAX : _____

Telephone: _____ Email: _____

Name and Title of Prefered Contact for QC Related Inquires: _____

Physical Address of Facility (If Different from Mailing Address) **Same as Above:** ☐

Street: _____

City: _____ State: _____ ZIP: _____

Telephone: _____ FAX : _____

Telephone: _____ Email: _____

Is Check-in Location at the Main Entrance of Facility (Yes/No)? _____

If No, driving directions to locations NCDOT Staff should Check-in: _____

_____

Plant Personnel Responsible for Quality Control (List phone # for Primary QC & QC Manger/Supervisor):

	NAME/TITLE	CERT #	PHONE NUMBER (Optional)
1)			
2)			
3)			
4)			
5)			

Material List (Only those materials sampled and tested in the QC/QA Program mark with an "X"):

ABC _____	ABC-M _____	ABC-Recy. Concrete _____		Lightweight Agg. _____	
#57 _____	#57M _____	#67 _____	#78M _____	#467M _____	
#5 _____	#4 _____	#6M _____	#14M _____	#9M _____	
2S Sand _____	2MS Sand _____	1S Sand _____	4S Sand _____		
Washed Screenings _____		Dryed Screenings _____			

Others: _____

*** If Quality Control Plan has changed or been updated this calendar year, send a copy of the new QC Plan to the Aggregate QC/QA Engineer at the time of submitting this Ownership Update.*

I certify that the forgoing entries are correct:

Signature: _____

Print Name: _____

Title: _____

Date: _____

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EXHIBIT B- LABORATORY TESTING EQUIPMENT LIST

Equipment Required for testing Coarse and Fine Aggregate	
Automatic Shakers	• Large shaker equipped with a timer • Mounted to a concrete floor or installed on a poured concrete base • Must include all required sieve sizes for applicable aggregate types
Precision Electronic Scales	• Readability and sensitivity: 0.1 gram • Minimum capacity: 2,500 grams • Accuracy: ±0.1 gram or ±0.1% of full capacity • **Must be calibrated annually**
Heavy-Capacity Electronic Scales	• Readability and sensitivity: 20 grams • Minimum capacity: 50 kilograms (110 lbs) • Accuracy: ±20 grams or ±0.1% of full capacity • **Must be calibrated annually**
Automatic Shaker for Soil Mortar and Fine Aggregate	• Shaker that can accommodate 8” or 12” sieves. • Includes timer, cover, and appropriate sieve sizes per NCDOT specifications
Sample Splitters	• Splitter with 8” × 14” × ¾” opening, two catch pans, and one pouring pan • Chute-style splitter with adjustable ½” bars and 24” width
Drying Pans	• Sufficient quantity of pans sized 24” × 12” × 3”
Sieve Sets	• One set of 8” or 12” diameter sieves for ABC soil mortar • One set of sieves for fine aggregate testing as per NCDOT specifications
Wooden Mallet or other Acceptable Equipment	• Dimensions: 1¾” × 3½” × 6” • Dowel: 1” diameter × 12” long (centered)
Bowl	Large stainless steel bowl for material preparation
Spoon	One large spoon 11"-13" stainless steel
Sample Cans	Sufficient quantity with approximately 400-gram capacity
Sieve Brushes	Adequate supply for routine sieve maintenance
Drying Oven	• Gas or electric • Thermostatically controlled at 110 ± 5°C
Oven Thermometer	Range: 0 to 150° ±0.5°C

****Facilities identified with potential plasticity issues, must also have the following additional equipment****	
Liquid Limit Machine	• Includes grooving tool • Conforms to AASHTO T-89 standards
Sieve	#40 Sieve
Mortar Bowl	Diameter: 210 mm (outside)
Pestle Device	Rubber-covered base (2” diameter) or drill press with rubber disc
Stiff Blade Spatula	Dimensions: 3½” × 13⁄16”
Glass Plate or Unglazed Rolling Surface	Smooth surface; unglazed paper must be fiber-free and lay flat
Mixing Dish	Porcelain evaporating dish or equivalent
Heat-Resistant Containers	With secure lids for sample processing
Equipment Required for testing <u>ONLY Fine</u> Aggregate	
Automatic Shaker	• Shaker that can accommodate 8” or 12” sieves. • Includes timer, cover, and appropriate sieve sizes per NCDOT specifications
Precision Electronic Scales	• Readability and sensitivity: 0.1 gram • Minimum capacity: 2,500 grams • Accuracy: ±0.1 gram or ±0.1% of full capacity • **Must be calibrated annually**
Divider or Splitter	• **Divider:** ~5” tall with four 14” legs at right angles (constructed from 18-gauge aluminum) • **Splitter:** 8” × 14” × ½” opening with two catch pans and one pouring pan
Bowl	Large stainless-steel bowl for material preparation
Spoon	One large spoon 11"-13" stainless steel
Sieve Sets	**One complete set of 8” or 12” diameter** sieves as per NCDOT fine aggregate specifications
Oven	Thermostatically controlled at 110 ± 5°C (gas or electric)
Oven Thermometer	Range: 0 to 150° ±0.5°C

EXHIBIT C- SAMPLING PROCEDURES

Sampling Procedures – Production Stockpile

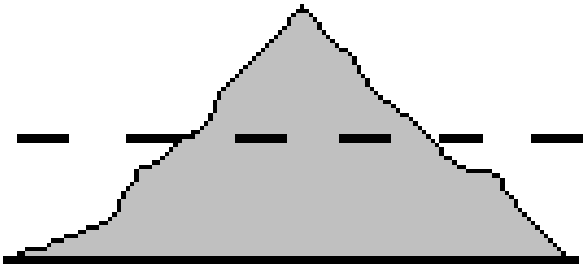
To minimize variables that impact correlation between samples, all sampling **must strictly follow the procedures** outlined in the manual. Adherence to these protocols ensures more accurate, consistent, and reliable comparison of test results.

When sampling from a stockpile:

- Take the sample from the **same section of the stockpile being shipped.**
- For base materials, sample **near optimal moisture** to avoid segregation.
- **Visually inspect** the load face for signs of contamination or segregation before sampling.
    - If issues are found, mix or remove affected material before proceeding.

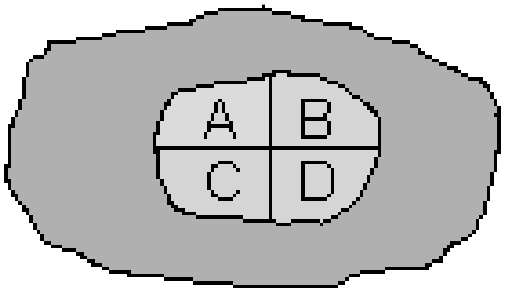
Sampling Method:

- Use material scooped by a loader from the existing stockpile
    - A single loader bucket may not yield a representative sample; multiple buckets may be needed across the stockpile to mix the coarse and fine sections. Same method should be used as loading trucks.
- Dump the material onto the ground as if loading a truck, avoiding high drops to prevent segregation.
- Strike off and level the pile to half its original height.
- Divide the surface into four equal sections labeled A, B, C, and D.
- Collect samples from two opposite quadrants (e.g., A and D or B and C) to preserve uniformity.



Material first dumped on ground

(Side View)



Material after being leveled off and sectioned

(Top View)

When collecting material with a shovel, take care to avoid spilling it while transferring it to the sample container.

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, including all fines. Samples obtained from a conveyor belt anywhere other than an approved QC/QA Aggregate facility, shall not exceed limits of Column C in **Table 3** *(page 57)*.

Tube Sampling

For tube sampling, **the sample must be collected from a portion of the stockpile that accurately represents the material being shipped.** Fine aggregate samples may be obtained using a tube approved by the Department. The tube shall have a minimum diameter of 1¼ inches (30 mm) and a minimum length of 6 feet (2 m). It must be constructed of either aluminum or PVC to ensure durability and compliance with specifications.

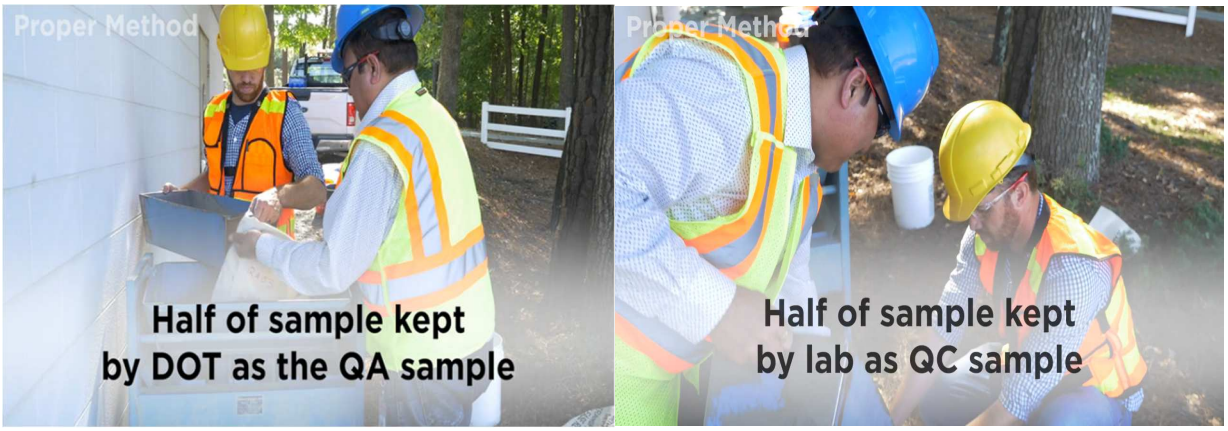
The sampling process requires inserting the tube into the stockpile at evenly spaced points across the exposed face of the pile. To achieve a representative sample, **a minimum of five insertions must be performed**. Each insertion shall be made at a **height of no less than three feet above the base of the stockpile**. This procedure ensures that the collected material reflects the quality and characteristics of the aggregate intended for shipment.

EXHIBIT D- PROCEDURES FOR SPLITTING AND LABELING SAMPLES

Method – Split in Two Halves

- Place **half** of the material (e.g., ~35 lbs of a 70-lb sample) into the splitter.
- Open the splitter **slowly** so material flows into the two catch pans.

- **Swap** the pans' positions and repeat with the remaining half.



General Requirements for Splitting
Finger gate settings must be at least **1.5 times the largest particle size**.
The splitter must rest on a **level surface**.
Split the sample **before it completely dries**.

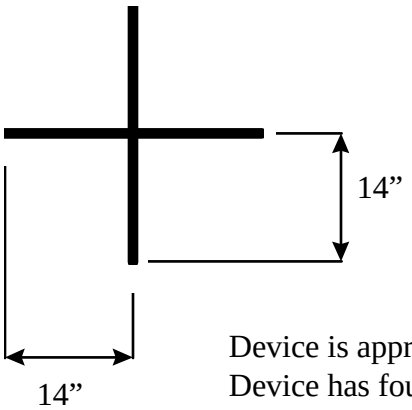
While not required to weigh each half; Producers may elect to do so to verify an appropriate split. It should be noted that measurable differences in weight between halves may still influence QC/QA result comparisons, even when all required procedures have been followed.

Fine Aggregate Sample Splitting Using a Divider

This method is an alternative to using a splitter and is intended for **moist fine aggregates** that do not flow freely.

Required Equipment

- **Impervious surface**, such as a steel plate or table (approx. 28" × 32")
- **Four-way divider**: 28" legs forming a right angle; about 5" tall
- Perform splitting **before material fully dries**



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.

Procedure

1. **Place** all moist material in the center of the table.

2. **Remix** thoroughly and shape into a **6" cone-shaped pile**.

3. Insert the **four-way divider** straight down through the pile until it touches the table.

4. **Slide** the divider slightly to separate the material.

5. **Remove** two opposite quadrants.

6. **Remix** the remaining two quadrants and **repeat** until you reach the sample size needed.

Sample Numbering Guidelines

Each material size/type begins a new sample number sequence on **January 1**, starting at **1** for each category.

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.**
***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.**

Check Sample Identification (Out of Spec Samples)	
Product (size)	Sample Number Sequence beginning January 1
#57	**QC-1, QC-2, QC-2A, QC-3, etc.**
#67	**QC-1, QC-2, QC-3, QC-3A, QC-3B, QC-4, etc.**
*A suffix of "A" indicates that the preceding sample was out of specifications, and the sample carrying the **"A" suffix is the first check sample**. A **suffix of "B" indicates a second check sample** was required.	

Key Points

- Separate numbering for each material type (e.g., #57, #67, #78M).
- QA split samples continue from their corresponding QC sequence.
- Out-of-spec samples add suffixes to identify corrective tests.

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EXHIBIT E – RAPID DRYING

If a facility is required by the Department to test for Plasticity Index (P.I.), the sample must be dried at a temperature not exceeding 60°C (140°F). For this reason, rapid drying is not permitted when material is to be tested for plasticity.

For drying operations, pans may be placed directly on electric heating elements or conventional oven-style gas elements.

When using large exterior gas-burning units, a metal frame such as angle iron or another suitable structure must be used to support the drying pans at least four inches above the burners. Each pan should contain 30 to 40 pounds of material, spread uniformly to ensure consistent drying.

When gas burners are used, the flame must be adjusted to prevent excessive heat from being applied directly to the bottom of the pan. **Throughout the drying process, a technician must remain present to monitor and adjust the heat as necessary, and to mix, stir, and turn the aggregate to prevent scorching.**

The sample should be dried until all moisture is removed, then allowed to cool. Stirring during cooling helps achieve uniform temperature throughout the sample. Once cooled, the sample must be processed promptly to prevent reabsorption of moisture from the air.

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

The **Quality Assurance Program (QAP)** is a secure, web-based platform utilized by the North Carolina Department of Transportation (NCDOT) and approved aggregate and asphalt producers/suppliers to support highway construction projects. The system is accessible at https://apps.dot.state.nc.us/vendor/qap.

- **Online Submission**: Enter and upload Quality Control (QC) and Quality Assurance (QA) test results efficiently.
- **Secure Data Transfer**: Ensure the safe transmission of sensitive testing information.
- **Report Access**: View both individual and summary test reports as needed.
- **Statistical Analysis Tools**: Utilize built-in features to assess and interpret test data.

All producers, suppliers, and their associated personnel must be registered in the **North Carolina Identity (NCID)** system to gain access to the QAP platform.

Immediately notify the **Aggregate QC/QA Engineer** or **QAP Liaison** upon discovery of test data errors.

- Include a detailed explanation to facilitate prompt correction.
- Repeated submission errors may result in disciplinary action, up to and including loss of certification.

QA results will be made visible to producers once QC data has been uploaded to the system.

Contact Information

Francine Ward
QAP Information Systems Liaison
Phone: (919) 707-2369
Fax: (919) 733-8742
Email: fdward@ncdot.gov

QAP/HiCAMS User Registration Form

To link a user's NCID account to the HiCAMS application in the Quality Assurance Program (QAP), the following steps are required:

- **Complete the designated form** with all required information.
- **Submit the form** 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.

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

Material Description	Code Name
Aggregate Base Course	ABC
Aggregate Base Course made from Recycled Concrete	ABCRC
Aggregate Base Course, Modified	ABCM
Stabilizer Aggregate	SA
Coarse Aggregate, #467M	CA467M
Coarse Aggregate, #5	CA5
Coarse Aggregate, #57	CA57
Coarse Aggregate, #57M	CA57M
Coarse Aggregate, #67	CA67
Coarse Aggregate, #78M	CA78M
Sand, 2MS	S2MS
Sand, 2S	S2S
Sand, 4S	S4S
Screenings, Dry	SD
Screenings, Washed	SW
Screenings, Super-Washed	SSW
Lightweight Concrete, (See Specs)	CALWT
Lightweight, Structural Concrete, (See Specs)	CALWTSC

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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	Sampling Tech. Name / Cert #

Place * in columns containing values that are outside of specifications
Remarks: @ Soil mortar fraction for ABC.

_____
Quality Control Testing Technician

EXHIBIT G – GRADATION SPECIFICATIONS & TOLERANCES FOR COMPARISONS

TABLE 1A – CORE AGGREGATES GRADATIONS

CORE AGGREGATE GRADATION SPECIFICATION																
Sieves	**2”**	**1-1/2”**	**1”**	**3/4”**	**1/2”**	**3/8”**	**#4**	**#8**	**#10**	**#16**	**#40**	**#200**	**@40**	**@200**	**LL**	**PI**
ABC*	-	100	75-97	-	55-80	-	35-55	-	25-45	-	14-30	4-12B	40-84[D]	11-35[D]	0-30	0-4
ABCRC	-	100	75-97	-	55-80	-	35-55	-	25-45	-	14-30	4-12B	40-84[D]	11-35[D]	0-35	0-4
#57	-	100	95-100	-	25-60	-	0-10	0-5	-	-	-	0-1[A]	-	-	-	-
#57M	-	100	95-100	-	25-45	-	0-10	0-5	-	-	-	0-1[A]	-	-	-	-
#67	-	-	100	90-100	-	20-55	0-10	0-5	-	-	-	0-1[A]	-	-	-	-
#78M	-	-	-	100	98-100	75-100	20-45	0-15	-	-	-	0-1[A]	-	-	-	-
[A.] See Sub article 1005-4 (A) [B.] See Sub article 1005-4 (B) [C.] See Sub article 1014-2 (6)																
[D.] For information only, unless PI exceeds 4. If PI exceeds 4, soil mortar limits apply. If PI exceeds 6, material shall be rejected.																
*Use ABC Specs for all base course materials such as: ABC, ABC Type A, CTBC, Select Material-Class IV																
Sieves	**1/2”**	**3/8”**	**#4**	**#8**	**#10**	**#16**	**#30**	**#40**	**#50**	**#80**	**#100**	**#200**	**F.M.**	**-**	**-**	**-**
2S	-	100	95-100	80-100	-	45-95	25-75	-	5-30	-	0-10	0-3	2.3-3.1	-	-	-
2MS	-	100	95-100	80-100	-	45-95	25-75	-	5-35	-	0-20	0-8[A]	2.3-3.1	-	-	-
A. When tested at the job site before use, the amount of material passing the No. 200 sieve shall not be greater than 10%																

TABLE 1B – NON-CORE AGGREGATES GRADATIONS

NON-CORE AGGREGATE GRADATION SPECIFICATION																
Sieves	**2”**	**1-1/2”**	**1”**	**3/4”**	**1/2”**	**3/8”**	**#4**	**#8**	**#10**	**#16**	**#100**	**#200**	**@40**	**@200**	**LL**	**PI**
#4	100	90-100	20-55	0-15	-	0-5	-	-	-	-	-	0-1[A]	-	-	-	-
#467M	100	95-100	-	35-70	-	0-30	0-5	-	-	-	-	0-1[A]	-	-	-	-
ABC(M)	-	100	75-100	-	45-79	-	20-40	-	0-25	-	-	0-12[B]	-	-	-	-
#5	-	100	90-100	20-55	0-10	0-5	-	-	-	-	-	0-1[A]	-	-	-	-
#6M	-	-	100	90-100	20-55	0-20	0-8	-	-	-	-	0-1[A]	-	-	-	-
#789	-	-	-	100	95-100	80-100	20-50	-	-	0-6	0-2	-	-	-	-	-
#8(VA)	-	-	-	-	100	85-100	10-30	0-10	-	0-5	-	0-1.5	-	-	-	-
#14M	-	-	-	-	100	98-100	35-70	5-20	-	0-8	-	0-1[A]	-	-	-	-
#9M	-	-	-	-	100	98-100	85-100	10-40	-	0-10	-	0-1[A]	-	-	-	-
[A.] See Sub article 1005-4 (A) [B.] See Sub article 1005-4 (B) [C.] See Sub article 1014-2 (6)																
[D.] For information only, unless PI exceeds 4. If PI exceeds 4, soil mortar limits apply. If PI exceeds 6, material shall be rejected.																
*Use ABC Specs for all base course materials such as: ABC, ABC Type A, CTBC, Select Material-Class IV																
Sieves	**1/2”**	**3/8”**	**#4**	**#8**	**#10**	**#16**	**#30**	**#40**	**#50**	**#80**	**#100**	**#200**	**F.M.**	**-**	**-**	**-**
4S	-	-	100	95-100	-	-	-	-	15-45	-	0-10	0-5	-	-	-	-

TABLE 2 – AGGREGATE QC/QA GRADATION TOLERANCES

AGGREGATE QC/QA GRADATION TOLERANCES																
Sieves	**2”**	**1-1/2”**	**1”**	**3/4”**	**1/2”**	**3/8”**	**#4**	**#8**	**#10**	**#16**	**#40**	**#200**	**@40**	**@200**	**LL**	**PI**
ABC*	-	+/- 2	+/- 4	-	+/- 5	-	+/- 6	-	+/- 5	-	+/- 5	+/- 3	+/- 6	+/- 5	+/- 4	-
#4	-	+/- 2	+/- 4	+/- 4	-	+/- 2	-	-	-	-	-	+/- 0.5	-	-	-	-
#467M	-	+/- 2	-	+/- 5	-	+/- 3	+/- 2	-	-	-	-	+/- 0.5	-	-	-	-
#5	-	-	+/- 2	+/- 5	+/- 2	+/- 2	-	-	-	-	-	+/- 0.5	-	-	-	-
#57 / #57M	-	+/- 2	+/- 3	-	+/- 5	-	+/- 3	+/- 3	-	-	-	+/- 0.5	-	-	-	-
#6M	-	-	+/- 2	+/- 3	+/- 5	+/- 5	+/- 3	+/- 5	-	-	-	+/- 0.5	-	-	-	-
#67	-	-	+/- 2	+/- 3	-	+/- 5	+/- 3	+/- 5	-	-	-	+/- 0.5	-	-	-	-
#78M / #8 (VA)	-	-	-	+/- 2	+/- 3	+/- 3	+/- 5	+/- 3	-	-	-	+/- 0.5	-	-	-	-
#9M / #14M	-	-	-	-	-	+/- 3	+/- 5	+/- 5	-	-	-	+/- 0.5	-	-	-	-
#789	-	-	-	+/- 3	+/- 3	+/- 3	+/- 5	-	-	+/- 3	+/- 3	-	-	-	-	-
*Use ABC Specs for all base course materials such as: ABC, ABC Type A, CTBC, Select Material-Class IV																
Sieves	**1/2”**	**3/8”**	**#4**	**#8**	**#10**	**#16**	**#30**	**#40**	**#50**	**#80**	**#100**	**#200**	**F.M.**	**-**	**-**	**-**
2S / 2MS	-	-	-	+/- 1	-	+/- 3	+/- 3	-	+/-2	-	+/- 1	+/- 1	+/- 0.2	-	-	-
4S	-	-	-	+/- 2	-	+/- 3	+/- 3	-	+/-3	-	+/- 2	+/- 1	-	-	-	-
Asphalt Sand, Screenings	-	-	+/- 2	+/- 6	+/- 6	+/- 6	+/- 6	+/- 6	+/- 4	-	+/- 2	+/- 2	-	-	-	-
Screenings – Dry Screenings, Washed Screenings, Super Washed Screenings																

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TABLE 3

GRADATION ABC, ABC-TYPE A, CTBC, AND SELECT MATERIAL CLASS IV		
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 #10 (Soil Mortar)		
***#40**	40-84	36-86
***#200**	11-35	10-36
LL	0-30	0-30
***PI**	0-4	0-4
NOTE: * For information only, unless PI exceeds 4. If PI exceeds 4, soil mortar limits apply. If PI exceeds 6, material shall be rejected.		

TABLE 4

Stabilizer Aggregate (SA) - Gradation	
Sieves	% Passing
1-1/2”	100
1”	72-100
1/2”	51-83
#4	35-60
#10	25-50
#40	10-34
#200	3-13
Material Passing #40	
LL	0-30
PI	0-6

Cement Treated Base Course (CTBC)

For Cement Treated Base Course (CTBC), the designated lot size for aggregate base material shall be **2,000 tons, or the shipped quantity if less**. A certified plant technician must collect one Quality Control (QC) sample per lot, with a **minimum weight of 35 pounds**.

All samples must be collected according to procedures detailed in Exhibit C and must be obtained prior to the introduction of cement. Each sample is to be clearly labeled for identification purposes. In cases where a split sample is collected, the remaining portion must be retained and made available to the Department upon request.

Rejection and Corrections

If a QC sample exceeds the criteria outlined in Column B of Table 3 *(page 57)*, the technician must follow the check sampling procedures described in Section III *(page 17)* of this manual. Once cement has been added to the material, check sampling is no longer permitted.

Any lot represented by a non-conforming sample shall be rejected and must be removed and replaced by the Contractor at no additional cost to the Department.

Additionally, material passing the No. 40 sieve must not exceed a Liquid Limit of 30 or a Plasticity Index of 4. Any test results exceeding these values will result in rejection of the lot, which must also be removed and replaced by the Contractor.

EXHIBIT H – Aggregate QC/QA Sampling and Testing Training Manual

Testing Procedures for Clean Coarse and Fine Aggregates

All sampling and testing of clean coarse aggregate and fine aggregate must follow the latest guidelines and procedures established by the North Carolina Department of Transportation (NCDOT). These procedures are described in detail in the **NCDOT Standard Specifications for Roads and Structures** as well as in the **Aggregate Sampling (Roadway)** guidelines.

In addition to those references, producers should also carefully follow the instructions provided in this manual to ensure all material testing is conducted accurately and consistently. Adhering to these standards helps maintain quality control and ensures that the materials meet the necessary specifications for use in NCDOT projects.

A wash test is required for all fine aggregate samples. For coarse aggregate, a wash test is not necessary on the Producer's split portion unless specifically requested.

Clean Coarse Aggregate – Sampling and Identification

Samples of clean coarse aggregate must be collected from **an approved location, such as a stockpile, conveyor belt, or another site approved by the Department**. These samples should be taken according to the procedures outlined in Exhibit C and then delivered to the laboratory for testing.

Each sample must be clearly labeled; NCDOT uses a sample card as shown in Exhibit D *(page 38)*. If the sample is split, with half retained for the Department, this must be done using the appropriate method with a sample splitter, also described in Exhibit D.

With site-specific approval from the Department, the retained portion of the sample may be rapid dried. This process must be carried out carefully to prevent overheating and should follow the guidelines listed in Exhibit E *(page 46)*.

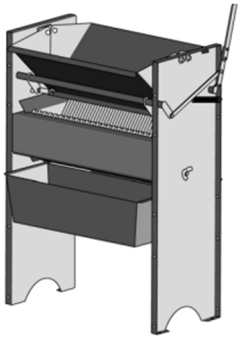
Once prepared, the coarse aggregate will be tested for gradation using the AASHTO T 27 procedure. Additionally, a wash test will be performed according to AASHTO T 11 standards to ensure the material meets required quality benchmarks.

Clean Coarse Aggregate

To begin testing, the sample must be reduced to a manageable size—**1,000 to 2,000 grams**. This reduction should follow the sample splitting methods outlined in Exhibit D *(page 38)*.

Washed Gradation Procedure – AASHTO T 11

Step 1: 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.



Step 2: Once the sample is dried to a constant mass it is allowed to cool to the touch prior to proceeding with any testing procedures.

Step 3: Weigh and record weight of sample (Total dry Wt.).

Step 4: Place sample in a container and cover with water to assure a thorough separation of material finer than the No. 200 sieve from the coarser particles.

Step 5: Using a large spoon vigorously agitate contents within the container.

Step 6: Immediately pour the wash water over a nest of sieves that are arranged with the coarser sieve on top.

Step 7: Care should be used to avoid pouring the coarse particles out of the container.

Step 8: Add water as previously described and repeat the procedures.

Step 9: Repeat this process until the wash water is clear.

Step 10: All material retained on the nested sieves shall be returned to the washed sample.

Step 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. *(page 46).*

Step 12: Weigh and record weight of the sample (Wt. after washing).

Step 13: Calculate the percent passing the No. 200 sieve.

Calculation of Percent Passing No. 200 Sieve

To determine the percentage of material passing the No. 200 sieve during a washed gradation test, use the following formula:

Percent Passing No. 200 Sieve Formula
((Total Dry Weight – Weight After Washing) ÷ Total Dry Weight) × 100

Example Calculation

A washed gradation test is performed on a sample of 57M aggregate material.

- **Total Dry Weight** = 1,520 grams
- **Weight After Washing** = 1,515 grams

Calculation: Percent Passing No. 200 Sieve = [(1,520 – 1,515) ÷ 1,520] × 100

Percent Passing No. 200 Sieve = (5 ÷ 1,520) × 100

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

Percent Passing No. 200 Sieve		
Product (size)	Percent Passing	Specification
#200	**0.3**	**0 - 1.0**
Result: The sample meets the specifications for 57M aggregate material tested from a quarry stockpile, specifically for the No. 200 sieve fraction.		

Clean Coarse Aggregate

Sieve Analysis Procedure – AASHTO T 27

This procedure outlines the method for determining the gradation of clean coarse aggregate using a mechanical sieve shaker.

Step 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.

Step 2: When testing material which 100% passes the ¾ sieve (such as #78, #14M, #9, etc), split the sample into a workable size of **10 to 15 pounds** to avoid overloading sieves. Follow procedures for splitting a sample described in Exhibit D *(page 38)*.

Step 3: Based on the Specifications for the material being tested, the proper sieves are selected. Additional sieve(s) may be added as needed to prevent sieve overloading.

Step 4: The sieves are placed into the mechanical shaker with the smallest opening on bottom and largest opening on top.

Step 5: Weigh and record the weight of the sample.

Step 6: Place the sample in the mechanical shaker and agitate for **10 minutes**.

Step 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.

Step 8: Calculate the cumulative percent retained for each sieve.

Step 9: Calculate the percent passing for each sieve.

Example: Calculating Percent Passing from a Sieve Analysis

This example uses a previously tested 57M aggregate sample, which showed **0.3% passing** the No. 200 sieve based on the wash gradation test. The total dry weight of the sample used for the sieve analysis is **22.1 lbs**.

Step 1: Calculate Cumulative Percent Retained

Use the following formula:

Cumulative % Retained Formula
(Cumulative Weight Retained ÷ Total Dry Weight) × 100

Example for the 1″ Sieve:

Calculation: Cumulative Percent Retained = (0.9 ÷ 22.1) × 100

Cumulative Percent Retained = (.041) × 100

Cumulative Percent Retained = **4 % Retained**

#57M		
Std. Size #	Cumulative Weight Retained	Cumulative % Retained
1-1/2”	0	0
1”	**0.9**	**4**

Step 2: Calculate Percent Passing

Use the formula:

Percent Passing Formula
100 – Cumulative % Retained

Example for the 1″ Sieve:

Calculation: Percent Passing = 100 – 4

Percent Passing = **96 % Passing**

#57M				
Std. Size #	Cumulative Weight Retained	Cumulative % Retained	% Passing	SPECS.
1-1/2”	0	0	100	100
1”	0.9	4	**96**	95 – 100

Sieve Analysis – Clean Coarse Aggregate <u>Work Problem #3</u>

- Total dry sample weight: **24.8 lbs.** (oven-dried)

#67				
Std. Size #	Cumulative Weight Retained	Cumulative % Retained	% Passing	SPECS.
1”	0			100
3/4”	0.2			90 – 100
1/2”	---	---	---	---
3/8”	19.0			20 - 55
#4	23.8			0 – 10
#8	24.5			0 – 5
Pan	24.8	---	---	---
Passing #200 (wash method)				
#200	---	---	0.1*	0 – 1

*Wash Test not required on QC samples but must be performed when requested.

Please review the sieve analysis results and determine whether the sample meets the minimum specification requirements for **#67 aggregate**.

Question:
Based on the data, does the sample meet the specification requirements for #67 stone? _____

Reminder:
The **1/2″ sieve** is **not a specified requirement** for #67 stone. However, its inclusion supports mix design and quality control for ready-mixed concrete applications.

Sieve Analysis – Clean Coarse Aggregate <u>Work Problem #4</u>

- Total dry sample weight: **15.6 lbs.** (oven-dried)

#78M				
Std. Size #	Cumulative Weight Retained	Cumulative % Retained	% Passing	SPECS.
3/4”	0			100
1/2”	0			98 - 100
3/8”	2.1			75 – 100
#4	12.9			20 – 45
#8	15.0			0 – 15
Pan	15.6	---	---	---
Passing #200 (wash method)				
#200	---	---	0.4*	0 – 1

*Wash Test not required on QC samples but must be performed when requested.

Please review the sieve analysis results and determine whether the sample meets the minimum specification requirements for **#78M aggregate**.

Question:
Based on the data, does the sample meet the specification requirements for #78M stone? _____

Test Procedures – Fine Aggregate

Fine aggregate samples must be collected from an approved location (e.g., stockpile or conveyor belt) following the sampling procedures outlined in **Exhibit D** *(page 38)*. Each sample must be clearly identified. (See Exhibit C for an example of a completed Sample Identification Card used by NCDOT.)

If the sample needs to be split so that half is retained for Department use, follow the **sample splitting procedure** using a mechanical splitter as described in **Exhibit D**.

When approved by the Department on a site-by-site basis, the split half of the **Quality Control (QC) sample** may be force dried. Care must be taken during drying to avoid overheating. When **Rapid Dring samples**, follow the procedures in **Exhibit E** *(page 46)*.

Fine aggregate must be tested in accordance with:

- Gradation testing shall be performed in accordance with **AASHTO T 27**, and wash tests in accordance with **AASHTO T 11**, **as modified by the Department**

Fine Aggregate

Washed Gradation Procedure – AASHTO T 11

Step 1: 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 *(page 38)*.

Step 2: Once the sample is dried to a constant mass it is allowed to cool to the touch prior to proceeding with any testing procedures.

Step 3: Weigh and record weight of sample (Total dry Wt.).

Step 4: Place sample in a container and cover with water to assure a thorough separation of material finer than the No. 200 sieve from the coarser particles.
(#16 and #200 sieves must be used)

Step 5: Using a large spoon vigorously agitate contents within the container.

Step 6: Immediately pour the wash water over a nest of sieves that are arranged with the coarser sieve on top.

Step 7: Care should be used to avoid pouring the coarse particles out of the container.

Step 8: Add water as previously described and repeat the procedures.

Step 9: Repeat this process until the wash water is clear.

Step 10: All material retained on the nested sieves shall be returned to the washed sample.

Step 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 *(Page 46).*

Step 12: Weigh and record weight of the sample (Wt. after washing).

Step 13: Calculate the percent passing the No. 200 sieve.

Calculation of Percent Passing No. 200 Sieve

To determine the percentage of material passing the No. 200 sieve during a washed gradation test, use the following formula:

Percent Passing No. 200 Sieve Formula
((Total Dry Weight – Weight After Washing) ÷ Total Dry Weight) × 100

Example Calculation

A washed gradation test is performed on a sample of fine aggregate material.

- **Total Dry Weight** = 552 grams
- **Weight After Washing** = 538 grams

Calculation: Percent Passing No. 200 Sieve = [(552 – 538) ÷ 552] × 100

Percent Passing No. 200 Sieve = (14 ÷ 552) × 100

Percent Passing No. 200 Sieve = **2.5 % Passing**

Percent Passing No. 200 Sieve		
Product (size)	% Passing	Specification
#200	**2.5**	**0 - 3.0**
Note: All Fine Aggregate samples must be washed in accordance with AASHTO T 11, as modified by the Department		

Fine Aggregate

Sieve Analysis Procedure – AASHTO T 27

This procedure outlines the steps for determining the particle size distribution of fine aggregate using a mechanical shaker and a set of sieves.

Step 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.

Step 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.

Step 3: The sieves are placed into the mechanical vibrator with the smallest opening on bottom and largest opening on top.

Step 4: Weigh and record the weight of the sample.

Step 5: Place the sample in the mechanical shaker and agitate for **10 minutes**.

Step 6: Carefully weigh and record the retained material on each sieve (cumulatively) using the following steps:

- Carefully remove the nest of sieves from the shaker.
- Remove the top sieve weigh and record material retained
- Remove the next sieve and add the retained material to the material from the first sieve.
- Record cumulative weight from both sieves
- Remove the next sieve and add the retained material to the material from the two previous sieves.
- Record cumulative weight from all three sieves
- Repeat this process for each of the remaining sieves to the catch pan.

Step 7: Verify mass of sample after sieving is within **0.3%** of sample mass originally placed on nest of sieves.

Step 8: Calculate the cumulative percent retained for each sieve.

Step 9: Calculate the percent passing for each sieve.

Example: Calculating Percent Passing in a Sieve Analysis

A sieve analysis was performed on a 2MS sand sample to determine the percent passing the No. 200 sieve using a wash gradation test.

- **Total Dry Weight** = 496.7 grams
- **Weight After Washing** = 481.3 grams

Step 1: Calculate Cumulative Percent Retained

Formula:

Cumulative % Retained Formula
(Cumulative Weight Retained ÷ Total Dry Weight) × 100

Example for #4 Sieve:

Calculation: Cumulative % Retained = (14.4 ÷ 496.7) × 100

Cumulative % Retained = (.029) × 100

Cumulative % Retained = **3 % Retained**

2MS		
Std. Size #	Cumulative Weight Retained	Cumulative % Retained
3/8”	0	0
#4	**14.4**	**3**

Step 2: Calculate Percent Passing

Formula:

Percent Passing Formula
100 – Cumulative % Retained

Example for the 1″ Sieve:

Calculation: Percent Passing = 100 – 3

Percent Passing = **97 % Passing**

2MS				
Std. Size #	Cumulative Weight Retained	Cumulative % Retained	% Passing	SPECS.
3/8”	0	0	100	100
#4	**14.4**	**3**	**97**	**95 – 100**

Verifying Sample Mass After Sieving Is Within Tolerance

According to Step 7 of the *Sieve Analysis Procedures – Fine Aggregate (AASHTO T27)*, the total mass of a sample after sieving must be within **±0.3%** of the original dry mass placed on the nest of sieves.

Example:

For a 2MS sand sample where the No. 200 sieve was determined using the wash method:

- Dry sample weight before washing: **496.7 grams**
- Dry sample weight after washing: **481.3 grams**

Since the sample was washed, use the **oven-dried weight after washing** (i.e., the weight of material placed on the sieves) for calculations.

Formula:

Sample Mass Tolerance Formula
Weight After Washing × 0.003 = Sample Mass Tolerance

Calculation: Sample Mass Tolerance = (481.3 × 0.003)

Sample Mass Tolerance = (1.44)

Sample Mass Tolerance = **1.4 grams**

This defines the acceptable mass range after sieving:

- **Lower limit:** 481.3 − 1.4 = **479.9 grams**
- **Upper limit:** 481.3 + 1.4 = **482.7 grams**

To stay within tolerance, the **cumulative weight of material retained on the pan after sieving** must fall between **479.9 grams and 482.7 grams**.

Sieve Analysis – Fine Aggregate <u>Work Problem #5</u>

- **Total Dry Weight** = 442.9 grams
- **Weight After Washing** = 434.6 grams

2S				
Std. Size #	Cumulative Weight Retained	Cumulative % Retained	% Passing	SPECS.
3/8”	0			
#4	15.3			
#8	52.4			
#16	96.6			
#30	179.9			
#50	349.1			
#100	420.0			
#200	---	---		
Pan	434.1	---	---	---

Please review the sieve analysis results and determine whether the sample meets the minimum specification requirements for **2S material**.

Questions:

1) Based on the data, does the sample meet the specification requirements for 2S material?

2) Does the total mass of the sample after sieving within **±0.3%?**

Fineness Modulus (F.M.) Overview

The **Fineness Modulus (F.M.)** is an empirical value that provides an index of the fineness or coarseness of an aggregate. Defined by the American Concrete Institute (ACI), it is calculated by summing the cumulative percent retained (by weight) on a specific set of standard sieves and dividing that total by 100.

For NCDOT: Standard Sieve Sizes Used in F.M. Calculation:

- 3/8", No. 4, No. 8, No. 16, No. 30, No. 50, No. 100

Note: The No. 200 sieve is included in gradation testing as required by specifications but is ***not used*** *when calculating F.M. Also, exclude the material retained in the pan from the F.M. calculation.*

Fineness Modulus Classification

Fineness Modulus (F.M.) Index	
F.M. Rating	**Index Range**
Coarse Sand	2.80 – 3.10
Medium Sand	2.50 – 2.80
Fine Sand	2.30 – 2.50

The F.M. should be between 2.3 and 3.1 and must not vary by more than 0.20.

Example: Fineness Modulus Calculation

Sample Information:

- **Total Dry Weight** = 496.7 grams
- **Weight After Washing** = 481.3 grams

Step 1: Calculate Cumulative Percent Retained

Formula:

Cumulative % Retained Formula
(Cumulative Weight Retained ÷ Total Dry Weight) × 100

2S / 2MS		
Std. Size #	Cumulative Weight Retained	Cumulative % Retained
3/8”	0	**0**
#4	14.4	**3**
#8	83.9	**17**
#16	183.8	**37**
#30	258.3	**52**
#50	347.7	**70**
#100	405.3	**82**
#200	---	---
Pan	481.1	---

Step 2: Calculate F.M.

Fineness Modulus (F.M.) is a numerical value used to describe the coarseness or fineness of aggregate. It is calculated by adding up the cumulative percentages of material retained on a set of standard sieves, and then dividing that total by 100.

Example:

Fineness Modulus (F.M.) Formula
(0 + 3 + 17 + 37 + 52 + 70 + 82) ÷ 100 = 2.61

Since the Fineness Modulus (F.M.) of the sand is **2.61**, it is rated as a **Medium sand**, based on the F.M. Index.

Sieve Analysis – Fine Aggregate <u>Work Problem #6</u>

- **Total Dry Weight** = 418.1 grams
- **Weight After Washing** = 402.8 grams

2MS				
Std. Size #	Cumulative Weight Retained	Cumulative % Retained	% Passing	SPECS.
3/8”	0			
#4	5.2			
#8	64.9			
#16	150.5			
#30	206.3			
#50	271.5			
#100	352.0			
#200	---	---		
Pan	403.1	---	---	---
F.M.	---		---	---

Sample Mass Tolerance Formula: Weight After Washing × 0.003	
Lower limit: 402.8 − _____ = _____ **grams**	
Upper limit: 402.8 + _____ = _____ **grams**	
What type of F.M. rating is this material?	

Test Procedures – Aggregate Base Products

Overview of Aggregate Base Types

Aggregate Base Course (ABC):
ABC is a well-graded mix of fine and coarse aggregate particles. When placed according to specifications and compacted to meet minimum density requirements, ABC forms a strong, stable foundation layer for pavement structures. Its primary function is to distribute traffic-induced stresses across the pavement layers. A well-constructed ABC layer enhances load-bearing capacity and reduces rutting. It also provides several additional benefits, including:

- Mitigating pumping
- Minimizing frost heave
- Improving surface and subsurface drainage
- Controlling subgrade volume changes in expansive soils
- Preventing lateral movement in flexible pavement systems

Cement Treated Base Course (CTBC):
CTBC is similar to ABC but includes cement to improve strength and load-bearing capacity. It's commonly used in high-traffic roadway projects where greater durability is required.

Aggregate Base Course – Modified (ABC-M):
ABC-M has a different gradation specification than standard ABC and is typically used for maintenance stabilization, offering structural support in repair work or temporary applications.

Stabilizer Aggregate (SA):
SA is designed specifically for subgrade stabilization. Its specification requirements differ from ABC, making it suitable for use beneath pavement layers to improve stability and reduce movement from underlying soils.

Aggregate Base Course (ABC)

Type A ABC – Production Stockpile:
This refers to ABC sourced from an active production stockpile. These stockpiles may be continuously replenished with new material while existing material is being distributed to customers.

Sampling and Handling Procedures

- **Sampling Locations:**
  Aggregate base material must be sampled from a stockpile, conveyor belt, or other Department-approved locations using established procedures. Refer to Exhibit C *(page 35)* for proper sampling methods.

Each sample must be clearly labeled with a completed sample card. Use the splitter per Exhibit D *(page 38)* for splitting procedure. Rapid drying may be used if done cautiously to prevent overheating; for rapid drying, follow Exhibit E *(page 46)*.

Important: If the sample is required to undergo testing for Plasticity Index (P.I.), it must be dried at temperatures not exceeding **60°C (140°F)**. Rapid drying is **not permitted** in such cases.

Aggregate Base Course

Procedures – AASHTO T 11 and AASHTO T 27

Step 1: **AASHTO T 27**
Once the sample is dried to a constant mass it is allowed to cool to the touch prior to proceeding with any testing procedures.

Step 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.

Step 3: Weigh and record the weight of the sample.

Step 4: Place the sample in the mechanical shaker and agitate for **10 minutes**.

Step 5: Carefully remove each sieve, weigh, and record the retained material using the following steps:

- Weigh and record material cumulatively retained on each sieve.
- 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.).

Step 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.

Step 7: Weigh and record weight of sample (Total Dry Wt., pre-washing).

Step 8: **AASHTO T 11**
Place sample in container and cover with water.

Step 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.

Step 10: Immediately pour the wash water over a nest of sieves that are arranged with the coarser sieve on top **(#16 and the #200 sieves must be used)**.

Step 11: Care should be used to avoid pouring the coarse particles out of the container.

Step 12: Add water as previously described and repeat steps from 9 – 11.

Step 13: Repeat this process until the wash water is clear.

Step 14: All material retained on the nested sieves shall be returned to the container

Step 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 E *(page 46).*

Step 16: Once the sample is dried it must be allowed to cool to the touch prior to performing any additional tests.

Step 17: **AASHTO 27**
Weigh and record weight of the sample (Total Dry Wt.., after washing). Calculate the percent passing the #200 sieve.

Step 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.

Step 19: The sample is screened for **10 minutes** in the mechanical shaker.

Step 20: Add the material retained on the #30 sieve to the material retained on the #40 sieve.

Step 21: Weigh and record the material retained on the #40 sieve.

Step 22: Add the material retained on the #100 sieve to the material retained on the #40 sieve.

Step 23: Add the material retained on #200 sieve to the #40 and #100 material.

Step 24: Weigh and record the cumulative material from the #40, #100, and #200 sieve to determine the cumulative weight retained on the #200 sieve.

Step 25: Verify mass of sample after sieving is within **0.3%** of mass placed on nest of sieves.

Step 26: Calculate the cumulative percent retained on each sieve to the #10 sieve.

Step 27: Calculate the percent passing each sieve down to the #10 sieve.

Step 28: Calculate the cumulative percent retained on the #40 and #200 sieve (- #10 material or Soil Mortar).

Step 29: Calculate the percent passing on the #40 and #200 sieves.

Step 30: Complete the gradation results with the percent passing for each sieve (top to bottom).

Step 31: When reporting the #200, use the percent passing the #200 sieve calculated after performing the wash process.

Example: Calculating Percent Passing – Sieve Analysis for ABC

Sample Information:

- **Total Dry Weight** = 41.4 lbs.

Step 1: Calculate Cumulative Percent Retained

Formula:

Cumulative % Retained Formula
(Cumulative Weight Retained ÷ Total Dry Weight) × 100

Example – 1” Sieve:

Example for the 1″ Sieve:

Calculation: Cumulative Percent Retained = (2.3 ÷ 41.4) × 100

Cumulative Percent Retained = (.056) × 100

Cumulative Percent Retained = **6 % Retained**

ABC		
Std. Size #	Cumulative Weight Retained	Cumulative % Retained
1 ½”	0	0
1”	2.3	**6**
½”	13.3	32
#4	23.7	57
#10	29.1	70
Pan	---	---

Step 2: Calculate Percent Passing the No. 200 Sieve (from -No. 10 Material)

Sample Information:

- **Total Dry Weight** = 320.0 grams
- **Weight After Washing** = 227.2 grams

Formula:

Percent Passing No. 200 Sieve Formula
((Total Dry Weight – Weight After Washing) ÷ Total Dry Weight) × 100

Calculation: Percent Passing No. 200 Sieve = [(320.0 – 227.2) ÷ 320.0] × 100

Percent Passing No. 200 Sieve = (92.8 ÷ 320.0) × 100

Percent Passing No. 200 Sieve = **29 % Passing**

Step 3: Calculate Cumulative Percent Retained for No. 40 Sieve (Soil Mortar)

Formula:

Cumulative % Retained Formula
(Cumulative Weight Retained ÷ Total Dry Weight) × 100

Example for #40 Sieve:

Calculation: Cumulative Percent Retained = (132.5 ÷ 320.0) × 100

Cumulative Percent Retained = (.414) × 100

Cumulative Percent Retained = **41 % Retained**

ABC		
Std. Size #	Cumulative Weight Retained	Cumulative % Retained
#40	132.5	**41**
#200	**---**	**---**

Step 4: Calculate Percent Passing

Formula:

Percent Passing Formula
100 – Cumulative % Retained

Example for the 1″ Sieve:

Calculation: Percent Passing = 100 – 6

Percent Passing = **94 % Passing**

ABC			
Std. Size #	Cumulative Weight Retained	Cumulative % Retained	% Passing
1 ½”	0	0	100
1”	2.3	6	**94**
1/2”	13.3	32	68
#4	23.7	57	43
#10	29.1	70	30

Example for the #40 Sieve (Soil Mortar):

Calculation: Cumulative Percent Retained = (153.6 ÷ 320.0) × 100

Cumulative Percent Retained = (.48) × 100

Cumulative Percent Retained = 48

Percent Passing = 100 – 48

Percent Passing = **52 % Passing**

ABC			
Std. Size #	Cumulative Weight Retained	Cumulative % Retained	% Passing
#40	153.6	48	**52**
#200	**---**	FROM STEP #2 →	**29**

Step 5 – Determine Percent Passing for each sieve (total sample)

Formulas:

Percent Passing Total Sample (#40)
Percent Passing Total Sample +40 = (% Passing #10 x % Passing S.M. #40) ÷ 100

Example for the + #40 Sieve:

Calculation: Percent Passing Total Sample +40 = (30 × 52) ÷ 100

Percent Passing Total Sample +40 = (15.6) ÷ 100

Percent Passing Total Sample +40 = **16 % Passing**

Std. Size #	% Passing
1 ½”	100
1”	94
1/2”	68
#4	43
#10	30
#40	**16**
#200	
Soil Mortar	
#40	52
#200	29

Percent Passing Total Sample (#200)
Percent Passing Total Sample +400 = (% Passing #10 x % Passing S.M. #200) ÷ 100

Example for the + #40 Sieve:

Calculation: Percent Passing Total Sample +200 = (30 × 29) ÷ 100

Percent Passing Total Sample +200 = (8.7) ÷ 100

Percent Passing Total Sample +200 = **9 % Passing**

Std. Size #	% Passing
1 ½”	100
1”	94
1/2”	68
#4	43
#10	30
#40	16
#200	**9**
Soil Mortar	
#40	52
#200	29

Sieve Analysis – Fine Aggregate <u>Work Problem #7</u>

- **Total Weight** = 36.6 lbs.
- **Total Dry Weight** = 410.0 grams
- **Weight After Washing** = 321.6 grams

ABC				
Std. Size #	Cumulative Weight Retained	Cumulative % Retained	% Passing	SPECS.
1 ½”	0			
1”	2.5			
3/4”	---	---	---	---
1/2”	14.1			
3/8”	---	---	---	---
#4	21.0			
#10	26.5			
#40	---	---		
#200	---	---		
Soil Mortar				
#40	209.3 g.			
#200	---	---	---	
Pan	321.1 g.	---	---	---

Sample Mass Tolerance Formula: Weight After Washing × 0.003	
Lower limit: 321.6 − _____ = _____ **g.**	**Sample Tolerance within 0.3%?**
Upper limit: 321.6 + _____ = _____ **g.**	

Sieve Analysis – Fine Aggregate <u>Work Problem #8</u>

- **Total Weight** = 43.7 lbs.
- **Total Dry Weight** = 324.3 grams
- **Weight After Washing** = 266.0 grams

ABC				
Std. Size #	Cumulative Weight Retained	Cumulative % Retained	% Passing	SPECS.
1 ½”	0			
1”	3.2			
3/4”	---	---	---	---
1/2”	12.8			
3/8”	---	---	---	---
#4	19.9			
#10	27.9			
#40	---	---		
#200	---	---		
Soil Mortar				
#40	166.5 g.			
#200	---	---	---	
Pan	265.2 g.	---	---	---

Sample Mass Tolerance Formula: Weight After Washing × 0.003	
Lower limit: 266.0 − _____ = _____ **g.**	**Sample Tolerance within 0.3%?**
Upper limit: 266.0 + _____ = _____ **g.**	

EXHIBIT I – ATTERBERG LIMIT PROCEDURES (LIQUID LIMIT AND PLASTICITY INDEX)

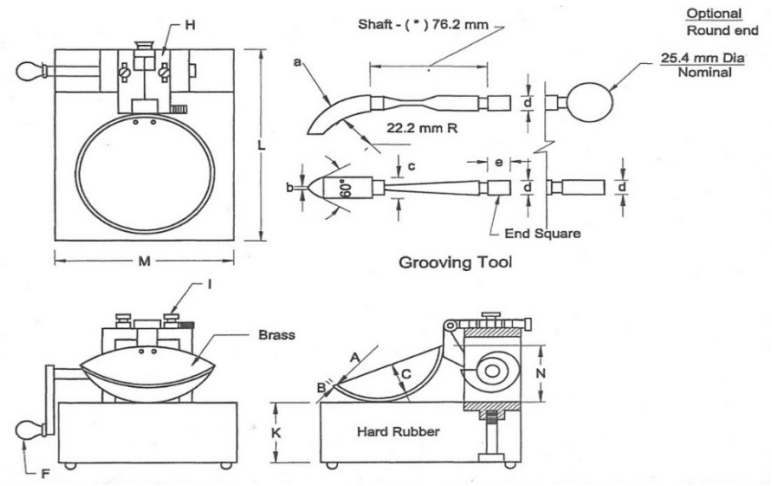
When a quarry has been flagged by the Department for potential concerns regarding Liquid Limit (LL) or Plasticity Index (PI), it is necessary to verify those properties using Atterberg Limits testing.

This verification must be performed by testing at a **minimum of every third sample reported to the Department.** The Liquid Limit is the moisture content at which soil transitions from a plastic to a liquid state, determined AASHTO T 89. The Plastic Limit is the moisture content at which soil begins to show plastic behavior, determined by AASHTO T 90. The Plasticity Index is a calculated value that reflects the range of moisture where soil remains plastic, and it is obtained by subtracting the Plastic Limit from the Liquid Limit **(PI = LL – PL).**

To perform the Atterberg Limits test, you'll need to **obtain -#40 material**. Begin by using the leftover -#10 material that was retained during the sieve analysis process. Because the LL and PI are evaluated using only the -#40 fraction, this material needs to be further processed. First, sieve the -#10 material using a #40 sieve and a catch pan. The material retained on the sieve (+#40) must be gently ground using a mortar and a rubber-covered pestle—or an equivalent mechanical tool—to break up clumped particles without crushing individual grains.

If the sample contains fragile particles like mica flakes or seashell fragments, handle the grinding with care and apply only enough pressure to detach finer particles from the brittle ones. After grinding, re-sieve the material to separate out more -#40 particles. Continue this grind-and-sieve cycle until only a small amount of additional -#40 material is generated and a tactile check of the +#40 portion (rubbing between thumb and forefinger) confirms it's clean.

Once these criteria are met, discard the remaining +#40 material. Thoroughly mix the -#40 material collected in the catch pan and transfer it into a clearly labeled sample can. This sample is what you will use to determine the Liquid Limit and Plasticity Index during testing.



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

1. Prior to performing Liquid Limit testing, inspect and adjust the Atterberg (Liquid Limit) device in accordance with AASHTO T 89 and verify that the brass cup is calibrated to produce a 1-centimeter drop.
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 the 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 the 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

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 the 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:

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

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

Plasticity Index (PI) = Liquid Limit (LL) – Plastic Limit (PL)

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) = $\frac{(86.0 - 82.2)}{15.9} \times 100 =$ **24**

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**

Plasticity Index (PI) = 24 – 21 = **3**

EXHIBIT J – AGGREGATE BASE COURSE PRODUCTS QC/QA SPLIT SAMPLES THAT ARE OUT OF TOLERANCE

When Quality Control (QC) and Quality Assurance (QA) split samples of Aggregate Base Course material fall outside the acceptable limits specified in Table 2 *(page 55)*, the Department must initiate a formal investigation to determine the cause of the discrepancy. This investigation may involve a comprehensive review of QC/QA test results, technician evaluations, laboratory inspections, or monitoring of subsequent samples. All findings must be documented on the Department's QC/QA Investigation form. Once the form is complete, copies shall be distributed to both the Producer and the Aggregate QC/QA Engineer.

If the investigation reveals that the issue originated from a procedural error or equipment malfunction on the Producer's side, the Department will inform the Producer of the findings and any necessary corrective actions. These will be noted on the investigation form. Repeated procedural or equipment-related issues may result in consequences for the QC Technician, such as mandatory retraining, suspension of certification, or removal of the Producer from the Approved Producers List.

On the other hand, if the problem is determined to be caused by deficiencies in the Department's sampling or testing process, the responsible technician will be informed, and both the root cause and resolution must be documented. Ongoing issues of this nature may result in similar disciplinary actions, including additional training, revocation of certification, or termination of employment.

EXHIBIT K – RANDOM NUMBERS

When sampling base course material, a verifiable random selection process must be employed to ensure unbiased results. Randomly choosing sample locations eliminates the potential for intentional or unintentional bias, and this can be accomplished through the use of random numbers. 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
2	7	3	0	7	4	8	3	3	4	0	8	2	7	6	2	3	5	6	3	1	0	8	9	6	9	1	3	7	6	9	1
0	5	6	0	5	2	4	6	1	1	1	2	6	1	0	7	6	0	0	8	8	1	2	6	4	2	3	3	8	7	7	6
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
2	0	0	2	7	8	4	0	1	6	9	0	7	5	0	5	0	4	2	3	8	4	3	0	8	7	5	9	7	1	0	8
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
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2	0	4	1	2	2	0	7	4	8	8	9	7	3	4	6	2	8	6	5	1	5	5	0	5	9	6	0	5	4	7	9
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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
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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
1	4	1	4	7	1	5	2	3	6	5	8	1	6	3	6	0	6	3	8	3	4	4	3	4	4	4	0	3	0	8	6
7	0	4	1	8	9	8	5	7	0	1	1	5	6	7	6	7	5	7	0	6	6	8	5	1	7	7	6	3	1	5	4
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7	9	2	2	4	9	3	1	5	7	5	3	6	1	6	0	6	5	6	6	8	6	0	2	3	4	2	3	9	0	7	4
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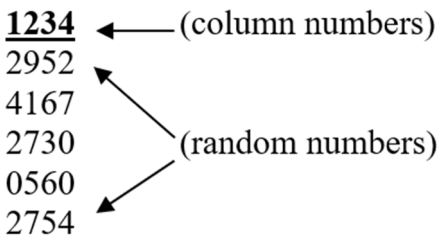
5	1	8	8	1	8	2	5	2	2	2	0	9	3	8	2	0	5	3	2	1	9	1	5	1	7	9	0	2	0	8	1
1	1	9	8	2	5	4	5	2	4	8	2	9	6	0	7	0	0	6	7	3	7	4	4	9	8	6	6	5	0	9	6
3	9	0	8	4	6	7	6	7	8	1	6	6	5	1	7	9	1	2	1	3	1	7	1	4	1	1	9	3	6	1	5
1	0	9	4	2	2	2	3	1	6	7	5	2	2	8	2	3	7	1	2	8	1	9	1	1	3	3	0	1	4	5	4
1	8	1	7	7	7	2	3	5	5	8	2	7	1	5	3	9	5	1	8	0	2	3	1	7	7	8	2	5	7	4	2
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
4	7	5	2	4	5	1	9	2	7	4	9	8	0	2	0	4	6	4	2	1	1	9	0	7	3	0	2	8	3	5	0
0	4	8	6	6	9	9	3	3	1	1	5	5	0	2	5	4	8	8	7	1	5	7	1	9	8	1	9	6	8	0	4
4	9	4	2	3	0	0	4	1	4	4	2	2	8	1	0	1	4	7	9	0	9	7	0	7	3	0	2	3	7	7	5
4	9	3	0	9	7	8	6	7	4	6	0	3	9	9	6	2	8	6	4	0	5	5	9	3	9	8	5	8	0	9	2
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

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:

Random numbers:



QC-1 - Calculate tonnage for the sample within the first **2,000-ton** lot using a random number from column 1 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 QC-1)

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.

QC-2 – For calculating QC-2 for the second **2,000-ton** lot use random number 52. Place a decimal in front to get the random number of **0.52.** Multiply the random number by the tonnage as shown below:

2,000 tons x 0.52 = **1,040 tons**

However, do not forget to add the previous tonnages. Therefore, add previous lots.

2,000 tons (1 Previous Lot) + 1,040 tons = **3,040 tons** (Pull the sample QC-2)

QC-3 – For calculating QC-3 for the third **2,000-ton** lot use random number 41. Place a decimal in front to get the random number of **0.41.** Multiply the random number by the tonnage as shown below:

2,000 tons x 0.41 = **820 tons**

4,000 tons (2 Previous Lots) + 820 tons = **4,820 tons** (Pull the sample QC-3)

This process would be repeated for each sample.

EXHIBIT L – COMMON AGGREGATE QC/QA PROGRAM FORMULAS

Coarse and Fine Aggregate Formulas

Percent Passing No. 200 Sieve $= \left(\frac{\text{Total dry weight – Dry weight after washing}}{\text{Total dry weight}}\right) \times 100$

Cumulative Percent Retained $= \left(\frac{\text{Cumulative weight retained}}{\text{Total dry weight of sample}}\right) \times 100$

Percent Passing = 100 - Cumulative Percent Retained

Tolerance = Oven dry weight (placed on sieves) x 0.003

Example: ODW = 400.0 grams
400 x 0.003 = 1.2 grams

400.0 + 1.2 = maximum allowable is 401.2 grams
400.0 – 1.2 = minimum allowable is 398.8 grams

Fineness Modulus = $\frac{\text{Sum of cumulative percent retained percentages from standard sieves}}{100}$

ABC Specific Formulas

Percent Passing Total Sample (#40) = % Passing #10 x % Passing #40 soil mortar ÷ 100

Percent Passing Total Sample (#200) = % Passing #10 x % Passing #200 mortar ÷ 100
(from washed #200 test)

Atterberg Limits

Liquid Limit (LL) $= \left(\frac{\text{Wet Soil – Oven Dry Soil}}{\text{Weight of Oven Dry Soil}}\right) \times 100$

Plastic Limit (PL) $= \left(\frac{\text{Wet Soil – Oven Dry Soil}}{\text{Weight of Oven Dry Soil}}\right) \times 100$

Plasticity Index (PI) = Liquid Limit (LL) – Plastic Limit (PL)

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GLOSSARY

Aggregate Producer - An approved facility responsible for manufacturing aggregate materials—such as crushed stone, gravel, or sand—that meet the specifications of the North Carolina Department of Transportation (NCDOT) for use in transportation infrastructure projects.

Certified Laboratory - A laboratory officially certified by the North Carolina Department of Transportation (NCDOT) to conduct aggregate testing for Quality Control purposes. Facilities may be located on-site or off-site, subject to Departmental approval.

Department - A term used to denote the North Carolina Department of Transportation (NCDOT), that has jurisdiction and responsibility over transportation-related matters, policies, and operations.

Department Representative (NCDOT) - A designated individual within the NCDOT who acts as the official point of contact for a specific division, project, or operational unit, responsible for communicating directives, coordinating activities, and ensuring compliance with departmental policies and procedures.

F-Test and t-Test - Statistical methods used to evaluate differences between Verification samples and Quality Control (QC) samples. The F-Test assesses variance equality, while the t-Test compares sample means. Both are conducted at a significance level of $\alpha = 0.05$ to determine statistical relevance.

Los Angeles Abrasion - A standardized test method used to evaluate the toughness and abrasion resistance of coarse aggregates by subjecting them to impact and grinding in a rotating steel drum with steel spheres. The resulting loss of material, expressed as a percentage, indicates the aggregate's durability and suitability for use in road construction and other structural applications.

NCDOT - An acronym for the North Carolina Department of Transportation, the state agency responsible for planning, building, and maintaining transportation infrastructure across North Carolina, including highways, railways, public transit, aviation, ferries, and bicycle and pedestrian systems.

NCDOT Right-of-Way - The real property, including land and associated rights, acquired and maintained by the North Carolina Department of Transportation (NCDOT) for public use in constructing, operating, and preserving transportation infrastructure such as highways, bridges, and related facilities.

North Carolina Aggregates Association (NCAA) - An organization representing the aggregate industry involved in the production and sale of crushed stone, sand, and gravel across North Carolina. It fosters collaboration between aggregate producers and the NCDOT, supporting industry standards, education, and regulatory compliance.

Paired t-Test - A statistical technique used to compare the mean values of a specific aggregate size or material measured under two different conditions, typically applied in Quality Control (QC) and Quality Assurance (QA) split sample analysis to detect significant differences between paired observations.

Plant Ownership Update Form - A document utilized by the NCDOT to record initial approvals of aggregate production facilities, and to document subsequent changes in ownership and contact information. This form is required at the initial request for facility approval, upon any change in ownership or personnel, and must be submitted annually by October 31.

QAP (Quality Assurance Program) - A web-based system utilized by the NCDOT to collect, manage, and analyze Quality Control (QC) and Quality Assurance (QA) data from aggregate and asphalt producers. The program supports data entry, secure file transfer, statistical analysis, and reporting to ensure compliance with departmental standards for highway construction materials.

Quality Assurance - A set of procedures designed to ensure that products or services consistently meet defined specifications and performance standards. It involves proactive measures throughout production to evaluate materials, processes, and outputs against established benchmarks, aiming to prevent defects and maintain quality integrity.

Quality Control Plan - A written document prepared by the Producer outlining procedures for managing production processes, materials, and equipment to ensure compliance with specified standards. It defines quality objectives, inspection methods, responsibilities, and corrective actions necessary to maintain consistent product quality.

Quality Control Technician - A certified individual who has successfully completed the NCDOT Aggregate QC/QA Sampling Technician or QC/QA Sampling and Testing Technician training courses, qualifying them to perform sampling, testing, and quality assurance procedures for construction materials.

Soundness - A measure of an aggregate’s resistance to disintegration caused by weathering, particularly freeze-thaw cycles. Soundness testing involves repeatedly immersing aggregate samples in sodium sulfate or magnesium sulfate solutions to simulate environmental stress. The percentage of material loss after multiple cycles indicates the aggregate’s durability and suitability for construction applications.

Unit Weight - The weight of a material per unit volume, typically expressed in pounds per cubic foot (lb/ft^3). Used by the NCDOT to establish target density values for testing the compaction of Aggregate Base Course (ABC) materials. In the private sector, this measurement is commonly referred to as a Proctor, derived from standardized compaction tests that determine a material’s maximum dry density and optimum moisture content.

QC/QA Program Contact Information

Todd Whittington, P.E.
State Materials Engineer
Materials and Tests Unit
1801 Blue Ridge Rd.
Raleigh, NC 27607
(919) 329-4000 (phone)
(919) 733-8742 (fax)

C.K. Su, P.E.
GeoMaterials Workgroup Supervisor
(919) 329-4153 (phone)
cksu@ncdot.gov (email)

J.J. Myers
Aggregate QC/QA Engineer
(336) 596-8768 (mobile)
jjmyers@ncdot.gov (email)

Contact - information regarding quarry approval, Aggregate QC/QA Program, QC/QA Class scheduling, certifications, QAP data correction/questions.

Website: **https://connect.ncdot.gov/resources/Materials/Pages/default.aspx**

Yogesh Chauhan
Aggregate QC/QA Specialist (Eastern Region)
(919) 633-2659 (mobile)
ychauhan1@ncdot.gov (email)

Scott Swicegood
Aggregate QC/QA Specialist (Western Region)
(336) 362-7978 (mobile)
jsswicegood@ncdot.gov (email)

Information regarding the QC/QA Aggregate Sampling and Testing Class Schedule can be found on the NCDOT Materials and Tests Unit website.
https://connect.ncdot.gov/resources/Materials/Pages/QCQAAggregateSamplingTestingClass.aspx

Information regarding the Approved Private Laboratories can be found in the following link.
https://connect.ncdot.gov/resources/Materials/Pages/Materials-Manual-by-Material.aspx?Method=MM-01-02#APPROVED%20GEOTECHNICAL%20LABORATORIES

ADDITIONAL WORK PROBLEMS

Work Problem #9

- Total dry sample weight: **21.9 lbs.** (oven-dried)

#57				
Std. Size #	Cumulative Weight Retained	Cumulative % Retained	% Passing	SPECS.
1-1/2”	0			
1”	0			
3/4”	---	---	---	---
1/2”	13.5			
3/8”	---	---	---	---
#4	20.9			
#8	21.3			
Pan	21.9	---	---	---
Passing #200 (wash method)				
#200	---	---	0.3*	

Work Problem #10

- Total dry sample weight: **25.8 lbs.** (oven-dried)

#57M				
Std. Size #	Cumulative Weight Retained	Cumulative % Retained	% Passing	SPECS.
1-1/2”	0			
1”	0			
3/4”	---	---	---	---
1/2”	18.6			
3/8”	---	---	---	---
#4	25.1			
#8	25.3			
Pan	25.8	---	---	---
Passing #200 (wash method)				
#200	---	---	0.3*	

Work Problem #11

- Total dry sample weight: **31.7 lbs.** (oven-dried)

#67				
Std. Size #	Cumulative Weight Retained	Cumulative % Retained	% Passing	SPECS.
1”	0			
3/4”	2.3			
1/2”	16.8	---	---	---
3/8”	22.9			
#4	28.7			
#8	30.7			
Pan	31.7	---	---	---
Passing #200 (wash method)				
#200	---	---	0.3*	

Work Problem #12

- Total dry sample weight: **15.2 lbs.** (oven-dried)

#78M				
Std. Size #	Cumulative Weight Retained	Cumulative % Retained	% Passing	SPECS.
3/4”	0			
1/2”	0			
3/8”	0.6			
#4	11.1			
#8	14.2			
Pan	15.2	---	---	---
Passing #200 (wash method)				
#200	---	---	0.3*	

Work Problem #13

- **Total Dry Weight** = 424.9 grams
- **Weight After Washing** = 414.6 grams

2S				
Std. Size #	Cumulative Weight Retained	Cumulative % Retained	% Passing	SPECS.
3/8”	0			
#4	0.7			
#8	11.4			
#16	75.6			
#30	246.3			
#50	378.3			
#100	409.7			
#200	---	---		
Pan	414.0	---	---	---
F.M.	---		---	---

Sample Mass Tolerance Formula: Weight After Washing × 0.003	
Lower limit: 414.6 − _____ = _____ **grams**	
Upper limit: 414.6 + _____ = _____ **grams**	
What type of F.M. rating is this material?	

Work Problem #14

- **Total Dry Weight** = 461.1 grams
- **Weight After Washing** = 449.5 grams

2S				
Std. Size #	Cumulative Weight Retained	Cumulative % Retained	% Passing	SPECS.
3/8”	0			
#4	2.3			
#8	62.2			
#16	158.9			
#30	236.7			
#50	309.0			
#100	384.4			
#200	---	---		
Pan	449.1	---	---	---
F.M.	---		---	---

Sample Mass Tolerance Formula: Weight After Washing × 0.003	
Lower limit: 449.5 − _____ = _____ **grams**	
Upper limit: 449.5 + _____ = _____ **grams**	
What type of F.M. rating is this material?	

Work Problem #15

- **Total Weight** = 35.8 lbs.
- **Total Dry Weight** = 323.1 grams
- **Weight After Washing** = 264.6 grams

ABC				
Std. Size #	Cumulative Weight Retained	Cumulative % Retained	% Passing	SPECS.
1 ½”	0			
1”	2.2			
3/4”	---	---	---	---
1/2”	13.3			
3/8”	---	---	---	---
#4	20.1			
#10	23.1			
#40	---	---		
#200	---	---		
Soil Mortar				
#40	124.0 g.			
#200	---	---	---	
Pan	264.0 g.	---	---	---

Sample Mass Tolerance Formula: Weight After Washing × 0.003
Lower limit: 264.6 − _____ = _____ **grams**
Upper limit: 264.6 + _____ = _____ **grams**

Work Problem #16

- **Total Weight** = 36.1 lbs.
- **Total Dry Weight** = 337.8 grams
- **Weight After Washing** = 258.7 grams

ABC				
Std. Size #	Cumulative Weight Retained	Cumulative % Retained	% Passing	SPECS.
1 ½”	0			
1”	2.8			
3/4”	---	---	---	---
1/2”	13.9			
3/8”	---	---	---	---
#4	21.4			
#10	24.9			
#40	---	---		
#200	---	---		
Soil Mortar				
#40	111.9 g.			
#200	---	---	---	
Pan	258.5 g.	---	---	---

Sample Mass Tolerance Formula: Weight After Washing × 0.003
Lower limit: 258.7 − _____ = _____ **grams**
Upper limit: 258.7 + _____ = _____ **grams**

Work Problem #17

Complete this work problem to determine the L.L., P.L., and P.I.

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
66.2	**77.5**	**75.0**	**8.8**	**2.5**

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
66.4	**75.2**	**73.4**	**7.0**	**1.8**

Atterberg Limits - Calculation	
Liquid Limit (LL) =	
Plastic Limit (PL) =	
Plasticity Index (PI) =	

Work Problem #18

Complete this work problem to determine the L.L., P.L., and P.I.

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
66.1	**81.1**	**78.0**	**11.9**	**3.1**

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
66.3	**80.3**	**77.5**	**11.2**	**2.8**

Atterberg Limits - Calculation	
Liquid Limit (LL) =	
Plastic Limit (PL) =	
Plasticity Index (PI) =	

Work Problem #19

Complete this work problem to determine if the samples are in tolerance.

ABC					
Sieve	QA-42A	QC-42A	Difference	Tolerance	Pass/Fail
1 ½”	100	100			
1”	94	93			
1/2”	72	68			
#4	49	49			
#10	34	34			
#40	20	19			
#200	8	8			
Soil Mortar					
#40	58	55			
#200	24	25			

Work Problem #20

Complete this work problem to determine if the samples are in tolerance.

2MS					
Sieve	QA-7	QC-7	Difference	Tolerance	Pass/Fail
3/8”	100	100			
#4	100	99			
#8	83	84			
#16	57	60			
#30	42	45			
#50	29	33			
#100	16	19			
#200	4.4	4.8			

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Work Problem Answers

Answer #1

#67					
Sieve	QA-13	QC-13	Difference	Tolerance	Pass/Fail
1”	100	100	**0**	**+/-2**	**PASS**
3/4”	94	95	**1**	**+/-3**	**PASS**
1/2”	---	---	---	---	---
3/8”	18	20	**2**	**+/-5**	**PASS**
#4	4	4	**0**	**+/-3**	**PASS**
#8	1	2	**1**	**+/-3**	**PASS**
#200	0	0	**0**	**+/-0.5**	**PASS**

Answer #2

2MS					
Sieve	QA-32	QC-32	Difference	Tolerance	Pass/Fail
3/8”	100	100	**0**	**---**	**---**
#4	100	99	**1**	**---**	**---**
#8	88	86	**2**	**+/-1**	**NO**
#16	63	61	**2**	**+/-3**	**PASS**
#30	45	44	**1**	**+/-3**	**PASS**
#50	30	30	**0**	**+/-2**	**PASS**
#100	16	17	**1**	**+/-1**	**PASS**
#200	5.2	4.9	**0.3**	**+/-1**	**PASS**

Answer #3

- Total dry sample weight: **24.8 lbs.** (oven-dried)

#67				
Std. Size #	Cumulative Weight Retained	Cumulative % Retained	% Passing	SPECS.
1”	0	**0**	**100**	**100**
3/4”	0.2	**1**	**99**	**90-100**
1/2”	---	---	**---**	**---**
3/8”	19.0	**77**	**23**	**20-55**
#4	23.8	**96**	**4**	**0-10**
#8	24.5	**99**	**1**	**0-5**
Pan	24.8	---	---	---
Passing #200 (wash method)				
#200	---	---	0.1*	0 – 1

Answer #4

- Total dry sample weight: **15.6 lbs.** (oven-dried)

#78M				
Std. Size #	Cumulative Weight Retained	Cumulative % Retained	% Passing	SPECS.
3/4”	0	**0**	**100**	**100**
1/2”	0	**0**	**100**	**98-100**
3/8”	2.1	**13**	**87**	**75-100**
#4	12.9	**83**	**17**	**20-45**
#8	15.0	**96**	**4**	**0-15**
Pan	15.6	---	---	---
Passing #200 (wash method)				
#200	---	---	0.4*	0 – 1

Answer #5

- **Total Dry Weight** = 442.9 grams
- **Weight After Washing** = 434.6 grams

2S				
Std. Size #	Cumulative Weight Retained	Cumulative % Retained	% Passing	SPECS.
3/8”	0	**0**	**100**	**100**
#4	15.3	**3**	**97**	**95-100**
#8	52.4	**12**	**88**	**80-100**
#16	96.6	**22**	**78**	**45-95**
#30	179.9	**41**	**59**	**25-75**
#50	349.1	**79**	**21**	**5-30**
#100	420.0	**95**	**5**	**0-10**
#200	---	---	**1.9**	**0-3**
Pan	434.1	---	---	---

Answer #6

- **Total Dry Weight** = 418.1 grams
- **Weight After Washing** = 402.8 grams

2MS				
Std. Size #	Cumulative Weight Retained	Cumulative % Retained	% Passing	SPECS.
3/8”	0	**0**	**100**	**100**
#4	5.2	**1**	**99**	**95-100**
#8	64.9	**16**	**84**	**80-100**
#16	150.5	**36**	**64**	**45-95**
#30	206.3	**49**	**51**	**25-75**
#50	271.5	**65**	**35**	**5-35**
#100	352.0	**84**	**16**	**0-20**
#200	---	---	**3.7**	**0-8**
Pan	403.1	---	---	---
F.M.	---	**2.51**	---	---

Sample Mass Tolerance Formula: Weight After Washing × 0.003	
Lower limit: 402.8 − **__1.2___** = **__401.6_ grams**	
Upper limit: 402.8 + **__1.2___** = **__404.0_ grams**	
What type of F.M. rating is this material?	**Medium**

Answer #7

- **Total Weight** = 36.6 lbs.
- **Total Dry Weight** = 410.0 grams
- **Weight After Washing** = 321.6 grams

ABC				
Std. Size #	Cumulative Weight Retained	Cumulative % Retained	% Passing	SPECS.
1 ½”	0	**0**	**100**	**100**
1”	2.5	**7**	**93**	**75-97**
3/4”	---	---	---	---
1/2”	14.1	**39**	**61**	**55-80**
3/8”	---	---	---	---
#4	21.0	**57**	**43**	**35-55**
#10	26.5	**72**	**28**	**25-45**
#40	---	---	**14**	**14-30**
#200	---	---	**6**	**4-12**
Soil Mortar				
#40	209.3 g.	**51**	**49**	**40-84**
#200	---	---	**22**	**11-35**
Pan	321.1 g.	---	---	---

Sample Mass Tolerance Formula: Weight After Washing × 0.003	
Lower limit: 321.6 − **_1.0____** = **__320.6__ g.**	**Sample Tolerance within 0.3%?**
Upper limit: 321.6 + **_1.0____** = **_322.6__ g.**	**Yes**

Answer #8

- **Total Weight** = 43.7 lbs.
- **Total Dry Weight** = 324.3 grams
- **Weight After Washing** = 266.0 grams

ABC				
Std. Size #	Cumulative Weight Retained	Cumulative % Retained	% Passing	SPECS.
1 ½”	0	**0**	**100**	**100**
1”	3.2	**7**	**93**	**75-97**
3/4”	---	---	---	---
1/2”	12.8	**29**	**71**	**55-80**
3/8”	---	---	---	---
#4	19.9	**46**	**54**	**35-55**
#10	27.9	**64**	**36**	**25-45**
#40	---	---	**18**	**14-30**
#200	---	---	**6**	**4-12**
Soil Mortar				
#40	166.5 g.	**51**	**49**	**40-84**
#200	---	---	**18**	**11-35**
Pan	265.2 g.	---	---	---

Sample Mass Tolerance Formula: Weight After Washing × 0.003	
Lower limit: 266.0 − **_0.8____** = **__265.2__ g.**	**Sample Tolerance within 0.3%?**
Upper limit: 266.0 + **_0.8____** = **_266.8__ g.**	**Yes**

Answer #9

- Total dry sample weight: **21.9 lbs.** (oven-dried)

#57				
Std. Size #	Cumulative Weight Retained	Cumulative % Retained	% Passing	SPECS.
1-1/2”	0	**0**	**100**	**100**
1”	0	**0**	**100**	**95-100**
3/4”	---	---	---	---
1/2”	13.5	**62**	**38**	**25-60**
3/8”	---	---	---	---
#4	20.9	**95**	**5**	**0-10**
#8	21.3	**97**	**3**	**0-5**
Pan	21.9	---	---	---
Passing #200 (wash method)				
#200	---	---	0.3*	0 – 1

Answer #10

- Total dry sample weight: **25.8 lbs.** (oven-dried)

#57M				
Std. Size #	Cumulative Weight Retained	Cumulative % Retained	% Passing	SPECS.
1-1/2”	0	**0**	**100**	**100**
1”	0	**0**	**100**	**95-100**
3/4”	---	---	---	---
1/2”	18.6	**72**	**28**	**25-45**
3/8”	---	---	---	---
#4	25.1	**97**	**3**	**0-10**
#8	25.3	**98**	**2**	**0-5**
Pan	25.8	---	---	---
Passing #200 (wash method)				
#200	---	---	0.3*	0 – 1

Answer #11

- Total dry sample weight: **31.7 lbs.** (oven-dried)

#67				
Std. Size #	Cumulative Weight Retained	Cumulative % Retained	% Passing	SPECS.
1”	0	**0**	**100**	**100**
3/4”	2.3	**7**	**93**	**90-100**
1/2”	16.8	---	---	---
3/8”	22.9	**72**	**28**	**20-55**
#4	28.7	**91**	**9**	**0-10**
#8	30.7	**97**	**3**	**0-5**
Pan	31.7	---	---	---
Passing #200 (wash method)				
#200	---	---	0.3*	0 – 1

Answer #12

- Total dry sample weight: **15.2 lbs.** (oven-dried)

#78M				
Std. Size #	Cumulative Weight Retained	Cumulative % Retained	% Passing	SPECS.
3/4”	0	**0**	**100**	**100**
1/2”	0	**0**	**100**	**98-100**
3/8”	0.6	**4**	**96**	**75-100**
#4	11.1	**73**	**27**	**20-45**
#8	14.2	**93**	**7**	**0-15**
Pan	15.2	---	---	---
Passing #200 (wash method)				
#200	---	---	0.3*	0 – 1

Answer #13

- **Total Dry Weight** = 424.9 grams
- **Weight After Washing** = 414.6 grams

2S				
Std. Size #	Cumulative Weight Retained	Cumulative % Retained	% Passing	Cumulative Weight Retained
3/8”	0	**0**	**100**	**100**
#4	0.7	**0**	**100**	**95-100**
#8	11.4	**3**	**97**	**80-100**
#16	75.6	**18**	**82**	**45-95**
#30	246.3	**58**	**42**	**25-75**
#50	378.3	**89**	**11**	**5-30**
#100	409.7	**96**	**4**	**0-10**
#200	---	---	**2.4**	**0-3**
Pan	414.0	---	---	---
F.M.	---	**2.64**	---	---

Sample Mass Tolerance Formula: Weight After Washing × 0.003	
Lower limit: 414.6 − **_1.2____** = **_413.4__ grams**	
Upper limit: 414.6 + **__1.2___** = **_415.8__ grams**	
What type of F.M. rating is this material?	**Medium**

Answer #14

- **Total Dry Weight** = 461.1 grams
- **Weight After Washing** = 449.5 grams

2S				
Std. Size #	Cumulative Weight Retained	Cumulative % Retained	% Passing	SPECS.
3/8”	0	**0**	**100**	**100**
#4	2.3	**0**	**100**	**95-100**
#8	62.2	**13**	**87**	**80-100**
#16	158.9	**34**	**66**	**45-95**
#30	236.7	**51**	**49**	**25-75**
#50	309.0	**67**	**33**	**5-30**
#100	384.4	**83**	**17**	**0-10**
#200	---	---	**2.5**	**0-3**
Pan	449.1	---	---	---
F.M.	---	**2.48**	---	---

Sample Mass Tolerance Formula: Weight After Washing × 0.003	
Lower limit: 449.5 − **__1.3___** = **_448.2__** **grams**	
Upper limit: 449.5 + **__1.3___** = **_450.8__** **grams**	
What type of F.M. rating is this material?	**Fine**

Answer #15

- **Total Weight** = 35.8 lbs.
- **Total Dry Weight** = 323.1 grams
- **Weight After Washing** = 264.6 grams

ABC				
Std. Size #	Cumulative Weight Retained	Cumulative % Retained	% Passing	SPECS.
1 ½”	0	**0**	**100**	**100**
1”	2.2	**6**	**94**	**75-97**
3/4”	---	---	---	---
1/2”	13.3	**37**	**63**	**55-80**
3/8”	---	---	---	---
#4	20.1	**56**	**44**	**35-55**
#10	23.1	**65**	**35**	**25-45**
#40	---	---	**22**	**14-30**
#200	---	---	**6**	**4-12**
Soil Mortar				
#40	124.0 g.	**38**	**62**	**40-84**
#200	---	---	**18**	**11-35**
Pan	264.0 g.	---	---	---

Sample Mass Tolerance Formula: Weight After Washing × 0.003
Lower limit: 264.6 − **_0.8____** = **_263.8__** **grams**
Upper limit: 264.6 + **_0.8____** = **__265.4_** **grams**

Answer #16

- **Total Weight** = 36.1 lbs.
- **Total Dry Weight** = 337.8 grams
- **Weight After Washing** = 258.7 grams

ABC				
Std. Size #	Cumulative Weight Retained	Cumulative % Retained	% Passing	SPECS.
1 ½”	0	**0**	**100**	**100**
1”	2.8	**8**	**92**	**75-97**
3/4”	---	---	---	---
1/2”	13.9	**39**	**61**	**55-80**
3/8”	---	---	---	---
#4	21.4	**59**	**41**	**35-55**
#10	24.9	**69**	**31**	**25-45**
#40	---	---	**21**	**14-30**
#200	---	---	**7**	**4-12**
Soil Mortar				
#40	111.9 g.	**33**	**67**	**40-84**
#200	---	---	**23**	**11-35**
Pan	258.5 g.	---	---	---

Sample Mass Tolerance Formula: Weight After Washing × 0.003
Lower limit: 258.7 − **_0.8____** = **_257.9__ grams**
Upper limit: 258.7 + **_0.8____** = **_259.5__ grams**

Answer #17

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
66.2	**77.5**	**75.0**	**8.8**	**2.5**

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
66.4	**75.2**	**73.4**	**7.0**	**1.8**

Atterberg Limits - Calculation	
Liquid Limit (LL) =	**28**
Plastic Limit (PL) =	**26**
Plasticity Index (PI) =	**2**

Answer #18

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
66.1	**81.1**	**78.0**	**11.9**	**3.1**

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
66.3	**80.3**	**77.5**	**11.2**	**2.8**

Atterberg Limits - Calculation	
Liquid Limit (LL) =	**26**
Plastic Limit (PL) =	**25**
Plasticity Index (PI) =	**1**

Answer #19

ABC					
Sieve	QA-42A	QC-42A	Difference	Tolerance	Pass/Fail
1 ½”	100	100	**0**	**+/-2**	**PASS**
1”	94	93	**1**	**+/-4**	**PASS**
1/2”	72	68	**4**	**+/-5**	**PASS**
#4	49	49	**0**	**+/-6**	**PASS**
#10	34	34	**0**	**+/-5**	**PASS**
#40	20	19	**1**	**+/-5**	**PASS**
#200	8	8	**0**	**+/-3**	**PASS**
Soil Mortar					
#40	58	55	**3**	**+/-6**	**PASS**
#200	24	25	**1**	**+/-5**	**PASS**

Answer #20

2MS					
Sieve	QA-7	QC-7	Difference	Tolerance	Pass/Fail
3/8”	100	100	**0**	**---**	**---**
#4	100	99	**1**	**---**	**---**
#8	83	84	**1**	**+/-1**	**PASS**
#16	57	60	**3**	**+/-3**	**PASS**
#30	42	45	**3**	**+/-3**	**PASS**
#50	29	33	**4**	**+/-2**	**FAIL**
#100	16	19	**3**	**+/-1**	**FAIL**
#200	4.4	4.8	**0.4**	**+/-1**	**PASS**


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